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Circle 3 on reader service card
SPECIAL FEATURES

33 Build Dyna-Micro 8080 Computer
Complete plans of a microprocessor that's easy to build and use. by Jon Titus

37 MATV/CATV Accessories
The working parts of antenna systems up close. by Warren Roy

BUILD ONE OF THESE

47 Electronic Ignition For Your Car
Solid-state system can be used with any standard ignition coil. by Dick Pace

GENERAL ELECTRONICS

4 Looking Ahead
Preview of tomorrow's news today. by David Lachenbruch

18 Komputer Korner
Input-output devices. by Jon Titus, David Larsen & Peter Rony

50 R-E Lab Tests Lafayette LR-2200
This new receiver comes up with a "very good" rating. by Len Feldman

60 Using Charts & Graphs
How they work and how you can make the most of them. by Irving Gottlieb

69 State-Of-Solid State
Microprocessor IC's and systems. by Karl Savon

HI-FI STEREO AUDIO

43 Linear Phase Response
A new parameter for measuring speaker-system performance. by Len Feldman

50 R-E Lab Tests Lafayette LR-2200
This new receiver comes up with a "very good" rating. by Len Feldman

56 R-E Lab Tests Marantz 2325
A new stereo receiver runs the gamut at our test lab. by Len Feldman

TELEVISION

24 Equipment Report
American Technology ATC-10 Color Generator.

30 Equipment Report
Hewlett-Packard 3476A Digital Multimeter.

40 All About Function Generators
"Part I" Everything you always wanted to know about how they work and how to use them. by Charles Gilmore

63 Service Clinic
Loop circuits—circuits that control themselves. by Jack Darr

87 Reader Questions
R-E's Service editor Solves reader problems.

DEPARTMENTS

110 Advertising Index 6 New & Timely
12 Advertising Sales Offices 86 New Literature
14 Letters 78 New Products
93 Market Center 89 Next Month
113 Reader Service Card

ON THE COVER

The computer hobbyist needs a better machine. So we've introduced the "dyna micro." It's an 8080 architecture on a single circuit board. We'll be presenting complete plans and construction information starting on page 33 in this issue.

SOLID-STATE IGNITION for your car isn't a difficult project. This unit is easy to build and works with almost any standard ignition coil. .............................................. see page 47

PHASE RESPONSE in speaker systems is an important measurement. Here's how a third speaker can fill the null between woofer and tweeter. ........................................ see page 43


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Secret picture tube

Around the television industry it had been rumored for some time that Zenith was up to something big in picture tubes. Suspicion grew after an unusually large number of new picture tube patents were issued to Zenith scientists and engineers. Then Tele- vision Digest, a trade publication, broke the story that Zenith had developed a "radically new picture tube, re-engineered from glass to gun, yoke to mask," that would provide higher performance at considerably lower cost than present designs.

Zenith finally confirmed that it did indeed have a new color tube that would be introduced in the 19-inch size in some sets late this summer, in other sizes next year. It indicated that the development took four years of intensive effort. In cooperation with Corning Glass Works, and that Zenith considered the new tube to be a major weapon against the inroads now being made by imports in the 19-inch size. Although Zenith hasn't yet released details, it's understood that the new tube presents a picture with a distinctive appearance, that it's lighter in weight than present types and that many operations in its production may be automated.

No picture tube

Getting rid of the picture tube completely is the goal of inventor William Glenn, whose previous contributions to television have been made at General Electric and CBS Labs. Glenn is now director of New York Institute of Technology's Science and Technology center, and he's working on a high-brightness projection television system that uses a charge-coupled device (CCD) instead of an electron gun.

The Glenn TV will be about the size of a Kodak Carousel projector and will be based on light-valve (or Ediphor) principles that use an external light source rather than a CRT to provide illumination for the projected picture. Glenn plans to use a CCD chip to modulate a membrane about the size of a 35-mm slide. A projection lamp is aimed through the membrane. The surface of the membrane is deformed by the CCD chip in accordance with the video signal. Actually, there would be three chip-membrane combinations (one for each color) converged by dichroic mirrors.

Glenn feels that his projector could make possible pictures of virtually any size, viewable in room light. "We've made small pieces of chips that work, but we don't have television resolution yet," he says, but he notes that CCD chips with adequate resolution already been made for developmental TV camera阵s. He estimates he'll have his tubeless TV in about three years.

More on projection

An increasing number of projection TV systems are coming on the market, most of them offered by small companies and based on the use of small-screen color sets, lens systems and directional Kodak EktaLite screens. Most major manufacturers have sat by with little real interest (exception—Sony, which has its own TV projector). Now the majors are beginning to stir. The most enthusiastic, apparently, is the Admiral Group of Rockwell International, whose president, Charles Urban, says: "There are so many reasons projection TV's going to fly that it's beyond the imagination. I've seen a lot of interesting ideas. Our Science Center is working on it. You'll start seeing prototypes of high-brightness systems in about a year and a half."

In addition, Zenith is understood to be underwriting development of special fresnel lenses for projection television, and General Electric is believed to be giving the projection concept another long look. Once there's a major breakthrough permitting the use of an ultra-bright light source (such as the Glenn project), projection TV could be off to the races.

New TV services

The White House Office of Telecommunications Policy has urged the FCC, broadcasters and television set manufacturers to start looking into new services that could be provided by home television without degradation of the broadcast signal. Based on a specially commissioned study made by the University of Denver, a concerted effort was urged to develop "ancillary signals for television."

The Denver study specifically dealt with three major projects: The first was stereophonic sound for television. It estimated that 10 to 25 percent of TV set buyers might be willing to pay $50 to $100 extra for stereo television sets. The second was a special captioning service for the nation's 13,000,000 people with hearing problems and 7,000,000 with limited knowledge of English. The captions would be receivable only on sets with special converters (at probably $55 to $110 installed) or on new sets equipped with captioning circuits (at $30 to $50 extra). The third was Teletext services that use the TV screen to display graphic material transmitted in the vertical interval between pictures. The report says Teletext should reach the commercial stage in the next 5 to 10 years.

One of the proposals promises to get prompt attention from the FCC. In response to an earlier petition by Public Broadcasting Service, the Commission has already proposed a special captioning system for the deaf and said it will move quickly to implement the proposal unless "compelling arguments" are offered against it. The PBS system would reserve line 21 of the vertical interval for captions, which could be decoded by optional TV set circuitry.

High-speed TV

A new, economical system for closed-circuit TV educational courses in the school or home has been developed by Peter Goldmark, president of Goldmark Communications Corp. It will be placed in service this fall in six community college districts across the country. Called Rapid Transmission & Storage (RTS), the system uses videotape or broadcast television. The tape system, RTS I, will be used this fall and makes possible the storage of up to 60 different half-hour programs on a single one-hour videocassette reel—and up to 30 may be shown simultaneously and directed to different monitors.

The RTS II system, to come later, provides for over-the-air transmission of similar information during nighttime non-program hours. A 30-minute course is transmitted in 12 seconds and stored in a special cassette recorder at the student's home for playback at will. The transmission speed of the Mark II system will make it possible to transmit 2,800 different half-hour lessons during an eight-hour period on a single channel.

AM stereo coming

The National AM Stereophonic Radio Committee (NASRC), an industry-wide organization, has set up shop to test various proposed systems to bring two ears to AM. Three systems have been proposed so far: RCA proposed one using frequency-modulated left-and-right information. Sansui and Comm Associates propose use of sideband approaches. Kahn Research Laboratories has also proposed a sideband system in the past and says it will use immediate standardization of its system by the FCC, rather than submit it to testing by NASRC.

DAVID LACHENBRUCH CONTRIBUTING EDITOR
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Electronic sales downtrend reversed at end of 1975

The year 1975 ended on an up-beat in all categories of consumer electronic products sales, except automobile radios, says Jack Wayman of the Electronic Industries Association (EIA). This was in contrast to the figures for the year, which were significantly lower than in 1974. In the final December sales week, television was up 19.8 percent, radio was up 66.2 percent and compact and component phonograph systems was up 10 percent.

The EIA reports color television sales for the whole of 1975 just short of 6.5 million, down 17 percent from 1974. Black-and-white TV sales were just below 5 million, down 16.4 percent from 1974. The AM and FM radio sales totaled approximately 25.5 million units in 1975, lower by 22.6 percent from the almost 33-million units sold in 1974. Automobile radio sales of about 9.2-million units were down 14.1 percent from the 1974 figures.

Total radio sales to dealers in 1975 were almost 34.7 million, a drop of 20 percent from 1974 sales. Compact and component phonograph sales to dealers, in round figures, were 3.4-million units, off 22.7 percent from the 4.4-million 1974 sales.

CSEA names Norman Wolfsel new executive director

The California State Electronics Association has announced the appointment of Norma J. Wooliscroft as successor to Howard G. Wooliscroft, the present executive director of the association. CSEA is a 21-year-old statewide trade association of more than 1,000 sales and service retailers of electronic home entertainment equipment.

Ms. Wooliscroft joins CSEA after 13 years with the California Moving and Storage Association, where she was assistant director. She is a second-year graduate of the U.S. Chamber of Commerce's Institute for Organizational Management, a member of the American Society of Association Executives and of the California society of the same name, serving for several years on its Executive Board. Until Mr. Wooliscroft's formal retirement later this year, she will assume title of assistant executive director of CSEA.

NESDA check shows big jump in number of service technicians

Figures submitted to the National Electronic Service Dealers Association by the ten major state or city licensing boards around the country indicate that the total number of service technicians in the United States has increased to 196,347—an increase of 6.5 percent—during 1975. At the same time, the number of business engaged in electronic servicing declined about 9 percent, from 72,165 in early 1975 to 66,000 at the beginning of 1976.

The increase in the number of service technicians is due to the recession, lives NESDA executive vice president Dick Glass, CET. "I think that the statistic showing 196,000 technicians is correct," he said. "My opinion is that the recession has cut overtime for many technicians working full time in other industries and has caused others to lose their jobs or be laid off. Many have therefore obtained licenses to obtain income with repair work, either for themselves or as employees of existing firms."

Radio tracking to help wolves

A Red Wolf Recovery Program has been organized by the U.S. Fish and Wildlife Service, cooperating with the Louisiana Wild Life and Fisheries Commission and the Texas Parks and Wildlife Department, with the object of preventing the wolf from becoming extinct.

Two members of the Red Wolf Recovery Program recording the vocal responses of a wolf—and any friends he might meet—on an Uher 4000 portable open-reel tape recorder.

As part of the program, wolves are fitted with collars carrying radio transmitters. Their movements are then monitored with the idea of gaining more knowledge of their wanderings and habits. The receivers are directional and make it possible to get a good idea of the whereabouts of the animal being tracked.

Technician apprenticeships initiated in Wisconsin

Through the cooperation of the Wisconsin Electronic Service Association (WESA), the Wisconsin Department of Industry, Labor and Human Relations and the Waukesha County Technical Institute, a Radio and Television Technicians Apprenticeship Program is being carried on in Wisconsin.

Apprentices will be indentured to qualified electronic service establishments in the State for a working period of 8,320 hours (approximately four years). The apprentice normally starts at 50 percent of the skilled rate for technicians and receives raises in accordance with a schedule that forms part of the apprenticeship indenture.

While working, the student will study at a certified school, or if no school is available, will take 576 hours of instruction through home study from the Waukesha County Technical Institute. Upon successful completion of all the requirements of the apprenticeship, the apprentice will receive a diploma from the Wisconsin Division of Apprenticeship and Training.

FCC moves to expand, localize Emergency Broadcast Service

The Emergency Broadcast Service (EBS) is a means for distributing emergency information swiftly to licensees and regulated services of the FCC, non-government entities and the general public. It is made up of AM, FM and TV broadcast stations operating on a voluntary, organized basis during emergencies.

At the national level, the EBS already effectively provides the President with a means of speaking immediately to all the people of the country in any time of grave national emergency. The FCC has now moved to increase the usefulness of the system by increasing its use at the state and local level for day-to-day emergencies—fires, floods or other disasters.

A key element in the plans is the establishment of single EBS points that public safety officials can contact to get emergency messages on the air—a Common Program Control Station (CPCS) that will pass the messages on to other EBS stations. This can save valuable minutes that would be lost in contacting stations individually, especially in emergencies such as tornadoes or flash floods.

New two-tone attention signal for emergency broadcast stations

The FCC established April 15, 1976 as the date at which broadcast stations (other than non-commercial educational FM's with not more than 10-watts power) must be equipped to generate (encode) and detect (decode) the new two-tone inter-station Emergency Broadcast System attention signal. The EBS is a system (Continued on page 12.)
In fact, "innovation" is the word that guides SBE engineers in their quest for better ways to improve personal communications equipment.

An example of SBE innovation at its imaginative best is OPTI/SCAN. This compact 10-channel scanning monitor requires no crystals but is capable of scanning over 16,000 radio frequencies between 30 MHz and 510 MHz.

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*Summary of survey results upon request.
that can keep the nation informed of national, state or local emergencies.

In November 1974, the FCC amended its rules to substitute a two-tone signaling system (a transmission with two audio-tones) for the system then in use—two 5-second carrier breaks followed by a 1000-Hz tone for 15 seconds.

There was some opposition to the April 1 date from broadcasters’ associations, who felt that more time should be allowed to make the changeover. They also demurred at the possible costs, which the National Broadcasters Association said could run to $700. The FCC’s reply was that when the carrier-break system went into effect in 1967, the FCC put out public notices stating that a two-toned technique, expected to prove superior to the carrier-break, was being developed and might make obsolete the emergency broadcast receivers then in operation. Thus, in effect, the industry had been put on notice for eight years. As to price, combination encoder-decoders were available at prices as low as $195, therefore the cost was neither exorbitant nor prohibitive.

Servicers support attack on in-warranty injustices

The Florida Electronics Service Association has pledged $1,000 in support of the Electo TV court-suit in California. The suit is aimed at forcing manufacturers to stop violating California law by soliciting service repair work below cost.

The question has been asked: Why go too low—if in-warranty payment rates are too low, why not simply refuse to service the brands involved? Some service concerns can do just that. But many warranty repair stations are also sales firms and are agents for only the one or two brands they sell. To refuse to handle in-warranty repairs on those brands—even if the rates are below cost—would mean that the customer would have to call a direct competitor to have the in-warranty work done.

Another case is that of a shop that handles all the repair work for a department store. The store obviously wants to handle all its repair business through one shop—not two or three. If the shop will not handle the unprofitable brands, the department store will be inclined to drop it and find one to which it can channel all the repairs.

For these reasons many service groups are supporting the litigation with cash. The Orange County chapter of the California State Electronics Association (CSEA) donated $1,000 to the fund, and a single shop in Los Angeles contributed $500. Other donations of $100 and $50 have come in from all over the country.

The National Electronic Service Dealers Association (NESDA) has set up a special fund for the in-warranty war-chest, and asks interested groups to send their donations to: SIS—Electro TV Fund, c/o the Finney Co., M. L. Finneburgh, Jr., EHF, 34 W. Interstate St., Bedford, OH 44146.

Federal Trade Commission rule helpful to mail-order customers

Under a new Trade Regulation Rule of the FTC, mail-order merchants will be required to make deliveries within a reasonable time, notify the customer if his order has to be delayed, and return his money if requested.

The Rule provides that if a mail-order seller is unable to ship merchandise within the time stated in the offer (or if no time is specified, within 30 days) he must notify the buyer of the delay and give him the option of canceling the order and having the purchase money refunded.

The buyer must be provided with a cost-free device—such as a postcard or postage-paid envelope—for this purpose. If the buyer does not respond, it will be assumed that he has consented to an additional 30-day delay. For any longer delay, the customer’s express consent must be gained; otherwise the money is to be refunded.

The Rule also makes provision for indefinite delays if agreed to by the customer, though a refund must be made if requested any time during the delay. It also requires sellers of mail-order merchandise to have a reasonable basis for claims about shipping time.

In the event of a violation, the FTC can obtain a court order for compliance or they could have the company fined $10,000 for each day of non-compliance. However, it is still legally debatable whether the FTC can go directly to Federal Trade Court.

Nationwide emergency channel adopted for police use

The FCC has designated 155.475 MHz as a nationwide emergency channel frequency for use in police emergency communications networks operated under statewide law-enforcement plans. The action was initiated on request of the APCO (Associated Public Safety Communications Officers).

Several states, APCO stated, now employ statewide emergency channels. It has been demonstrated that police can respond more effectively by using such common facilities. The 155.475 MHz frequency is limited to state police systems. Operations on 155.475 MHz that are not now limited to emergency communications may continue until January 1, 1985.
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letters

AMERICAN TV STANDARDS

I note with horror that the changing of American TV standards is being seriously considered ("Looking Ahead", February issue). While it is true that the present system was developed in the middle 30's and the color system added to it in the early 50's, the system isn't all that bad.

- The information bandwidth in the present system is 4.2 MHz. Color sets normally pass about 3.5 MHz of it; black-and-white sets more like 2.5 to 3 MHz.
- The color signal consists of two variables, called I and Q, corresponding more or less to red-blue and green-purple separations. The I signal bandwidth is 1.5 MHz, the Q is 500 KHz. Most sets use 600 kHz for both.
- The soundtrack is required to have frequency response from 50 to 15,000 Hz — the same as "hi-fi" FM. Most sets come with amplifiers and speakers of quality similar to that of a portable transistor radio.

Clearly, if receiver manufacturers were convinced that the people would pay more for higher quality, they'd make sets that could take full advantage of this 25- to 35-year-old set of standards. Such a set wouldn't cost much more. But there are a few other reasons, all due to the TV stations and the networks:

- Many programs are on film, which has an inherent contrast limit compared to TV — film does not look "live." Most film uses an optical sound system, developed in the twenties. The frequency response, distortion, and signal-to-noise ratio are decidedly inferior to that of the transmitter.
- Networks limit audio frequency response from any source to about 200 to 5000 Hz, and signal-to-noise is well below the transmitter capability.
- Network shows delayed for viewing in the western half of the U.S. are played back one generation down, no matter what the source. This often causes color banding, usually seen as stripes of off-color or color contrast changes, especially in the red hues which include most skin tones.
- Local newsfilm is 16 mm or super-eight, with the limited resolution already mentioned. Some improvement is made on the audio track of super-eight by use of magnetic recording, but it is partially offset by the even slower film speed.
- Electronic news-gathering (ENG) equipment, which uses videotape instead of film, uses a high bandwidth of the capability of the television channel, since the increased bandwidth would increase the complexity, size, weight, and cost of those items.

Almost all pay-TV "movie packages" are played from videotapes, which have less than half the resolution the channel can provide. This degradation is obvious on almost any receiver.

If we were to go to a 1000-line system, we would no longer be compatible with Canada, Mexico, or Japan, to name a few, and anything we presently have on videotape would be obsolete — we could scan-convert it, but that wouldn't improve it. The thought of "Let's Make A Deal" on a 10-foot screen makes me ill. Incidentally, the main resolution limitation on our present system is in the vertical direction, since that's across the lines, while the horizontal is continuous. Vertical resolution could be doubled by going to a 4:1 interface instead of the present 2:1, and still be compatible with all the TV sets in the country. Such an arrangement could be switched on and off at will by the TV station, FCC consenting.

Let's hope that nobody's serious about all this. Look at the picture from an Advent 7-foot screen projector set — it ain't half bad. And there's always the movies.

JAMES REIGER
Ridgecrest, CA

COMPUTER HOBBYISTS

To me, the most critical thing in the hobby market right now is the lack of good software courses, books and software itself. Without good software and an owner who understands programming, a hobby computer is wasted. Will quality software be written for the hobby market?

Almost a year ago, Paul Allen and myself, expecting the hobby market to expand, hired Monté Davidoff and developed Altair BASIC. Though the initial work took only two months, the three of us have spent most of the last year documenting, improving and adding features to BASIC. Now we have 4K, 8K, EXTENDED, ROM and DISK BASIC. The value of the computer time we have used exceeds $40,000.

The feedback we have gotten from the hundreds of people who say they are using BASIC has all been positive. Two surprising things are apparent, however:

1) Most of these "users" never bought BASIC (less than 10% of all Altair owners have bought BASIC), and
2) The amount of royalties we have received from sales to hobbyists makes the time spent of Altair BASIC worth less than $2 an hour.

Why is this? As the majority of hobbyists must be aware, most of you steal (continued on page 16)
The Realistic® STA-90 Will Change Your Ideas About Who's #1 in Hi-Fi Features, Value and Style!

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Recognizing that a penny saved is a penny earned, may we suggest that trying to economize by putting off the replacement of a worn stylus could be like throwing away five dollars every time you play a record. (Multiply that by the number of records you own!) Since the stylus is the single point of contact between the record and the balance of the system, it is the most critical component for faithfully reproducing sound and protecting your record investment. A worn stylus could irreparably damage your valuable record collection. Insure against this, easily and inexpensively, simply by having your dealer check your Shure stylus regularly. And, when required, replace it immediately with a genuine Shure replacement stylus. It will bring the entire cartridge back to original specification performance. Stamp out waste: see your Shure dealer or write:

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Circle 9 on reader service card

LETTERS
(continued from page 14)

your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?

Is this fair? One thing you don't do by stealing software is get back at MITS for some problem you may have had. MITS doesn't make money selling software. The royalty paid to us, the manual, the tape and the overhead make it a break-even operation. One thing you do do is prevent good software from being written. Who can afford to do professional work for nothing? What hobbyist can put 3-man years into programming, finding all bugs, documenting his product and distribute for free? The fact is, no one besides us has invested a lot of money in hobby software. We have written 6800 BASIC, and are writing 8080 APL and 6800 APL, but there is very little incentive to make this software available to hobbyists. Most directly, the thing you do is theft.

What about the guys who re-sell Altair BASIC, aren't they making money on hobby software? Yes, but those who have been reported to us may lose in the end. They are the ones who give hobbyists a bad name, and should be kicked out of any club meeting they show up at.

I would appreciate letters from any one who wants to pay up, or has a suggestion or comment. Just write me at 1180 Alvarado, SE, #114, Albuquerque, New Mexico 87108. Nothing would please me more than being able to hire ten programmers and deluge the hobby market with good software.

BILL GATES
General Partner, Micro-Soft
Albuquerque, NM

OOOOPS!

In your February, 1976, Komputer Korner example on page 86, it appears that you have mixed up your architecture and the direction of the moves.

With architecture B; to move A to output requires:
02 (move A to C)
07 (move C to output)

But if C contains needed data, the instructions should be:
06 (move C to B) not B to C
02 (move A to C)
07 (move C to output)
04 (move B to C)

PHILLIP L. EDELSBERG
Systems Analyst
Indianapolis, IN

DON'T MISS THEM!

This month's hi-fi test reports include two stereo receivers. One is the Marantz model 2325 and the other is Lafayette's model LR-2200. See how these two receivers match-up against each other. Turn to pages 50 and 56 for the complete story and full specifications.

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MAY 1976

Circle 10 on reader service card
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Dealer inquiries invited.

KOMPUTER KORNER

How to interface the microcomputer with input/output devices.

DAVID LARSEN, PETER RONY, and JOHN TITUS

THE VARIOUS DATA PATHS IN A MICROCOMPUTER consists of the data input, data output, external device addressing, in and out function pulses, and interrupt signals. These are the vital lines of communication between the microcomputer and the "outside world", for example, those signal lines that are necessary to interface the microprocessing unit (MPU) to the input/output or I/O devices that you would like to control.

What is an I/O device?

Some useful definitions include the following:
input/output—General term for the equipment used to communicate with a computer and the data involved in the communication.1

I/O—Abbreviation for input-output.2

I/O device—Input/output device. Any digital device, including a single integrated-circuit, that transmits data to or receives data or strobe pulses from a computer. The in and out functions are always referenced to the computer.3

The traditional view of an I/O device is that it is somewhat large or complex. Card readers, magnetic tape units, cathode-ray tube displays and teletypes certainly fit such a description. However, a single integrated circuit such as a latch, shift register, counter or small memory can also be considered to be an I/O device to a computer.

Another important point is that several device-select pulses may be required to interface a single I/O device. For example, a 74198 shift register has a pair of control inputs that determine whether the register shifts left, shifts right, or parallel-loads 8-bits of data. This IC also has a clock input and a clear input. Thus a single 74198, when serving as an output device, may require up to four device-select lines from the microcomputer. Therefore, the fact that we can generate 256 different input and 256 different output device-select pulses does not necessarily mean that we can address 512 different "devices." A more reasonable number is of the order of 50 to 100 different devices.

Device-select pulses are inexpensive and easy to implement. We encourage you to use them as often as possible as you attempt to substitute computer software for integrated circuit hardware. We shall repeat this theme often: software vs. hardware. There exists a tradeoff between the two, but your main objective in using microcomputers will usually be to substitute software for hardware. When you do so, the only penalty that you may pay is time—it takes time to execute computer instructions. If you can accept the delays inherent in computer programs, then you can vastly simplify the circuitry required to accomplish a specific interfacing task.

Interfacing

Interfacing can be defined as the joining of members of a group (such as people, instruments, etc.) in such a way that they are able to function in a compatible and coordinated fashion. By "compatible and coordinated fashion," we usually mean synchronized. Some important definitions include the following:

synchronous—In step or in phase, as applied to two devices or machines. A term applied to a computer where a sequence of operations is controlled by equally spaced clock signals or pulses.2

synchronous computer—A digital computer that has all ordinary operations controlled by equally spaced signals from a master clock.2

(continued on page 22)
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For additional information, contact your B&K-Precision distributor for our comprehensive brochure describing the operation of the Model 1040 CB Servicemaster and the CB Service Center—or write us for your free copy.

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synchronous operation—Operation of a system under the control of clock pulses. Such synchronization pulses—Pulses that are originated by the transmitting equipment and introduced into the receiving equipment to keep the equipment at both locations operating in step—is called computer interfacing. The synchronization of digital data transmission between a computer and one or more external input/output devices.

Although the details of computer interfacing vary with the type of computer employed, the general principles of interfacing apply to a wide variety of computers. Such principles include the following:

- The digital data transmitted between a computer and an I/O device are either individual clock pulses or else full data words.
- The computer and the I/O device are both clocked devices. At the very least, the I/O device has a single flip-flop that is set or reset by the computer. All data transmission operations are synchronized to the internal clock of the computer.
- The computer sends synchronization pulses, called device-select pulses, to the I/O device. These pulses are generated by the computer program and are usually quite short—for an 8080 microcomputer operating at 2 MHz, they last for only 500 ns. The pulses synchronize and select at the same instant of time.
- Individual device-select pulses are sent to individual input or output devices. This is called external device addressing. The pulses are used for latching data output and strobing data input.
- Computer program operation can be interrupted by the transmission of a clock pulse from an I/O device to a special input line to the computer. This is called interrupt generation. Upon being interrupted by an external I/O device, the computer goes to a computer subroutine that responds to, or services, the interrupt.
- Full data words can be output from, or input into, the accumulator register. For the 8080 microcomputer, a full data word contains 8 bits. Output data from the accumulator is available for only a very short period of time and usually must be latched. Input data into the accumulator is acquired over a very short period of time and usually must be strobed into the accumulator.

Interfacing basically consists of the synchronization of parallel input or output data via the use of the 512 device-select pulses. (See Fig. 1.) Hardware is required to tie the MPU to the external device and is just as important as the microcomputer software. We shall tackle both of these facets of microcomputer interfacing in detail in subsequent columns.

References

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VISIT OUR BOOTH 2122 AT ELECTRO '76

Solid-State News

National Semiconductor has submitted a 4K RAM memory that is different from the competition.

The MM5270 Tri-Share™ 4096 x 1 bit RAM is packaged in an 18 pin DIP in contrast to the industry standard 22 pin packages. Three functions share the use of a single lead—read/write, logical chip select and Vcc. One lead is also used for both data input and output.

The 18-pin packages can be squeezed in with a density nearly twice that possible with the 22-pin packages. National claims memory system costs are kept low because of the savings in PC cards, card frames, connectors and wiring. The cost of the memory package itself is lower. The access and cycle times are 200 ns and 400 ns, respectively.

RCA has also joined the NMOS memory field with the MW7001ID 1024 x 1 bit static RAM. The device is pin compatible with the AMS70011 and has a 60 ns maximum access-time and 180 ns maximum cycle-time. Also planned is a 4096 bit dynamic RAM.

Both the National and RCA chips are TTL compatible except for the chip select input.

The SHM-IC-1 from Datel Systems is a high performance sample-and-hold that uses only an external storage capacitor. Sample-and-hold systems are used in sampled data control systems, in the reconstruction of sampled waveforms and for data acquisition.

Acquisition time is 4 μs with a .001 μF capacitor; the signal droop is 50 mV/μs. The capacitor can be lowered to 100 pF for a faster 2 μs acquisition time, but droop also increases in the same ratio.

Three blocks make up the sample and hold. A high gain input differential amplifier, the electronic sampling switch, and an output buffer amplifier. The SHM-IC-1 sells for $29 in small quantities.
There's plenty of power packed in this beautiful receiver. Muscle your receiver needs for more than just sound volume. Power produces clear distortion-free sound. And it gives it to you even at low volume.

The Lafayette LR-3500 has a well-developed 47 watts per channel minimum RMS. Each channel is driven at 8 ohms from 20-20,000 Hz with no more than 0.5% total harmonic distortion.

The top of the Lafayette line, the LR-3500 AM/FM stereo receiver has all the features you've come to expect as the trappings of power: it has state-of-the-art electronics, complete power controls to personalize the sound. And many convenience features like dual tape monitors, and FM mute. Power is yours with the Lafayette LR-3500. It's $399.95 at your Lafayette dealers. There are dealers coast to coast. Or shop from our free catalog.

The Lafayette LR-3500 can make your dreams for power come true.

Electronically Speaking, Who Knows Better Than

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American Technology Corp.
ATC-10 Color Pattern Generator

The American Technology Corp., 225 Main St., Canon City, CO 81212, is one of the new "high-technology" companies in the test-equipment field. Their first instrument is a color-bar pattern generator, model ATC-10. This is an all solid-state instrument, using the newest digital IC techniques to produce not only the stock test patterns, but several new ones. Its a versatile instrument that will do all of the regular things, and many others as well; its really a "Color-Bar-Plus" generator!

The ATC-10 uses 31 digital IC's, an IC-regulated DC power supply, and is well made. For stability, all frequencies, line-widths and spacing are crystal controlled. Due to the crystal control, all patterns are as solid as a rock.

All of the standard test patterns can be used for purity, convergence and color alignment. The ATC-10 provides 10 x 10 dot, crosshatch, vertical and horizontal lines, and the standard 10-bar gated rainbow color patterns.

Now for the new patterns. There is a Hatchdot—a crosshatch with a single dot in the exact center. There is also a Hatch-dot pattern—a crosshatch with center dot and a "frame" of dots all the way around the edges. Handy for centering and linearity adjusting. By the way, the center dot in the dots pattern is isolated—the dot above and below the center is blanked out so that you can identify it instantly.

The 10-bar color-bar pattern, the 6th (blue) bar is "flagged"—there is a blank in the center that saves a lot of counting! The ATC-10 actually has three color-bar patterns in all. The next one is called Vector. This is the 10-bar pattern with the luminance signal blanked out. It produces much sharper vectorscope patterns. The last one is really useful. This one is called 3.58 Monitor and it is the ten-bar pattern once more, but this time the burst has been blanked out. You will see exactly the same effect you get when you ground the burst-amplifier grid to let the TV set's 3.58 MHz oscillator free wheel. You can do this without taking the back of the set off. If the color bars float or fall out of sync, you definitely know that the 3.58 MHz oscillator is or isn't able to run on-frequency.

The next color pattern is one called Red Raster. It's a 3.58 MHz signal that is 67.5-degrees away from the burst. You do not have to do anything to the receiver aside from turning the phase control (handless purity!) Turn the color-control down and the brightness up, and you get a clear white raster for checking gray-scale adjustments. For another test like this, turn to the gray quad position. This displays a screen divided into four segments, white, light gray, dark gray and black. This can also be used to check deflection yoke polarity. If the white quadrant isn't in the lower right corner, one of the yoke windings is reversed. There are eleven different test patterns in all. Since all of these have their chroma and sweep frequencies tightly phase-locked, the stability is excellent. Another automatic circuit prevents over-modulation.

The RF output of the ATC-10 is on channel 2, crystal controlled. If channel 2 is used in your area, you can change to channel 3 by installing another crystal. The RF output of the ATC-10 can be varied from 15 µV to 90,000 µV at 75-ohms output, and 180,000 µV on the 300-ohm output. There is also an IF crystal-controlled output at 45.75 MHz. To obtain this, just pull out on the RF gain-control knob.

Both 75- and 300-ohm output cables are provided. These two cables and the line cord slow in a compartment provided in the back of the case. The 75-ohm IF output can be used to check the tuner in any TV set. In sets with the IF input soldered, just hook the cable right across the terminals. There is ample output.

Video signals, in either sync polarity are available from a separate jack. (Phase too are variable, from 0 to 1.8 volts P-P. Both IF, RF and video outputs may be used at the same time. One novel use for this is to feed the video signal directly to one trace of a dual-trace scope and feed the signal picked up from the TV set to the lower trace input. (The signal may be fed to the TV antenna input or IF input.) This will let you use the burst signal from the video for phase checks, bandwidth and several other things in the TV set circuitry. The luminance pedestal in the color-bar pattern is a good square wave. By tracing this through the TV set's video circuitry, you can check damping, bandwidth, frequency and phase response. Works in other stages as well, of course.

(continued on page 30)
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EQUIPMENT REPORTS
(continued from page 24)

Finally, horizontal or vertical trigger signals for a scope can be obtained from front-panel jacks. For checking horizontal sync, burst, etc., use —- sync polarity; for looking at the scan period of the sweep, use + sync polarity on the scope.

Before I forget to mention it, the panel and controls of the ATC-10 are an excellent example of human engineering. Knobs are large enough to get hold of, and they’re all very plainly marked. The use of push-pull switches makes for a compact yet handy panel layout. Only four knobs are needed, and three banana jacks for the trigger signals. BNC connectors are used for RF, IF and the video outputs. These are at each end and out of the way.

It’s a very easy instrument to use. When I first hooked it up, I obtained some very peculiar patterns! Then, I found that I had the RF cable in the video jack and that the TV set was on Channel 8. After reading the plainly marked panel and hooking it up right, it worked much better! Speaking of reading, you get not one but two instruction books with the ATC-10. One covers in-home servicing (including a darned good basic course in convergence!) and the other covers in-shop techniques using a scope. A great many previously difficult tests can be made with the precise patterns from this instrument—DC restoration, demodulation angle, vector-scope patterns, bandwidth, phase shift, and many more. All of these are covered in simple terms in the well-written manuals.

The instrument has a two-year warranty on it. Price is in the ball-park for an instrument that will do as many things as the ATC-10 will. The firm told me that this instrument had been field tested by several TV technicians, and their reports were used in the final design. This testing was carried on for over a year and a half period.

Hewlett-Packard 3476A Digital Multimeter

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I OPENED THE BOX AND SAID TO MYSELF "Oh, good! Someone has sent me a beautiful shoulder purse!" A closer look showed a modest little bug at one side and the name Hewlett-Packard. Unzipping the case, I pulled out a little light gray plastic case. This turned out to be the newest thing in portable digital multimeters; Hewlett-Packard’s 3476A digital multimeter. It’s not at all the conventional instrument, the case is flat and very thin.

The 3½ digit bright red LED display is at one side and six pushbuttons at the other. The test leads plug into the right side of the case.

The small size is made possible by the use of new technology. This includes tantalum-nitride precision resistor networks that eliminates the need for more expensive and bulky discrete precision resistors in the dividers. The circuitry is on only one PC board although the 3476A has full autoranging capability on all of its five functions: DC volts, AC volts, DC current AC current and resistance. The decimal point and polarity indications are automatic and so is the zeroing. All you have to do is touch the test prods to the circuit and note the reading.

Ranges cover everything needed. You can read DC voltages from 0.0001 volt (100 microvolts!) up to 1,000 volts, and AC voltage from the same low point up to 700 volts RMS. Accuracy on DC volts is 0.5% or better; on AC volts, 0.6% or better. Current ranges, both AC and DC cover from ±0.11 A up to 1.1 A. The AC volts range is rated up to 10 kHz with good accuracy.

The shoulder purse turned out to be a very cleverly designed carrying case. With this, the instrument can be hung around your neck. Opening it up will let you see the display and controls. Both hands are free to do the testing. Ample space is provided to hold the instrument, test leads and accessories. It is a very good-looking accessory.

The 3476A is the AC-powered version and the 3476B can be powered from AC or rechargeable batteries. The power supply is the only difference.

There are several useful features built-in. Using the 3476A in the autorange mode, it will set itself to whatever range is needed to display the voltage or resistance across the test prods. If you want to, you can take one reading and press the hold button. This locks the instrument on that range so that you can take several readings around the same stage without waiting. This doesn’t take too much time since it updates very rapidly, but in the hold position it’s even faster.

Another handy though too often neglected feature is the test leads. An instrument must be easy to connect into or across a circuit if its to be of any use. The instrument comes with a pair of stout test prods and a neat little plastic pouch that contains a whole array of different screw-in tips, clips, spade lugs, etc., to make hooking the leads to any type of circuit construction very easy. They’re easy to change and they make this instrument even more versatile.

The price of the 3476A is even more impressive. It’s only $225.00 for the 3476A AC version. This is quite a bit less than many other instruments with the same ratings. This has been made possible by the use of only two chips—one is the tantalum-nitride film resistor pack and the other a N-MOS control chip that does everything else! It contains the counters, buffer storage, display circuits, 3,500 bits of ROM and all of the mid-state analog switching for the autorange circuitry and so on and on. All in all, quite a piece of fine test gear.
The Black Watch kit

At $29.95, it's

*practical—easily built by anyone in an evening's straightforward assembly.

*complete—right down to strap and batteries.

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The Black Watch by Sinclair is unique. Controlled by a quartz crystal . . . powered by two hearing aid batteries . . . it's also styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash . . . just touch the front of the case to show hours and minutes and minutes and seconds in bright red LEDs.

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All you provide is a fine soldering iron and a pair of cutters.

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build
"dyna-micro"
an 8080 microcomputer

Complete with keyboard for data entry, LED readout of the address and data, breadboard socket for experimenting, 500-bytes of PROM and 500-bytes of RAM, expandable to 65K and self-contained power supply

JOHN TITUS

Many experimenters, hobbyists and professionals are interested in learning about microcomputers and how they work, but the cost of a development system can be high and even inexpensive systems may require an expensive peripheral such as a teletypewriter to get them to work. None of the available systems have any easy hardware breadboarding capability and none have a series of experiments to teach you both interfacing and software fundamentals.

The Dyna-Micro is a complete microcomputer using the 8080A microprocessor chip. It isn't a stripped-down version of another system since it was designed specifically for the beginner. This system has been designed to teach you about microcomputers whether you're a high-school student or a digital design engineer—both will learn a great deal about computers. With the Dyna-Micro, you won't be spending your time wire wrapping a prototype or debugging a complex "hobby" system, you'll be doing hardware and software experiments to learn more about the microcomputer revolution.

The Dyna-Micro won't run FORTRAN, BASIC, editors, assemblers or other complex software in its present form. It isn't meant for that. You can, however, expand the memory if you want to. By the time you finish the experiments, you will know how this is done.

All the Dyna-Micro functions, including the keyboard, are contained on a single 10" × 12" printed-circuit board. The power supply is external.

Using the Dyna-Micro

The Dyna-Micro is one of the easiest
FIG. 1—CENTRAL PROCESSOR shows 8080A microprocessor and associated components. Power supply is external while voltage regulator is on-board.
to use microcomputers since it uses a software controlled "front-panel." Data is entered through a 15-key keyboard and data is displayed by LED's. The keyboard is used to enter address and memory data, to examine the contents of any memory location and to start your program from any location desired. The software to do this is pre-programmed in a 1702A PROM and is called the Keyboard Executive or KEX program. Since the 8080A microcomputer uses 16-bits of address and 8-bits of data, the LED display registers are divided into groups of 8-bits each. The KEX program uses OUTPUT 1 for the highest 8-bits of address (HI) and our next 65,536 words (commonly referred to as 65K) of memory may be addressed and added to the basic 8080 system. The Dyna-Micro uses only 1K of memory, more than enough for all the experiments and for most of your own needs when getting started. The memory is segmented, with the first 500-bytes being PROM and with the next 500-bytes being R/W. Table 1 shows how the memory is divided between PROM and R/W. The output ports and the keyboard input are used in conjunction with the 8080 program, but since they are not...
hardwired, you can use them for data input and output with your own software. This is easily done with the software as we'll see later. Additional input and output ports are easily added by breadboarding them on the SK-10 socket or connecting them to the edge connector.

Interfacing experiments are all done on the SK-10 socket. All you will need to do the experiments are some no. 24 jumper wires and the necessary integrated circuits. No additional soldering or wire wrapping is necessary with the Dyna-Micro.

Construction

The Dyna-Micro is constructed on a single printed-circuit board and it will be built and checked-out in stages to assure proper operation. These checks are fairly simple and all that is required is a voltmeter and a means of detecting for TTL level pulses. A monostable and LED will work quite well for this purpose. An oscilloscope is not needed, but might be helpful if you have one.

The schematic diagram of the Dyna-Micro is divided into two sections—the central processor unit and the I/O (Input/Output) section. The schematic diagram of the central processor unit is shown in Fig. 1 and the I/O section is shown in Fig. 2.

All the components of the Dyna-Micro, including the keyboard, are contained on a single 10" x 12" printed-circuit board. A double-sided board is used to minimize the number of jumper wires necessary for construction.

The power supply should be constructed first. If an assembled supply is purchased, it should be tested. The power supply must be capable of providing +5 volts at 1.5 A, and ±12 volts at about 150 mA. The power supply may be purchased from one of the many suppliers or from a surplus house. It should be ready before construction proceeds since it will be used to check the sections as we go along.

Mount the capacitors, resistor, and Zener diodes in the voltage regulator section of the PC board. Be sure that the binding posts are in the upper-left corner when the board is in front of you. The +12 volts is used only by the 8080A and the 8224 crystal clock IC. The −12 volts is used by the voltage regulator circuitry to obtain the −5 volts for the 8080A chip and the −9 volts for the 1702A type PROM's. After soldering in the parts, connect the power supply and check for the voltages at the power supply to be sure that there aren't any shorts. Check for +12 volts at pin 28 of the 40-pin socket and at pin-9 at IC5 (both sockets will not be soldered in at this time). You can also check for −5 volts at pin 11 of the 40-pin socket. The −9 volts will not be present unless a PROM is in one of the sockets.

The clock circuit uses an Intel 8224 integrated circuit. This is a crystal clock oscillator that provides the proper MOS clock levels for the 8080 system. It also contains circuitry for a TTL level clock (Q2), reset and

(Continued on page 74)
understanding MATV accessories

There's a lot of individual parts in a MATV system. Here we look at the most important ones and see what it is that they do and how best to use them.

WARREN ROY

There are more than 30 different kinds or categories of equipment that go into a MATV system. The individual items vary from antennas and rotators, to distribution amplifiers and power supplies, to connectors and cables. You need every one of these items to assemble a complete working system. In this article we will take a look at the more common elements; discuss their important characteristics and applications; and try to provide some guidelines to us when buying them.

Start at the top

We'll start with the antenna, the top of the iceberg in a MATV system. For the purposes of this article we'll look at broadband antennas as opposed to the single-channel antennas used in some systems. The single-channel approach works well where the stations to be received lie in different directions from the receiving antenna or where the signal from one station is much stronger than another. But in many systems a single broadband antenna is all that is needed.

The antenna selected must provide adequate signal levels for all of the channels to be received. Obviously, the further the antenna is located from the transmitters, the more gain, and therefore the more elaborate it must be. Most antenna manufacturers provide a full range of antennas to cover all possible circumstances. We suggest that you get an antenna that exceeds the minimum requirements. In other words, get an antenna that's one step better than you need.

Almost all modern antennas are made of aluminum and are anodized or otherwise plated or coated to protect against corrosion. In most instances a VHF/UHF antenna will do the job. But if there are no active UHF channels in your area, you can use a simpler and less costly VHF-only antenna. When using either a VHF-only or a VHF/UHF antenna there is one possible complication. Does the antenna cover the FM radio band or does it drop out those signals? If your customer wants FM reception, obviously you'll have to use an antenna that does provide that coverage.

Preamps fight snow

Preamps for weak signals are a must in many fringe areas. The preamp should be mast mounted and provide a lot of gain. At the same time it must have a low noise figure. Preamps are available that provide one wide-band amplifier or as many as three separate amplifiers in one package. The separate amplifier approach offers the benefits of greater reliability and protection from strong signal overloads. Since noise is the most important specification in a preamplifier, make sure you select one with the lowest noise figures you can obtain.

One important point to remember. A preamp can improve a snowy picture by reducing fading and loss of color and compensating for losses in the transmission line. But it cannot make a poor picture perfect.

Since the preamp contains a transistor amplifier it also requires a source of dc power. This is frequently provided by a separate power supply, located inside the house, that feeds the needed voltage up the transmission line to the amplifier. Older units may require a separate power supply connection, but this type unit is almost never seen any more.

By selecting a preamp that also converts a 300-ohm input to a 75-ohm output you can kill two birds with one stone—amplify the signal and reduce snow in the picture and match the antenna to the coax cable of the antenna system at the same time.

Filters and traps

Filters and traps are used in the head-end of many MATV systems to eliminate undesired signals and provide interference-free signals. A wide variety of equipment is available. Some are fixed, others are variable. The fixed ones are designed to cover a specific frequency range, such as individual television channels. The variable type can be tuned to any given frequency in its range.
Traps and filters

Bandpass filters permit the desired range of frequencies to pass through unobstructed, yet severely attenuate all other signals. The ideal filter has sharp slopes that make it possible to attenuate even nearby unwanted signals.

Traps are actually the opposite of a bandpass filter. They are designed to attenuate some specific undesired frequency. A good trap must have a high Q, making it extremely selective. The more selective it is, the better it can eliminate the undesired frequency without having any great effect on the wanted signals.

System amplifiers

The more sets you have connected to an antenna system the more signal you need to feed them all and have them deliver clear snow-free pictures. Remember, no matter how good the antenna itself is, there is a finite limit to how much signal it can pick up. When the demands on the system exceed this, we must use an amplifier to make up the difference. The amplifier also compensates for losses caused by the coaxial cables used in the system.

While these amplifiers are selected to deliver enough gain to operate the system, an equally important operating parameter is the noise figure of the amplifier. Amplification must be relatively...
noise free or the result will be worse than what you have without any gain at all.

About splitters
The first piece of equipment we encounter next is the splitter. The coaxial cable that carries the signal from the distribution amplifier toward the set is called the main trunk line. Some MATV systems have only a single trunk line, but it is much more common and practical to find that the signal is separated into individual lines that run directly to the sets in various parts of the house.

This kind of splitting usually requires a two-, three- or four-way splitter. Even if the plans call for only two outlets it may be wise to use a three-way splitter so that you can easily add another outlet at some later date. In strong signals areas use back-matched splitter/mixers. Back-matching provides a good match for reverse current flow, minimizing the possibility of signals re-entering the system.

Tapoff styles
The tapoff delivers the signal from the distribution lines to the TV sets. At the same time it keeps the sets from interfering with each other. Each set in a MATV system ideally gets about the same amount of signal, but there will be more signal available at outlets that are closer to the distribution amplifier than at outlets that are further away. By using variable-isolation wall tapoffs, it is relatively easy to balance this difference in signal strength out.

In most applications four types of tapoffs are most commonly used: the wall tap, the line drop tap, the directional coupler and the pressure tap.

The wall tap is the one that you are the most likely to see and use as part of a MATV system. It is used in much the same way as an electrician uses an AC outlet. In a new building, the distribution amplifier runs inside the wall and the tap is mounted in a standard electrical box inside the wall. In existing buildings it is not always possible or

DISTRIBUTION AMPLIFIERS are usually located inside the building and provide up to four outputs.
practical to snake transmission coax through the walls and in these instances the distribution coax can be run along the baseboard or the surface of the wall. The tapoff is then enclosed in a special surface-mounting housing.

Wall taps
Three types of wall taps are available. There's a 300-ohm outlet, a 75-ohm outlet, and a dual outlet. The correct one to use depends on two factors: the number of outlets required per room and the signal strength in the area.

Generally, it is best to use a 75-ohm outlet with a matching transformer. In strong signal areas the 300-ohm line between the outlet and the set will pick up signals directly and can cause ghosts, and interference. Using coax cable and 75-ohm outlets prevents this since the cable is shielded from direct signal pickup.

In some systems you will have to provide an outlet or outlets for both television and FM. In these instances you'll want to use a dual 300/75-ohm tapoff. The 75-ohm section is used for TV and the 300-ohm section for FM.

Line drop taps
The line drop tap is used in attics and crawl spaces. Each line-drop tap provides up to four drop lines to carry the signal to the set. The drop lines can be run directly to the set and the matching transformers or they can be run to a 0-dB wall tap. The line-drop tap is most commonly used in schools, motels, and hospitals.

The pressure tap is used outdoors where distribution lines are strung between poles, under the gables of apartments or other external systems.

The circuitry inside directional couplers incorporates design techniques that assure excellent impedance matching at all terminals, high accuracy of coupling and low insertion loss. Directional coupler tapoffs provide attenuation of 40 to 60 dB to signals leaving the line and returning because of receiver mismatch or disconnection.

This directional coupler circuitry is available in line tapoff configurations with one, two or four taps to the line.

Band separators
These devices are used in all channel (UHF/VHF) MATV systems to separate the UHF signal from the VHF signal before it is fed into the TV set. Unlike splitters that divide the signal equally, band separators contain circuitry to separate one band from another.

Terminators
The end of each 75-ohm distribution cable must be terminated with a 75-ohm resistor to prevent signals from traveling back up the line and causing ghosts on the individual TV sets.

That about wraps up our coverage of the important elements of MATV systems. We did not cover every item, but did look at the important ones, and the part that they play in a total system. R-E
The function generator is now occupying more service benches than ever before. This series of articles will cover the fundamentals, specifications, operation and applications of this instrument.

**All about Function Generators**

Charles Gilmore*

Introduced to the laboratory in the 1950's as a multi-thousand-dollar instrument, the function generator had dropped in cost to a $250-plus product by the early 1970's. This generator has always been a popular laboratory signal source because of its numerous waveforms (sine, square, and triangle being the most popular), its low output-impedance, its wide frequency range, and versatile frequency control. The past year has seen function generators in the $100 range introduced. These will be serious contenders for the slot on the service bench now filled by the classic sine-wave oscillator. That instrument may soon be relegated to high-precision audio testing where ultra-low distortion (below 0.05%) is required. The standard bench generator will then be a function generator covering the 0.1-Hz to 1-MHz range or more and providing at least, sine, square, and triangle waveforms.

**Fundamentals**

The function generator produces waveforms very differently from the classical sine/square oscillator. In classic higher-frequency instruments, an L-C circuit is used in the basic oscillator. Square waves are obtained from squaring circuits acting on the sine wave. If low-frequency waveforms are desired, the twin-T R-C oscillator or some other variation of an R-C oscillator is usually employed. The function generator's requirement of an extended frequency range is not easily met by either of these two classic circuits.

This new generator must span from millihertz (thousands of a hertz) to megahertz, and has evolved through a completely different technique. Note we are discussing a generator, as opposed to an oscillator, which implies a basic sinusoidal source. A simple block diagram of the function generator is shown in Fig. 1. The circuit's uniqueness is apparent on first inspection. The signal source itself is not a sinewave oscillator but a triangle generator. After passing the triangle through a special circuit (called a sine shaper), a sinewave of ½ to 2 percent total harmonic distortion is produced.

The heart of the function generator is the triangle generator, the design of which is based on the special voltage-time characteristics of a capacitor charged by a constant-current source. Fig. 2-a shows the well known voltage-time curve on a capacitor when charged through a resistor from a constant-voltage source. Fig. 2-b shows the voltage-time curve of a capacitor charged from a source of constant current. If there is no stray resistance across the capacitor (usually ensured by using extremely low-leakage capacitors), the voltage across the capacitor increases linearly as time increases. Obviously, this curve may be reversed. As shown in Fig. 2-c, if the capacitor is discharged at a constant current rate, a linearly decreasing voltage will be produced.

A triangle generator may be created by first charging a capacitor with a constant-current source until a desired positive peak voltage is reached. At this point, the charging constant-current source is turned off and a discharging (oppositely polarized) constant-source is turned on. When the voltage across the capacitor is reduced to the desired negative peak by the discharging constant-current source, this source is turned off and the charging source is again turned on. The voltage across the capacitor will again begin to increase. The waveforms associated with this operation are shown in Fig. 3. A level-detecting circuit that monitors the triangle amplitude signals the reversal of the constant-current generators when the desired peak positive and negative voltages are reached. The output of the level-detecting circuit is used as the wave source.

Note that the phase relationship of the square wave is constant with respect to the triangle wave and is 90° out of phase with the triangle wave zero crossing.

In practice, one or two switched current sources may be used. For example, if the charging constant current source has a current I, and the discharging current source has a current —2I, only the discharging current source need be switched. As the capacitor is charged, with the discharging current source off, the rate of charge will be determined by the current I.

When both current sources are on, the net current will be

\[ I - 2I = -I; \]

thus the rate of discharge will be exactly opposite and equal to the rate of charge.

At any point in time the voltage across the generator is given by

\[ E = \left( T \times I \right) / C, \]

E (volts) is the voltage across the capacitor, T (seconds) is the time of charge, I (amperes) is the charging current, and C (farads) is the value of capacitance being charged. Rearranging this expression, we have

\[ T = \left( E \times C \right) / I, \]

which gives the time for either the positive or negative slope of the triangle wave.

This expression shows that two parameters control the time required to reach a desired limit voltage E: C and I. The greater the charging current, the shorter the time; or the smaller the capacitor, the shorter the time. In most function generators both variables are employed. The capacitance is varied for purposes of range changing, usually in decade steps. The current amplitude is continuously varied by the front panel dial. Frequently this current can be varied by as much as a thousand to one, giving a wide range of frequency control to the front panel dial without a change in the range (capacitor) setting. The upper frequency limit is determined by the maximum current available from the current source and the minimum value of the range capacitor.

At the lower frequency limit, the lowest

![FIG. 1-FUNCTION GENERATOR BLOCK DIAGRAM. A TRIANGLE WAVE generator is the basic signal source. Sine and square waves are produced from it by shaping.](image-url)
feasible current that may be reliably drawn from the current sources and the largest range capacitor determine the frequency. This large capacitor must still be of extremely high quality to preserve the linearity of the triangle waveform. As an example, presume the constant current generators may be varied over the range of 1 microampere to 1 milliampere (1,000 μA), the largest capacitor is 5 μF, and the limit voltage is 10. Using the expression $T = \frac{(E \times C)}{I}$:

$$T = \frac{(10 \text{ V} \times 5 \text{ μF})}{1 \text{ μA}} = 50 \text{ Sec.}$$

But this is only the time for the positive slope. To complete a triangle wave, a negative slope must be generated as well. The time or period of the triangle becomes twice the above calculated rate, or 100 seconds. A cycle that has a period of 100 seconds has a frequency of 0.01 Hz or 10 millihertz.

To reach the highest frequency, a much smaller capacitor is chosen, but the same 10 volt limit is used. Assume a 50 picofarad (0.00005 μF) capacitor. Using the same formula gives

$$T = \frac{(10 \text{ V} \times 0.00005 \text{ μF})}{100 \text{ μA}} = 0.000005 \text{ sec.}$$

or 0.5 microsecond. Again, this time must be doubled to arrive at the period of the triangle wave. This gives a time of 1 microsecond or a frequency of one megahertz. Thus, in this example the generator has an operating range of 10 millihertz to 1 megahertz or 100 million to one.

As the basic waveform is not a sine wave, the sinewave must be synthesized by some form of circuitry. The usual method of creating the sinewave is to shape the triangle wave with a circuit called a shaper. A simplified schematic diagram of a sine shaper and the associated waveforms is shown in Fig. 4. The technique is to increase the load on a high impedance triangle source as the level of the triangle waveform increases, thus distorting the triangle wave to approximate a sinewave with a series of straight line segments.

At levels below E1 (see Fig. 4), none of the diodes conduct and this portion of the triangle waveform is passed through the shaper undistorted. As the voltage level of the triangle wave reaches and exceeds the value E1, diode D1 conducts and the triangle source, of resistance $R$, is loaded by resistance $R1$. As the output voltage of the source continues to increase, diode D2 will conduct when the output voltage exceeds

E2. When diode D2 conducts, the triangle source is now loaded by the parallel combination of $R1$ and $R2$. This increased loading further reduces the amplitude of the triangle source and further decreases the slope of the wave. This process continues until all diodes are conducting and the triangle source is completely loaded. As the triangle reaches its peak and reverses, the action of the sine shaper is reversed. As each diode stops conducting, the load on the triangle source is decreased.

The number of diodes determines the number of break-points shaping the sinewave, and so determines the purity of the wave. Typically, function generators are not known for their ultra-low distortion, and total harmonic distortion figures of 0.1 to 3 percent are common. Note that figures of this order are usually quite acceptable for all but the most exacting audio work. Fig. 5 shows a typical aberration the sine shaper leaves at the crest of a sinewave. Such a peak will not substantially increase the total harmonic distortion of the sinewave, but may be quite noticeable when the waveform is viewed on an oscilloscope.

Referring to the simple block diagrams, (Fig. 1) the three waveforms are selected by a waveform selection control and then applied to the output amplifier. This amplifier is somewhat more sophisticated than those in the output stages of the simple sine/square generator. As a typical amplifier must pass a square wave of one megahertz or more, its bandwidth must be nine to ten times that value.
Generally, an amplifier of fairly high gain, reduced by negative feedback, is used to obtain the low output impedance required of a function generator. Not only must the amplifier pass frequencies in the tens of megahertz, it is also required to faithfully reproduce the output signal whose frequencies are in the milli- or microhertz region. This requirement dictates a DC-coupled amplifier.

Other frequent requirements for these amplifiers are: 10-volt peak-to-peak output into 50 ohms (2 watts); 20-volt peak-to-peak output into an open circuit; and short-circuit protection. Often a user-variable DC voltage is combined with the waveform entering the output amplifier so the user may add a DC bias or offset to the signal. The output amplifier is usually followed by some form of attenuator to decrease the output signal amplitude to a desired value. Generally, variable level controls are placed before the output amplifier and step attenuators are placed after it.

What has just been described is basic to most function generators; however, the function generator is commonly adorned with an abundance of “neat” features that vary from one manufacturer to another. Usually these features involve modifications to or additional controls on the tri- angular generator to produce such effects as swept frequency operation, variable symmetry waveforms, voltage (external) control of the oscillator, gated bursts, single cycle, and triggered start points.

Specifications
A common ground of understanding about specifications used in reference to function generators is needed before comparisons can be made. As in any complex instrument, the specifications that elabo- rate on the basic device are those that enable the user with a thorough understanding to obtain maximum usefulness from his purchase. Of course, a solid understanding of the basic specifications is also helpful when attempting to utilize even the simplest function generator.

Frequency range
As noted previously, the frequency range of function generators is controlled by two variables, the range selector and a continuously variable front panel dial. Typically the range control will be in decade steps, although some lower-cost gen- erators have switched steps that are a factor of 100. The specified frequency range for the generator will usually be from the lowest frequency that may be obtained (variable dial set at its lowest point and the range switch set in the lowest position) to the highest frequency that may be obtained (variable dial set at its lowest point and the range switch set in the highest position). When selecting a generator for its low-frequency capability, the low-frequency limit should be considered, as the accuracy of the frequency setting at the low-fre- quency point will be rather poor. Fre- quency range specifications for each generation will also note the frequency ratio given by the variable dial. Common ranges of control are 10:1, 100:1 and 1000:1. 1000:1 is popular, especially as it permits sweeping the complete audio range of 20 Hz and 20 kHz without step range changes.

Frequency stability, accuracy
Frequency stability is usually given for two different time spans. A short-term specification will be given for some time period such as 10 minutes, and long-term stability will be given for a period of 24 hours. Frequency stability specifications may be deleted on lower cost function generators.

The accuracy of the frequency setting is usually given as a percentage of full scale. For example, a generator with a frequency accuracy rated at 3% of full scale is set on the X1K range. The variable dial has a 10:1 decade, (0.1 to 10), and the dial is set at the “1.” The generated frequency will be 1 kHz ± 300 Hz (3% of full scale setting of 10 kHz). The “0.1” setting on the dial yields a frequency of 100 Hz ± 300 Hz! The accuracy is often specified only over the first decade, with the additional decades strictly for wide manual frequency control.

Frequency control (external)
In addition to the variable dial and the range switch, many function generators offer frequency control from an external voltage source. A voltage source of one variable dial. Such an external control is known as a voltage controlled generator (VCG).

A controlling voltage (such as 1 to 10 volts) is specified for the specified range of frequencies.

The maximum rate at which the VCG may be controlled is specified by the -3dB bandwidth of the VCG circuits as well as the slew rate specifications, which tell the maximum rate of change at which the VCG can be operated. The VCG spec- ification indicating the degree of match between the theoretical frequency of the generator and the actual frequency caused by the controlling voltage is called VCG linearity. VCG linearity is usually ex- pressed as a percent of maximum control voltage. The input impedance of the VCG is often in the one to ten-kilohm range.

Swept frequency mode
On more sophisticated function genera- tors, a second generator with a sawtooth waveform which will give swept-fre- quency output of the main generator, may be included. When this feature is present, the sweep generator will have a frequency range of its own, although its range is not usually as wide as that of the main generator. Frequently the rate of this generator will be given in time rather than in frequency, to assist in its use as a time base.

Other generator controls
Another control found on function gen- erators is one to trigger the start of a single burst externally. Some generators having trigger capability also have the ability to trigger a single cycle and define the phase of the start point with a level control. This allows the user to start the wave from at +90°, for example. The amount of change in the generator to output an integral number of cycles of the desired waveform during the presence of a DC gating signal. Gated cycles of the generator start and stop at zero crossing, usually on the positive-going slope of the triangle waveform.

Generators having a subgenerator for sweeping purposes may have a multiple cycle or burst mode. In this mode, the pe- riod of the subgenerator gates the main generator, again producing an integral number of cycles.

Sine wave harmonic distortion
The major specification applied to the sinewave output of a function generator is the total harmonic distortion (THD). THD will frequently be specified over a limited frequency range (such as 20 Hz to 20 kHz), as the ability to measure THD above a few hundred kHz below a few Hz is limited. A specification indicating that all harmonics are below 30 dB, for example, may be given for frequencies above 100 kHz.

Triangle linearity
Triangle linearity indicates the degree to which the positive or negative slopes of the triangle waveform conform to a perfect straight line, and is given in one of two ways. The manufacturer may specify a triangle linearity of 95%, indicating the triangle waveform will not deviate from a perfect waveform by more than 5% of the full scale value. Other manufacturers specify maximum nonlinearity. A maximum nonlinearity of 5% would be the same specification as a 95% linearity specification. High degrees of linearity (1% to 0.5%) are obtainable at a price, but 5% nonlinearity is sufficient for most applica- tions.

Square wave rise and fall
The rise and fall time of a square wave is defined as the time required for the wave edge to travel between its 10% and 90% voltage points. The rise and fall times lie in the 100-nanosecond range for 1-MHz generators and may be as fast as 10 nano- seconds on 10 to 30-MHz function genera- tors. Rise and fall times will be consistent across the generator frequency range.

Time symmetry
Time symmetry specifies the time match between the positive and negative-going slopes of the triangle wave. Any deviation from a perfect match indicates some in- crease in total harmonic distortion of the sinewave and will effectively add DC offset to the sine, square, and triangle waves. Time symmetry is not specified in the same manner by all manufacturers. A specifi- cation of 2% time symmetry indicates that the symmetry of the waveforms is such that the duty cycle of the positive pulse of the square wave will not be less than 48% nor more than 52%. This is alternately specified by noting that two of the narrow- est pulses (positive or negative) would make up at least 96% of the period of the cycle.

Vertical precision or flatness
Another important feature of the func- tion generator is the inherent flatness of the output amplitude. Flatness indicates the maximum variation in output amplitude with variations in frequency, includ- ing range changes. With the exception of the uppermost range, most function gen- erators give flatness specifications in the tenths of a dB. Frequently the uppermost frequency range of the sinewave output (continued on page 88)
Anyone who has ever connected a pair of speaker systems to a stereo amplifier knows they need proper phasing. If the stereo pair is connected out of phase, we know that one speaker cone (or set of cones in a multi-driver system) will “push” air while the other “pulls”. The result is a combination of loss of apparent bass and of vague positioning of instruments in the stereo sound field. The reason for the loss of bass is fairly obvious. Since low, bass tones are fairly non-directional (bass sound seems to fill a listening room rather than originate from a pin-point location), when recordings are made the left channel microphone or microphones pick up as much of the bass energy as the right channel mikes. In reproduction, both speakers are expected to deliver approximately the same bass energy. If the bass tones coming from one speaker are out of phase with those coming from the other, the wave fronts tend to cancel each other and there is a noticeable absence of bass in the reproduced music.

But what about the other effect? Why—when speakers are out of phase—do we find it difficult to pin-point instrument locations in the reproduced music? Despite early studies (which suggested that the human ear is not sensitive to “phase errors” in complex waveforms) an increasing amount of recent evidence suggests that, indeed, phase linearity (or, more simply, correct relative time relationships of all tones and their harmonics) is a necessary ingredient of true high-fidelity sound reproduction. It is simple enough to insure that left and right speaker systems are operating “in phase” (there’s a 50-50 chance of correct connection to begin with, and if you suspect an out-of-phase connection you just reverse the wires to one of the speaker systems). But there’s much more to “phase linearity” than that. Remember, most modern high-fidelity speaker systems consist of two or more drivers. We have woofers, tweeters, and in some cases mid-range drivers as well as super-tweeters, each attempting to reproduce a given portion of the audio spectrum. How about the phase relationship between these various drivers within a given speaker system?

Some manufacturers have come to the conclusion that the various speaker elements in a multi-driver system must be arranged so that all audio frequencies arrive at the listener’s ear in correct time (or phase) relationship. The very nature of woofers and tweeters makes this difficult if all drivers are mounted on a common baffle, in a single plane, as illustrated in Fig. 1. Because the woofer cone is deeper than that of the tweeter, sounds produced by the woofer arrive at the listener’s ear a fraction of a second later than those produced by the tweeter. Some manufacturers (such as Dahlquist in their DQ-10 design) have sought to compensate for this by
feeding low frequencies to the woofer and high frequencies to the tweeter. Note that at the crossover point itself, relative amplitude is down 3 dB for each driver, so that the sum of energy delivered to the two drivers is the same as at frequencies outside the crossover region. With a simple crossover such as this, overall phase response of the system will be quite good—even in the region of crossover. If a square wave at 1 kHz were fed into such a system (and assuming that the drivers were otherwise perfect in response), the output waveform from the woofer would look like the waveform drawn in Fig. 4-a while the output from the tweeter would have the appearance of Fig. 4-b. Add these two components together and you have the waveform of Fig. 4-c—a perfect square wave with no phase distortion.

The problem with using such a moderate-sloped crossover network is that it requires woofers and tweeters to operate effectively (with low distortion and flat frequency response) well outside their intended regions of best performance. Since the contribution of each driver can be heard at least until it is 12 dB below reference program level, the overlap region in a 6 dB/octave crossover arrangement extends for a full four octaves, as illustrated in Fig. 5-a.

If a steeper rate of roll-off—such as 12 dB per octave—were employed, overlap would need to extend only for a total of two octaves, as shown in Fig. 5-b and optimum performance of each driver would not have to be extended so far outside its “normal” frequency region. For this reason, most better systems do utilize 12 dB/octave crossover networks (some even employ 18 dB/octave slopes). But here is where the problem arises. When such a network is used, the phase angle of the waveform fed to the woofer goes in a negative direction as the crossover frequency is approached, while that for the tweeter goes positive, as shown in Fig. 6. Thus, although single-amplitude plots (without regard to phase) of the output voltages of a 12 dB/octave network, as shown earlier in Fig. 5-b, suggest that total energy output of the system in the
region of the crossover frequency will be "flat," yet if outputs are plotted with regard to amplitude and phase, the actual output energy in the crossover region appears as in Fig. 7 because of the cancelling effect of the out-of-phase outputs from the two legs of the crossover network.

![Fig. 7](image)

**FIG. 7—PHASE ANGLES INTRODUCED by the 12 dB/octave network create a sharp cancelling null at the crossover frequency when the phases of the sections are reversed.**

When a square wave is fed to such a system, the output from the woofer will theoretically appear as shown in Fig. 8-a, that of the tweeter as shown in Fig. 8-b, and the composite waveform will appear as shown in Fig. 8-c—not at all like the square wave input signal with which we started.

Some manufacturers have been aware of this out-of-phase problem for some time. One attempt at correction has been to reverse the phase of the tweeter with respect to the woofer (or, in the case of 3-way systems, the midrange with respect to the woofer). As can be seen from the composite diagram of Fig. 9, this produces a peak in total energy output in the frequency region of the crossover instead of a null. Because of the phase response characteristics over the entire frequency band (shown as a dotted line), application of a square wave to a system arranged in this manner would result in the woofer output shown in Fig. 10-a, the tweeter output in Fig. 10-b and the composite output shown in Fig. 10-c—still a long way from the desired square wave shape.

**Bank & Olufsen's solution**

The answer to the problem of phase linearity in speaker design was discovered by Erik Baekaard, who read a paper on his work at an AES convention in London. It is represented in a new line of speakers which were demonstrated to me while I was in Denmark. Design work on these speakers was led by Esben Kokholm, of B & O and I have since had an opportunity to evaluate them in my own laboratory.

In addition to the usual woofer, midrange and tweeter, this family of speaker systems employs what B & O calls a "filler driver." The general form of crossover network used is that of Fig. 11. Note that the center circuit is neither a low-pass or a high-pass filter, but rather a series resonant arrangement that provides a peaked response to the filler driver (or phase-link speaker, as they call it) at the crossover frequency and a rolloff of 6 dB per octave above and below that frequency. Added to the responses of a conventional 12 dB/octave network, we have the composite crossover network response shown in Fig. 12. The theoretical outputs from the three drivers are now as shown in the three parts of Fig. 13. When these are added together graphically, we do come up with an exact replica of the original square-wave input waveform.

Having achieved a solution to the crossover problem, the people at B & O were not about to ignore the driver positioning problem mentioned earlier. While they maintain that flat-baffle positioning produces less phase distortion than that introduced by conventional crossover networks, they nevertheless were looking for as near perfect a phase response characteristic as possible. Accordingly, they developed a new front-baffle shape (actually precision molded of high density foam resin which, they...
What happened was perfectly content with what later proved to be the somewhat vague stereo localization of music using a well-known speaker pair—until I pushed the A-B switching arrangement and listened to the linear-phase units for comparison. Suddenly, the previous pair’s sound wasn’t quite as gratifying.

The square-wave drawings shown in earlier diagrams are purely theoretical, and derived mathematically. I was curious to see if results could be duplicated in practice, allowing for the fact that my lab is anything but an anechoic chamber and that microphone placement would have a great bearing on the results. I therefore hooked up a square-wave generator to my system, placed a calibrated microphone at what I thought was an optimum spot in front of my regular lab speaker, and photographed what was picked up by the microphone. The results are shown in the scope photo of Fig. 15. Without moving the microphone, I carefully replaced my regular speaker with the sample M-70 model from Bang & Olufsen and repeated the experiment. The

FIG. 14—ANGLED FRONT BAFLE compensates for the phase delay caused by difference in depths of woofer and tweeter.

Does it make a difference?

Obviously, we don’t listen to square waves, and it can be argued that when listening to complex musical waveforms some of these fine points tend to be obscured. I can only tell you that in comparison tests made with three other speaker system types (all popular, well-accepted brands) I was able to sense better localization of stereo images, better transient response with certain program material, and a more natural sounding overall musical quality.

How much of the improvement is a result of the linear phase response of these new systems and how much is simply the result of otherwise excellent driver selection, enclosure design and generally good speaker system design I am not prepared to say. The fact is that “hearing memory” in humans is extremely poor. We tend to listen to our favorite speakers and to convince ourselves that we are hearing reality. This happened in my listening tests, too. I

FIG. 15—SQUARE-WAVE SIGNAL IS reproduced by actual conventional speaker system much as shown in the theoretical mathematical addition of Fig. 8-c.

scope photo of Fig. 16 shows the results I then obtained. Maybe Bang & Olufsen has something here!

DON'T MISS IT!

This month’s in-depth hi-fi test reports include the Marantz model 2325 stereo receiver and the Lafayette model LR-2200 stereo receiver.

RCA closes Harrison tube plant, oldest in world

“...A sharp decline in demand for receiving tubes in the face of the continuing shift to solid-state devices in consumer, industrial and defense electronic systems” was given by Paul B. Garver, head of RCA’s Distributor and Special Products Division, for the July closing of RCA’s last tube manufacturing facility, at Harrison, NJ, July 30. Industry sales have declined almost 80 percent since 1966, he said, with replacements in older electronic equipment responsible for most of the present volume.

The Harrison plant was opened by Thomas Edison in 1882, to manufacture electric light bulbs. Ten years later, it was acquired by General Electric, who continued to manufacture lamps until 1918 when the first radio tubes were made. Throughout the 1920’s, G-E continued to supply tubes to the various manufacturers of radios. In 1930 the plant was purchased by an RCA subsidiary, RCA Radiotron Co., and the tubes were called Radiotrons.

At its peak, the Harrison plant had a work force of more than 7,000 (as compared to a recent figure of 1,100 employees) and made 87 million tubes in one 12-month period. Besides mass-producing tubes for consumer use, the plant made special ones for industrial, military and aerospace equipment, some in rather small quantities. RCA, now the sole source for about 110 types of receiving tubes, plans to meet as far as possible all future requirements for these types, and will continue to sell replacement receiving tubes.

550,000 calls-per-hour on new telephone central system

The world’s highest-capacity long distance telephone switching system went into action in Chicago last January 17. The new facility, No. 4 Electronic Switching System (ESS), has a peak capacity of 550,000 calls-per-hour. This works out to a little over 9,000 calls-per-minute, or 150 calls-per-second.

FIG. 16—TEST SETUP OF FIG. 15 with the new B & O speaker system. Output more closely resembles the square-wave input.
Build This Solid State Ignition System For Your Car

This electronic ignition can be used with any standard ignition coil to provide a constant-amplitude spark

DICK PACE

TRANSISTOR IGNITION SYSTEMS WERE INTRODUCED by Ford as optional equipment in 1966. A year later, GM offered similar systems. Chrysler developed a system so economical and reliable that it was supplied as standard equipment on all models, beginning in 1973. Other manufacturers are following this lead, and electronic ignitions are becoming standard on most cars. The prime advantage of these systems is that they provide high peak voltage to drive the spark plugs.

The circuit to be described has several advantages over previous types. Most transistor ignition systems require special coils; this project is designed for use with any standard ignition coil.

It provides a constant-amplitude spark at engine speeds in excess of 6,000 RPM. At low speeds, spark duration is relatively long. This minimizes pollution and increases engine efficiency. At high speeds, spark duration is shorter, allowing time to charge the coil fully. (At high speeds, long spark duration is not necessary for thorough fuel burning.)

Since this ignition system is triggered by the ignition points on the car, point wear is virtually eliminated. A convenient switch enables you to operate the car from its regular ignition system in the unlikely event of circuit failure. Finally, the unit is very stable. The spark duration is computed automatically so that once turned on by the car's points, shutdown occurs at the right instant. Previous transistor ignition projects were turned both on and off by the points.

Essentially, this is an electronics project rather than an automotive one. Except for hooking up the transistor ignition system, no changes are required to the automobile. All parts are readily available, for under $30.

How it works

When the points are closed in a conventional auto ignition system, current flows through the coil, charging it. When the points open, current is interrupted. The collapse of the magnetic field creates high voltage across the points. The voltage rise (about 200 volts peak) is stepped up by the coil, which is actually a transformer, about 100 times (to about 20,000 volts) to fire the spark plugs. The capacitor serves to slow the rate of voltage rise across the points and to form a resonant tank circuit, together with the coil. The capacitor and the coil resonate in damped oscillations until the stored energy is spent. Should the points close before the energy were completely dissipated, the points would arc.

When you add this transistor circuit to the ignition system, it is power transistor Q4 (see Fig. 1) that interrupts current to the coil, rather than the points.

Transistors Q1 and Q2 form a monostable or one-shot multivibrator with some modifications. A monostable multivibrator is a pulse generator that operates only when triggered. It has two states, stable and unstable.

In its stable state, Q1 is "off," with 12 volts at its collector, and Q2 is "on," with the collector at ground. (All the transistors act as saturation switches. Either they are completely on or completely off.) Q3, a PNP, is "on," because current flows through the collector-emitter junction of Q2, R8 and the base-emitter junction of Q3. Q4 is "on" because current flows through its base-emitter junction from collector emitter current of Q3 through R9.

When a pulse is applied to the base of Q1, it turns on and its output immediately goes to ground. Therefore, the plus end of C1 also goes to ground. Since the voltage or charge across the capacitor cannot instantly go to ground, the minus side of the capacitor goes to —12 volts.

This negative voltage turns off Q2 by reverse-biasing it. Q2 will not stay off for a fixed period of time. The collector of Q2 is now at battery voltage and the base of PNP Q3 is at battery voltage (equal to its emitter voltage) and is turned off. Base current to Q4 stops and Q4 turns off, interrupting the current in the coil.
While the sparkplug is firing, R3 is (relatively) slowly charging the minus end of C1 in a positive direction. Current is flowing through R6, keeping Q1 on. Eventually, the minus end of C1 reaches +0.6 volts and turns Q2 on. This removes the voltage from the base of Q1 and it turns off. At this point in time, Q2, Q3 and Q4 are all on.

The pulse that determines when Q1 turns on comes from the ignition points in the car. When the points are closed, the junction of R1 and R4 is at ground. When the points open, +12 volts appears at R4 through R1. Capacitor C6 differentiates the voltage, forming a positive spike that turns on Q1. R1 (40 ohms) allows about 1/4-amp of current to flow through the points when they are closed. This is not enough current to cause contact wear but is enough to prevent the points from oxidizing, which could cause the system to fail. The charge time across the points capacitor (condenser?) through R1 is fast enough to be insignificant.

The spark is not turned off by the points. Spark duration is determined independently by the circuit time constants. The on time of the multivibrator is determined by C1 and R3 by the formula \( T_0 = \frac{0.6}{R_3C_1} \). This "on" time is relatively independent of supply voltages because when the capacitor charge increases, the available recharge current also increases.

The above formula assumes that C1 is fully charged. The recharge of C1 is through R2. In most multivibrator applications, a constant-duration output is desired. An attempt to operate the monostable multivibrator faster than a certain rate will cause the output pulse to become narrower, because capacitor C1 has not had time to fully recharge through its charge resistor R2. This problem is utilized to advantage in this circuit. R2 would normally be a smaller value (about 470 ohms) to allow for quick recharge. In this circuit it is made larger to increase C1 charge time. Thus, as engine speed is increased to exceed 900 RPM, the spark duration begins to narrow or shorten in time. The duration is about 1.7 milliseconds at 700 RPM, about 1.4 milliseconds at 2,000 RPM and only 0.75 milliseconds at 6,000 RPM.

The result is a long spark at low speeds, which will result in thorough combustion.

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**Parts List**

- **All resistors 10% carbon unless noted**
  - R1–40 ohms, wirewound, 10 watts
  - R2–2700 ohms, 1/4 watt
  - R3–1000 ohms, 1/2 watt
  - R4–1000 ohms, 1/4 watt
  - R5, R6–3000 ohms, 1/4 watt
  - R7–75 ohms, wirewound, 5 watts
  - R8–22 ohms, 1/2 watt
  - R9–10 ohms wirewound, with brackets, 25 watts (Mallory type 2.5HJ or equivalent)
  - R10–150 ohms, 1/2 watt
  - R11–220 ohms, 1/2 watt
  - R12–470 ohms, 1/2 watt
  - C1–2.7 µF, ±10% high-quality tantalum (Mallory TAC 275K025P04 or equal.)
  - C2–0.1 µF ceramic, 50 V or higher, -20 +80%
  - C3–470 µF, 25-50 V, -20+80% electrolytic

- **Miscellaneous:**
  - Case–aluminum "Minibox" 5 1/2 x 3 x 2 1/4-inch
  - Circuit board. Make your own PC board or use perforated board with push-in clips.
  - Heat sink for TO-3 case (Q4). Burstein-Applebee catalog No. 12A2229-9 or any type with equivalent radiating surface.
  - Silicone grease for Q3 and Q4
  - Coil dope for Q4
  - TO-3 transistor socket for Q4. (Radio Shack 276-029 or equivalent)
  - One-inch standoffs for printed-circuit boards.
  - Barrier strip or strain relief for wires going to car
  - Printed-circuit board L-brackets for mounting case to car.

---

**FIG. 1—THE FOUR-TRANSISTOR ELECTRONIC IGNITION SYSTEM.**

---

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and a short spark at high speeds. This short spark allows a longer charge time for the ignition coil at high speeds than with points. Points have about a 50% duty-cycle or a nearly square-wave output. An attempt to have the points open for a shorter time would cause pointing as the coil would not have discharged completely. A transistor can be turned on while the coil is still charged and sparking, without any problem.

While standard ignition systems rapidly lose voltage above 2,000 RPM, this system ensures virtually constant output voltage to over 6,000 RPM. (See Fig. 2.)

Standard ignition systems sometimes have a problem known as point bounce at high speeds. Points operating at high speeds tend to vibrate slightly, causing an erratic charge and discharge of the coil. This erratic point operation could cause the electronic ignition to operate erratically, but circuitry is included in the system to prevent this problem. Basically, the circuit prevents the unit from retriggering for a fixed period after the spark has ended. This effectively places an upper speed limit on the engine at about 10,000 RPM. The network is formed by C7, R12 and R5. When the monostable multivibrator is in its unstable state, there is a charge on C7, with +12 volts on its right side through R4. When Q2 turns on, -12 volts appears at the base of Q1. This discharged through Q2. Until it does, the unit will not trigger. When the points close, a negative voltage appears at the base of Q1 from differentiation capacitor C6. This adds to the negative charge from C7 and further prevents premature operation.

R10, D1, and D2 form a protective network to prevent excessive voltage from destroying Q4. D1 and D2 are Zener diodes in series, giving a Zener voltage of 300. R10 provides isolation and circuit limiting. If the voltage across the diodes exceed 300, the Zeners conduct and the current flow of Q4, turning it on slightly to limit the voltage at its collector. The gain of Q4 is utilized to lower requirements of the Zeners.

C8 allows a controlled buildup of voltage when Q4 turns off and effectively limits the voltage to about 220 to 270. The unit will work without it but the waveform is uncontrolled and spiky. The initial spike, if not limited by the Zener circuit, will go above the breakdown voltage of the transistor and eventually cause it to fail. C2, C4, C5 are RF and transient filters. C3 is a power supply ripple filter. The switch is used to bypass the unit, in case of component failure, for tuneup purposes or for comparison. When switched to the bypass position, the +12 volt supply is removed; the points and coil are switched out of the circuit and connected to each other.

Construction

A conventional aluminum box can be used to house the unit. The circuit layout is not critical. Most of the components can be mounted on a circuit board. While a pre-patterned board was used for the original, a perforated board with clips will be fine, or you can make a printed circuit board. D1, D2, D11 and C8 can be wired point-to-point near Q4 using a terminal strip. Mount Q4 to a heat sink, using a TO-3 socket. Heatsink Q3 by fastening it with a screw to the case. Don't forget the mica insulators and silicone grease. Wipe off excess silicone grease and coat transistor Q4 with coil dope, especially where it meets the case, to prevent water splashing from shorting across the transistor. Mount R9 outside the case with brackets; it gets quite hot. Wires running to the engine should be passed through a strain relief, or a barrier strip can be used. Use No. 18 gauge stranded wire.

In choosing transistors, there is nothing really critical about Q1 or Q2. Q3 is not critical, but should have low leakage. If you substitute, be sure to use silicon transistors that will saturate easily at the required currents. If Q2 does not saturate, for example, the unit will oscillate. The collector-base voltage ratings should be 35 volts or better. Use discretion in substituting for Q4. Here we need a high-voltage power transistor, at least 300 collector-emitter volts, high current capability, operating from 3.5 amps to 5 amps, with some gain of saturation voltage (Vce(s)). The Motorola HEP 707 and HEP-S5020 have these characteristics. Many high-voltage transistors do not.

When selecting parts remember that the unit will be operated in temperature extremes from -10°C to 100°C or greater.

Bench Testing

This unit, or other electronic ignition systems, can be bench tested without a car or even a distributor. You will need:
1. Ignition coil of the type for use with the ignition system under test.
2. a single spark plug
3. squarewave generator
4. audio amplifier
5. ballast resistor or a 1/2 to 1-ohm 25 to 50-watt resistor
6. oscilloscope with attenuator probe
7. 12-volt power supply
8. 500 µF 25V capacitor
9. clip leads

The coil and ballast resistor are connected to the unit and power supply as they would be in the car.

The squarewave generator and amplifier replace the points. For ignition systems that use points, connect the generator to the amplifier and connect the amplifier through a 500 µF, 25V or larger capacitor to the points input (minus to the amplifier, plus to the system). Adjust the amplifier volume control for a 12-volt peak-to-peak squarewave. The capacitor is to keep the 12-volt DC output from the amplifier. Ignition systems without points, such as those with a pickup coil, should be connected direct to the squarewave generator, since these units are very sensitive.

Connect the scope probe to the primary terminal of the ignition coil. Connect a sparkplug to the secondary. Don’t forget to ground the spark plug. RPM is determined by the formula for a 4-cycle engine:

\[
Hz = \frac{RPM}{60} \times \frac{No. of cylinders}{2}
\]

Operate the squarewave generator from 40 to 400 Hz.

Installation

The unit can be attached to the car with "L" brackets. Mount the unit in a dry location in the engine compartment, well away from the exhaust manifold and other hot spots. Connect the wires to the car as shown in the schematic (Fig. 1). At the ignition coil, remove the wire that goes to the points. Connect the collector of Q4 to this coil terminal. Fasten the point wire to its input (junction of R1 and R4). Connect the +12V terminal to the car's ignition circuit. It can be attached to the battery side of the ballast resistor in cars that have it, or to an ignitio terminal at the fuse block (not an accessory or battery terminal). Some cars (typically GM) use a piece of resistance wire in the lead to the coil (+) terminal for ballast resistance. Others (frequently foreign cars) have the ballast resistor inside the coil. Only in these cars can the +12V be taken from the coil's plus terminal.

Tune-up

Follow manufacturers specifications on tune-ups. Timing can be set with the switch at "normal". If you use the dwell meter technique to set the points, be sure to set...
WHEN THE NAME LAFAYETTE IS MENTIONED in electronic circles, most people think of a national network of retail stores that sell all types of consumer electronic equipment from ham gear to hi-fi. In fact, the people who run Lafayette also consider themselves to be a major manufacturer of electronic equipment and their line of high-fidelity amplifiers, tuners, receivers, and other hi-fi components is as broad as that of some of the better known makers of sound equipment. Furthermore, since they act as suppliers and retailer, they claim to offer more performance per dollar in their hi-fi equipment than do some of their competitors who have to first make a profit in selling to dealers before the dealer applies his or her profit.

We chose to investigate their moderately priced LR-2200 receiver because it seemed to offer good features and power output for its under $300.00 price. The receiver, shown in Fig. 1, follows a traditional front panel design approach with a well illuminated dial area that lights up when power is applied. Frequency calibration is minimal, with marks supplied only every 2 MHz apart of the FM scale. To the left of the tuning scales are a pair of tuning meters—one for signal strength indications on AM or FM, the other for center-of-channel tuning when listening to FM. The usual stereo indicator lights up between the frequency scales and the meters when a stereo FM signal is received. A tuning knob is located to the right of the dial scales and is coupled to a fairly effective flywheel for ease of tuning.

Along the bottom of the control panel are six major rotary knobs. The first of these, at the left, is a program selector. The other volume and balance controls are located near center of the panel. The bass and treble controls are of the dual concentric, clutch type so that individual tonal control of each channel is possible. At the lower right is a speaker mode knob that includes a power-off position as well as a position for synthesizing 4-channel effects from stereo program sources if two pairs of speakers are connected in the same room. Alternatively, two pairs of speakers may be arranged as “main” and “remote” for stereo reproduction in two different locations. Small pushbuttons located between the two left-most knobs take care of such functions as loudness, hi-cut filtering, stereo/mono switching and activation of either or both of the available tape-monitor circuits. The rear panel, shown in Fig. 2, has switched and unswitched convenience AC receptacles at the left, the required input and tape out jacks at the upper right and a loopstick ferrite AM antenna that can be retracted from chassis surface for better AM reception. Adjacent to the phono input jacks is a slide switch that alters phono input is sensitivity from 2.5 millivolts to 6.0 millivolts to better accommodate cartridges of widely varying outputs. The main pair of speakers are connected via a barrier-type terminal strip while connection of a second pair of speakers (or rear speakers if the pseudo-quadrifilar effect is desired) is made by means of phono-type pin plugs. A screw-terminal strip accepts outdoor AM or FM antennas and two of the terminals are connected by a removable jumper that couples to a line cord-capacitor arrangement that serves as an indoor FM antenna. A chassis ground terminal, left and right speaker fuses and a power line fuse complete the rear panel layout. Connection of possible associated equipment is illustrated in the diagram of Fig. 3.

Figure 4 is a photo of the internal layout of the LR-2200 receiver. Four major circuit board modules are used: a large one for the FM and AM tuner section, one for the preamplifier and voltage amplifier plus tone control section, a third module for the power amplifiers, and a fourth module that houses the power supply.

Circuit highlights

The FM front-end of the LR-2200 employs a four-section variable capacitor for tuning, a dual-gate FET as an RF amplifier, a junction FET as a mixer and a bipolar device as a local oscillator. Two ceramic filters are used to tune IF frequencies with IF amplification accomplished by one bipolar transistor and pair of IC stages. Most of the multiple decoding circuitry is contained in a single IC. The AM circuitry consists largely of a multipurpose IC, with IF frequencies tuned by another ceramic filter. Phono preamplifiers and equalizers are IC's (one per channel), while voltage amplification and tone control stages of the popular feedback type employ discrete bipolar devices. The input stage of each power amplifier section is a differential amplifiers.
TABLE I

FM PERFORMANCE MEASUREMENTS

<table>
<thead>
<tr>
<th>SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE</th>
<th>R-E</th>
<th>R-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Evaluation</td>
<td></td>
</tr>
<tr>
<td>IHF sensitivity, mono (µV) (dB)</td>
<td>2.4 (13.0)</td>
<td>Fair</td>
</tr>
<tr>
<td>IHF sensitivity, stereo (µV) (dB)</td>
<td>10.0 (25.4)</td>
<td>Good</td>
</tr>
<tr>
<td>50 dB quieting signal, mono (µV) (dB)</td>
<td>3.0 (14.9)</td>
<td>Very good</td>
</tr>
<tr>
<td>50 dB quieting signal, stereo (µV) (dB)</td>
<td>35.0 (36.3)</td>
<td>Good</td>
</tr>
<tr>
<td>Maximum S/N ratio, mono (dB)</td>
<td>70</td>
<td>Excellent</td>
</tr>
<tr>
<td>Maximum S/N ratio, stereo (dB)</td>
<td>65</td>
<td>Very good</td>
</tr>
<tr>
<td>Capture ratio (dB)</td>
<td>1.6</td>
<td>Very good</td>
</tr>
<tr>
<td>AM suppression (dB)</td>
<td>50</td>
<td>Fair</td>
</tr>
<tr>
<td>Image rejection (dB)</td>
<td>80</td>
<td>Very good</td>
</tr>
<tr>
<td>IF rejection (dB)</td>
<td>80</td>
<td>Very good</td>
</tr>
<tr>
<td>Spurious rejection (dB)</td>
<td>88</td>
<td>Good</td>
</tr>
<tr>
<td>Alternate channel selectivity (dB)</td>
<td>61</td>
<td>Good</td>
</tr>
</tbody>
</table>

FIDELITY AND DISTORTION MEASUREMENTS

| Frequency response, 50 Hz to 15 kHz (dB) | 0.75 | Excellent |
| Harmonic distortion, 1 kHz, mono (%) | 0.35 | Very good |
| Harmonic distortion, 1 kHz, stereo (%) | 0.5 | Very good |
| Harmonic distortion, 100 Hz, mono (%) | 0.35 | Very good |
| Harmonic distortion, 100 Hz, stereo (%) | 0.5 | Very good |
| Harmonic distortion, 6 kHz, mono (%) | 0.6 | Good |
| Harmonic distortion, 6 kHz, stereo (%) | 0.8 | Excellent |
| Distortion at 50 dB quieting, mono (dB) | 1.2 | Very good |
| Distortion at 50 dB quieting, stereo (dB) | 0.5 | Very good |

STEREO PERFORMANCE MEASUREMENTS

| Stereo threshold (µV) | 10 | Fair |
| Separation, 1 kHz (dB) | 40 | Excellent |
| Separation, 100 Hz (dB) | 42 | Excellent |
| Separation, 10 kHz (dB) | 26 | Good |

MISCELLANEOUS MEASUREMENTS

| Muting threshold (µV) | 10 | Fair |
| Muting threshold (± kHz @ MHz) | 200 @ 88 | Good |

EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION

| Control layout | Fair |
| Ease of tuning | Good |
| Accuracy of meters or other tuning aids | Very good |
| Usefulness of other controls | Very good |
| Construction and internal layout | Excellent |
| Ease of servicing | Good |

OVERALL FM PERFORMANCE RATING

| Good to very good |

Laboratory FM measurements

Results of our FM performance measurements are listed in Table I and may be compared with those published by the manufacturer. It should be noted that Lafayette seems to be a bit behind the times, or is reluctant to publish all the specifications now required by the new FM Tuner Measurement Standards. Or, perhaps, they have not had sufficient time to amend or add to their manuals, which may have been published before the new standards went into effect last May. While usable sensitivity fell short of the 1.75 µV claimed (which would have equaled 10.25 dBf if Lafayette has used the new power reference as we do), the 2.4 µV figure (13.0 dBf) obtained is considered quite acceptable for a unit in this price class. While distortion figures were not as low as those measured for more expensive sets, Lafayette is to be complimented in keeping stereo distortion as low as it measured (0.8%) at 6 kHz, where most other low-cost sets produce greater distortion. Separation was excellent, measuring exactly the 40 dB claimed at mid-frequencies and even a bit better at the low end. Smooth transition from mono to stereo at about 10 µV (25.4 dBf) is just about the optimum point of switching for a set with this quieting characteristic. AM suppression was acceptable, though not outstanding, but this is offset in part by the low measured capture ratio. Used with a good outdoor antenna (Lafayette should not have encouraged use of an indoor linecord antenna by supplying that jumper), the FM performance of this receiver in most signal areas will be hard to distinguish from that of sets costing much more.

Laboratory amplifier measurements

If we had to rate the amplifier section and the tuner section of this receiver separately we would probably favor the amplifier section. One tends to view those power modules skeptically, but they certainly delivered what was ex-
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55
pected of them and then some. Results of our amplifier measurements are shown in Table II. The amplifier delivered 37 watts into each 8-ohm load before reaching rated THD of 0.5%. At the rated output of 27 watts-per-channel at mid-frequencies, harmonic distortion measured 0.15% though there was a tendency for the THD to rise with decreasing power output levels, suggesting the presence of a small amount of notch or crossover distortion.

Ordinarily, we would consider an overload capability of only 67 mV for the phono inputs as being on the low side but since Lafayette does offer a lower sensitivity setting for high output cartridges (at which setting overload capability increased to 160 mV) we cannot fault the phono circuits on this point.

The spectrum analyzer scope photo of Fig. 5 shows the range of control of the bass and treble controls and the action of the high-cut filter circuit which has no greater slope than the treble control when the latter is turned fully counter clockwise. We would not be overly critical of this point if the beginning of the filter action were set to a higher pivot or turn-over frequency, but as you can see from the superimposed curves of Fig. 5, the cut action begins almost at the same frequency as does the treble action. The behavior of the loudness control is depicted in Table II.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Lafayette</th>
<th>Model: LR-2200</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL PRODUCT ANALYSIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retail price</td>
<td>$299.95</td>
<td></td>
</tr>
<tr>
<td>Price category</td>
<td>Low-Medium</td>
<td></td>
</tr>
<tr>
<td>Price/performance ratio</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Styling and appearance</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Sound quality</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Mechanical performance</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Comments: While the control layout of this receiver is generally well executed, we found it awkward to have to switch through the FM MPX filter position to get from FM muting to unmuted FM operation. The muting switch should have been a separate control. The use of pin-jacks for one set of speakers and screw terminals for the other strikes us as a poor choice, since few, if any, separately purchased speaker systems come with pin cables of this sort. Aside from these cosmetic and human engineering problems, the LR-2200 performed well for its price category. The inclusion of two full tape monitor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Marantz Model 2325**

IF YOU'LL CHECK THE DIMENSIONS OF THIS hefty top-of-the-line stereo receiver from Marantz you'll find that it measures exactly the same as their popular model 4400 4-channel receiver reviewed in these pages some months ago and weighs four pounds less than that quadriphonic model. Styling is similar, too, with the easily identifiable thumb-wheel "gyro-touch" fly-wheel tuning arrangement (as Marantz calls it) identifying the product the moment you look at its attractively finished, precision machined front panel and matching metal knobs and buttons as shown in Fig. 1. The blacked-out dial area lights up in a soft blue color when power is applied, revealing a linearly calibrated FM dial scale, an AM dial scale and a 0—100 reference logging scale. Multicolored illuminated words appearing just above the dial scales spell out the program source selected, a red colored word indicates when stereo is selected for other program sources by means of the front-panel MODE switch. To the left of the dial scale area are a pair of meters, each of which performs a double function. The center-of-channel tuning meter doubles as a multi-path indicator when a button is depressed, while the signal-strength meter is also used to calibrate the built-in Dolby noise reduction circuitry when that feature is selected. Centered below the dial scale, but still in the dark panel area, is a slide BALANCE control that operates horizontally from left to right. Its knob resembles the knobs of the two clusters of push-button and sub-controls located at the left and right ends of the front-panel. The left cluster of eight knobs and buttons includes a switch that selects left- or right-channel meter-monitoring of the Dolby calibration, a
<table>
<thead>
<tr>
<th>TABLE II continued</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIGH LEVEL INPUT MEASUREMENTS</strong></td>
</tr>
<tr>
<td>Frequency response (Hz-kHz, ±-dB)</td>
</tr>
<tr>
<td>Hum/noise referred to full output (dB)</td>
</tr>
<tr>
<td>Residual hum/noise (min. volume) (dB)</td>
</tr>
<tr>
<td><strong>TONAL COMPENSATION MEASUREMENTS</strong></td>
</tr>
<tr>
<td>Action of bass and treble controls</td>
</tr>
<tr>
<td>Action of secondary tone controls</td>
</tr>
<tr>
<td>Action of low frequency filter(s)</td>
</tr>
<tr>
<td>Action of high frequency filter(s)</td>
</tr>
<tr>
<td><strong>COMPONENT MATCHING MEASUREMENTS</strong></td>
</tr>
<tr>
<td>Input sensitivity, phono 1/phono 2 (mV)</td>
</tr>
<tr>
<td>Input sensitivity, auxiliary input(s) (mV)</td>
</tr>
<tr>
<td>Input sensitivity, tape input(s) (mV)</td>
</tr>
<tr>
<td>Output level, tape output(s) (mV)</td>
</tr>
<tr>
<td>Output level, headphone jack(s) (V or mV)</td>
</tr>
<tr>
<td><strong>EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN</strong></td>
</tr>
<tr>
<td>Adequacy of program source and monitor switching</td>
</tr>
<tr>
<td>Adequacy of input facilities</td>
</tr>
<tr>
<td>Arrangement of controls (panel layout)</td>
</tr>
<tr>
<td>Action of controls and switches</td>
</tr>
<tr>
<td>Design and construction</td>
</tr>
<tr>
<td>Ease of servicing</td>
</tr>
<tr>
<td><strong>OVERALL AMPLIFIER PERFORMANCE RATING</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE III continued</th>
</tr>
</thead>
<tbody>
<tr>
<td>circuits is worthwhile, and rarely found on receivers in this price class. The high-cut filter might just as well have been omitted, since it is no more useful in reducing noise than the already available 6 dB-per-octave treble controls. The parallel connection of one of the tape out circuits on the front panel is handy when friends bring over their tape decks for dubbing of your favorite tapes.</td>
</tr>
<tr>
<td><strong>FM reception</strong> was better than we would have guessed from reading the “numbers” but we did experience one or two cases of poor selectivity on the dial. We do object to the labelling of the mode switch. One of the positions is identified as “4 channel,” suggesting four independent amplifiers, which of course are not present in this strictly stereo receiver. As for power output, the LR-2200 is conservatively rated and more than meets its claims. The unit was found to be thermally stable even after running for several hours at high volume levels and with continuous sine-wave test signals. This Lafayette receiver offers good to very good value for the budget minded audiophile who wants control flexibility, reliable performance and good styling without having to purchase more power than he or she rightly needs. The unit will drive medium to high efficiency speaker systems to adequate sound levels for serious listening in all but the very largest home listening areas.</td>
</tr>
<tr>
<td><strong>pair of knobs for Dolby “play” calibration, another pair for “record” calibration</strong> of Dolby, a button that actuates a 400-Hz built-in tone generator useful for calibrating the Dolby circuitry and two more buttons that select either the TAPE 1 or TAPE 2 monitor circuits and choose either source or tape to be fed through to the rest of the amplifier circuitry. The right-most cluster of pushbuttons includes one that converts the meter to a multipath indicator, HIGH-FILTER and LOW-FILTER buttons, a HIGH-BLEND switch (for reducing noise during stereo FM listening), a LOUDNESS switch, and FM MUTING switch and individual speaker switches for MAIN and REMOTE pairs of speaker systems connected to the receiver.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MANUFACTURER’S PUBLISHED SPECIFICATIONS:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FM TUNER SPECIFICATION:</strong></td>
</tr>
<tr>
<td>FM Quieting: 30 dB for 1.8 µV; 55 dB for 5.0 µV; 70 dB for 50 µV. Harmonic Distortion (mono): 0.15%; (stereo): 0.3%. Selectivity: 80 dB. Capture Ratio: 1.25 dB. Spurious and IF Rejection: 100 dB. AM Suppression: 65 dB. Stereo Separation: (1 kHz): 42 dB.</td>
</tr>
<tr>
<td><strong>AMPLIFIER AND PREAMPLIFIER SECTION:</strong></td>
</tr>
<tr>
<td>Power Output: 125 watts minimum continuous average power per channel into 8 ohm loads, from 20 Hz to 20 kHz at no more than 0.15% total harmonic distortion. IM Distortion: 0.15%. Damping Factor: 70. Frequency Response (High Level) 20 Hz to 20 kHz ±±25 dB. Input Sensitivity: (phono): 1.8 mV; (high level): 180 mV. Equivalent Input Noise: 1.5 µV. Dynamic Range: (phono): 96 dB. Tone Control Range (bass, 50 Hz): ±±15 dB; (treble, 15 kHz): ±±15 dB; (mid-range 700 Hz): ±±6.0 dB.</td>
</tr>
<tr>
<td><strong>GENERAL SPECIFICATIONS:</strong></td>
</tr>
</tbody>
</table>

in the scope photo of Fig. 6 and is typical of this type of circuit where manufacturers choose to emphasize both low and high frequencies at low volume settings. |

A summary of our reaction to the LR-2200 will be found in Table III, together with our overall product analysis. In our view, whether you consider Lafayette a retailer or a manufacturer, their LR-2200 qualifies as a worthwhile product in its price category. | R-E
other Dolbyized program sources or in the OFF position for bypassing of Dolby circuitry entirely, in the record I position for making a Dolby recording of a non-Dolby program source and-you guessed it—in the record II position for making a non-Dolbyized recording of a previously Dolby encoded program source.

Have we (or Marantz) left anything out? We strongly doubt it. The interesting combination of tone-mode and tone control knobs is shown in detail in the photo of Fig. 2. A pair of DUMBING IN and OUT jacks on the front-panel duplicate the TAPE 2 jacks on the rear panel and are useful for connecting a tape deck without having to gain access to the rear panel once the unit has been permanently installed.

A view of the rear panel is shown in Fig. 3. Speaker connection terminals for MAIN and REMOTE speaker systems are of the push-to-insert-wire type and are color coded. Below the speaker connectors are SWITCHED and UNSWITCHED convenience AC receptacles and a power line fuse post. A MUTING threshold control is screwdriver adjustable and varies the signal strength at which interstation noise muting is overcome. Terminals for AM, 75-ohm and 300-ohm FM external antenna connections are spring loaded and similar to those used for speaker connection.

What Marantz chooses to call an FM QUADRADIAl OUTPUT jack is simply an FM detector output jack that provides access to the composite FM audio signal that may be needed some day for connection to a discrete 4-channel FM adapter. A pair of screwdriver-adjustable controls are used to adjust the FM Dolby level to correspond with tones transmitted by FM stations who broadcast Dolby programs for that purpose. The usual complement of input and tape output jacks, plus a pivotable AM ferrite bar antenna complete the rear-panel layout. The flexibility of the receiver is indicated by Fig. 4 which shows how the receiver fits into a complete system and how many additional program sources can be connected to it.

Circuit description

A view of the inside of the chassis of the model 2325 is shown in Fig. 5. The power transformer is one of the most massive we have ever seen in a one-piece receiver. Power output stages are mounted on large heat sink assemblies, one on each side of the chassis. Amplified signals from the RF amplifier are fed to a triple-tuned Butterworth filter and then to an FET mixer stage. A five-section tuning-capaci-

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**TABLE I**

**FM PERFORMANCE MEASUREMENTS**

<table>
<thead>
<tr>
<th>Manufacturer: Marantz</th>
<th>Model: 2325</th>
</tr>
</thead>
</table>

**SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE**

<table>
<thead>
<tr>
<th>IHF sensitivity, mono: (µV) (dB)</th>
<th>Measurement</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity, stereo (µV)</td>
<td>27.0 (34.0)</td>
<td>Fair</td>
</tr>
<tr>
<td>50 dB quieting, mono (µV)</td>
<td>5.0 (17.4)</td>
<td>Good</td>
</tr>
<tr>
<td>50 dB quieting, stereo (µV)</td>
<td>55.0 (40.2)</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

**Maximum S/N ratio, mono (dB)**

47.0

**Maximum S/N ratio, stereo (dB)**

72.0

**Capture ratio (dB)**

1.2

**AM suppression (dB)**

65

**Image rejection (dB)**

100+

**IF rejection (dB)**

100

**Spurious rejection (dB)**

100+

**Alternate channel selectivity (dB)**

82

**FREQUENCY AND DISTORTION MEASUREMENTS**

- Frequency response, 50kHz to 15 kHz: 1.0
- Harmonic distortion, 1 kHz, mono (%)
- Harmonic distortion, 1 kHz, stereo (%)
- Harmonic distortion, 100 Hz, mono (%)
- Harmonic distortion, 100 Hz, stereo (%)
- Harmonic distortion, 6 kHz, mono (%)
- Harmonic distortion, 6 kHz, stereo (%)
- Distortion at 50 kHz quieting, mono (%)
- Distortion at 50 kHz quieting, stereo (%)

**STEREO PERFORMANCE MEASUREMENTS**

- Stereo threshold (µV) (dB)
- Separation, 1 kHz (dB)
- Separation, 100 Hz (dB)
- Separation, 10 kHz (dB)

**MISCELLANEOUS MEASUREMENTS**

- Multiple threshold (µV) (dB)
- Dial calibration accuracy (°kHz/°MHz)

**EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION**

- Control layout
- Ease of tuning
- Accuracy of meters or other tuning aids
- Usefulness of other controls
- Construction and internal layout
- Ease of servicing
- Evaluation of extra features, if any

**OVERALL FM PERFORMANCE RATING**

- Excellent
- Very Good
- Good

**S/N**

<table>
<thead>
<tr>
<th>S/N</th>
<th>dB</th>
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<tr>
<td>mono</td>
<td>30.0</td>
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<tr>
<td>stereo</td>
<td>37.0</td>
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**TABLE II**  
**RADIO-ELECTRONICS PRODUCT TEST REPORT**

<table>
<thead>
<tr>
<th>Manufacturer: Marantz</th>
<th>Model: 2325</th>
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**AMPLIFIER PERFORMANCE MEASUREMENTS**

<table>
<thead>
<tr>
<th>R-E</th>
<th>Measurement</th>
<th>Evaluation</th>
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<tbody>
<tr>
<td>POWER OUTPUT CAPABILITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMS power/channel, 8-ohms, 1 kHz (watts)</td>
<td>140.0</td>
<td>Very good</td>
</tr>
<tr>
<td>RMS power/channel, 8-ohms, 20 Hz (watts)</td>
<td>135.0</td>
<td>Excellent</td>
</tr>
<tr>
<td>RMS power/channel, 4-ohms, 1 kHz (watts)</td>
<td>N/A</td>
<td>Good</td>
</tr>
<tr>
<td>RMS power/channel, 4-ohms, 20 Hz (watts)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>RMS power/channel, 4-ohms, 20 kHz (watts)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Frequency limits for rated output (Hertz)</td>
<td>11-20</td>
<td>Very Good</td>
</tr>
</tbody>
</table>

**DISTORTION MEASUREMENTS**

| Harmonic distortion at rated output, 1 kHz (%) | 0.10         | Excellent    |
| Intermodulation distortion, rated output (%)  | 0.11         | Excellent    |
| Harmonic distortion at 1 watt output, 1 kHz (%) | 0.022        | Excellent    |
| Intermodulation distortion at 1 watt output (%) | 0.004        | Excellent    |

**DAMPING FACTOR, AT 8 OHMS**

73  Very good

**PHONO PREAMPLIFIER MEASUREMENTS**

| Frequency response (RIAA ±_dB) | 0.5 dB       | Very good   |
| Maximum input before overload (mV) | 125          | Good        |
| Hum/noise referred to full output (dB) | 71         | Excellent   |
| (at rated input sensitivity) |             |             |

**HIGH LEVEL INPUT MEASUREMENTS**

| Frequency response (Hz, kHz, _+_ dB) | 20-20, 0.25 | Excellent |
| Hum/noise referred to full output (dB) | 55         | Superb     |
| Residual hum/noise (min. volume) (dB) | 99           | Good       |

**TONAL COMPENSATION MEASUREMENTS**

| Action of bass and treble controls | See Fig. 7 | Very good |
| Action of secondary tone controls | See Fig. 8 | Very good |
| Action of low-frequency filter(s) |            | Good      |
| Action of high-frequency filter(s) |            | Good      |

**COMPONENT MATCHING MEASUREMENTS**

| Input sensitivity, phono 1/phone 2 (mV) | 2.05         | Excellent |
| Input sensitivity, auxiliary inputs (mV) | 187          | Very good |
| Input sensitivity, tape inputs (mV) | 187          | Excellent  |
| Output level, tape outputs (mV) | 187          | Good       |
| Output level, headphone jack(s) (V or mV) | Not measured |           |

**EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN**

Adequacy of program source and monitor switching | Excellent |
Adequacy of input facilities | Excellent |
Arrangement of controls (panel layout) | Excellent |
Action of controls and switches | Excellent |
Design and construction | Excellent |
Ease of servicing | Very good |

**OVERALL AMPLIFIER PERFORMANCE RATING**

Excellent

---

The phase-locked-loop stereo demodulator IC circuit where it is decoded into left and right channel signals.

The AM tuner section consists of one IC and three transistors. A three section variable capacitor is used for AM tuning and automatic AGC circuits are applied to RF and IF sections.

The Dolby system circuitry is a single-process two-channel circuit with inputs and outputs determined by the setting of the front-panel Dolby selector switch. The phono preamp-equalizer section provides RIAA equalization and 40 dB of gain (at 1 kHz) for phono input signals. Tone control amplifiers are of a continuously variable feedback type and turnover frequencies are determined by the control knob switch explained earlier. Filters provide high- and low-frequency roll-off at 12 dB-per-octave slope with the -3 dB points set at 9 kHz and 50 Hz.

Power amplifier stages are direct-coupled from the input differential stage all the way through to the loudspeaker outputs. The output stage consists of four push-pull parallel complementary-symmetry power transistors (NPN-PNP pairs). Electronic protection circuits sense excessive output current and voltage conditions and limit the signal to the driver transistors to a safe, predetermined value. Thermal compensation circuits are also provided and a relay protects speakers in the event of transistor failure and also eliminate pops and transient bursts when the unit is turned on or off.

**Laboratory FM measurements**

Considering the price and quality of Marantz receivers, we have often wondered why that company steadfastly refuses to quote specifications in accordance with accepted new standards. For that matter, they did not even subscribe to the old IHF standards that everyone else used for years before the new, universally accepted (by IHF, IEEE and EIA) standards became official. We don't know what they claim for usable sensitivity in the case of the 2325, since they insist on giving quieting figures only—which do not take into account distortion at low signal strengths.

By our more standardized measurement, IHF usable sensitivity was 2.1 µV (11.8 dBf) in mono and a rather unimpressive 27.0 µV in stereo. This is also the point at which the circuits switch from mono to stereo automatically—and far too late in our opinion. A signal level 55 µV (40.2 dBf) was required to produce 50 dB of quieting in the stereo mode—again not particularly outstanding in view of the price and features of this otherwise excellent piece of equipment.

It wasn't long before we realized that this particular set was not optimally aligned, as evidenced by some of the other test readings (particularly stereo distortion) listed in Table I. Despite certain performance failings in FM, other performance factors such as rejection of IF, image rejection and spurious rejection were excellent—as good or better than claimed. Signal-to-noise ratio in mono and stereo was also superb. Generally, those tests which involve weak signals were the ones that turned up poor performance, indicating clearly that the front end of our sample was not properly aligned.

**Laboratory amplifier measurements**

The amplifier, which of course involves no alignment, did much better than the tuner section, as evidenced by the measured results listed in Table II. The output power of 125 watts-per-channel proved to be the limit at the high frequency end of the spectrum (20 kHz) rather than at 20 Hz. Unlike many amplifiers whose rated power is determined primarily by the power supply resulting in limitations at the low-frequency end of the spectrum, the Marantz 2325 delivered 133 watts-per-channel at 20 Hz with both channels driven—at a rated THD of only 0.15%. IM and THD at the low-power levels were so low as to be barely measurable on our equipment.

In quoting phono hum and noise specifications as well as overload capabilities, Marantz again takes off on a path of its own.
Make Graphs Work for You

Graphs contain a lot of information that can be easily misinterpreted. Understanding graphs and interpreting them correctly is easy if you know how.

by IRVING M. GOTTLIEB

GRAPHS ARE USED EXTENSIVELY IN THE TECHNICAL LITERATURE of electronics. When we see a graph depicting the relationship between a cause and its effect, we know we have encountered a fast and effortless educational mechanism. At a single glance, the behavior of a device or system becomes clearly obvious. But, does it? The following scenario, though fictional, accurately discloses some misleading interpretations that can be both plotted into, and misread from graphs.

A project engineer for a large firm wanted to develop a complex system. The easiest way to get the ball rolling was to collect “building blocks” from the company’s file of circuits already used for other projects. One functional block of the system required a simple low-frequency amplifier with priority on faithful response. In other words, such an amplifier had to be linear (input signal amplitude vs. output signal amplitude). For the purpose at hand, all other performance parameters, such as frequency response beyond a few hundred Hz, power output, gain, etc., need not be considered for the first go-around. Four departments were requested to submit examples of linear amplifiers that they had previously used. Compliance with this request was inordinately fast—perhaps too fast, as we shall see.

Department “A” submitted the graph shown in Fig. 1. Departments “B”, “C”, and “D” submitted the curves respectively illustrated in Figs. 2, 3, and 4. All claimed the amplifiers had a linear transfer characteristic as evidenced by the graphs. Although all of the graphs were valid plots of output power vs. input voltage, only one was acceptable. Let’s analyze these “linear” amplifiers and see where the three unacceptables went astray.

Interpreting graphs

It cannot be said that the graph of Fig. 1 is not linear—it obviously does show a straight line relationship between the input signal voltage and the output power delivered by the amplifier. But, unfortunately, such a relationship does not describe a linear amplifier. In a linear amplifier, the output power is proportional not to the input voltage, but rather to the square of the input voltage. Indeed, in any circuit, not necessarily an amplifier, power increases as the square of the voltage monitored across a constant resistance. So, we see, department A made an incorrect interpretation of their graphically-linear curve. Actually, had their amplifier been linear, it would have plotted out as shown in Fig. 5.

The plotter of Fig. 2 from department B did not forget about the square law relationship between voltage and power. However, to translate this relationship from mathematics to graphics, he used dBm units for power. Enclosed with his straight line curve was an explanation of how he obtained a straight line relationship. This, he accomplished by adjusting the bias networks in the amplifier. Alas, this amplifier, too, was relegated to the “circular file.” Even with the uniformly-spaced coordinates of his graph and the use of the logarithmically derived dBm units, a little study reveals something very much wrong. For example, if the amplifier develops 20 dBm when the input signal is 1.25 volts, we shouldn’t see 40 dBm for 2.5 volts input (40 dBm represents ten times as much power as 20 dBm. No hi-fi amplifier is this!

Having been momentarily caught off guard by department B, the project engineer inspected the graphical results of department C’s amplifier (Fig. 3). With a chip-on-the-shoulder attitude, he noted the use of semi-log paper. This should have solved the oversight of department B’s plotter—but hold on a minute! It happens that the technique used by department C is exactly equivalent to the erroneous plot submitted by department B. A little contemplation shows that both must be faulted for the same reason—non-compliance with the square law relationship between voltage and power. More exasperated than hopeful, the project engineer turned his attention to the work of the next “contestant”, department D.

Another straight line plot (Fig. 4)—but did it represent the transfer characteristics of a linear amplifier? The answer was speedily forthcoming, for it was seen that any time the
input voltage doubles, the output-power quadruples. This was recognized as clear evidence of the required square-law relationship. However, a straight line plot on log-log paper does not necessarily reveal a square-law relationship. For example, the dashed and dotted lines superimposed on Fig. 4 indicate other than square law functions. So, log-log paper is great, if such plots are interpreted with a practiced eye. Significantly, once it is determined that the slope of the straight line does represent the square-law relationship, we know that the amplifier is very linear indeed! This is because the slightest departure from the square-law is readily recognized as a change in the slope of the graph. Note that to make a similar evaluation of the curve of Fig. 5, many coordinate points and much computation would be required to determine whether the curvature is just right.

The log-log plot shown in Fig. 4 does, however, leave us in the dark concerning the operation of the amplifier at low levels. To convey full information, graphs should start at the origin—the zero-zero point. But, how does one define the origin of log-log graph paper wherein the left-bottom corner is never 0-0? Here, experience and common sense must be used. In Fig. 4, the characteristic of the amplifier is shown over an output range of 0.1 watt to ten watts. Thus, we see its performance down to one-hundredth of the highest power plotted. And if the relationship had been plotted on a three-cycle graph, rather than two, the plot would have extended down to 0.01 watt, or one thousandth of the highest power plotted. Not bad, but for the purist who must see the action right down to zero-zero, the log-log graph will forever frustrate him regardless of the number of cycles used.

**Log graphs**

Open almost any engineering textbook to the chapter on *transients or energy storage*, and the chances are good that you'll find graphs similar to that shown in Fig. 6. This graph tells us what percentage of original voltage is left in a charged capacitor C after a discharge path is provided by a resistance R. Time is scaled off in R-C units, otherwise known as time constants. (To determine actual elapsed time in seconds, simply evaluate the R-C product—thus; if $R = 100,000$...
ohms and \(C=5.0\) microfarads, then one time-constant \(=1\times10^4\times5\times10^{-4}=5\times10^{-1}\) or 0.5 second. The curve of Fig. 6 has the following shortcomings:

- Many points must be plotted to produce an accurate plot.
- The measurement of coordinate values is difficult.
- After two, and most certainly three time-constants, both plotting and reading become increasingly difficult.

Consider next, the same function plotted on semi-log paper. In Fig. 7, the plot is made on two-cycle paper. Note that the time constant corresponding to 1% of the initial capacitor voltage can be accurately determined. And with three-cycle paper, the range could be extended down to 0.1% of the initial voltage. Another aspect of this graphical technique is that we only need know two coordinates to lay out such a “curve” for any number of time constants. It happens that we already know those two points! At zero time, the capacitor voltage is 100%. And it is a mathematical axiom that one time-constant always corresponds to a capacitor voltage of 36.8%. We do not even have to know the values of \(R\) or \(C\) to make this straight-line plot. Even if the plot on ordinary graph paper shown in Fig. 6 were desired, it would be wise to first construct the semi-log graph. With this procedure, we avoid measurements and math.

An interesting and useful straight-line graphical technique is illustrated in Fig. 8. This is the plot of the reactance of an electrolytic capacitor as a function of frequency. In other words, it is a plot of \(1/2\pi fC\). A quick inspection of this log-log graph tells us that this is not the best of capacitors for hi-fi amplifier circuits or for the output capacitor of a regulated power supply. The change in the slope of the plot in the 7 kHz to 10 kHz region, and thereafter, indicates that the impedance of this capacitor no longer obeys the law, \(X_c=1/2\pi fC\) for these higher frequencies. The practical aspect of this is that the bypass or filter-action of this capacitor becomes progressively worse at higher frequencies. Note that this phenomenon is not obvious in the “conventional” plot of Fig. 9. Here, several or more computations would be required in order to discover the poor high-frequency performance. To make matters even worse, Fig. 9 is both difficult to plot and to read.

### When to use which graph

A natural question is when to use conventional, semi-log or log-log graph paper. First, it is permissible to use any type of graph to represent any relationship! All three techniques can display cause and effect information. The subtle trap lying in our pathway is the interpretation of the shape of the plotted curve. With regard to straight line graphs on log paper, the following rules apply:

**Semi-log paper:** Use for exponential functions. This includes the equations for the charge and discharge of voltage or current in \(R-C\) or \(L-R\) circuits. Plot voltage or current on the vertical axis. Plot time units on the horizontal axis. The plotted “curve” will then be a straight line.

(continued on page 90)
**R-E's Service Clinic**

**Loop circuits**

*A circuit that controls itself*

by JACK DARR
SERVICE EDITOR

A LOT OF "LOOP CIRCUITS" ARE USED IN electronics; feedback loops, control loops, and on and on. We find a lot of them in TV and radio. By a "loop circuit" I mean a function consisting of an active circuit (amplifier, oscillator) and a control circuit. The output of the circuit is used to control its own action. When we find trouble in such a circuit, we must remember that it could be one of two things: a fault in the active circuit or a fault in the control circuitry.

Let's look at the basic test method we must use. We have a circuit with two parts. So, we can't tell which one is the guilty one as is. To isolate the trouble we disable the control circuitry and let the controlled circuit run free to see if we can get a normal output from it. If it will do this, we know that the fault is in the control circuit; if it still won't work, the fault is in the active circuit.

A good example of this is the horizontal oscillator and AFC circuit. This is a servo-loop; the phase of the reference signal is compared to the phase of the horizontal sync signal. The result is a small DC voltage directly proportional to the phase error. This voltage is used to control the frequency of the horizontal oscillator. (Yes; this is a phase-locked loop. The horizontal multivibrator type of oscillator is actually a voltage-controlled oscillator.)

Figure 1 shows a block diagram.

```
    HORIZONTAL OSCILLATOR
       |  NORMAL OUTPUT
       |  CONTROL CIRCUIT (AFC)
       |  COMPARISON SIGNAL
          |  SYNC
```

**Troubleshooting**

Suppose the horizontal oscillator won't run on-frequency. We have two possibilities; either the horizontal oscillator has a bad part which is throwing it off-frequency or a fault in the AFC Automatic (Frequency Control) circuitry is pulling it off frequency. So, we kill the AFC by grounding the output of the phase detector.

In the tube-type multivibrator circuit, we have an open grid that isn't really needed in the oscillator itself. The AFC control voltage is applied to this grid. If the frequency goes high, the AFC develops a voltage that pulls it back on. If it goes low, the voltage is of opposite polarity. If the oscillator is running right on frequency, this grid will be zero volts. To clamp this and kill the AFC, we simply ground this grid.

Now check to see if the oscillator will run on-frequency under this condition. Adjust the frequency control (horizontal hold) to see if you can get a single picture, with straight sides. If you can, the oscillator is definitely able to run on-frequency. This picture will float from side to side since there is no control, but if you can see that there is only one picture, that's it. We've cleared the oscillator circuit.

Now put the AFC back in. The picture should snap in sync and hold. If it falls out of sync, we know that there is a fault in the AFC circuit. In only two steps we have isolated the cause of the trouble. This narrows it down to about 4 or 5 components—the AFC diode unit and a few resistors and capacitors.

**AFPC**

There are several other common circuits that are actually identical to this one. The Automatic Frequency and Phase Control (AFPC) in a color TV set works exactly like the horizontal AFC. All tests and reactions are the same. The only difference is in the observed symptoms. In this case the color will fall out of sync while the picture remains locked.

To break the control loop and let the 3.58 MHz oscillator free-wheel, just kill the control voltage. In most sets this is done by grounding the grid of the burst amplifier. Now adjust the frequency control(s) to see if you can make the colors straighten up and hold momentarily. Note the similarity of the color-rainbows to a picture out of sync horizontally. Out of sync, they make slanting lines of red, green and blue. As the frequency control is adjusted, they will become fewer and wider, and slant less.

If the oscillator can be adjusted to the right frequency, the bars will straighten up and the colors lock in momentarily. If you can not make them lock in, the oscillator is not able...
save on gas!
save on tune-ups!
save on maintenance!

Electronic ignition is "IN"! So says Detroit.
Update your car with either a TIGER CD or a TIGER I breakerless system.
Enjoy the benefits of better gas mileage, quicker starting, elimination of tune-ups, 50,000 miles on points and plugs, and reduced maintenance expenses.

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tbody>
<tr>
<td>TIGER MAX CD</td>
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</tr>
<tr>
<td>TIGER 500 CD</td>
<td>59.95</td>
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<tr>
<td>TIGER SST CD</td>
<td>42.95</td>
</tr>
<tr>
<td>SIMPLIKIT CD</td>
<td>31.95</td>
</tr>
<tr>
<td>TIGER I</td>
<td>45.95</td>
</tr>
</tbody>
</table>

Postpaid U.S.A. only.

**Tri-Star Corporation**
Dept. WW, P.O. Box 1727
Grand Junction, Colorado 81501
Circle 19 on reader service card

---

...to run on the precise frequency we need. For example, if the bars start to straighten up but then turn around and start slanting more instead of straightening up and then slanting in the opposite direction, the oscillator can't run at the right frequency (crystal slightly off frequency, etc.)

If you can get this reaction, then the oscillator circuit is working. If you put the AFPC back in the circuit and the color sync is still poor, go directly to the color sync circuits themselves—the burst amplifier, AFPC diodes, and so on. The details of the circuit differ in many sets, but if you'll check it out, the basic reaction is always the same—the burst is compared to the frequency of the 3.58 MHz oscillator and the resulting control voltage used to lock the color in place.

We could draw a block diagram of this circuit, but it would look just like Fig. 1, so we won't bother. Only the operating frequency is different!

**AGC**

Another loop that is often unrecognized is the IF and its AGC circuit. The IF is a multi-stage amplifier with its gain controlled by the amplitude of the video signal from its output. This is fed back to the input, once again in the form of a small DC control voltage.

Here, it controls the gain of the circuit so that it will neither clip nor drop below a certain level.

Test methods are exactly the same though with one minor difference. We have been killing the control by grounding things to clamp the active device input at zero. Now we have to use a definite value of DC voltage to clamp the control loop. If we have what we think is an IF problem, its symptoms will be no picture at all or a distorted picture—too dark, too light, etc.

So, we clamp the control voltage so that the IF amplifier is held at maximum gain. Now, we use the same old simple method—look at the picture! If we can get a good picture, this shows that the IF stages are able to amplify the signal properly.

How do we know exactly what voltage and polarity we need to do this? Look at the schematic! The bias voltages shown on the IF amplifiers are read at no-signal input. In this condition, they are at maximum gain. This may be a very low DC voltage or quite high and of either polarity. The last is especially true in solid-state TV sets. Just check the voltage shown on the schematic and hook up a bias box to the AGC test point. This will always be somewhere in the grid return circuit (continued on page 68)
TABLE III
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Marantz Model: 2325

OVERALL PRODUCT ANALYSIS

<table>
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<th>Feature</th>
<th>Rating</th>
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<tr>
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<tr>
<td>Styling and appearance</td>
<td>Excellent</td>
</tr>
<tr>
<td>Sound quality</td>
<td>Very good</td>
</tr>
<tr>
<td>Mechanical performance</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Comments: We especially appreciated the tone control permutations available on this receiver. With its selectable crossovers for both bass and treble plus the extra mid-range control it comes close to being able to adjust response for almost any listening situation or component deficiency, much like the separate graphic equalizers can do. Clearly, the amplifier has enough power to drive virtually any speaker system to loud, clean listening levels and it seemed adequately protected in terms of thermal overload and accidental shorts. We suspect that in our sample, FM performance, and particularly stereo FM performance, was not up to standards and that a minor realignment could have brought things into line. Stereo switching takes place at too high a level, preventing reception of weaker stations in that mode. Stereo sensitivity was also poorer than on receivers costing far less, all of which suggests that quality control must have missed a few points on this one. We very much doubt if this is a design fault, having measured any number of Marantz tuners and receivers that do much better on FM and stereo FM. It is our policy, however, to “call them as we see them”, since an unsuspecting consumer could just as easily have ended up with this particular unit.

Performance of the amplifier section and preamplifier section, on the other hand, was as near perfect as anything we’ve heard from an all-in-one receiver. The front-panel control arrangement is sensibly organized, considering the number of control features, tape monitoring facilities, and the like.

(continued on page 66)

With RCA’s SK Series you need stock fewer different semiconductors than you’d have to with any other major brand. Because our 300 devices can replace 112,000. And they’re all immediately available.

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Circle 20 on reader service card

Circle 21 on reader service card

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own. This time, the numbers are at least translatable to ones we are all more accustomed to reading. For example, when Marantz says that phono input noise is 1.5 \(\mu\)V and that input sensitivity for full output is 1.8 mV, it is easy enough to establish a ratio of these two numbers, take a log of the ratio and multiply by 20 to get the S/N ratio in dB. It works out to 61.5 dB, but why not state the overload capability of these two numbers, take a log of the ratio and multiply by 20 to get the S/N ratio in dB. This important specification. In the case of overload capability of the preamp-
equalizer section, Marantz comes up with a figure called dynamic range, which they define as the ratio of input overload voltage to equivalent input noise. Happily, our scientific calculator could translate all this to a millivolt figure for phono overload which turns out to be about 95 millivolts, given their "96 dB dynamic range" specification. Again, our test sample did much better than that, with overload of the phono inputs occurring at about 125 millivolts—not the highest we have measured for a receiver but certainly good enough. Additional lab measurements are shown in Table II and, generally speaking, the amplifier section of this receiver comes off looking a lot better than the tuner section. While no measurements are presented in

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of the first IF amplifier stage if you don't have a schematic.

If you have a good strong signal, you may see that the picture shows signs of overload—too dark and with bending or buzz. If you see this, vary the control voltage toward the direction of reduced gain. If you can find a setting that gives you good picture and sound, this clears the IF stages. Go and scratch around in the AGC circuitry for the trouble.

There are quite a few other circuits that turn out to be loops. For example, the boost voltage in the horizontal output stage is one form of a loop. This voltage is developed by the high pulse-voltage from the plate of the horizontal output tube. It also serves as the plate voltage of that same stage. So, you can't have one without the other. Low boost-voltage produces a low output that produces low boost.

When you run into mysterious symptoms, look around carefully and see if the circuit is some form of a loop. If it is, then divide and conquer—kill the control voltage and then see if the active circuit will work. This will tell you instantly where to look for the cause of the trouble!

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**Service Clinic**

(continued from page 64)

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**You don't need a bench full of equipment to test transistor radios!** All the facilities you need to check the transistors themselves—and the radios or other circuits in which they are used—have been ingeniously engineered into the compact, 6-inch high case of the Model 212. It's the transistor radio troubleshooter with all the features found only in more expensive units. Find defective transistors and circuit troubles speedily with a single, streamlined instrument instead of an elaborate hook-up.

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KARL SAVON
SEMICONDUCTOR EDITOR

LET THERE BE NO DOUBT ABOUT IT! THE microcomputer is a full-fledged member of the computer clan. All the basic functional processes are found on a single or a compatible series of integrated circuits. “Micro” is much less a characterization of the processing power than the physical size and fabrication process. As a computer, the micro carries out a programmed sequence of arithmetic and data-shuffling instructions in a way that completes a useful task. The task may be the solution of differential equations, thousands of calculations, or intelligent control of a simple or complex piece of machinery.

Logic designers are learning a new discipline—programming—and leaving their AND's and NOR's behind. Many sequential logic systems were controlled by gates and flip-flops are now done cheaper and quicker with the μP. They are cropping up all over in electronic sales, appliances, pinball machines, auto ignition controls, games, communication controllers, medical instruments, and test equipment. Updating and logic flaws are corrected by changing a few lines of program code rather than costly circuit redesign.

But although the microcomputer is aptly named, you would be a little optimistic to expect it to replace an IBM370 or a large scale minicomputer system. Here lies one of the principal areas of confusion quite evident in discussions with people new to this revolutionary art. In general, the μC is slower and more awkward in carrying out its computer assignments than its bigger brothers. They are the most economical when the job is small or medium sized. When the project acquires large dimensions, the computer may be the lowest cost item on the list. Outshading it will be the expensive peripherals.

There are wide variations in speed capability, in memory addressing, and instruction repertoire. Remember though that speed alone is not the selection criterion. Overall ability to do the prescribed job at the lowest cost is the objective. Some applications are better handled by 4-bit microprocessors. If there is not much computation to be done the use of an 8-bit machine would unnecessarily up the cost.

Then there are the NMOS types, a notch up including the latest with depletion mode loads. Here we have the Intel 8080 and Motorola's 6800 at 2 μs, the Signetics, 2650 at 4.8 μs, the Fairchild F8 at 2 μs, and Electronic Arrays' 9002 with a 2 μs add time.

Continuing, we come to a group of elite devices which have been designed to be building blocks for the larger machines. These are the 2 and 4-bit slice machines with their microprogrammability and higher prices. On this list you’ll find the TI T/L SRP8040 at 1 μs, and the TTL group including the MM1 3701 (0.2 μS), the Intel 3002 (0.15 μS), and AMD's 2900 (0.125 μS). They are in a class by themselves and are not chips you are likely to build into a home project.

[Already a number of processors have become popular with users. Notably the Intel 4040 and 8080, the Rockwell PPS-4, and the Motorola 6800 which have taken into the confidence of manufacturers.] Speed is largely governed by the monolithic process. Silicon-gate MOS seems like it will be the dominant process for a while. Using PMOS are Mostek's MK5065, Rockwell's PPS-4 and National's SCAMP, which have add times of 7, 4, and 28 microseconds respectively.

In an effort to dominate a segment of the market, each manufacturer has developed a specific computer organization or architecture which he feels best meets particular needs. Some of the latest types are designed to take a crack at minicomputer applications. General Automation has a new GA-16 system that uses two NMOS chips by Syntek. The new machines are software compatible with their versatile SPC-16 minis. Also in the mini category are Motorola's 10800 ECL, MMI's system 300 Micromini, and TI's 9900. Texas Instruments is one of the stronger contenders with a sophisticated line of hardware and software designed around the 9900. Just as minicomputers are creeping up on the big boys, micros are closing in on the minis. μCs are today about where the mini was 10 years ago.

Mics are in their third generation of development. Concentration is now on putting the clocks on the processor chip and using single voltage supplies. The AMI 9209, TI's TMS-1000, the Rockwell PPS-1, and National's SCAMP are all efforts in this direction. Slower PMOS is used so they can sell close to calculator chip prices. The Rockwell 6801's PACE has most of the features of the earlier IMP16 on one chip reducing costs. The comparison reference for all these is the Intel 8080, the most widely used of all μPs. San Francisco's BART system has just finished development of a 6-bit arithmetic price collection system using the 8080.

The μP is only one element of a complete μC system. It receives the lion's share of attention because its design dictates the performance limitations of the entire system to which it is connected. Designers have learned to shun types with an incomplete supporting family. When micros first came out the designer had his hands full figuring out driver, multiplexing, and decoder circuitry. Newer devices have this critical logic on the chip. The total package count has been slashed. Interface problems have been reduced to cookbook procedures.

Understandingly there is general confusion as the manufacturers huddle and reduce their prices and update their designs. Designers are uneasy that the model they are working with today will be obsoleted by next year's model. The rapidly changing technology makes it very hard to keep up. Choosing the right machine is no easy task. But using one of the leading types is a pretty sure bet. Hand's on experience is vital for real solid evaluation and fortunately distributors are setting up so—they can run benchmark programs for your application on competitive machines.

When the dust clears, for an unbelievable few dollars you will see products that make life more fun. And the general purpose computer will be introduced as a mind expanding tool for both you and your school-age child.

Microcomputer news

We might as well wrap up with some μC-related items.

Processor Technology Co. (2465 Fourth St., Berkeley, CA 94710) has put together an operating system for program development on Intel 8080 systems. The program listing is available for $3 and paper tapes will be sent to computer clubs or societies.

Software Package No. 1 requires 6K of memory plus additional space for user storage of source and object files.

The operating system will keep track of 6 program files that are assigned names by the programmer. A line oriented editor is part of the package. Two assembly passes convert the mnemonic program listing produced with the editor into machine code which can then be executed by the EXEC command. The operating system will provide an output to program 1702A PROM's.

FANIS, Inc. (110 First St., Suite B, Los Altos, CA 94022) has developed a six-volume programmed learning course on microcomputers. It specifically covers the Intel series in detail starting with the 4004, through the 4040, the 8080, and the 8080. The course proceeds with 700 pages beginning with binary arithmetic through microcomputer assemblers and prototype systems.

Additional learning materials include wall-size system charts, pocket reference books, and programming pads. The introductory course is $99.50 and has a 15-day money back guarantee.
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If all the keys operate correctly, peel off the protective backing and apply them to the tops of the keys.

After the power supply, voltage regulator, clock, LED display and keyboard sections have been tested, install the remaining parts. Remember to add the 0.01 μF decoupling capacitors. If you are only going to be using 256 words of R/W memory, at least to start, be sure that it is correctly installed in the locations allocated for IC9 and IC10. If you have not already done so, obtain one of the 1702A PROM's with the Keyboard Executive (KEK) software in it. Preprogrammed PROM's are available (see parts list) and if you already have a 1702A PROM, it may be programmed from the listing provided. There are currently a number of 1702A type PROM's available. These are the 4702A and the 8702A. These are pin-for-pin equivalents of the 1702A, but their access times are slower. The 1702A PROM's or equivalents should have a maximum access time of about 1.3 ms to work with the Dyna-Micro. If you purchase a "surplus" PROM, be sure that these conditions are met.

The PROM containing the KEK software must be placed in the location allocated for IC15. It will not work correctly if placed in the location for IC16 since the addresses will be incorrect.

Next month, the foil patterns, component placement diagram, schematic diagram of the monostable-LED circuit and the final check procedures will be given.

R-E

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(continued from page 66)
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The Stamp 50 is a high-performance high-fidelity system designed to parallel the works. The Stamp 50 on page 80)

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The service technician's job is a tough one. Customers are always grumbling about the high cost of TV service calls. And they complain about poor reception—even when it's almost impossible to get a good signal.

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B-T Boosters can produce a dramatic improvement in picture quality, particularly on color and especially in difficult reception areas. After 25 years of making outdoor boosters, B-T is number one in sales, and enjoys the finest reputation for making products of highest performance and reliability. B-T Boosters do cost a bit more than competition, but they perform and last longer. And that's what makes satisfied customers.

The VAULTER, for example, is the number one outdoor booster today in the B-T line...and in the entire industry. This ultra-high performance, all-channel amplifier offers the ideal combination of lowest possible noise figure (4.6dB, VHF; 7.0dB, UHF) and high gain (15dB). While it can't make unusable, snowy pictures perfect, it can reduce fading, loss of color, overcome cable loss and reduce lead-in cable noise. It can even feed more than one TV set from the same antenna in fringe reception areas. It has separate U/V inputs and a coax output. Finally, it's specially designed for lightning prone areas.

The B-T line consists of 5 all-channel models (including the popular VOYAGER); 5 VHF models and 4 UHF boosters (the ABLE-U2bi is a favorite).

See your B-T distributor for details. And see why you can count on boosters inside, when you install B-T Boosters outside. Blonder-Tongue Laboratories, Inc., One Jake Brown Road, Olc Bridge, N.J. 08857.

Circle 26 on reader service card
NEW PRODUCTS (continued from page 78)

performance quality of home stereo components. It can be installed in a car, van, boat or airplane.

The DG-coupled Stamp 50 amplifier delivers 20-35 watts RMS per channel (40 to 70 watts in stereo). Distortion less than 0.3% THD, 20 Hz to 20 kHz at full output.

The PEQ50 preamp/equalizer has separate high- and low-frequency controls level and LED indicator. The input accepts an FM/FM stereo signal source and all 8-track and cassette players. The 6½-inch rear-mounting woofers are complemented by forward-placed hemispherical Mylar dome radiating tweeters.

Speaker grilles, all wiring, crossover components and owners’ installation manual are included in the kit. $388.00—AudioMobile, Inc., 3225 McArthur Blvd., Santa Ana, CA 92704.

Circle 33 on reader service card

LIQUID CRYSTAL DISPLAYS. Standard digit sizes are 2, 4, 6, and 8 in., with large sizes up to 12 in. available on special order.

Single- and multi-digit assemblies are available with integral lighting or in a reflective mode for external front lighting. The units are completely self-contained requiring only BCD inputs to generate numerics, and use less than 50 milliwatts of power per digit of exclusive lighting. Excellent legibility with contrast ratios greater than 10 are achieved in ambients of up to 300 foot-candies with back lighting, and in any ambient, including direct sunlight, in the reflective mode.

Applications include message boards, process control “score boards”, clocks, arrival/departure boards, and other uses requiring large numeric readouts—North Hills Electronics, Inc., Glen Cove, NY 11542.

Circle 34 on reader service card

NEW SEMICONDUCTOR TESTER, the model 520-B, features a new HI-LO Power Drive system, is AC-powered and designed for maximum operating convenience for technicians at the service bench.


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Anybody who’s into electronics certainly should be getting the everyday convenience and family security of automatic garage door operation...especially now, with Perma Power’s great Electro Lift opener...made to fit in the trunk of your car, designed for easy handling and simple do-it-yourself installation. Available now at a surprisingly low price from your distributor.

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Perma Power

Chamberlain Manufacturing Corporation
Perma Power Division
5740 North Tripp Avenue, Chicago, Illinois 60646
Telephone (312) 539-7117

Circle 67 on reader service card
In LO Power Drive, the base, emitter, and collector leads of the device being tested are automatically identified. HI Power Drive enables a technician to perform accurate in-circuit gain tests on devices in circuits with shunt resistance as low as 10 ohms and shunt capacitance as high as 15 µF. An audible tone indicates proper operation, and LED indicator lamps identify the functioning device as PNP or NPN.

The model 5028B can perform a complete in-or-out-of-circuit test in less than 10 seconds. The new unit also tests out-of-circuit leakage with an automatic identification of silicon or germanium semiconductor types. The polarity of diodes, FET's and SCR's is also indicated. $160.00—B&K-PRECISION Division of Dynascan Corporation, 1801 W. Belle Plaine Ave., Chicago, IL 60613.

Circle 35 on reader service card

NON-CONTACT AC/DC CURRENT PICKUP. The model ID-5001M current sensor is designed to sense both AC and DC currents on one or more conductors passing through the sensing aperture. The device produces an output voltage proportional to the total current through the aperture.

This method of current sensing is unique in four main areas: (1) Non-contact operation provides complete isolation from the bus.

(2) Introduces a negligible power drain in the measured circuit. (3) The extremely low insertion impedance has a negligible effect upon a measured circuit performance. (4) The DC current capability allows the measurement of DC, AC or combination waveforms.

An optional electronic package is available with the ID-5001M sensor. This package contains the power supply for the control current and the output amplifier—F. W. Bell, Inc., 4949 Freeway Drive East, Columbus, OH 43229.

Circle 36 on reader service card

SOLDERING AIDS, designed with the production worker in mind, have non-magnetic steel blades to which solder won't adhere. Blades are set into black plastic handles that are hex-shaped so the aids won't roll off the workbench. Solder aids are available in the 8-inch standard size and the 6-inch version for micro work.

Models are available with a forked end that straddles wire for looping, bending or guiding; a reamer end that cleans and burrs lug holes; the hook end probes for loose connections; the knife/scaper removes surplus solder and the brush cleans solder connections. The dual-ended regular models have an overall length of 8 inches. The hex handle is 5/8 x 4 inches, blades are 3/32 x 2 inches. Three models pair the fork with hook, brush and reamer. The fourth pairs the knife and brush, $1.39 each.

The Micro models are 6 inches overall. Handle is 1/4 x 3 inches; blade 1/4 x 1-1/2 inches. Available as fork/hook and fork/hook models at $1.79—Hunter Tools, Marshall Industries, 9674 Telstar Ave., El Monte, CA 91731.

Circle 37 on reader service card

POCKET PORTABLE DVM as an analog meter replacement. The DVM35 is more accurate than most general-purpose analog instruments due to its 3-digit display; 1% DC voltage accuracy and 15-megohm input impedance. It measures more than most portable analog meters; including 1-ampere and 10-megohm capabilities, plus 2000 VDC measurements available when using the TIMES TWO button on the probe—thus doubling all voltage ranges and increasing the input impedance to 30 megohms. Measurements up to 50 KV are possible when using the HP200 accessory high-voltage probe.

Long battery life is assured by using the TOUCH ON button on the probe. The DVM35 is turned off between measurements, thus extending battery life. AC line operation is possible using the optional power adapter/recharger model PA 202. $124.00—Sencore, Inc., 1260 Sencore Drive, Sioux Falls, SD 57107.

Circle 38 on reader service card

DISTORTION METER. The LDM-170 audio circuit distortion meter also measures signal-to-noise ratio and signal levels in all audio-frequency circuits. It has a balancing circuit to suppress the fundamental frequency in the 20 Hz-20 kHz range while distortion products are fed to a stable, high-

Look for the June issue of Radio-Electronics at your newsdealer May 18

MAY 1976

Circle 70 on reader service card
DIGITAL ELECTRONIC STOPWATCH, mod- 1671, is designed for use in simple start/stop and time in/time out applications, it is ideal for industrial time and motion studies, excellent for use in the research lab. You start, stop and reset with one hand, and it times to 59 minutes, 59.9 seconds (with automatic recycle) in increments of 1/10 second. Fail- safe design means timing cannot be reset. Equipped with solid-state. Compact (4.45 x 2.45 x 1.46), lightweight (6 oz.) and durable for use in the field or lab, the watch's bright 5-digit LED display gives excellent readability under most light conditions. Neck strap and replacement AA batteries are included. $49.95.

For under eighty dollars, you can get a wrist model (6559) with all the features detailed above, plus standard split-fuction for partial event times. You can freeze times on a partial event while you continue to measure total elapsed time (allows for timing of two or more "openings" or participants in a single event). Rechargeable NiCad batteries, AC charger and leather carrying case are included. $79.95.

The deluxe model 1655, similar to above but with no charger, comes with four replaceable alkaline batteries to provide 18 hours of continuous use. Transistor Radio astonished allows for a series of individual event times without losing total elapsed time. Its 6-digit display is bright neon orange with ±0.001% accuracy. $149.95. These three, and other electronic digital stopwatches, are available by mail, postpaid.—Edmund Scientific Co., 80 ESSCRO Bldg., Barrington, NJ 08007.

Circle 39 on reader service card

LAFFAYETTE L-8 3-WAY PEDESTAL SPEAKER—L-8 is a three-way design employing a 10-inch woofer with a magnetic 4-lb. P-C type, open cell, 1-1/8" x 1-1/8" x 1-1/8" aluminum voice coil, and a 5-inch sealed-back mid-range speaker, and four suicide tweeters. Front speakers are set in front and either side to provide 270° sound dispersion.

The columnar enclosure incorporates an internal tuned duct for high acoustic effi-
ciency and improved bass response. Frequency response of the L-8 is 30–20,000 Hz. Nominal impedance is 8 ohms. Multistage RLC crossovers are used at frequencies of 2300 and 6000 Hz providing 12dB per octave. Mid- and high-frequency controls on rear panel are used to adjust output for room acoustics. Power handling capacity is 30 watts RMS, 60 watts, program material. The cabinet is finished on four sides in a mar- proof walnut finished laminate over solid ¼-inch acoustic wood and has a removable

### LEADER

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**LBO-502**
5” Triggered Scope w/Graded Scale
- Ideal for most electronic applications; easy pushbutton operation; 1-5, 5-graded scale readings & 15 MHz b’width. Has auto and trig sweep, 17 steps calib.: X5 mag.; and 10mV to 20Vp-p/cm vert.
- Sensitivity. Complete with probe, leads and adapter.

**LBO-511**
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Pomona, CA 91766

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Circle 74 on reader service card

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**Circle 73 on reader service card**
brown foam grille. It measures 37½ inches high x 12½ x 12½ inches cross-sectionally. $165.95—Lafayette Radio Electronics Corp., 111 Jericho Turnpike, Syosset, NY 11791.

Circle 41 on reader service card

HOME MUSIC SYSTEM. The model RH-606 8-track record/playback, AM/FM stereo system is one of four in the Pioneer Centrex Series of seven having recording capabilities. Automatic or manual program change, lighted program and recording indicators are among features. Unit has magnetic phono input jacks, 120-volt AC-outlet, front-panel microphone and headphone jacks. The two-way acoustic suspension speakers have foam grilles. $260.—Pioneer Electronics of America, 1555 E. Del Amo Blvd., Carson, CA 90746.

Circle 42 on reader service card

MAGNETIC-MOUNT CB ANTENNAS. The 39-in. Liberty series are designed for fast attachment and removal that helps prevent thefts. The need for mounting holes or brackets is eliminated with these virtually theft-proof antennas that magnetically clamp to any 4 square-foot metallic surface on cars, trucks, RV's, or boats. (Not recommended for soft vinyl tops). The husky base magnet has 40 lb. holding power which prevents crawling or cislodgement and is ABS encapsulated to prevent surface scratches. The Liberty I (Model 10-285) has a fiber glass whip, and the Liberty II (Model 10-286) features a weather-resistant stainless steel whip with base-load coils.

Both models have extra-distance radiation patterns and corrosion resistant stainless steel whip spring and marine-type hardware.

16 ft. coax transmission cable with a PL-259 plug, plus a capacitive impedance match that eliminates the need for matching transformers. $27.95.—Breaker Corp., Marketing Dept., 1101 Great Southwest Parkway, Arlington, TX 76011.

Circle 43 on reader service card

HAND-HELD DIGITAL MULTIMETER measures capacitance along with AC and DC volts and resistance. Called the model 21, this palm-sized instrument has four DC voltage ranges with 1 mV resolution: Four AC voltage ranges with 1-mV resolution: Four resistance ranges with 1-ohm resolution and four capacitance ranges with pF resolution. Other features and specifications include: 0.27” LED displays 3½ digit readout (up to 2,000 counts); simplified five-step calibration.

Designed for field or bench operation, the model 21 operates from 4 rechargeable Ni-Cad batteries. (An optional converter for line operation is also available). Inside the high-impact polycarbonate case, the model 21 uses all components laid down to withstand impact and shock. Only standard compo-

(continued on page 86)
AUTOMOTIVE IGNITION SYSTEM
(continued from page 49)

the unit in the “bypass” position while setting the points.
Point contact wear is almost completely eliminated with the unit. Other point wear factors should be considered. The rubbing block surface of the points can wear. It is important to follow the car manufacturers instructions on lubricating the distributor cam surface during tune-up. Some cars have a lubricating wick; this should be replaced. On other cars, a thin layer of grease is put on the cam. If the rubbing block does wear, it will retard ignition timing somewhat. (The author has not experienced any rubbing block wear problems.)

Another possible source of failure is breakage of the points tension spring from age and fatigue. I have never seen this happen. However, it is probably good preventive maintenance to replace the points every 50,000 miles.

Due to the more positive spark from the unit, sparkplug life should be a little longer with this unit than with a standard ignition.

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MAY 1976

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If your ears are ready for $600 speakers, but your budget isn’t, we have a way to satisfy both. Sennheiser headphones. Using the same acoustic design principles that have made our professional microphones industry standards, Sennheiser Open-Aire* headphones reproduce sound with a realism most loudspeakers can’t begin to approach. With wide, flat response. Low distortion. Excellent transient response (even in the bass region!) And sheer intimacy with the music. All without sealing in your ears. Whether you’re waiting for that pair of $600 speakers or just curious about a pair of headphones some experts have compared with $1000 speakers...the answer’s at your audio dealer’s.

*Manufacturer’s suggested list for Model HD4/4. Deluxe Model HD242 also available at $79.75.

If your ears are ready for $600 speakers, but your budget isn’t, we have a way to satisfy both. Sennheiser headphones. Using the same acoustic design principles that have made our professional microphones industry standards, Sennheiser Open-Aire* headphones reproduce sound with a realism most loudspeakers can’t begin to approach. With wide, flat response. Low distortion. Excellent transient response (even in the bass region!) And sheer intimacy with the music. All without sealing in your ears. Whether you’re waiting for that pair of $600 speakers or just curious about a pair of headphones some experts have compared with $1000 speakers...the answer’s at your audio dealer’s.

*Manufacturer’s suggested list for Model HD4/4. Deluxe Model HD242 also available at $79.75.
reader questions

LOSS OF VERTICAL SWEEP
I've got a black-and-white portable with no vertical sweep at all. I want to check a quick to the vertical output transformer and yoke. Can I use a separate 6.3 volt filament transformer to feed a signal into the output tube? This set has a series heater string—J.G., Arlington, VA.

If you feed the test signal into the grid of the vertical output tube, OK. If you feed it directly to the plate, either disconnect the plate voltage or use a good-sized blocking capacitor (0.25 or 0.5 μF).

TOO MUCH RIPPLE IN PICTURE
I wrote you before about checking the excessive ripple in the picture of a Gamble TV-2761 black-and-white TV. You suggested checking ripple on the power-supply filters. That was it! I had to add 80 μF of extra capacitance to get rid of it! Works now. Thanks—J.W., Hastings, MI.

Glad to hear I was right.

EXCESSIVE WIDTH
The raster in this Sylvania D05-14 is so wide that I can see only 8 vertical lines of a cross hatch pattern! All of the DC voltages seem to check out all right. I tried reducing the screen grid voltage of the horizontal output tube. That didn't work—C.M., Diamond Bar, CA.

Well, there went one of my favorite ways of reducing excess width! So now what? In several cases this chassis has shown excessive width if that VDR from the pin-3 cathode of the 6CL8 high-voltage regulator tube to ground goes bad. This is part No. 38-15257-9. Replace with exact factory duplicate; couldn't find a listing on it.

MAY 1978

The Money Generator

It's a DOG FIGHTER, TOO!
The Model ATC-10 is much more than a color bar pattern generator. It should be called a portable multi-purpose TV diagnostic and servicing aid, but it looks too much of a mouthful. We would have to rename it the Dog Fighter (instead of the Money Generator), but that might be misinterpreted to mean that it's only useful in the shop. The versatile ATC-10, a portable, moderately-priced instrument, combines the most essential features of a color bar pattern generator, a TV "analyzer," and a substitute tuner plus several brand new "dog fighting" and timing innovations. With all this extra versatility, however, the ATC-10 is human engineered with only four simple-to-master controls.

Two illustrated brochures describe the ATC-10. The first brochure describes the many unique and unusual features which make the ATC-10 a "dog fighter" and a time-saver. The second brochure illustrates the timesaving (money making) potential of the ATC-10 by comparing its capabilities with 18 competitive instruments. In all, 33 representative features are evaluated. We think the results of this evaluation will be a sure surprise to many. It clearly illustrates how easily it is for most TV shops to purchase or continue to use less versatile equipment and shows how the ATC-10 has the potential of returning its $299.95 purchase price in as little as 3 to 4 months.

These brochures are yours for the asking — write direct for immediate reply.

American Technology Corporation
225 Main, Dept. 5C, Canon City, CO 81212
FUNCTION GENERATORS (continued from page 42)

will decrease in output amplitude by as much as —2 dB when changed from the lowest to highest frequency. This —2 dB roll-off is due to filtering circuits used in the output amplifier to eliminate high-frequency discontinuities present in the synthesized sawtooth.

Amplitude symmetry (DC offset)

As noted before, lack of time symmetry can cause an apparent DC offset in the output signal. The output signal may also have DC offset contributed by lack of symmetry in the limit detectors, and DC offset contributed by amplifying stages elsewhere in the generator. Amplitude symmetry is usually specified as a percentage match between the peak positive and negative amplitudes of a wave.

Output specifications

The output impedance, the maximum peak-to-peak output voltage, and the clipping level of the output voltage are all of interest to the potential user. The common output impedance of a function generator is 50 ohms. This value is chosen to permit driving low-impedance loads and to minimize reflections on the 50-ohm coaxial cables commonly used to connect the generator to a load. This is especially important when fast rise time square waves are used. Some lower-cost generators have sacrificed 50-ohm output impedance to reduce their price. These generators specify the 600-ohm output impedance common in the older sine/square oscillators.

The peak-to-peak output voltage of the generator is specified into the rated load impedance as well as into an open circuit. The open circuit voltage will be twice that of the loaded output voltage when the output impedance of the generator is the same as the rated load impedance. A common value of peak-to-peak output voltage is 10 volts minimum into the rated load. The value varies from manufacturer to manufacturer, and sometimes from model to model, and should be clearly noted when purchasing a function generator.

Frequently the sum of the peak output signal and the variable DC offset signal will exceed the peak limits of the output amplifier. When this condition occurs, the desired waveform may be clipped or otherwise distorted. Limit detectors are offered on some models of function generators, and a rare few offer an output amplifier with enough dynamic range to handle both the signal and the DC offset signal. The vast majority of function generator manufacturers expect the user to keep track of this condition.

Offset control

The offset control permits a variable amplitude/variable polarity DC bias to be applied to the output signal. This is usually a ±5 volt offset signal. Generally, offset signals will not be attenuated with an increase in attenuation of the variable attenuator, but will be attenuated by the step attenuator. On some generators, offset may not be turned off, and some generators have switched position allowing the user to return to a signal symmetrical about zero volts. Offset is not available on all generators and is frequently deleted from low-cost units.

Attenuator

The amount of attenuation and the type of attenuators vary considerably from generator to generator as well as from manufacturer to manufacturer. The simplest attenuators are nothing more than a single variable control, offering as little as 20 dB attenuation and a maximum of 40 to 60 dB. Other function generators combine a variable control with 20 dB range with a step attenuator offering 10 or 20 dB per step. Step attenuations vary from one 20 dB section to six or seven 10 dB sections. Of course, the more attenuation sections available, the better. The maximum output voltage is usually known only to be greater than some specified value (say 10 volts) but not to be an exact voltage. For this reason, most attenuators are calibrated in decibels of attenuation rather than in voltage steps. The user interested in the exact signal voltage at the load should measure it separately.

Often the variable attenuator may appear to give more total attenuation than specified by the manufacturer. Use of the function generator at greater than specified attenuation levels may result in an output waveform with excessive distortion, resulting from high-frequency signals.

(continued on page 92)
Build Super-Pong & Bumper
Two TV games that are fun to build and exciting to play. They connect into the video circuits of your TV set, IC circuitry. Complete plans and instructions start in this issue.

Video Discs & Tape
They are still just a little further down the road as far as in-home devices go; but they'll be here soon. Here's a report on where they stand today.

Ball Lightning And How To Make It
You build a giant Tesla generator, of course, out in the desert and then... But you'll have to read about this one for yourself. By the way have you ever seen 5- and 10-foot long electrical discharges?

Hi-Fi Test Gear
A fresh look at test equipment for hi-fi gear. See the equipment and how it is used.

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Circle 88 on reader service card
The FM-2400CH provides an accurate frequency standard for testing and adjustment of mobile transmitters and receivers at predetermined frequencies. The FM-2400CH with its extended range covers 25 to 1000 MHz. The frequencies can be those of the radio frequency channels of operation and/or the intermediate frequencies of the receiver between 5 MHz and 40 MHz. Frequency Stability: ±.0005% from +50°F to +104°F.

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Self-contained in small portable case. Complete solid state circuitry. Rechargeable batteries.

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RF crystals (less temperature correction) 18.00 ea.
IF crystals catalog price

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**CHARTS & GRAPHS**

(continued from page 62)

Log-log paper: Use for power functions—those involving “x” raised to a power, “n”. This embraces all square-law equations, such as those connecting power and voltage or current. Example: \( \ln P = \frac{1}{2} \ln R \), \( I \) corresponds to “x”, and “n” is 2. Plot I on the horizontal axis vs. \( P \) on the vertical axis. The plotted “curve” will then be a straight line.

Interestingly, log-log plots are also straight lines for reciprocal functions. Commonly-encountered reciprocal functions are the Ohm’s law equations, \( I = \frac{E}{R} \) and \( R = \frac{E}{I} \). In the first equation, assume \( E \) is constant, then plot \( I \) on the vertical axis and \( R \) on the horizontal axis. In the second equation, assume \( E \) is constant, then plot \( R \) on the vertical axis and \( I \) on the horizontal axis.

Another reciprocal function is the equation connecting capacitive impedance or reactance, \( X \), with capacitance, \( C \), and frequency, \( f \). This equation is \( X = \frac{1}{2\pi fC} \). Plot \( X \) on

---

**Fig. 10—Characteristic Curves** of a typical junction FET. Circled portion is sometimes omitted.

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**Fig. 11—Behavior** of a Schottky diode. Circled portion is sometimes omitted.
FIG. 12—RESPONSE of a 4-kHz low-pass filter plotted on conventional graph paper.

FIG. 13—SEMI-LOG GRAPH of response of same filter as in Fig. 12.

the vertical axis, and either f or C on the horizontal axis. (Actually, the reciprocal function is a power function in which the power of the exponent is −1. Thus, another way of writing the equation for capacitive impedance is $X_c = \frac{1}{2\pi fC}$.)

Some graphical entrapments stem from incompleteness. Because of sales department specmanship or engineering department laziness, the encircled portions of the graphs in Figs. 10 and 11 are sometimes absent. This can lead to dire application results. There is nothing to warn us of the limits of allowable drain-source voltage for the FET. And unless you had reason to suspect otherwise, the inordinately low reverse avalanche voltage of the Schottky rectifier could lead to fireworks.

Graphs depicting the frequency response of tuned circuits, filters and other devices are often deceiving. Consider, as an example, the two plots of the same 4-kHz low-pass filter shown in Figs. 12 and 13. Both display the same information with respect to the "skirt". Yet, the semi-log plot of Fig. 13 appears to show much greater selectivity than is revealed by Fig. 12. Heightening the illusion, we see that the passband is geometrically longer in the semi-log plot than in the conventional plot. And that is despite the fact that a log scale has the ability to compress range! A filter maker would be guilty of no chicanery at all by showing the performance of his filters on semi-log plots. He would simply be putting his best foot forward!
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FUNCTION GENERATORS (continued from page 88)

that capacitively bypass the attenuator and add to the desired signal.

Trigger output
A second output is frequently found on the function generator. This output is a square wave or a spike of a fixed level. The trigger signal is related to the leading edge of the square wave at the main output. This signal may be used to trigger such external devices as an oscilloscope, for example, in situations where the main output signal is attenuated below the point that would allow it to be used for this purpose. Often these trigger outputs are not 50-ohm amplifiers but are TTL outputs. Therefore, the user must remember that the waveform may not pass through zero volts, and may be of variable source impedance.

Other features
On the more exotic generators, features such as remote programmability, digital display of frequency, logarithmic frequency sweep, amplitude modulation, and variable symmetry control may be had, to mention a few of the more popular options. Most of these features will not be found on the low-cost function generators for a few years to come. Generators employing these features must be considered more than simple replacements for the sine/square oscillator.

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<thead>
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<th>Part</th>
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### 8000 SERIES

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<td>$25.00</td>
<td>Waveform Generator Kit</td>
</tr>
</tbody>
</table>
ADVERTISING INDEX

RADIO-ELECTRONICS does not assume any responsibility for errors that may appear in the index below.

READER SERVICE CARD NO.  PAGE

Allison Automotive Co. 85
American Technology Corp. 87
AP Products 83
15
Arrow Faster 24
83
Bell P/A Products 86
12
B & K Division of Dynason Corp. 20,21
26
Blonder Torque Laboratories 79
85
Brooks Radio & TV Corp. 87
96
Card Electronics, Inc. Cover IV
22
Channellock, Inc. 66
91
Chemtronics 27
CIE, Cleveland Institute of Electronic Engineering 70-73
66
Continental Specialties Corp. 5
CREI, Division of McGraw-Hill Continuing Education Center 26-29
92
Dana Laboratories, Inc. 92
90
Delta Products 91
72
Digi Electronics 82
62,94
Edsyn 70
70
EICO, Electronic Instrumentation, Inc. 84
28
E & I Instruments, Inc. 74
10
Electronics Technical Institute, Division of Technical Home Study Schools
17
EMC, Electronics Measurement Corp. 68
25
Fordham Radio Supply Co. 25
16
General Electric 25
88
Grantham School of Electronics 89
18
GTE Sylvania—Electronic Components 32
63
Harwil 76
100
Heath Co. 19
7
Hickok Electrical Instruments Co. 14
IMS 18
20
Indiana Home Study Institute 65
89
International Crystal Mfg. Co. 90
14
Lafayette Radio Electronics Corp. 23
75
Leader Instrument Corp. 83
74
McKay Dymek Co. 83
MITS, Micro-Instrumentation 1
80
MOS Technology, Inc. 67
24
Mountain West Alarm Co. 80
National Camera Co. 74
29
Neal, Division of McGraw-Hill Continuing Education Center 8-11
National Technical Schools 52-55
PAIA Electronics, Inc. 85
79
Panavise, Division of Colbert Ind. 84
93
Perma Power 80
97
Polystar Corp. 92
8
PTS Electronics, Inc. Cover II
RCA Distributor & Special Prod. Div. 64,65
87
Rye Industries 88
68
Sabtronics International 80
69
SBE 7
8
Scholar Organ Corp. 66
32
Sencore, Inc. 88
82
Sennheiser Electronics 86
9
Share Brothers 16
Sinclair Radionics, Inc. 31
9
Southeast Technical Products 80
Cover III
61
Sphere Corp. 76
73
Tab Books 83
17,64
Techtronics, Inc. 85
19
Telematic, Inc. 30,17
Tri-Star Corp. 64
6
Tuner Service Corp. 13
3
Vaco 2
13
Vector Electronics Corp. 22
65
Welger-Xcetile
Electronics Division 78
30
Zodiac Communications 75
MARKET CENTER
105
Active Electronics 97
110
Alfaj 100-101
AMC Sales 96
American Calibration Services 100
American Used Computer Corp. 94
121,122,123
Anorona Corp. 109,110,111
Baby Electronics 106
Karen Barta 93
CRF Associates 106
Command Productions 94
Cornell Electronics 106
Dage Scientific Instruments 100
Delta Electronics 104
Dena Electronics 94
Digi-Key 96
25
Electronic Materials 96
Formula International 92
31
Bill Godbout Electronics International 104
Information Unlimited, Inc. 106
International Electronics Unlimited 107
120
Jade 108
106,107
James Electronics 98-99
Lab Science 100
Lakeside Industries 91
Mesha Electronics, John Jr. 100
Micro-Peripheral, Inc. 113
Micro-Electronics 102
Nexus Trading 94
108
Olsen Electronics 106
Parasitic Engineering 106
99
Polyatomic Systems 93
118
Poly Paks 105
113
Processor Technology Corp. 102
112
Quest 102
54
Satellite Tape Sales 94
116
SD Sales 103
Security Systems 94
Solid State Sales 106
101
Stanley Lin 94
43
Trumbell 96
Valley West 93

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- Simple to operate, minimum of operating adjustments.
- Principle of operation similar to output meter and attenuator system of expensive signal generators.
- Standard signal level for proper color reception (1mV to 4mV = 0dBm to +12 dBm) clearly indicated for instant identification.
- Measures signals from 300uV to 30,000uV.
- Uses ordinary 9v transistor batteries, low current consumption ensures low cost per measurement.
- IC amplifier and meter driver circuits.
- Electronic voltage regulation.
- Quasi-peak detector.
- LED IC battery status system, shows when batteries are below operating voltage.
- Sturdy, high impact ABS plastic case for field use.
- Made in USA.

Castle products — advanced technology — modern styling — and they work!

See your stocking distributor . . . or write for more details and complete specifications.

CASTLE ELECTRONICS, INC.

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Circle 96 on reader service card