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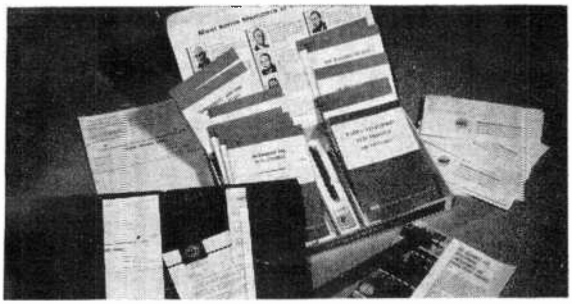

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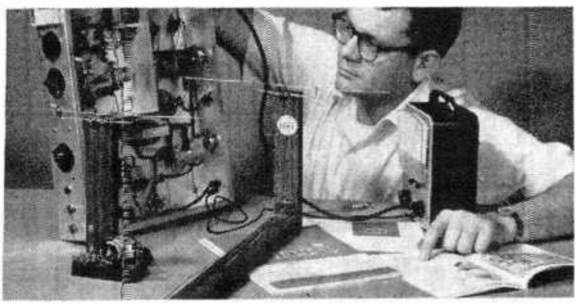

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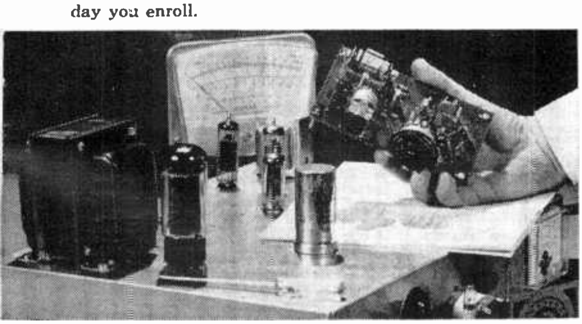

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Editorial

By Milton S. Snitzer, Editor

THE CB PLEASURE SEEKERS

Want to chat about anything in any part of the world over radio for any length of time? Get a ham license! Want the no-test privilege of transmitting brief, personal or business messages up to 150 miles away ("I'm stuck in traffic, hold dinner till I contact you again")? Get a CB license!

But it doesn't work out this way. The CB bands have become "party lines," with attendant clogging of channels. Linear power amplifiers manufactured for use in the 10-meter ham band are being used for the 11-meter band to soup up CB rigs so that they exceed the legal 5-watt input limit. Result? TV interference and bottling up local CB channels at a great distance away.

Abuses are rampant. Millions of CB'ers are not covered by an FCC license, depriving the government of revenue and inviting users to work CB illegally by not having call letters that must be used when transmitting.

Who is responsible for the misuse of the Citizens Radio Service? Heaviest blame must rest with the FCC for not covering the loopholes that existed when the service was initiated. Without a policing force that would match our standing army or some hard-nosed checks and balances, it should have been obvious that the pleasure of hobby use would win out over limited communication privileges. Even type acceptance (see "CB Scene," March 1974) of Class-D CB transmitters, adopted only recently, could have been required of manufacturers many years ago.

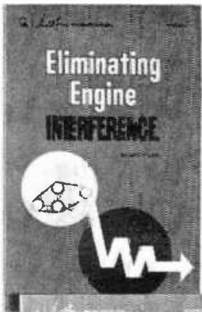
Sure there have been violation fines imposed here and there. But they've been minuscule in percentage. The FCC has witnessed blatant violations of its Part 95 of FCC Rules with hardly a raised eyebrow (or at least without a mailed fist).

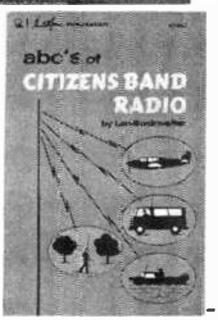
With the proposed Class-E CB service planned to supplement, not supplant Class D, some of these problems will be alleviated by the opening of more communication channels and virtual elimination of "skip." But with brisk sales of CB rigs expected to continue, some of the problems—idle chatting, no call letters, etc.—will continue and eventually result in busy channels once again.

What's the solution? CB'ers who want to clean up the service for their own good could start by getting licenses, using callsigns, limiting lengths and types of conversations and ceasing transmission beyond legal limits. There is certainly great value remaining in CB—sending important personal and business messages, reporting local traffic conditions to persons engaged in furnishing this information to the public, requesting routing directions or any other assistance needed in transit (food, lodging, etc.), communicating emergencies involving safety of life or property, and much more. Free the channels and everyone will benefit.

There's a wealth of enjoyment and information in Sams books for the hobbyist.

One or more of the eight shown here could be right down your alley.





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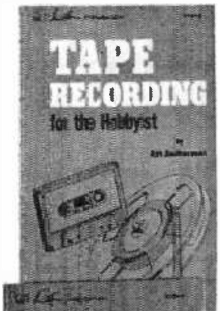

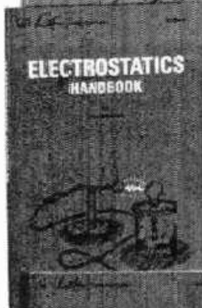

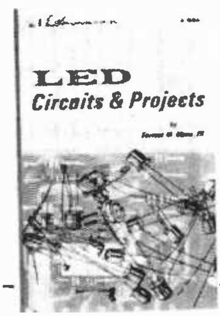

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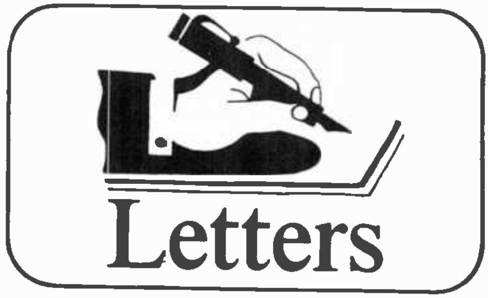

Letters

CHECK THE LEGALITY

California limits the use of "siren" devices such as the "Electronic Siren" (December 1973) in unauthorized vehicles. California readers of POPULAR ELECTRONICS should be made aware that sirens cannot be legally used as the alerting devices in automobile burglar alarm systems in this state. We appreciate your interest in other types of auto theft warning systems as contributing towards a reduction in vehicle thefts.

WARREN M. HEATH
Commander, Engineering Section
Dept. of California Highway Patrol
Sacramento, Calif.

We are sorry that the limited space we had for the story precluded our inserting the usual admonition to the reader to check with his state motor vehicle department on the legality of using a siren sound in an auto theft alarm system. We hope this belated warning will rectify the situation.

WANTS TO KNOW ABOUT TESLA

In school and on the radio, I have been hearing a lot about Nikola Tesla. So far, all I have been able to find out is where he lived and how great an inventor he was. I would like to know a lot more about him. Can you tell me where to look?

JIM HERRICK
Kent, Ohio

Nikola Tesla is among the most famous men in electrical science. Hence, it should be easy to find detailed information on his life and contributions. A good place to start is the encyclopedia. Even more information can be found in your local library.

WRONG SIDE UP

I was so fascinated by the "Logidex" (November 1973) that I decided to build one for myself and another for a friend. To do a really professional job, I had the boards professionally made. I was frustrated when the circuit boards I had ordered turned out to be the mirror image of what they should have been. I suspect that someone goofed because the etching and

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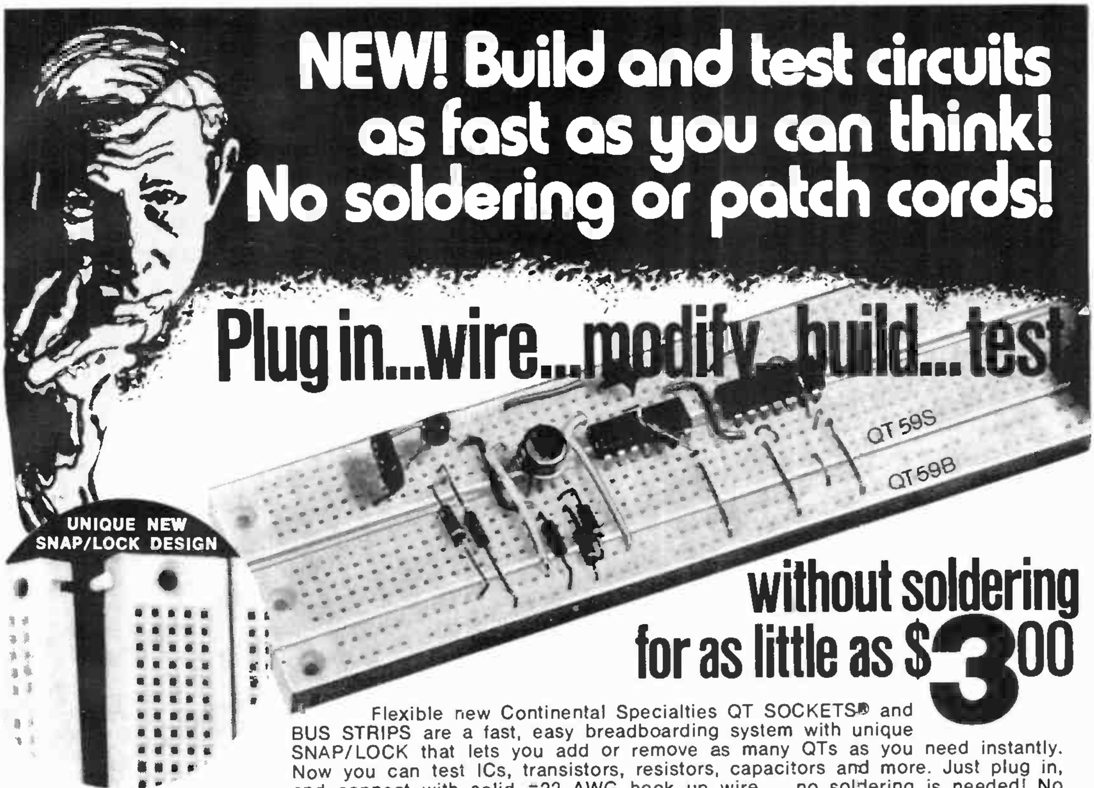

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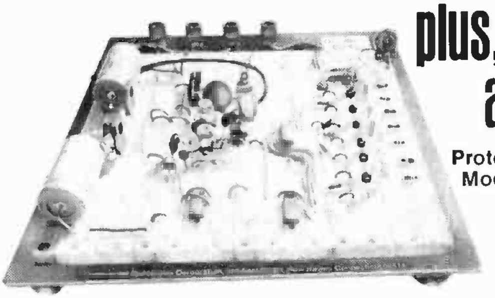

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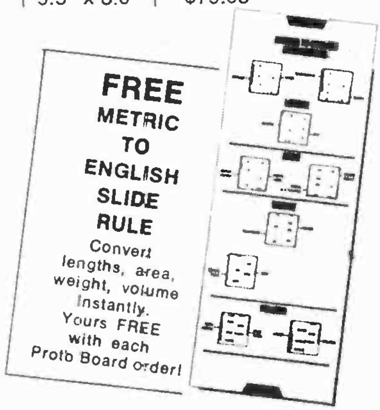

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CIRCLE NO. 9 ON READER SERVICE CARD

drilling guide shown in the story was given from the component-side view.

DOUG EDMONDS
Independence, Ore.

In the process of reproduction, the foil pattern did, unfortunately get printed the wrong way.

ADVERTISEMENT CAUSES CONCERN

On page 93 of the January 1974 issue, there is an advertisement for the sale of POPULAR ELECTRONICS indexes from an outside source. I sincerely hope that this does not mean the demise of the publication of PE's own cumulative index in the December issues.

D.H. POMEROY
Manchester, N.H.

Rest assured that we will not cease the publication of our cumulative index. However there seems to be some confusion about the "outside source" index offered in the ad. To clarify, the two indexes are different. Our index is a compilation of Tables of Contents for the year. The outside-source index is a "working" reference, going into greater depth and detail.

BATTLE OF THE BATTERIES

Because my company manufactures electronic watches and clocks, the article "Build Your Own Electronic Digital Wristwatch" in the January 1974 issue was of great interest to me. I must, however, take issue with the recommendation of using a hearing-aid battery in the watch. Watch and hearing-aid cells are often identical in dimensions, but there are significant differences that make interchanging the two rather risky.

By design, a battery for watch use is built to supply a minuscule constant current for as long as two years. A hearing-aid cell, however, is designed to supply currents many times greater for a few weeks. The result is that the use of a hearing-aid cell in an electronic watch could result in a much shortened battery life—or worse yet, destruction of the interior of the watch from leaking electrolyte. Even if the A-H ratings of the two types of battery are the same, different sealing techniques, barrier materials, and electrolytes are often used.

JAMES L. BECK
Vice President of Engineering
Integrated Microsystems Inc.
Mountain View, Calif.

In essence, a hearing-aid battery is not designed for use in an electronic watch. However, the S-14 battery specified is inexpensive and easy to obtain. Also, in watches that we have been operating since September 1973, no damage or sign of potential damage has occurred.
—Bill Green, Alpha Electronics

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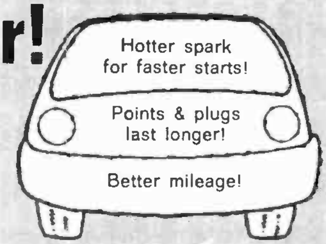

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CIRCLE NO. 27 ON READER SERVICE CARD

Stereo Scene

Legislating Power Output Claims

By Ralph Hodges

NEW YORK City's Consumer Protection Law Regulation 36 (". . . Disclosures in the Sale of Home Audio Equipment") went into effect on October 17, 1973. It is still too early (in mid-January 1974) to judge what the law's long-term influence will be, but at least no one can call it a lax or unspecific directive. Among its requirements are: *minimum* amplifier power to be specified in continuous sine-wave rms watts per channel, with all channels driven to rated output simultaneously; impedance to be 8 ohms; rated power to be available over a bandwidth of at least 60 to 10,000 Hz; total harmonic distortion to be less than 1 percent at all power levels up to rated. If a manufacturer or retailer chooses to employ another power rating system as well, he is free to do so, as long as the above information also appears "clearly and conspicuously," *and* as long as the performance specified is "obtainable . . . when the equipment is operated by the consumer in the usual or normal manner without the use of extraneous aids."

Aside from a quibble on the correct technical usage of rms (see box on page 14), there is little in the document that is open to broad interpretation. New York clearly means to clean up the audio retail industry by making a "uniform basis of comparison" among competing brands available. If that basis is a little rigorous for all types of equipment (pocket transistor radios can either claim 0.15 watt continuous—150 milliwatts would look better—or keep quiet about power), the asking price will (or should) balance things out.

Consumer Protection Law Regulation 36 is a direct fallout from hearings begun by the Federal Trade Commission several years ago, at which a number of representatives of industry groups (principally the EIA or Electronic Industries Association and the Institute of High Fidelity or IHF) and members of the audio press testified. The object of the hearings was to examine the chaos in amplifier power rating systems used regularly in product advertising, with the possible aim of disallowing some of the flagrantly unrealistic or meaningless ones.

What they stumbled on, of course, was the well-known quagmire of trying to correlate audible phenomena with measurable parameters. In the end, finding none of the existing rating systems completely definitive (in view of the testimony), the FTC devised its own, the particulars of which were announced in a revised, "final" form in late 1973. A mild uproar ensued, with the result that the FTC has been challenged to show that it has not overstepped its charter as a rule-*enforcing* agency and become, in this instance, a rule-*making* one. At the moment, the issue is still being debated.

Various Rating Systems. Why all the controversy over establishing a few uniform guidelines for the hapless consumer? It's a long and complicated story. We might as well begin by exploring the differences between the current FTC proposal and the rating systems espoused by the EIA and IHF. The IHF standard (IHF-A-201) was promulgated in 1966 as an updating of a previous standard from some years before. The EIA standard (EIA RS-234-B) came out in early 1971—virtually coincident with the first FTC hearings—as a display of solidar-

DOES RMS POWER EXIST?

A brief time ago there was a short-lived flurry in the audio press about the expression "watts rms," which has long been the nomenclature for continuous-power output in many manufacturers' literature. "There is no such thing!" it was hotly asserted, and there was a general deploring of loose standards and sloppy thinking in the industry. Well, I have heard that rms power *does* exist, at least as a concept, but it is of no interest to the audiophile. What we're concerned with is watts computed from rms *voltage*, which is a much easier concept to understand.

Way back when electricity had just emerged from Leyden jars, it was desired to find a way of expressing ac voltages that would compare them with dc in respect to work-doing potential. The following means was hit upon. A dc current was passed through a resistor and the heat generated was measured. Any ac current that generated the same amount of heat passing through the resistor was then considered to have the same effective voltage as the dc. Shortly it was discovered that the "dc equivalent voltage" of alternating current could be calculated by the rms (root-mean-square) method, which consisted of squaring all the instantaneous voltage values of the ac, computing the mean, and then extracting the square root. Thus rms voltage was born.

Power output is determined in the laboratory by the formula $P=E^2/R$, where E is the rms voltage and R is the load resistance. The rms "power," as the critics point out, is a misnomer, although probably a harmless one. The real curiosity is that "rms power" has come to mean, in audio, the same thing as "continuous sine-wave power." The rms voltage of a half cycle of a sine wave could easily be calculated, so the expression implies nothing about the continuity of the power output (music power is also calculated from rms voltage); nor does it suggest sine-wave signals in any way, except in that almost everyone knows the rms voltage of a sine wave is 0.707 of its peak value. But as long as rms means the same thing to everybody, we're probably all right.

ity with the IHF, and possibly as a demonstration of the industry's willingness to adopt self-regulatory policies in the face of impending government controls. Both standards are very similar, and they differ significantly from the FTC's only on seemingly minor points:

(1) The FTC proposal calls for amplifiers to be tested with a line voltage of 117 volts. The EIA specifies 120 volts, and offers an extensive study showing that the vast majority of the population has at least that much or more voltage available at the wall socket. Testing with 120 volts would theoretically provide an increase in power output of somewhat less than 10 percent; so would a slight modification of the equipment's power transformer. So this is a minor point; but, in my view, the EIA wins it on the basis of its documentation, provided this era of 10 percent brownouts hasn't negated the 1966 study of line voltage. The IHF also calls for 120 volts.

(2) The IHF standard specified that the amplifier be preconditioned before testing by being operated at 10 percent of its rated output for one hour. The EIA follows suit. The FTC proposal calls for 30 percent of rated output for the same period. I am told that continuous operation at 30 percent of capacity is approaching the condition under which typical amplifiers generate—and thus must dissipate—the most heat. In other words, after an hour of such conditioning there may not be a working amplifier left to test. This point could become a serious bone of contention, or it might just fade away.

(3) Both the EIA and the IHF standards describe a supplementary measuring procedure for rating short-term power-output capability—essentially the IHF's controversial "music" or "dynamic" power system. The FTC proposal recognizes no such system, specifying only continuous power.

The first two conflicts, although they have taken on the proportions of large issues for the moment, are resolvable because all equipment will be treated equally by whatever uniform standards are finally adopted. Point three is not so easily dealt with, because it poses the question of what exactly is "useful" power for an audio amplifier, and will therefore affect design philosophy as well as (possibly) the final cost.

IHF music power, for those who are not aware of the particulars, is usually measured in exactly the same way as continuous power. A steady sine-wave signal is applied to the inputs of the amplifier, the maximum

Circle No. 33 On Reader Service

rms output voltage at rated distortion is measured, squared, and divided by the resistance of the load to give the watts of output. However, the voltage provided by the power supplies of many amplifiers begins to drop rapidly as soon as a large output is required of the device, and when it finally stabilizes, it is often at a significantly lower value than it was under idle conditions. This results in a lower power-output measurement (continuous power, that is). Now, what the proponents of a music-power rating originally argued to the IHF was that the maximum output voltage of an amplifier, even if it lasts for only an instant under continuous-power testing, is significant for musical reproduction (and therefore of benefit to consumers) because music signals do not impose a steady drain on the amplifier's reserves, and thus don't drag down power-supply voltage as drastically. In other words, the maximum voltage of the supply, although unavailable for steady sine waves at full power output, *is* available for many types of music signal at "normal" listening levels, and thus deserves a rating.

It got one, even though it has been an occasional source of embarrassment for many, including the IHF, ever since. Ignoring audible consequences for the moment, the accepted method of measuring music power has always seemed suspicious. As noted above, it is basically the same as a continuous-power measurement, except that a highly regulated power supply that *can* hold maximum voltage under drain is substituted for the supply the amplifier will be sold with. Not only does this look bad, it could be interpreted as a violation of Regulation 36 (no "extraneous aids"). So many people, myself included, were pleased when first the U.S. government and then New York City decided to ignore music power completely. But was it the right decision?

Power Ratings. Recently I participated in a listening session designed to determine whether music power can audibly benefit sound reproduction, and if so, how. (The session was an unofficial part of an IHF program now under way to devise new evaluation standards for all types of audio equipment.) These preliminary tests were carried out with an amplifier having two power supplies that could be interchanged at will. One was highly regulated so that almost no combination of load and demand could affect the voltage it provided. The other, although it exhibited the same voltage as the first supply under continuous power measurement, had a considerably higher voltage when idling. (That is, its music power rating was significantly higher than its continuous-power rating; the first supply had identical music- and continuous-power ratings.) It might also be mentioned that this second power supply was appreciably smaller and less expensive than the first.

I approached this session with ill-concealed skepticism, having always associated music power with very brief sonic phenomena (the first instant of a cymbal crash, for example)—probably too brief to be heard. However, I had failed to take into account the great variety of steady-state musical sounds that have periodic spikes in their waveforms—little glitches that can often be coped with quite handily by a power supply that would collapse quickly under sine-wave drive. I can't go into the full details of our results here. They are too sketchy to be conclusive, and they fail to consider the *duration* of music-power availability, which is probably at least as important as its measured or calculated maximum value. (On that point, a Crown DC 300A in my possession not long ago proved to be able to play 22 seconds of recognizable music at reasonable levels *after being turned off*. With supply capacitors like that, the difference between music power and continuous power becomes practically insignificant.) But as slender as it is, the evidence I heard during that session has convinced me that I was wrong about music power. So, perhaps, were New York and the Federal Trade Commission.

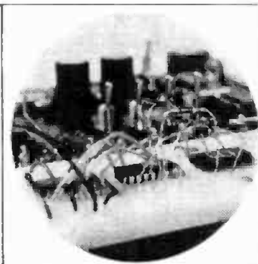
This is the trouble with trying to legislate amplifier power: complex subjective phenomena are too difficult to pin down with measuring instruments and armchair philosophizing about what they should measure. With this trouble comes a danger, which was well expressed by one of the people present at the listening session. All performance standards, he said, should be designed to point the way toward improvement of the breed in its actual application (i.e., music listening). If not, manufacturers will ultimately be selling—and consumers paying for—"improved" products that only seem improved when tested by some complicated piece of lab gear. For example, highly regulated (stiff) power supplies have often been touted as being a desirable design feature. However, such a supply could come off a poor second when compared to an inexpensive, poorly regulated power supply that happens to better the stiffer supply in *music power*. Consider also the 60-to-10,000-Hz bandwidth demanded by New York's Regulation 36. Any pocket transistor radio with an amplifier boasting appreciable output at those frequency extremes would simply be wasting battery power since its speaker could never hope to reproduce them.

Lest I give the impression that I am against consumer safeguards in the area of audio equipment, let me applaud the FTC and the New York Consumer Affairs Dept. for chasing "instantaneous peak power" and other such abuses from the marketplace, and for bringing about a new uniformity in advertised amplifier specifications. My only concern is with the future, which will inevitably be built upon what is decreed today. Our best defense against expensive engineering with no audible benefit still rests with an informed consumership that recognizes the need for standards and also their limitations. ◈

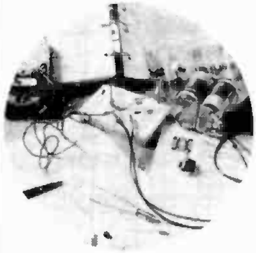
Communications Engineering

Aeronautical & Navigational

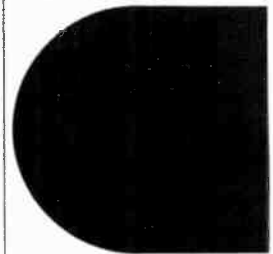
Television Engineering



Automatic Control Engineering

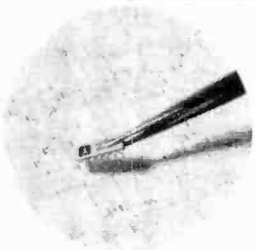


Missile & Spacecraft Guidance

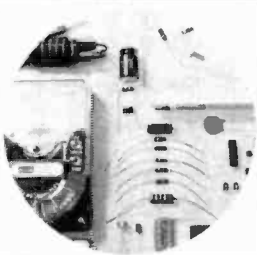


Radar & Sonar Engineering

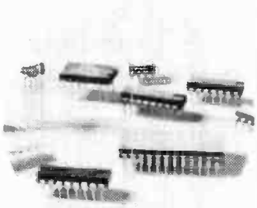
Digital Communications



Industrial Electronics



Microwave Engineering



Satellite Communications

Cable Television Engineering

Electronic Engineering Technology

Nuclear Instrumentation & Control

Special Programs for Electronic Engineers

News Highlights

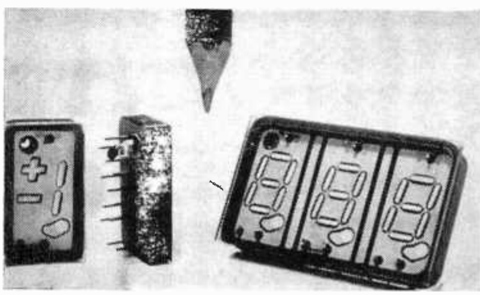
Advent to Begin Full-Scale Production of Projection TV

Some 88,000 additional square feet has been leased by the Advent Corp. to provide for the manufacture of Videobeam™ projection color TV systems. Production is initially scheduled at 5000 sets per year; estimated capacity for the new facilities is 10,000 sets per year on a single-shift basis. Initial deliveries from the new facilities are scheduled for late April. The system, which sells for $2500, receives conventional TV programs or other video sources and displays them on a screen 4¼ feet high by 5⅝ feet wide. The floor-standing receiver/-projector is positioned 8 feet from the screen.

Britain's Booming Hi-Fi Market

In spite of Britain's economic woes, the country is now one of the fastest-growing export markets for audio electronics of all kinds. Sales of hi-fi tuners, amplifiers and receivers there increased by an estimated 60 percent in the last year, a faster rate of growth than in most other countries, and imports accounted for a dominant share of the increase. Imports to Britain now account for 70 percent of the $42 million British hi-fi electronics market. Japan is by far the biggest source of imports, but the US, West Germany, Denmark, the Netherlands and other Western European countries make a large contribution. Above are among the conclusions of a new report by a British company specializing in market research.

New Small, Low-Profile Readouts



A new "flat pack" vacuum fluorescent readout, the Digivac 2000, has been developed by the Tung-Sol Division of Wagner Electric Corp. The 2000 is available in a rectangular, low-profile package and its low-voltage, low-current requirements make it compatible with all MOS IC logic units. The readouts come in either one- or three-digit packages with flexible language (alpha/numerical/symbolic). The cathodoluminescent readout has a broad color spectrum, which, with filters, offers virtually any visible hue.

EIA Requests Phase IV Exemption for Semiconductors

A petition to exempt semiconductors and related devices from Phase IV regulation has been filed with the government by the Electronic Industries Association's Solid State Products Division. EIA pointed out that the semiconductor industry has been characterized by declining prices and increased productivity resulting in non-inflationary behavior. The government was told that the price elasticity of semiconductors and the industry's continued technological advancement are self-regulating factors which will insure future non-inflationary behavior.

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PE TESTED

Using only two IC's, this simple-to-build alphanumeric system can be your springboard to many sophisticated applications

BY DON LANCASTER

MANY advanced electronic projects start with an alphanumeric keyboard. The difficulty is in finding one that is reasonable in cost, reliable in use, and equipped with the proper 7- or 8-bit parallel ASCII code. (See box.) This is particularly true if it is to be used with computer circuits, a calculator, ham RTTY equipment, video titling, etc. Commercial keyboards of this type are very expensive and hard to find. Surplus keyboards are limited in availability and usually have encoders and keytops that may

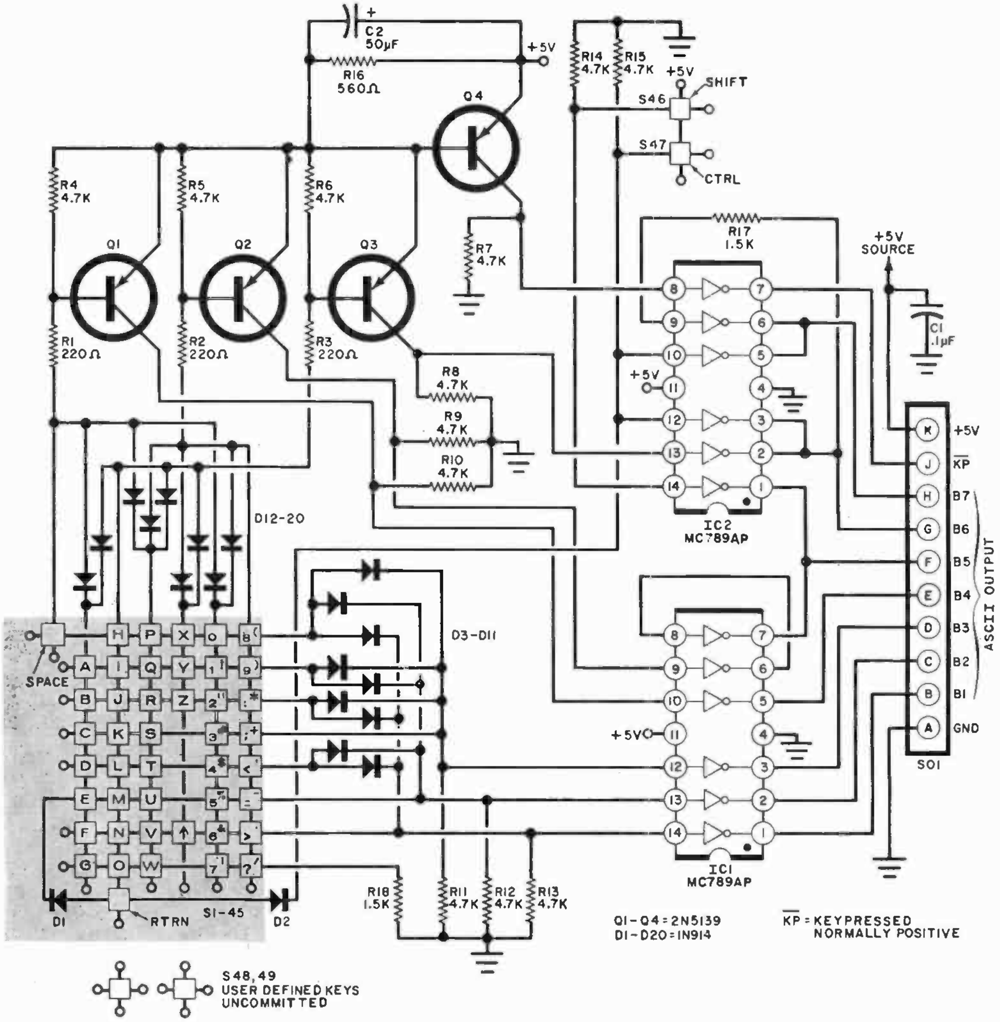


Fig. 1. The 48 keys are arranged in a 6-by-8 matrix as shown in block at lower left. The encoder, Q1 through Q4 and IC1 and IC2, provides the proper output.

PARTS LIST

C1—0.1-µF, 10-volt disc ceramic capacitor
C2—50-µF, 10-volt electrolytic capacitor
D1-D20—1N914 diode
IC1,IC2—MC789AP hex inverter (no substitute)
Q1-Q4—2N5139 transistor
R1-R3—220-ohm, ¼-watt resistor
R4-R15—4700-ohm, ¼-watt resistor
R16—560-ohm, ¼-watt resistor
R17,R18—1500-ohm, ¼-watt resistor
S1-S49—Keyswitches (Mechanical Enterprises LFW-CT)
SO1—Socket (Molex 09-52-3103)
Misc.—Keytops (two-shot molded) (shift and return are 1½ width); spacebar with equalizer and #2-56 mounting hardware; pc board (see text); #6 mounting hardware; solder; etc.

Note—The following are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, TX 78216: actual-size pc foil patterns and component installation diagram free on request; pc board, etched and drilled #Kb at $17.50; complete kit of all parts #KBC at $39.50 plus postage for 3 lb.

BIT NUMBERS															
→ b_7								0	0	0	0	1	1	1	1
→ b_6								0	0	1	1	0	0	1	1
→ b_5								0	1	0	1	0	1	0	1
b_7 ↓	b_6 ↓	b_5 ↓	b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	COLUMN → / ROW ↓	0	1	2	3	4	5	6	7
			0	0	0	0	0	NUL	DLE	SP	0	@	P	\	p
			0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
			0	0	1	0	2	STX	DC2	"	2	B	R	b	r
			0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
			0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
			0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
			0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
			0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
			1	0	0	0	8	BS	CAN	(	8	H	X	h	x
			1	0	0	1	9	HT	EM	)	9	I	Y	i	y
			1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
			1	0	1	1	11	VT	ESC	+	,	K	[	k	{
			1	1	0	0	12	FF	FS	,	<	L	\	l	|
			1	1	0	1	13	CR	GS	–	=	M	]	m	}
			1	1	1	0	14	SO	RS	.	>	N	Λ	n	~
			1	1	1	1	15	SI	US	/	?	0	—	o	DEL

WHAT IS ASCII?

ASCII is a standard 8-bit information interchange code, which is used with virtually every computer and data base system. It is essential as an input to such integrated-circuit character-generation systems as the Signetics 2513. ASCII is a machine language. It should not be confused with such programming languages as "Basic," "Fortran," "PLI," "APL," etc. All of the alphanumeric communications between machines using any of these programming languages are really nothing but a group of ASCII coded commands.

The eighth bit of the code is often a 1 all the time, though some systems use the eighth bit for parity or error testing. The remaining seven bits provide 128 possible different codes or characters. Of these, 32 are allocated for the upper-case alphabet and some are often used for punctuation. Another 32 are used for numbers, spacing, and other punctuation. Assigned but very rarely used is a third group of 32 for lower-case alphabet and little-used punctuation. Finally, the remaining 32 possible codes are "transparent" or machine commands, called control or CTRL commands. They never appear in print, but they handle the sequencing of machinery at both ends. A carriage return (CR) is a typical machine command. If only upper case alphanumerics are needed, only six of the eight bits of the code are used. This is called the ASCII-6 code.

The complete code is shown above. The first four bits are read from the left—the remaining three from the top. For instance "H" is 100-1000. A carriage return command is 000-1101, and a 7 is 011-0111. Note that the bottom four number bits are identical to the four-bit binary (BCD) code. By the same token, if the serial form of the ASCII is used with a start bit and two stop bits added, the result is the 11-bit Teletype code such as that used on an ASR-33.

ASCII can be used in parallel form (all bits at once) or serial form (one bit at a time, least, or B1 significant bit first.)

inverted on either end); or as an annunciator or electronic catalog.

On a more ambitious scale, the keyboard can be used as a computer timesharing terminal, either in commercial service or for home or school. The keyboard, with a simple parallel-to-series converter, forms half of an ASR-33 Teletype at a very reasonable cost.

Other applications include programmable calculators, ham RTTY transmission, videotape and TV titling and annotation, electronic editing and page composition, and data search and retrieval systems. ◈

Q MULTIPLIER

BOOSTS SW SELECTIVITY & GAIN

Add this low-cost accessory to your shortwave receiver and enjoy more stations with greater clarity

BY JOE A ROLF

IF YOU are using a typical medium-priced shortwave receiver, chances are you need more gain and better selectivity to separate the stations on the crowded SW bands. Before you make the decision to trade in your receiver for a newer, "hotter" one, consider adding a Q multiplier; it is relatively inexpensive and just might save you a lot of money.

The reason most medium-priced SW receivers are far from ideal for serious SW listening is that they are designed with i-f bandwidths of between 5 kHz and 10 kHz. This is okay for good performance on the relatively uncluttered AM broadcast band, but on shortwave, where stations operate almost on top of each other, such a broad i-f bandwidth is often less than satisfactory. So, for a receiver that lacks a narrow i-f bandwidth, the Q multiplier can prove a

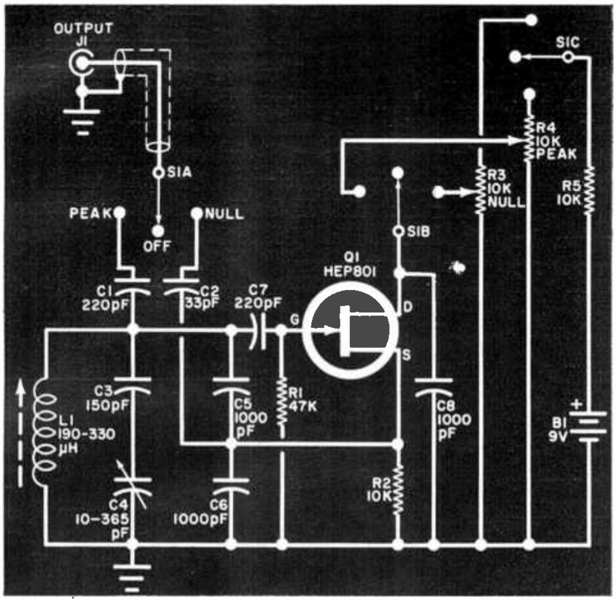


Fig. 1. The circuit is essentially a Colpitts oscillator which is adjusted by R3, R4.

PARTS LIST

B1—9-volt battery
C1,C7—220-pF polystyrene capacitor
C2—33-pF polystyrene capacitor
C3—150-pF polystyrene capacitor
C4—10-365-pF tuning capacitor (Archer No. 272-1341, or equivalent)
C5,C6—1000-pF polystyrene capacitor
C8—1000-pF ceramic disc capacitor
J1—Phono jack
L1—190-330-µH miniature adjustable choke (J.W. Miller No. 4565, or equivalent)
Q1—HEP801 (Motorola) field-effect transistor
R1—47,000-ohm, ¼-watt resistor
R2,R5—10,000-ohm, ¼-watt resistor
R3,R4—10,000-ohm miniature potentiometer (Mallory No. MLC14L or similar)
S1—Three-pole, three-position non-shorting rotary switch (Calectro No. E2-168 or similar)
Misc.—Metal chassis box; printed circuit or perf board with solder clips; battery connector; phono jack (for receiver); phono plugs (2); shielded cable; etc.

valuable accessory for shortwave tuning.

The Q multiplier described here is designed around a single field-effect transistor to provide the equivalent gain of an extra i-f stage. Additionally, it doubles as a bfo. Best of all, it can be built for less than $20.

Theory of Operation. The schematic diagram of the Q multiplier is shown in Fig. 1. The circuit consists of a simple 455-kHz Colpitts oscillator that can be adjusted in and out of oscillation by *R3* and *R4*. A field-effect transistor is used for *Q1* to provide a high impedance to the tuned circuit consisting of *L1* and *C3* through *C6*.

When the circuit oscillates, the Q (selectivity) of the tuned circuit is determined primarily by the components used. However, when the oscillator is adjusted to a regenerative point just below oscillation, component losses are offset by feedback, and the selectivity rises to many times the normal value. If the oscillator (Q multiplier) were connected in parallel with a 455-kHz i-f transformer in a receiver, the selectivity of the transformer would also be greatly increased.

In Fig. 2 is shown a typical i-f response curve for a medium-priced SW receiver and the effect a Q multiplier has on selectivity. The i-f bandpass of the receiver is reduced to a fraction of the original by the Q multiplier. Since the multiplier is tunable, it can be used to peak any signal in the original bandwidth.

By connecting the Q multiplier in a slightly different manner, the i-f response can be left unaltered except for a very sharp adjustable notch. Used in this manner, the circuit can tune out or null unwanted signals.

Since both the peak and the null functions are desirable, the Q multiplier has been designed to operate in either mode, simply by flipping selector switch *S1*. A small 365-pF tuning capacitor (*C4*), trimmed by *C3*, tunes the circuit across the receiver's i-f bandpass. When neither the peaking nor nulling function is needed, the Q multiplier can also be switched out of the circuit and the receiver is on its own.

Construction. The Q multiplier can be assembled in any metal chassis box large enough to accommodate it. A box with a front-panel area measuring roughly 2¼" high by 3¼" wide and a depth of about 4", such as the Archer No. 270-251 from Radio Shack, will be suitable.

Since the circuit of the Q multiplier is very simple, perforated phenolic board and solder clips can be used for mounting most of the parts. Alternatively, you can design and make your own printed circuit board.

Mount *B1* on the bottom of the chassis, close to the rear wall. On the rear wall itself goes *J1*. The front panel should have mounted on it NULL and PEAK controls *R3* and *R4*, MODE switch *S1* (with appropriate position legends), and TUNE capacitor *C4*. Coil *L1* should be mounted on the board assembly in such a manner that its slug adjustment is readily accessible.

To simplify hookup to your receiver, it is a good idea to mount a phono jack on its rear apron and use a length of shielded cable to interconnect the jack and first i-f transformer as shown in Fig. 3. (Note: ground this cable only at the jack.)

Finally, solder phono plug to the ends of a length of Belden No. 8421, or equivalent, low-capacitance shielded cable. This cable should be as short as possible, preferably less than 24 inches.

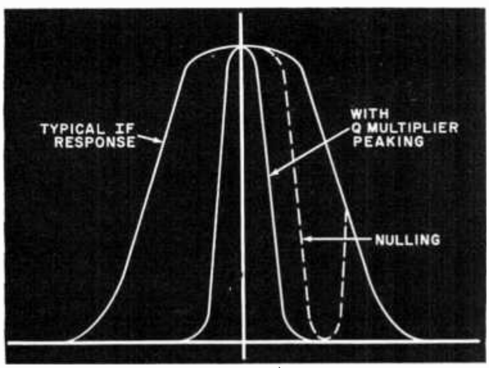


Fig. 2. Waveforms show effect of Q multiplier on i-f response of medium-priced receiver.

In Use. To put the Q multiplier into operation, connect it to the receiver with the shielded cable. Turn on your receiver and tune to a quiet spot on the AM broadcast dial. Set the Q multiplier to PEAK. With *C4* (TUNE) set to mid-position and PEAK control *R4* fully clockwise, tune *L1* until you hear a signal. If the Q multiplier is tuned to the receiver's i-f, the signal will be heard continuously across the AM band, with a beat note when you tune across a broadcast

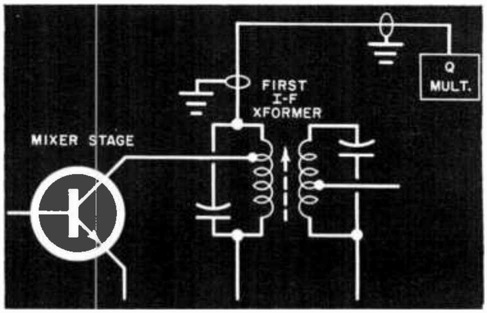


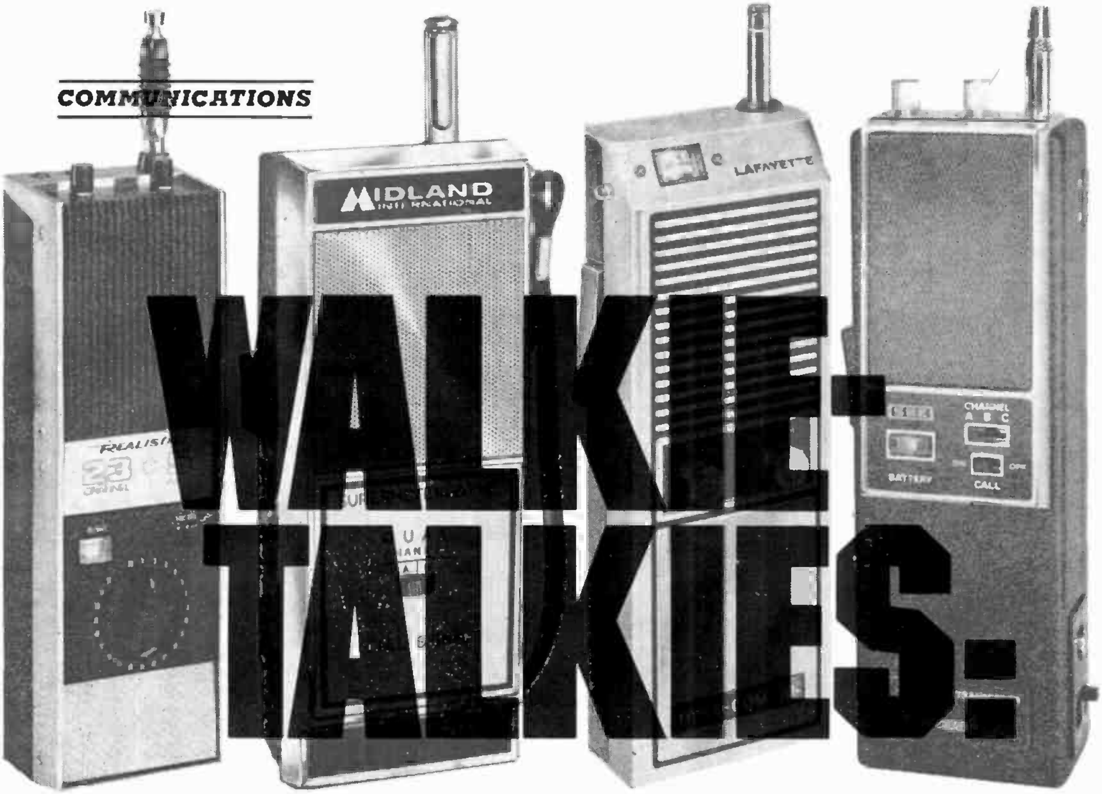
Fig. 3. Diagram shows how to connect the Q multiplier into your receiver using coax.

station. In this mode, the Q multiplier can be used as a bfo.

Switch to NULL and rotate the TUNE knob until a signal is again heard with the NULL control fully clockwise. (The setting of *C4* in the NULL and PEAK positions of the MODE switch will be slightly different, in which case it may be necessary to make a compromise adjustment of *L1* to get both to fall as near the center of the TUNE capacitor's setting as possible.) Finally, set the Q multiplier to a point below oscillation and peak the i-f transformer to which it is connected as needed.

It takes a little practice to learn how to use a Q multiplier efficiently if this is the first time you have used one. Adjusting the PEAK control clockwise increases selectivity and decreases i-f bandwidth. Greatest selectivity occurs just before oscillation, indicated by a ringing sound when the receiver is tuned across a signal.

When in NULL, the notch is made sharper as the NULL control is turned clockwise, and a very noticeable drop in signal will be heard when the Q multiplier is tuned to an unwanted signal. A little practice at the controls will enable you to peak or null any signal you hear for best reception. ◈



WALKIE-TALKIES: SOMETHING FOR EVERYONE

BY HERB FRIEDMAN

CHILDREN eagerly look forward to getting a toy walkie-talkie for Christmas or birthday presents. To their big brothers, those walkie-talkies aren't toys but indispensible units for things like relaying football plays from the stands to the high-school teams. On the top of the heap with much better w-t's are the CB'ers involved in REACT and Rescue Team programs where the compact communicators can prove invaluable over relatively short distances. And outside workers have adopted the w-t as their principal "no-wire"communication system.

The CB walkie-talkie which began life as a plaything for children has grown into the most popular communication device of the day. The reason for the popularity of the relatively low cost w-t that operates on the CB frequencies is due to there being a model almost tailor-made for any applications. Whether you are looking for a cheap present for a child, a tone-controlled radio tripper device for woodland photography, or a pocketful of power for search-and-rescue operations, there is a CB w-t to fill your need.

Low-Cost W-T's. The basic CB walkie-talkie, priced at less than $20, is usually a three- or four-transistor device with a super-regenerative receiver and a simplified single-frequency, crystal-controlled transmitter. Its power input is generally stated at a nominal 100 mW, making it license-free (anyone can use it), although the actual input might be as low as 20 mW, providing a dependable range of only two or three city blocks.

The superregenerative receiver, noted for a sensitivity almost the equal of a good superheterodyne receiver, is also noted for its poor selectivity. The less-than-$20 w-t might well receive every signal frequency on the Citizens Band, regardless of the frequency to which it is tuned. Still, the least expensive w-t does make a desirable gift for children. But for more serious work, one inevitably must look to more expensive models.

Moving up the ladder to the $25-$50 range, you will find 100-mW models that are really useful. Featuring superhet receivers and fully modulated 100-mW transmitters, these w-t's serve a very useful purpose

(*Continued on page* 40)

This important job (and its big income) **is reserved for a qualified electronics technician. It can be you!**

It's a fact. There are *thousands* of jobs like this one available *right now* for skilled electronics technicians. What's more, these men are going to be in even *greater* demand in the years ahead. But how about you? Where do you fit into the picture? Your opportunity will never be greater . . . so act *now* to take advantage of it. The first step? Learn electronics fundamentals . . . develop a practical understanding of transistors, trouble-shooting techniques, pulse circuitry, micro-electronics, computers and many other exciting new developments in this growth field. Prepare yourself now for a job with a bright future . . . unlimited opportunity with lasting security . . . prestige and a steadily growing paycheck.

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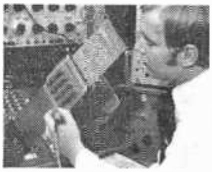

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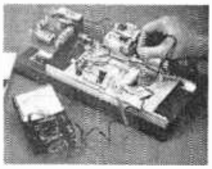

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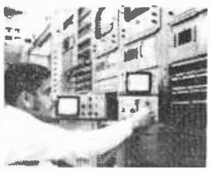

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CIRCLE NO. 8 ON READER SERVICE CARD

for short-range work. The transmitter and receiver sections are crystal controlled, and some means is provided for easily changing crystals.

The receiver generally contains an r-f preamplifier and a 455-kHz i-f amplifier. The i-f section can provide as much selectivity as can be expected of an inexpensive 5-watt base or mobile CB rig. Models near the top of the price range often feature an extra stage of i-f amplification, or a ceramic or mechanical filter, for more selectivity to yield performance that approaches that of the better single-conversion 5-watt transceivers.

Unlike the superregen w-t's that usually use small 9-volt batteries with average lives of 2-4 hours. the low-cost superhet w-t uses some type of "penlight" battery, whether it is throw-away or rechargeable being left up to the user. Depending on the type of battery used, you can expect anywhere from 20 to 50 hours of dependable service before it must be replaced or recharged.

A full 100-mW input power w-t will have a reliable range of about one mile in open country, less in areas where the terrain is interrupted by hills, buildings, etc. One important advantage of these units is that they can be used at relatively short range without overloading the receiver; higher powered models generally overload at close range.

While there is usually no need for multifrequency capability, it is conceivable that you might have to communicate with two or more systems operating on different frequencies. The higher-priced 100-mW models ($35 and up) can give you two or three switch-selectable channels, and they often include some form of tone signalling system to get the monitor's attention. Another feature you get is a "talk-power" modulator, with speech clipping or compression similar to that found in 5-watt rigs.

The 5-Watt W-T. When you need long-range communication from a hand-held device, you need lots of power to get through. Consequently, you will find w-t's with transmitter power inputs ranging from 1 to 5 watts. Power input definitely determines the price you will have to pay for a unit; so, the cost differences between models usually represent transmitter input power rather than differences in operating features. (Any w-t with a power input in excess of 100 mW must be operated under a CB license.)

Except for the "stripped" models in the $50 price area, most high-power CB w-t's have features you would expect to find in quality mobile equipment, starting with a power input jack that permits operation from an ac-operated power supply. All models have squelch controls, antenna jacks, earphone jacks, and S/r-f meters that double as battery-condition indicators. Some models have only a battery-condition indicator.

The circuits in the high-power units are often identical to those used in higher quality base and mobile CB rigs. Receiver sensitivity is generally 1 μV or better, while selectivity can be 50 dB or greater between channels.

Depending on total cost (high-power w-t's ranging from $50 to almost $200), you might have a choice of three to 23 channels coverage. In most cases, 23-channel models are supplied with all crystals. (You pay for all whether you need them or not.) One 23-channel model is presently available on a build-up basis; you purchase only the crystals you want as you go along.

For w-t's with less than 23-channel coverage, you add a channel at a time. The usual two crystals, one for transmit and the other for receive, are required.

As a general rule, the higher power models have some type of "talk power" booster. Though the high-power w-t's provide extended range, they also prove a decided convenience for short-range work when portability is a prime requirement. The length of antennas used with CB w-t's can run up to and beyond 4 ft. Hence, one of the most convenient accessories to have is a loaded whip antenna whose total length is 12 in. to 18 in. Their short length easily adapts the w-t to belt or shoulder-strap carrying use.

Unfortunately, loaded whips have very low efficiency. When used on a 100-mW unit, the signal might not make it the length of a city block. (Transmit losses are many times greater than receiver losses.) But with a loaded whip on a 3- or 5-watt w-t, there is still plenty of power available—more than enough to cover a large office building, school, stadium, or playground.

A secondary advantage of the loaded whip is that the reduction of output signal power makes the w-t less prone to front-end "jamming" caused by signal overloads. Of course, the loaded whip cuts down maximum range. So, when you need maximum range, you can always switch back to the regular whip. ◈

HOW TO MAKE CUSTOM METERS FROM SALVAGED PARTS

Surplus D'Arsonval movements are easily converted to special-purpose voltmeters and ammeters

BY PROF. ROBERT KOVAL

WITH the switch to digital logic and numeric readout devices in modern test equipment, the surplus market is becoming glutted with D'Arsonval meter movements. Actually, the availability of these parts is a boon to the electronics experimenter because the going prices for the movements are often only a small fraction of what he would have to pay if purchased from an industrial supply house.

Most surplus meter movements can be refurbished and custom designed to suit just about any metering need imaginable. The process is relatively simple.

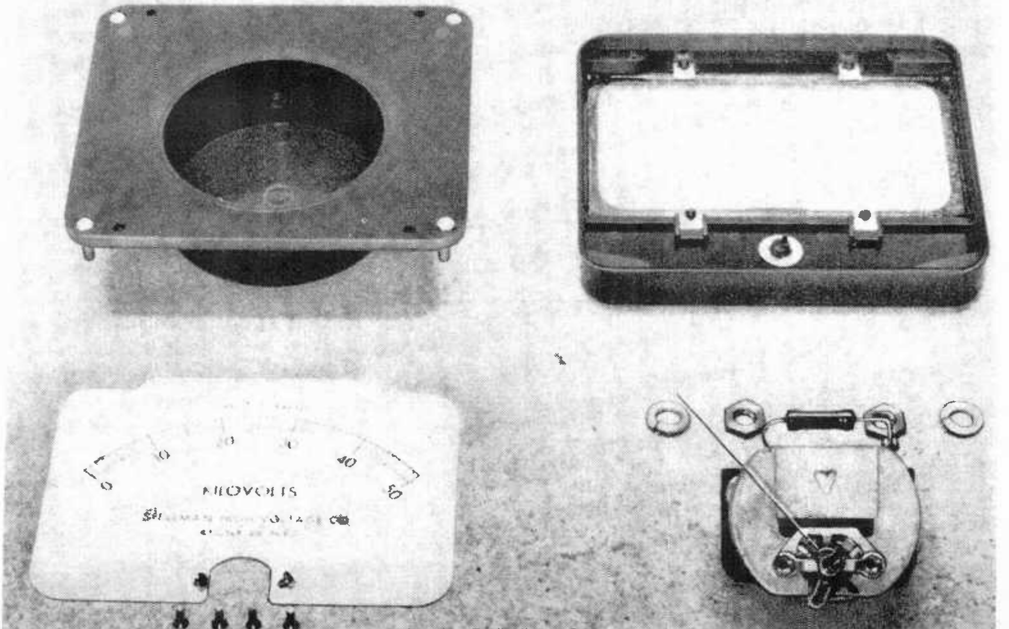
Preliminary Steps. Because the meter movement is from a surplus parts store, the first task is to clean away all dirt and other foreign matter from the case. This can be done with warm water and soap. For tough, greasy build-ups, try using some rubbing alcohol.

Once cleaned, carefully disassemble the movement (Fig. 1). Then inspect the movement to determine whether or not any resistors have been installed. Since you need only the basic movement for the next step, any resistors you find can be discarded.

Now, get out your VOM, a 2-megohm potentiometer, and a 1.5-volt dry cell with holder. Wire up the circuit shown in Fig. 2, but do not install the battery in its holder until after you adjust the pot for maximum resistance. Connect the battery and slowly adjust the setting of the pot to obtain exactly full-scale pointer deflection on the meter movement. (Note: Temporarily replace the old meter scale to locate the full-scale position.) Since the meter under test is in series with the VOM, both units carry the same magnitude of current. Hence, the VOM's reading is the full-scale current sensitivity of the meter movement.

At this point, the resistance of the meter

Fig. 1. The first step is to disassemble and clean the surplus meter.



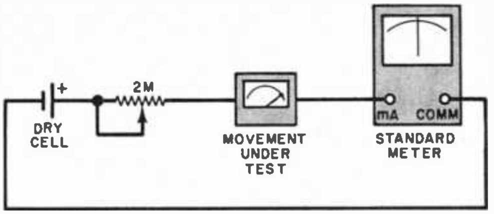


Fig. 2. Use this setup (with VOM and 1.5-V cell) to check movement's full-scale value.

movement (*Rm*) must be determined. Do *not* use an ohmmeter to measure the movement's resistance; the current supplied by the ohmmeter could easily damage the movement beyond repair. A method has been developed for calculating *Rm* using only the basic movement, two resistors of known value, and a 1.5-volt dry cell. The circuit hookup is shown in Fig. 3. Series resistor *Rser* should have a value large enough to permit *I1* to fall within the upper third of the scale. As a guide for choosing *Rser*, use Ohm's law. Assume the dry cell to be delivering 1.5 volts, and work this against the basic movement's full-scale current sensitivity. A fixed precision resistor would be ideal for *Rser*. The value of *Rsh* should be 1/10 or 1/20 the value of *Rser*. You can determine *I1* and *I2* from the meter's scales. Calculate *Rm* as follows:

$$Rm = \frac{Rser \times Rsh \times (I1 - I2)}{Rser \times I2 + Rsh\ (I2 - I1)}.$$

You now have enough information to custom-design a voltmeter or ammeter.

The Custom Voltmeter. It is usually convenient to customize a meter movement in such a manner that it retains the same numeric sequence on the original meter scales to obviate the necessity of relabeling the scales. However, this is not absolutely necessary if you do not mind the task of removing the old and applying new legends.

Since the meter movement shown in Fig. 1 has a numeral 50 at its full-scale index, let us design a voltmeter with a 0-5-volt range. Assume that 50 μA is needed to deflect the pointer to full scale and that *Rm* is 2090 ohms. To calculate the value of the multiplier resistor (*Rmult*) for any given voltage range (*Vr*), use the following equation:

$$Rmult = (Vr \times 1/Im) - Rm$$

In the equation, *Rm* is the basic movement's resistance (2090 ohms in our example), *Vr* is the voltage range desired (0-5 V full-scale), and *1/Im* is the reciprocal of the current needed to obtain full-scale pointer deflection (1/0.000050). Hence, $Rmult = (5 \times 1/0.00005) - 2090 = 97{,}910$ ohms.

As illustrated in the above example, a 97,910-ohm resistor will yield a 0-5-volt range when connected in series with the basic meter movement. To change ranges, simply substitute the desired full-scale figure for *Vr* in the equation. If you want multi-range capability, calculate *Rmult* for each range desired and use a rotary switch for range selection.

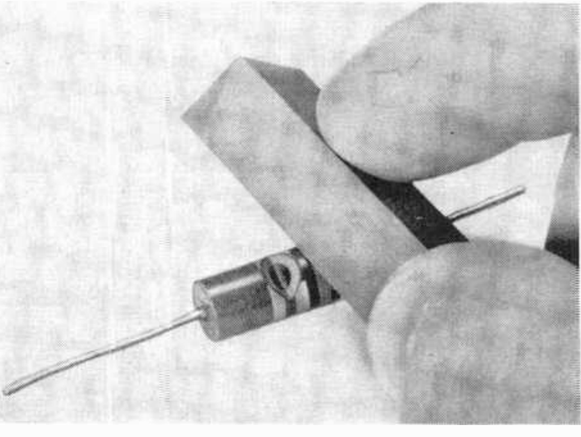


Fig. 4. The resistance of an ordinary carbon resistor can be trimmed by using a file.

Very likely, the value calculated for *Rmult* will not be readily available from the commercial selections listed. Do not let this deter you. It is a simple matter to arrange two or more resistors in series/parallel hookups to yield the required ohmic value. Alternatively, you can "trim" an ordinary carbon resistor to the proper resistance with the aid of a file (see Fig. 4). Select a fixed resistor of slightly lower value than required. For example, if you need 97,910

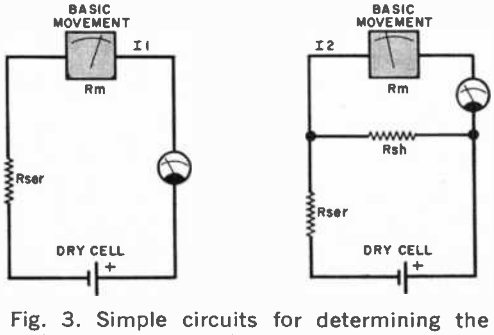


Fig. 3. Simple circuits for determining the resistance of the original meter movement.

ohms, a standard 91,000-ohm carbon resistor can be used. Use an ohmmeter to verify that it is indeed less than 97,910 ohms; a 10-percent tolerance resistor can go as high as 100,100 ohms, a useless figure for the trimming procedure.

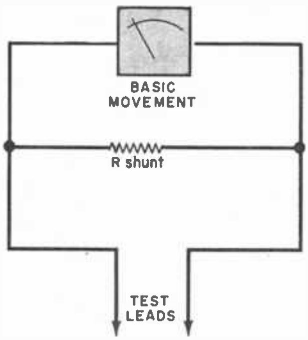


Fig. 5. The basic setup to be used for determining shunt resistor for an ammeter.

Use a resistance bridge or an ohmmeter to monitor your progress as you cut into the resistor with the corner of a triangular file. Work very carefully so as not to trim away too much of the composition resistance material and end up with a valne too high for your needs. When the resistor is trimmed to the proper value, liberally coat the notch with coil dope to seal out moisture. This will assure a constant resistance under changing humidity conditions.

The multiplier resistor can be mounted inside or outside the meter's case. A tag indicating the range and units can then be affixed to the meter face. Make it large enough to completely cover the original legend.

The Custom Ammeter. A custom ammeter can be designed around the basic meter movement with much the same case encountered when making the voltmeter. The basic hookup is shown in Fig. 5. The equation to use for determining the resistance of the shunt resistor is:

$$Rshunt = \frac{Rm \times Im}{Imax - Im}$$

Maximum current *Imax* is the desired full-scale current the meter is to indicate; *Im* is the current required to deflect the meter's pointer to full-scale; and *Rm* is the resistance of the basic movement.

Assume that you want a range of 0-50 mA and that *Rm* and *Im* remain the same as in the voltmeter example given above. Then, *Rshunt* would be equal to $(2090 \times 0.00005)/(0.05 - 0.00005)$, or 2.092 ohms. Again, if a different range or ranges are desired, the maximum current wanted would be inserted into the equation as *Imax*. A switching arrangement would be used to provide several ranges.

The value of *Rshunt* will normally be very low, sometimes on the order of only a fraction of an ohm. In cases where its value would be too low to be conveniently trimmed with a file, you will have to wind your own shunt resistors. Enamel-coated copper wire

Fig. 6. A hand-wound shunt resistor. Next the assembly is protected with a coil dope.

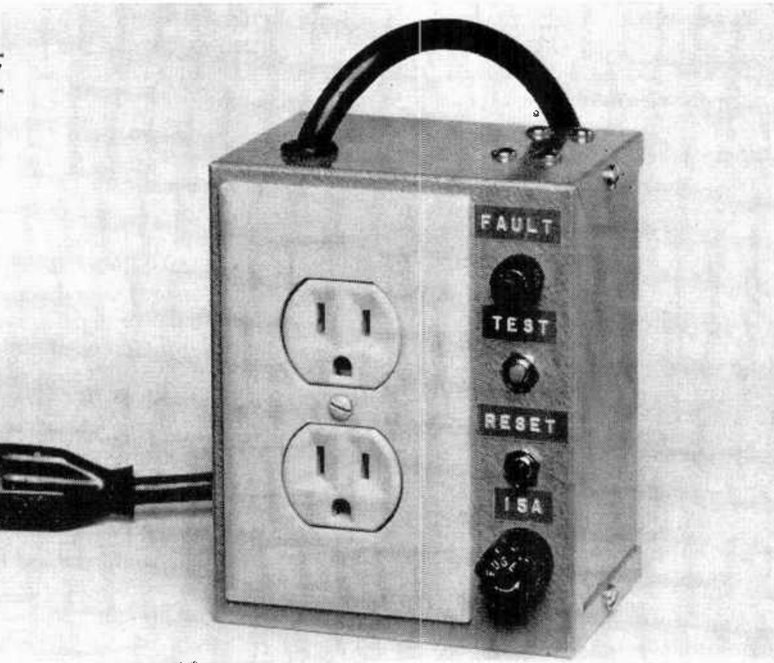
can be used as the resistive element, while the resistor form can be any high-value resistor (1 megohm will do). Wire gauges and the resistance they yield are given in the Table. A hand-wound shunt resistor assembly is shown in Fig. 6. After winding the wire onto the resistor body and soldering the wire's ends to the resistor's leads, coat the assembly with coil dope.

As with the voltmeter, the ammeter's shunt resistor can be mounted inside or outside of the meter's case. Also, be sure to label the meter face with the range and unit for which it is designed. To check out your ammeter, connect it in series with a VOM and current source; both meters should indicate the same magnitude of current. ◈

RESISTANCE PER UNIT LENGTH OF COPPER WIRE AT 25° C

Gauge	Ohms per 1000 ft.	Gauge	Ohms per 1000 ft.
18	6.510	30	105.2
20	10.35	32	167.3
22	16.46	34	266.0
24	26.17	36	423.0
26	41.62	38	672.6
28	66.17	40	1069.0

CONSTRUCTION



BY C. C. LO

ELIMINATE RISK OF FATAL ELECTRIC SHOCK WITH THE GFI

The ground fault interrupter automatically removes power when it senses leakage current

HAVE YOU ever used a power tool outdoors while standing on wet ground? Do you have a swimming pool with electrical equipment (or an ac radio) nearby? How about using an electric lawn mower on a damp lawn on a hot day and taking your shoes off? Every time you let your body make good contact with a ground (whether it is the earth itself or a pipe or other metal object that is grounded) and, at the same time, use a power tool or other electric equipment, you expose yourself to a possible electric shock which can be fatal if the current is sufficiently high and you can't let go in time.

That's why many people today are using ground fault interrupters (GFI's) on their electrical equipment. There are commercial devices available, but you can build your own GFI easily and at low cost. The GFI is connected between the power line and the appliance. The device described here senses ground (leakage) currents of about 2 mA and automatically turns off the primary power within 30 milliseconds. This provides protection at a sufficiently low current and in a sufficiently short time to prevent serious shock injury. Of course, if the leakage current occurs, the apparatus is shut down, whether someone is touching it or not.

Circuit Operation. The main sensing element of the ground-fault interrupter (see Fig. 1) is transformer *T1*. It consists of a

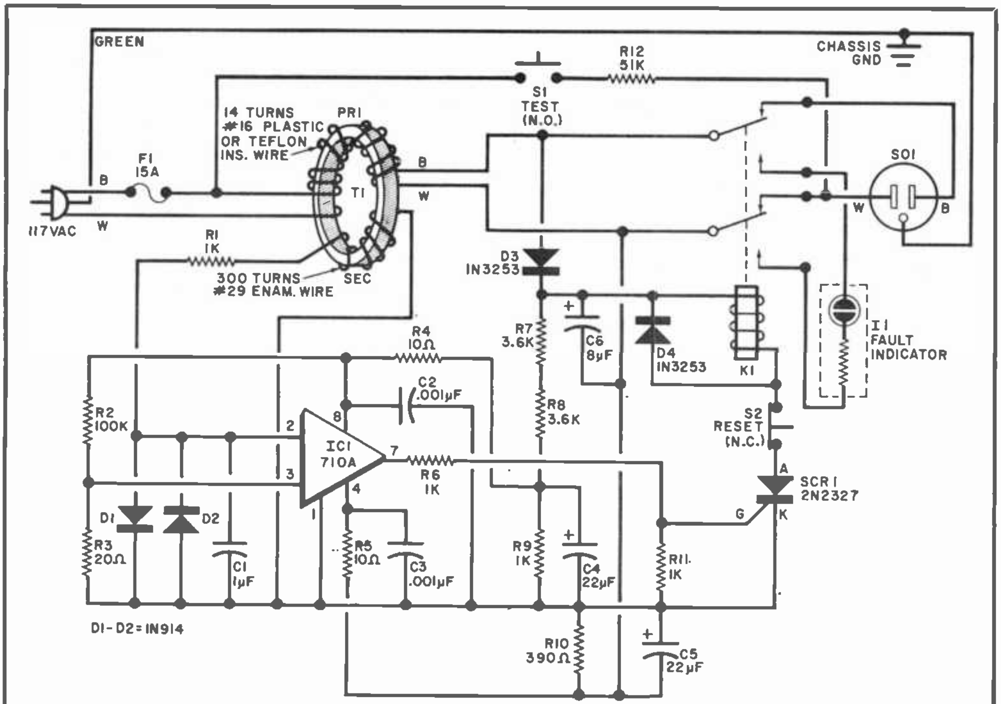


Fig. 1. When the secondary of T1 senses an imbalance in the two power-line feeds, the difference is amplified and turns on SCR1, which cuts the power to the socket.

PARTS LIST

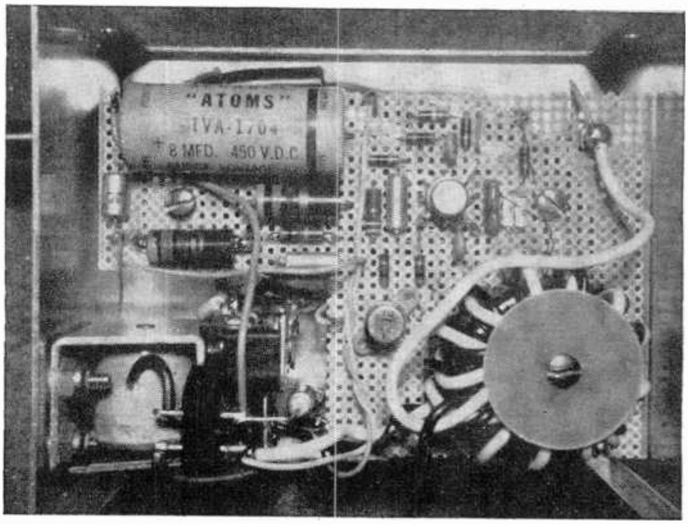
C1—1-μF, 15-volt, Mylar capacitor
C2,C3—0.001-μF ceramic disc capacitor
C4,C5—22-μF, 15-volt miniature electrolytic capacitor
C6—8-μF, 450-volt electrolytic capacitor
D1,D2—1N60 diode or similar
D3,D4—1N914 diode or similar
F1—15-ampere fuse and holder
I1—Neon indicator light (117 volts)
IC1—Voltage comparator (710A or similar)
K1—Dpdt relay, 120-V dc, 11-mA coil rating. Allied Control Co. Type BO-6D (100 Relay Rd., Plantsville, CT 06497) or Allied Electronics Corp. part No. KN105-2C-120D.
R1,R6,R9,R11—1000-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—20-ohm, ½-watt resistor
R4,R5—10-ohm, ½-watt resistor
R7,R8—3600-ohm, 2-watt resistor
R10—390-ohm, ½-watt resistor
R12—51,000-ohm, ½-watt resistor
S1—Spst normally open pushbutton switch
S2—Spst normally closed pushbutton switch
SCR1—2N2327, HEPR1004, or similar
SO1—Single or dual three-way socket
T1—See text
Misc.—Suitable chassis (3" x 4" x 5") (Bud CU-2105-A or similar), perf board and terminals, mounting hardware, plastic washers (2), three-lead power cord, rubber grommet for line cord, press-on type, etc.
Note—The following are available from C. C. Lo, P. O. Box 975, El Cerrito, CA 94530: toroid for T1 at $4.00. complete transformer at $9.50, postage paid.

ferrite core with the two power lines wound around it to form the primary windings and a secondary winding of #29 enameled wire. The transformer does not respond to power consumed by the load but is extremely sensitive to unequal currents in the two power lines. This would be the case if there were leakage to ground through any device plugged into *SO1*. The transformer compares the current in the two sides of the line and, if they are not the same, induces a voltage in the secondary winding.

If there is no leakage, and no voltage in the secondary of *T1*, the power supply goes through the contacts of relay *K1*. When there is a voltage induced in the secondary of *T1*, it is compared in *IC1* to a reference voltage applied to pin 3. When the generated voltage, applied to pin 2, is high enough, the output of *IC1* drives the gate of *SCR1* positive so that it turns on and energizes the relay. This cuts off the power line and turns on the fault indicator lamp. Since *SCR1* is powered by a rectified and filtered

HOW MUCH CURRENT

The amount of current that the human body can withstand varies from one person to another. Generally, at a frequency of 60 Hz, current above 0.5 mA produces some sensation. At 10 or 20 mA, voluntary muscle control may be lost and the person is unable to let go of the current-carrying object. Slightly above that, the victim's chest muscles contract and breathing stops as long as the current persists. The equivalent 2-mA level required to trip the ground-fault interrupter described here is below the dangerous level for an average person, including a child. It is essential to mention that, while the ground-fault interrupter will protect a person from current flowing from the appliance through him to ground, it will not protect him if he gets directly across the power line. This must be avoided at all times.



Component layout of the prototype. The perforated board is mounted on the chassis with two 1½-in. aluminum standoffs, and the same two holes are used for output socket.

dc, it remains on until the reset pushbutton (*S2*) is operated. The fault that caused the power-line imbalance must then be corrected before the protection system is enabled again.

Resistor *R12* and test switch *S1* are included to produce a low current imbalance (about 2 mA) and should be operated before each use of the system to be sure that it is operating properly. After testing, of course, the reset button must be pushed.

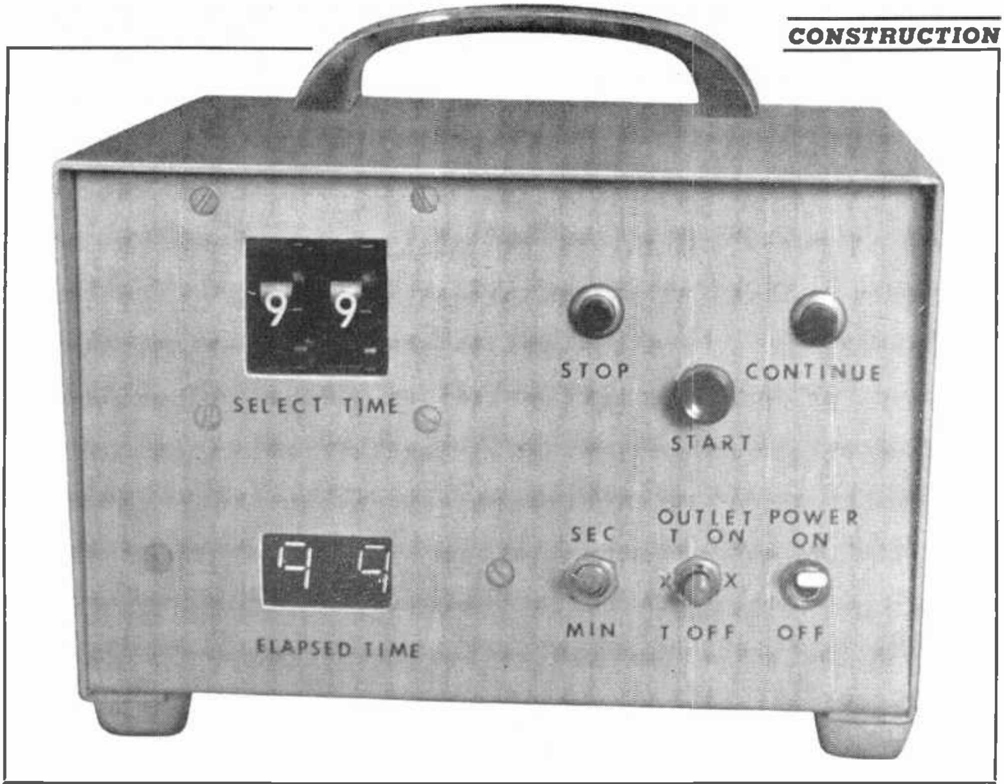
Construction. The circuit can be assembled very easily on perf board and mounted in any suitable chassis. The test and reset switches, fault indicator light, and fuse should be mounted on the front panel. If the chassis is metal, be sure that no part of the circuit is contacting the chassis. Also be sure that the ground lead of *SO1* and the green lead of the three-way power line are connected to the metal chassis.

The relay specified has 10-ampere (1200-watt) contact ratings, which should be sufficient for most purposes. If higher contact ratings are required, be sure that the current required by the relay coil is below 20 mA and above 5 mA.

The core of the transformer is a Ferroxcube K300501-3E. Wind 300 turns of #29 enameled wire through the toroid to form the secondary, leaving long lead ends. Then cover this winding with a layer of plastic insulating tape. To form the primary, use a twisted pair of #16 plastic or Teflon insulated wires and wind 14 turns through the toroid and over the secondary winding. The finished transformer can be supported on the perf board with a long screw and a pair of large insulated (plastic) washers.

Use. Be sure to perform the operating test by depressing the test button and noting that the relay operates and the fault indicator lamp comes on. Then press the reset switch.

The circuit shown here is for three-wire electrical systems—which everyone should have. However, two-wire appliances can be plugged into the fault interrupter to take advantage of its protection. ◈



BUILD A PRECISION SECONDS/MINUTES INTERVAL TIMER

Digital readout provides accurate on or off timing to 99 seconds or 99 minutes for powering 117-volt equipment

BY JOHN D. COLLIN

TIMERS of one sort or another are fairly common around the house today (on radios, blenders, etc.), but most of them are relatively "rough" when it comes to the accuracy of the interval. This timer provides precise increments of time either in seconds or minutes from 1 to 99, with digital readout. The timer can be set to turn the controlled device either off or on after the selected elapsed time. It makes a valuable accessory in the photo darkroom and can also be used in adult and children's games. Other practical applications include control of kitchen appliances, radios, or TV's. The timing interval can be stopped at any point and reset or allowed to continue. You can extend the time if desired.

With the relay specified in the Parts List,

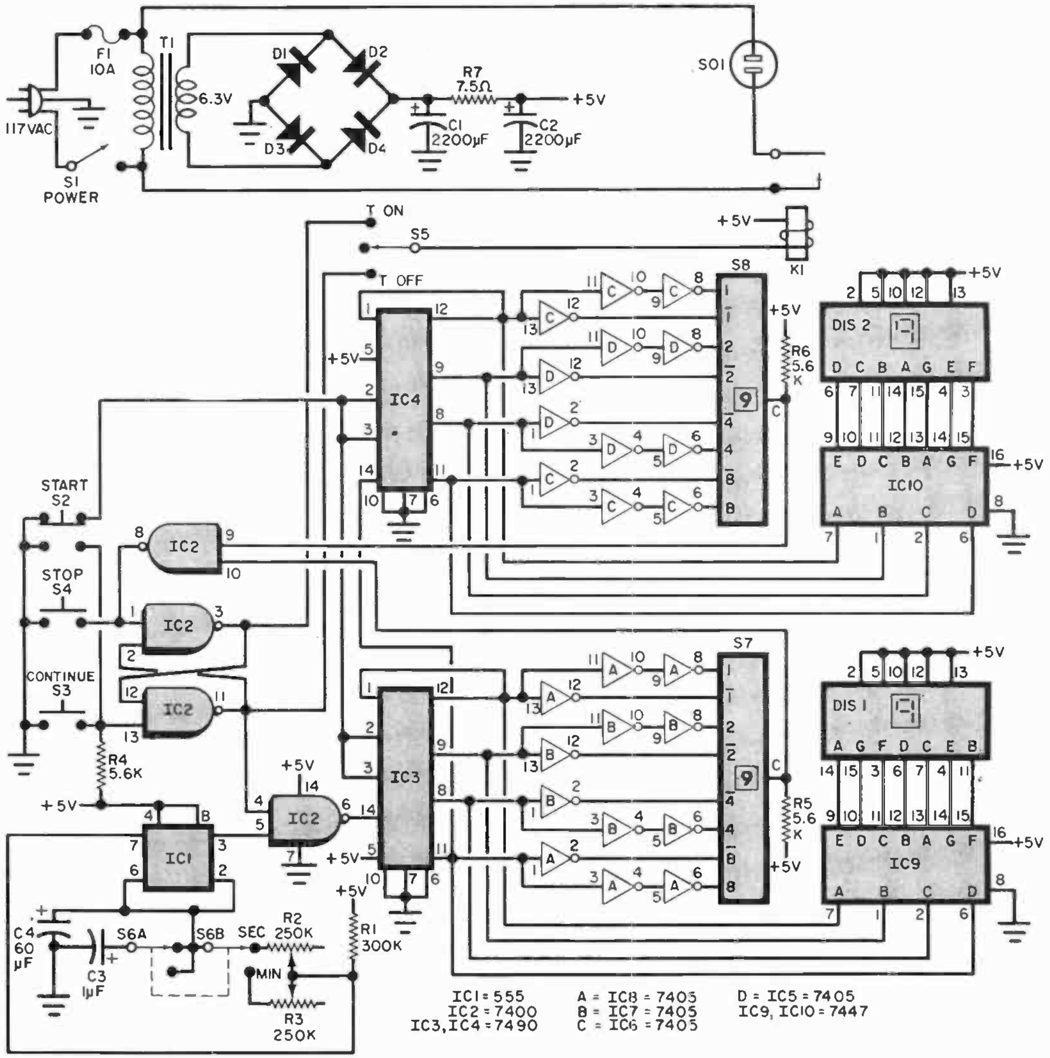
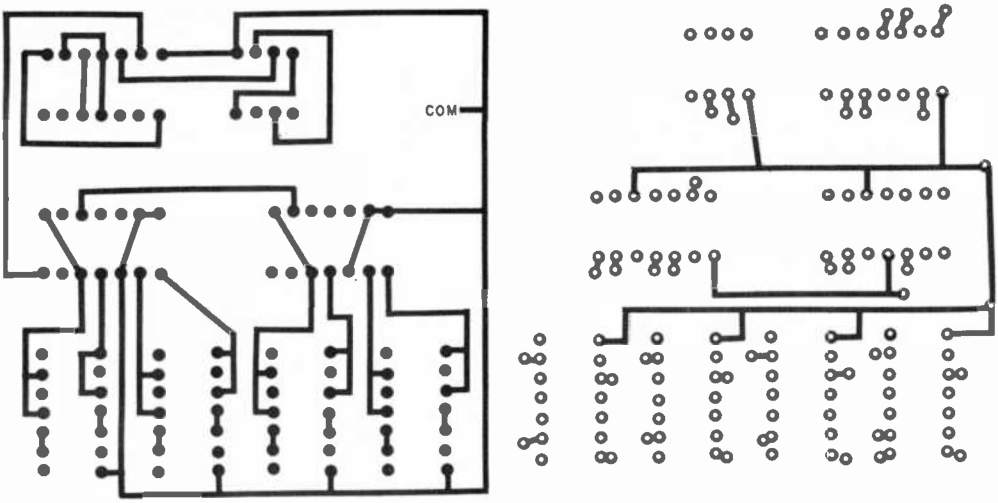


Fig. 1. The basic timing interval is generated by IC1, while IC3 and IC4 are decade counters. The displays are driven by IC9 and IC10. Thumbwheel switches S7 and S8 form a value detector for individual numeric selections.

PARTS LIST

C1,C2—2200-µF, 10-volt electrolytic capacitor
C3—1-µF, 10-volt electrolytic capacitor
C4—60-µF, 10-volt electrolytic capacitor
D1-D4—Silicon rectifier diode
DIS1,DIS2—7-segment display (Poly-Pak 92CU1299 or similar)
F1—10-ampere fuse and holder
IC1—555 timer IC
IC2—7400 IC
IC3,IC4—7490 IC
IC5-IC8—7405 IC
IC9,IC10—7447 IC
K1—Spst relay; coil: 6 V at 10mA; contacts: 115 V ac at 3 A (Calectro D1-966 or similar)
R1—300,000-ohm, ¼-watt resistor
R2,R3—250,000-ohm potentiometer
R4-R6—5600-ohm, ¼-watt resistor
R7—7.5-ohm, 2-watt resistor
S1—Spst slide or toggle switch
S2—Spdt pushbutton switch
S3,S4—Spst pushbutton switch
S5—Spdt, center off, slide or toggle switch
S6—Dpdt slide or toggle switch
S7,S8—10-position thumbwheel switch (1,2, 4,8 and complements inputs—usually found at electronic surplus houses)
T1—Transformer: secondary: 6.3 V, 1.2 A
Misc.—Suitable chassis (LMB-564 or similar), line cord, spacers, terminal strips, mounting hardware, etc.



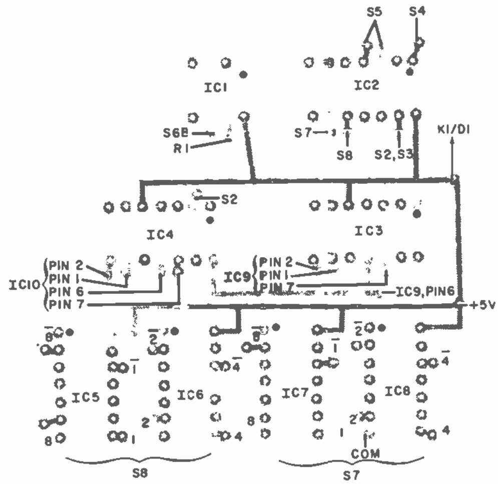


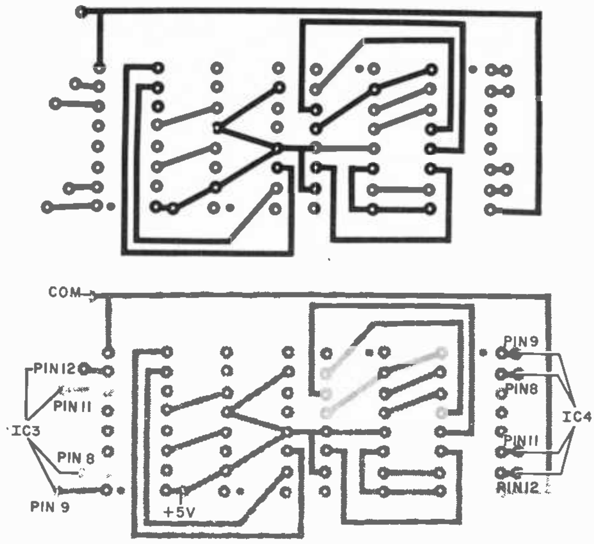
Fig. 2. The counter circuits are mounted on a double-sided pc board whose foil patterns are shown above. Components, however, mount on only one side, as shown at right.

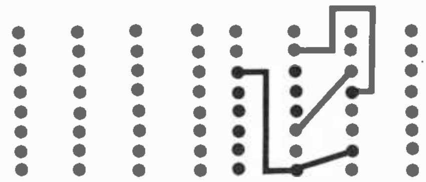
the timer can be used with any 117-volt device drawing less than 3 amperes. If more power is required, an external relay or an SCR or triac circuit can be used.

About the Circuit. The basic timing interval is generated in *IC1*, a 555 timer (Fig. 1). Switch *S6* is used to select seconds or minutes, and *R2* sets the timing for seconds, *R3* for minutes. The clock pulses are applied to two series decade counters, *IC3* and *IC4*, through one gate of four-gate *IC2*. Two of the gates are used as a set-reset flip-flop that serves two purposes: to control the clock pulses to *IC3* in accordance with the positions of *S2*, *S4*, *S3*, *S7*, and *S8*; and to energize relay *K1* at the proper time.

The outputs of decade counters *IC3* and *IC4* drive conventional seven-segment decoders (*IC9* and *IC10*) and associated readouts, *DIS1* and *DIS2*, respectively. These outputs also feed the thumbwheel switches, *S7* and *S8*. The latter form a value detector for individual numeric selections. Their mechanical wafers and sliders connect corresponding weights of the binary inputs (from the decade counters) and their complements to a common output. Each decimal selection requires both polarities of a 4-bit BCD value. For example, to detect a decimal 7, the BCD switch input must equal 0111 and its complement 1000. The common output of the switch remains at logic 0 until all logic 1 input requirements are satisfied.

As the decade counters continue with their count, the inputs to the thumbwheel switches eventually satisfy both numeric selections and turn on the fourth gate of *IC2*. The output of this gate then goes low, and





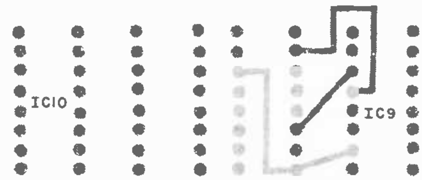
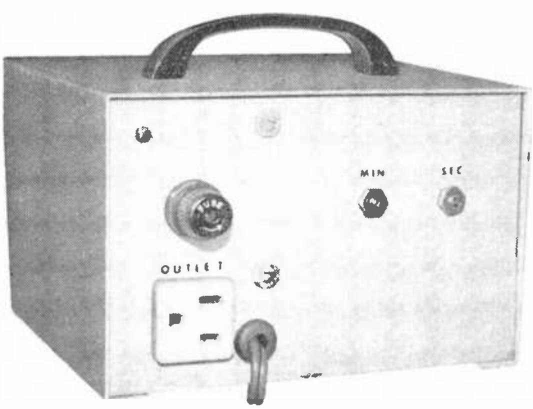


Fig. 3 Above, left and right, are foil patterns for double-sided pc board for readouts. Component layouts are below, left and right.

the circuit shuts down the clock gate to stop the count. New values of thumbwheel selection will not affect the clock gate.

Due to the internal construction of the thumbwheel switches, the decade counter outputs must be isolated from the switch. This is provided by *IC5* through *IC8*, which have open collector circuits. TTL hex inverters with active pull-ups are not suitable for this application because their outputs are not predictable when tied together.

The relay is connected by *S5* to either side of the set-reset circuit formed by the two sections of *IC2*. In one position of *S5*, the relay is activated during the timing period; in the other position, it is activated when the system times out.



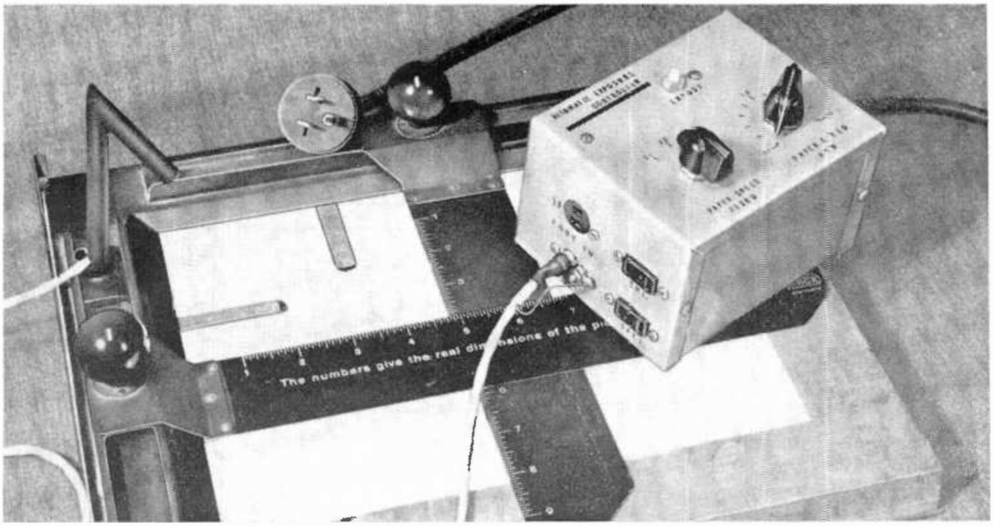
Mounted on the back panel are the power outlet, the fuse, and adjustments R2 and R3.

Construction. The circuit can be assembled on perf board or on a double-sided pc board, using the foil pattern shown in Fig. 2. IC sockets are optional. Note that the readouts and associated decoders are mounted on a separate board (Fig. 3) so that they can be installed in the chassis with the digits visible through a hole in the front panel.

Mount the controls, readouts, potentiometers, etc. on the front and back panels as shown in the photos.

Adjustment. Connect a conventional household electric clock, with a sweep second hand to *SO1*. Put *S5* on OUTLET ON and *S6* on SEC. Set the thumbwheel switches to 90 and turn on the power. It is best to have the clock second hand at 12, but if it isn't, note its exact position. Depress the START pushbutton and allow the timer to run to 90, noting that the readouts keep count. At the end of 90 seconds, the clock will stop. Compare the clock indication to the readout. They should be indicating 90 seconds, but the clock will be off. Readjust *R2* and repeat the timing procedure until both the clock and the readout indicate 90. Once this has been done, lock the shaft of *R2* so that it can't be moved accidentally to throw off the calibration.

With *S6* in the MIN position, calibrate *R3* in the same way as *R2* was set. This will take some time, so use some small minute values as displayed on the thumbwheel switches. ◈



AUTOMATIC PHOTO ENLARGER CONTROLLER

SELECTS THE PROPER EXPOSURE TIME AND CUTS DOWN ON PHOTO PAPER WASTE

BY JOSEPH GIANNELLI

IF you're presently making photographic enlargements using a light meter, a gray scale, test strips, or some other such device, you'd probably welcome a simple pushbutton device that automatically selects the correct exposure and exposes your print for precisely the correct time. Well, with this automatic exposure controller, you can have such a device for a great deal less than you would have to pay for a professional unit.

The controller is a new device for the amateur photographer. A search through camera catalogs and visits to photo suppliers will quickly reveal that the only thing remotely resembling this device is the simple light meter—and the resemblance is remote indeed. You can build the automatic exposure controller for about $17. (*Heart of the device is a timer IC, the Signetics NE555 discussed in detail in a previous issue and widely used in timing circuits.* —*Editor)*

How It Works. The sensor used in the controller (*LDR1* in Fig. 1) is sensitive to the entire visible spectrum, adapting the system to color printing and multi-contrast paper. It is mounted on the edge of the easel where it "looks" down at the photographic paper and picks up the reflected light from a large area of the projected image the moment EXPOSE pushbutton switch *S2* is depressed. A certain resistance value for a given light level is then established by *LDR1*. This resistance, coupled with *C3*, determines the on time of the enlarger lamp plugged into *SO2* to extinguish.

Field effect transistor *Q1* increases the input resistance at pin 6 of *IC1*, allowing larger resistance swings for *LDR1* with smaller capacitance values for *C3*, *C4*, and *C5*. This eliminates the need of inherently leaky electrolytics for these capacitors but requires that low-leakage Mylar units be used in the fixed paper speed circuit.

When pushbutton switch *S2* is depressed, a negative-going trigger pulse is applied to pin 2 of *IC1*, sending the output at pin 3 to the high state. This, in turn, energizes *K1* and turns on the enlarger lamp plugged into *SO2*. The initiation of the expose trigger also opens up the IC's discharge circuit at pin 7, allowing the *C3*, *C4*, or *C5* (whichever is switched into the circuit via *S3*) voltage to rise through *LDR1* as a function of the reflected light level seen by the LDR.

The voltage continues to rise at pin 6, where it is compared with an intrinsic control voltage; that appearing at pin 5 of *IC1* (equal to 0.667 the supply voltage). When

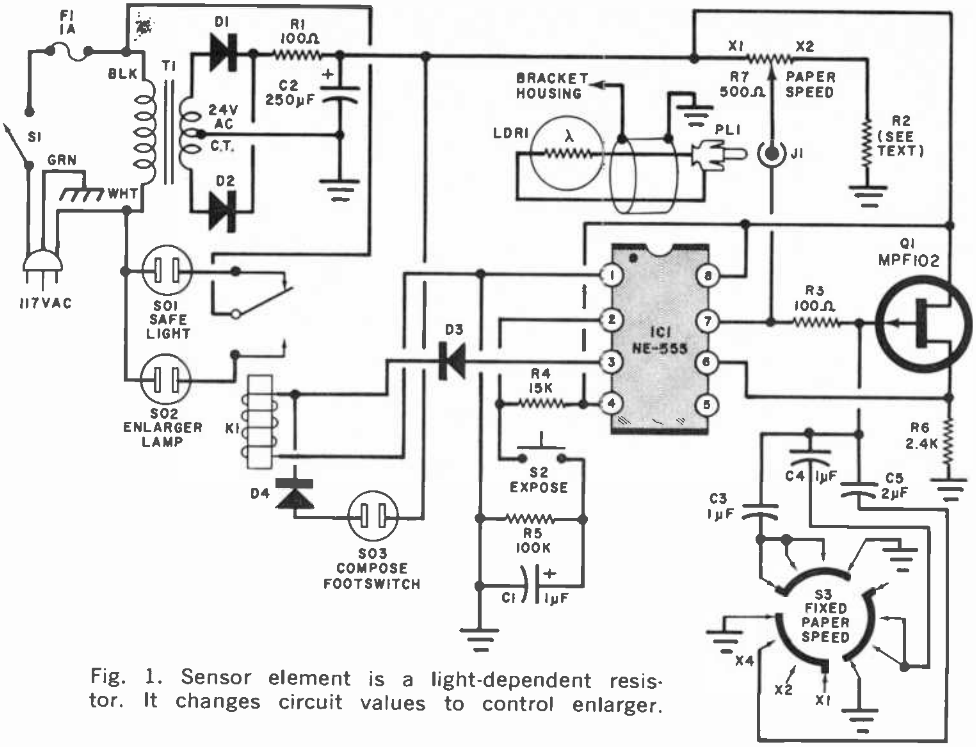


Fig. 1. Sensor element is a light-dependent resistor. It changes circuit values to control enlarger.

PARTS LIST

C1—1-µF, 25-volt electrolytic capacitor
C2—250-µF, 25-volt electrolytic capacitor
C3,C4—1-µF, 25-volt Mylar capacitor
C5—2-µF, 25-volt Mylar capacitor
D1-D4—1N458 diode
F1—1-ampere fuse
IC1—NE555 timer IC (Signetics)
J1—Phono jack, insulated from chassis
K1—12-volt, 1640-ohm relay (Sigma No. 65FP1A-12DC)
LDR1—Light-dependent resistor (Clairex No. CL605)
PL1—Phono plug
Q1—MPF-102 p-channel field effect transistor (Motorola)
R1,R3—100-ohm, ½-watt resistor
R2—See text
R4—15,000-ohm, ½-watt resistor
R5—100,000-ohm, ½-watt resistor
R6—2400-ohm, ½-watt resistor
R7—500-ohm linear potentiometer
S1—Spst switch
S2—Spst normally open pushbutton switch
S3—3-pole, 3-position nonshorting switch (Centralab No. PA1006)
SO1-SO3—Chassis-mounting ac receptacle
T1—24-volt ac, center-tapped power transformer
Misc.—5" x 4" x 3" metal chassis box; spade lugs; printed circuit board or perforated phenolic board with clips; three-wire line cord with plug; rubber grommet; two-conductor shielded cable for cell assembly; hookup wire; solder; etc.

the rising voltage at pin 6 equals the fixed control voltage at pin 5, the flip-flop in *IC1* changes state and discharges the paper speed capacitor through *R3* and de-energizes *K1*. As a result, the enlarger lamp at *SO2* extinguishes and the safe light plugged into *SO1*, if any, comes on.

VARIABLE PAPER SPEED control *R7* provides smaller changes in time (as opposed to the rough changes provided by *C3*, *C4*, and *C5* through *S3*). Control *R7* multiplies the fixed values introduced by the fixed paper speed capacitors by a factor of 2 or more. This control is especially useful when exposure time corrections must be made for filter packs in color work. It should be a linear potentiometer to permit easy calibration (see lead photo) after the circuit is assembled.

A simple OR circuit, *D3* and *D4*, is provided for permitting a footswitch plugged into *SO3* to be used to turn on the enlarger lamp via *K1*. This feature frees both hands for the job of focusing and composing the projected image.

The automatic exposure controller is ex-

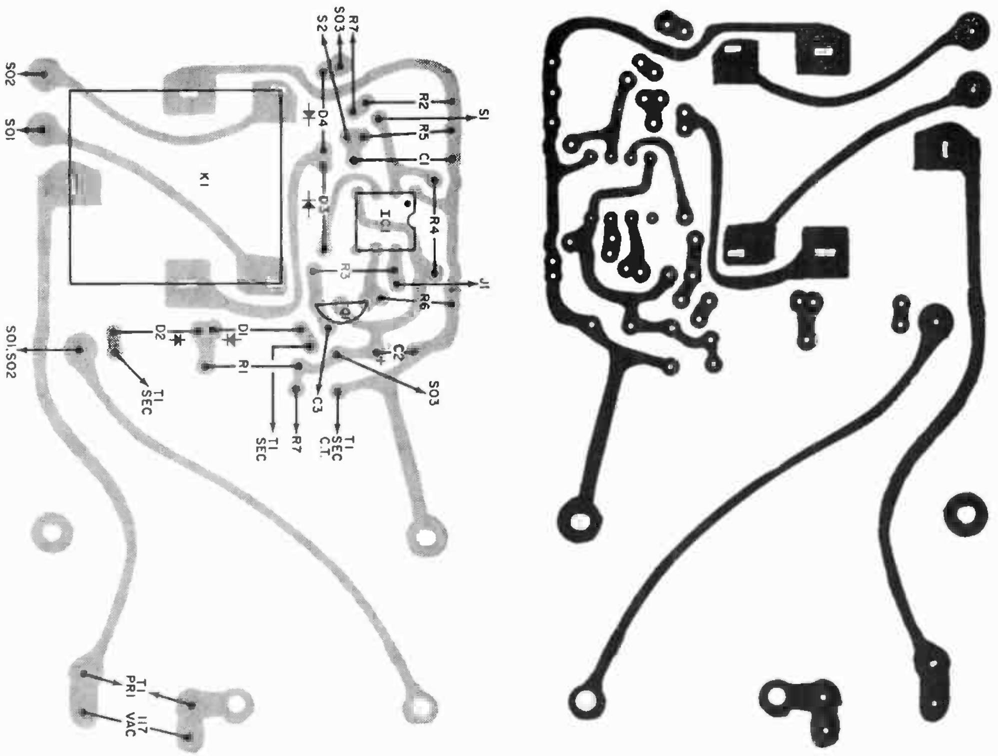


Fig. 2. Foil pattern for PC board is at right, component layout shown at left.

tremely linear in its performance. With the components specified, the timing range is from 1 second to more than 2 minutes, which more than covers the various paper speeds. Furthermore, the system is insensitive to line voltage variations.

Construction. For the sake of neatness and convenience, it is suggested that you assemble the controller on a PC board (see Fig. 2 for etching and drilling guide and components placement diagram). The prototype was assembled with two PC boards; one for the main circuitry and the other for the bulky *C3*, *C4*, and *C5* capacitors. However, you can obviate the need for the capacitor board by joining one lead of each capacitor in common, slipping a length of insulated spaghetti over the common lead, and soldering this lead to the hole marked *C3* on the main board. The free leads of *C3*, *C4*, and *C5* can now be soldered directly to their respective S3 lugs.

Aside from the normal precautions to be taken with any solid-state circuit, assembling and wiring the PC board is simple. (If you elect to use perforated phenolic board construction, it is suggested that you use a socket with *IC1*; do not solder directly to the IC pins.)

Mount *J1*, *R7*, *SO1-SO3*, and *S1-S3* on the top half of the case, and route the line cord through a grommet-lined hole as shown in Figs. 3 and 4. Connect the earth-ground (green) power cord wire to one of the mounting lugs of *T1* and case ground. (Note: In the prototype, no power switch was used. But the use of *S1*, mounted to the case top and connected in series with the black power line lead and *F1*, is recommended.) (*Continued on page* 58)

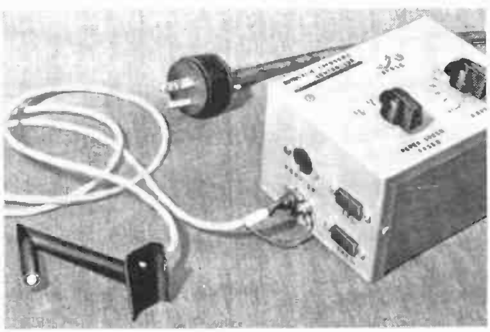
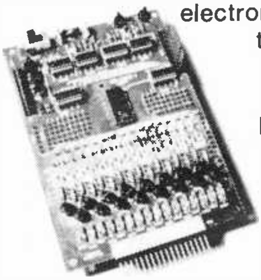


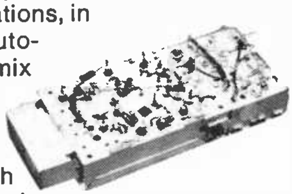
Fig. 3. Overall view of controller. Bracket which holds the LDR sensor is extreme left.

tomorrow's TV design today!

The Heathkit GR-2000 Digital Color TV has electronic on-screen readout that puts channel number and an optional digital clock into the picture. Change channels, or touch the "recall' button and you have instant, highly visible station identification.

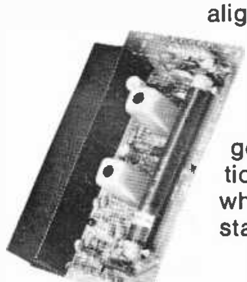


Digital logic circuitry selects channels. You program up to 16 stations, in any sequence, for automatic recall — intermix UHF with VHF, even repeat a station in the cycle. You'll never switch through a "dead" channel again.



A solid-state UHF-VHF varactor tuner takes the place of the noisy mechanical "thunker", corroding contacts, humming motors and mechanical linkages. It's completely silent and never needs cleaning.

Yet another "first" is the unique fixed-filter IF amplifier that never needs instrument alignment! The picture retains its brilliance and clarity year after year, without periodic IF servicing. And you get truly superior reception, even in urban areas where the high density of stations causes adjacent channel interference.

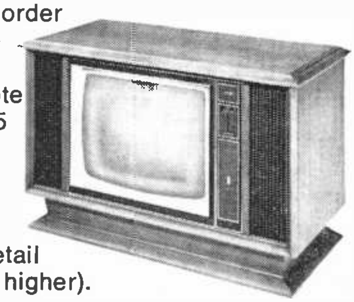


The 100% solid-state chassis uses more integrated circuits than any other TV around. The 25" (diagonal) matrix picture tube is the most advanced available. There's even a volume controlled hi-fi output jack, so you can reproduce TV audio through your separate amplifier.

Plus, the Heathkit Digital Color TV comes with a complete complement of self-service instruments. And a service manual that shows you how to use them all.

The Heathkit GR-2000 Digital TV is also an easier kit-form TV to build. More modular circuit boards, plus more prefabricated wiring harnesses and cables, hold point-to-point connections to a minimum. It may well be the most rewarding kit-building experience of your life.

You can order the Heathkit GR-2000 Digital Color TV with the optional on-screen digital clock (it can be set for 4- or 6-digit readout), ultrasonic digital remote control, and any of four beautiful factory assembled and finished cabinets. Mail order price for chassis and tube, $649.95. Remote Control, $79.95 mail order. Clock, $29.95 mail order. Cabinets start at $139.95. (Retail prices slightly higher).



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CIRCLE NO. 5 ON READER SERVICE CARD

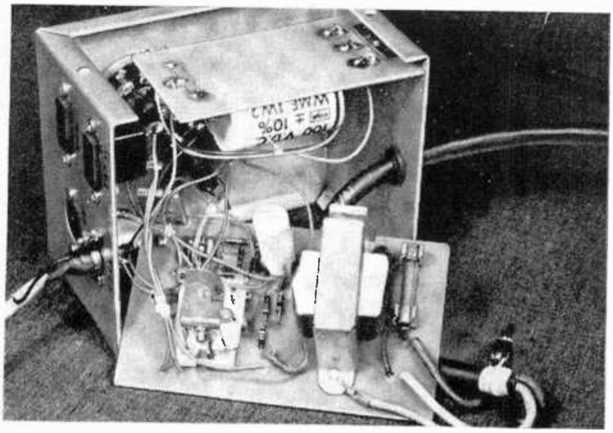


Fig. 4. Photo shows inside of prototype chassis with bottom removed and board detached.

Details for fabricating the cell bracket for *LDR1* are shown in Fig. 5. Use only solderable brass or copper tubing. You can make the cell holder as shown, cutting and soldering it as required. Alternatively, you can fill the tubing with dry sand or slide into it a tubing bender spring and heat the tubing just enough to permit its bending without crumpling. Either method should yield the same results with respect to orientation over the photographic paper when the bracket is mounted on the easel.

After drilling and deburring the cable exit hole and soldering the tubing to the modified Leica easel adaptor, spray the entire assembly with flat black paint. When the paint dries, slip the two conductors of the shielded cable up the tubing and solder them to the leads of the LDR. Slip the LDR, with enough filler around it to hold it in place, into the tubing. Solder a spade lug to the cable shield at each end and a phono plug to the insulated conductors at the end of the cable that goes to the control box.

At this point, the entire system should be assembled, minus *R2*. Tack solder a 10-megohm resistor across the lugs of *J1* and a 10,000-ohm potentiometer across the points marked *R2* on the PC board. Set the pot to its midpoint. Plug the line cord into an ac outlet and your enlarger lamp into *SO2*. Set *R7* to its minimum-resistance position, turn on *S1* and momentarily depress *S2*. Time out the cycle. Then set *R7* to its maximum-resistance position, depress *S2*, and time out the cycle. If there is not a 2:1 ratio between this and the first position of *R7*, adjust the tacked-in potentiometer until you get this ratio.

Turn off the power, unplug the line cord and enlarger lamp cord, and unsolder the 10-meg resistor and pot (do not disturb the latter's setting). Use an ohmmeter to measure the pot's resistance and select a fixed resistor of a value close to your reading for *R7*, soldering it in the appropriate location on the PC board. Then assemble the case. The controller is now ready to use in your darkroom.

Making A Print. It is now necessary only to determine the settings of the FIXED and VARIABLE PAPER SPEED controls for the types of paper you are using. Place the LDR bracket to look at an area of interest, avoiding hot spots, and simply make a small enlargement at different settings of the controls. Use low numbers for lighter and high numbers for darker areas. Record the best

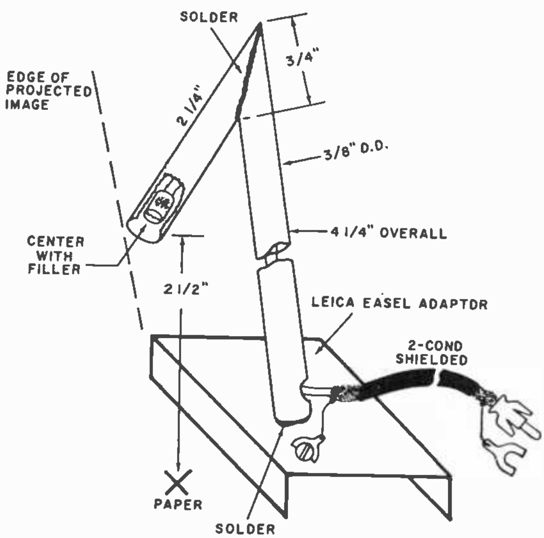


Fig. 5. Details of the cell bracket which holds LDR. Tubing is brass or copper, obtainable in hobby stores, and painted black.

setting on your package of paper. This setting is now always used for that paper, regardless of the magnification and film density. A new setting will be required for other grades of paper.

If Kodak Polycontrast paper is used, the controller will automatically adjust for filters and the inherent paper speed change, using only one setting.

Although the controller has the potential for discerning colors and their varying densities, no color prints were made with it at this time. ◈

A GUIDE TO CMOS OPERATION

PART 2

BY WALTER G. JUNG, Contributing Editor

HERE ARE PRACTICAL APPLICATIONS OF CMOS IN LOGIC CIRCUITS

HAVING considered the basics of CMOS operation in Part 1, last month, we can move on to the use of CMOS in circuits that provide the various logic functions. These run the gamut from simple gates and flip-flops to registers, arithmetic units, and even memories. Space does not permit our going into detail on all of the circuits, but we will be able to get an idea of how the low-order functions operate. Most of them can actually be assembled using either the CD4007AE or CA3600E for experimentation.

Inverters and Buffers. The basic inverting function is a natural for CMOS. In fact, the CD4007AE and CA3600E contain three inverters in one package with pin connections as shown in Fig. 1A. Note that there are three pins for V_{DD} and three for the ground.

A noninverting buffer can be made by cascading two inverters as shown in Fig. 1B. However, note that in the second stage of this circuit, sections B and C are connected in parallel. This allows them to function as a single stage with twice the output drive—a neat trick to remember. This paralleling of like stages can be done with as many CMOS sections as necessary, as long as they are in the same package. With the CD4007AE or CA3600E, up to 3 sections can be connected in parallel as shown in Fig. 1C.

Paralleling can be used in digital or linear applications. A single CD4007AE section can handle up to 2.5 mA of output current with a 10-volt supply; 3 sections boost the output to 7.5 mA. This is valuable in driving TTL with CMOS; for example, three CD4007AE sections with a 5-volt supply will drive four low-power TTL stages. When driving into CMOS from TTL, however, be sure to add a pull-up resistor (about 4700 ohms) to the 5-volt supply.

NOR and OR Functions. The gate structure of CMOS logic is as interesting as the basic amplifier and is almost as uniquely simple. It involves interconnections of p and n transistors to perform the required logic. Figure 2A shows how simple it is to construct a NOR (or OR) gate. In the NOR gate, if either input is high, the out-

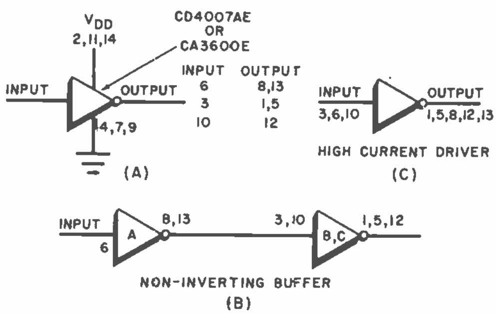


Fig. 1. Using the CMOS as a triple inverter (A), a noninverting buffer (B), and (C) as high-current driver with units in parallel.

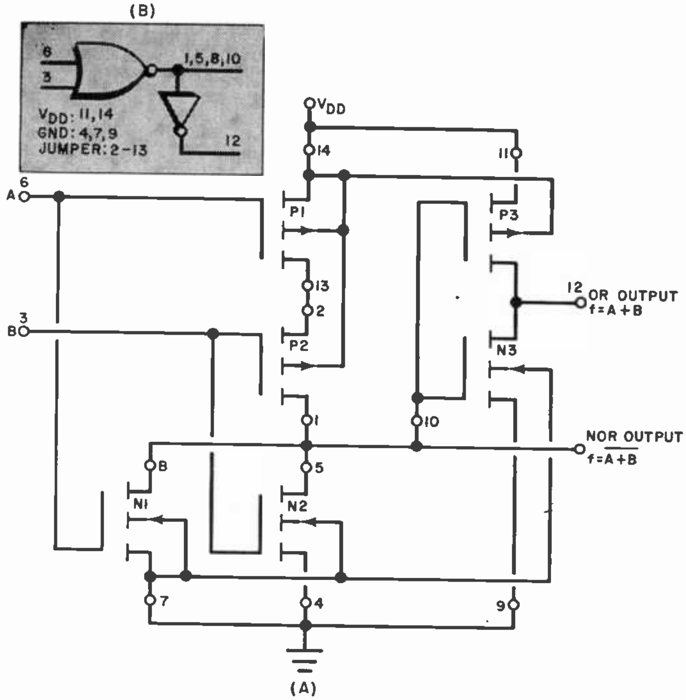


Fig. 2. A CD4007AE or CA3600E can be interconnected as shown to create NOR or OR logic (A). Symbol is at (B).

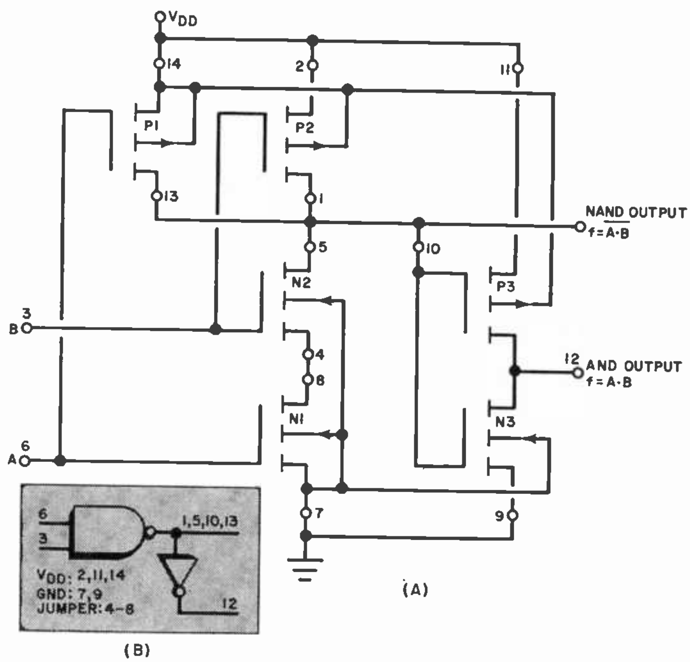


Fig. 3. The interconnections for a NAND or AND circuit are similar to those in Fig. 2, with units upside down. Symbol is at (B).

put will be low. If both inputs are low, the output is high. The NOR logic is performed by *P1*, *P2*, *N1*, *N2*. If either the A or B input is high, *N1* or *N2* is held low by the low on resistance of *N1* (or *N2*). Also, during a high input, either *P1* or *P2* is off, so there is no series path to V_{DD}. But suppose both inputs are low. Then, both *P1* and *P2* are on and *N1* and *N2* are off. The output is pulled high to V_{DD} by the low on resistances of *P1* and *P2* in series. With only 4 transistors, this circuit performs the NOR function; and it can be wired up easily using the pin connections shown.

By adding a third stage as shown in Fig. 2A, a 2-input OR/NOR gate is obtained. The logic symbol for the complete gate is shown in Fig. 2B.

Two-input gates are by no means the limit. NOR gates with three, four, or more inputs, can be built by stacking more p units in series and adding more complementary n units in parallel. In fact, the CD4007A data sheet shows an example of a 3-input NOR. However, beyond 3 inputs, or for a number of gates, it is better to use units already manufactured—of which there are several. The CD4001AE, for example, is a quad, two-input NOR; the CD4002AE is a dual, four-input NOR; and the CD4025AE is a triple, three-input plus inverter. By examining the schematics of these devices, it can be seen that more inputs are added by building on the basic gate of Fig. 2A.

NAND and AND Functions. NAND logic is also very simply created by interconnecting p- and n-channel transistors. The NAND function means that, if both inputs are high, the gate output is low. If either input is low, the output is high. This is shown in Fig. 3A.

Note that this circuit is somewhat similar to the NOR gate with the series and parallel devices "turned upside down." The series-connected units, *N1* and *N2*, are both on when A and B are high. Consequently, the output is low only when this is true. If either A or B is low, the series *N1-N2* path is broken. Also, a low on either A or B means that *P1* or *P2* is on, so the output is high. With the pin numbers shown, either a CD4007AE or CA3600E can be used for this gate. To get an AND function, add the *P3/N3* inverter. The logic is in Fig. 3B.

As with the NOR gate, more inputs can be added by stacking more series n units and more shunt p units. For example, the CD4007A data sheet also shows a 3-input NAND. For multiple circuits, however, there are devices that will serve the purpose without stacking. The CD4011AE is a quad, two-input NAND; CD4012AE is a dual four; and CD4023AE has triple, three-input capability.

While these basic multiple gates offer either NAND or NOR logic as they stand, AND/OR functions can be obtained by using inverters. Having both NAND and NOR logic readily available greatly simplifies logic designs since it isn't necessary to invert to use only one type of gating (often necessary with TTL or DTL, which use NAND logic).

Transmission Gates. The logic functions we have discussed so far are really just variations on the basic inverter. For counting and storage elements, a new type of CMOS is used—one which has no counterpart in other types of logic. This is the transmission gate, a basic building block which is used in flip-flops, counters, shift registers, and memories.

As its name implies, a transmission gate is used to transmit or block a signal. Its circuit is quite simple, as shown in Fig. 4A.

To form a transmission gate, p- and n-channel transistors are connected in parallel and placed in series with the signal to be controlled. Since a CMOS transistor is really a voltage-controlled resistor, a transmission gate uses this property to switch both devices to a low-resistance state when on and a high-resistance state when off. This is effectively an electronic switch whose state is controlled by the drive to the gates of the transistors. Transmission gates are bilateral switches, which means they can pass signals in either direction, so either signal terminal can be used for an input or output.

Since p and n units require opposite polarities on the gates to be on or off simul-

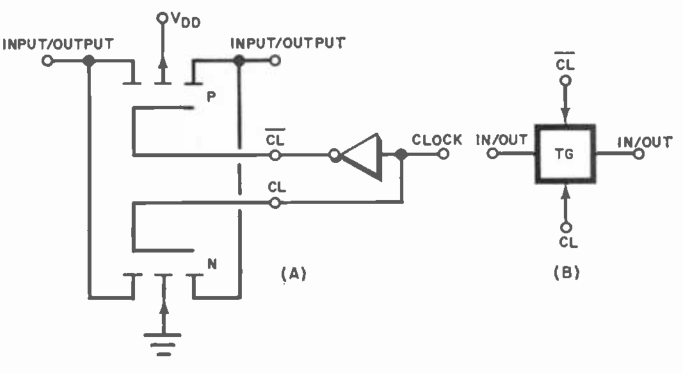


Fig. 4. A CMOS transmission gate (TG) has both pass transistors on or off together when driven by clock signals (A). The logic diagram is at (B).

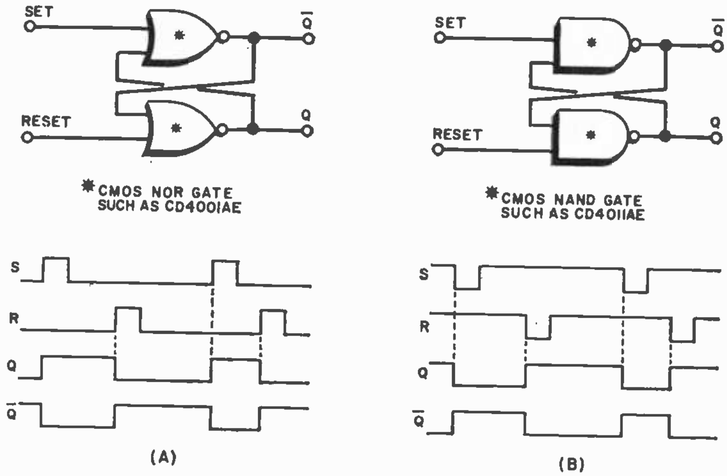


Fig. 5. Cross-coupled NOR gates respond to positive-going input signals (A) while cross-coupled NAND gates respond to negative.

taneously, a transmission gate requires a two-phase (push-pull) gate drive. This is usually obtained from a single clock (control) line with an inverter. In both the actual circuit (Fig. 4A) and the symbolic equivalent (Fig. 4B), the gate is on when the clock is high and off when the clock is low.

Latching (RS) Flip-Flop. The simplest form of flip-flop is the latch or RS (set/reset) device; and it can be made by cross-connecting a pair of gates—either NOR or NAND depending on the input triggering requirements. The general function of a latching flip-flop is to store the information commanded by the last active input pulse. NOR gates respond to positive input pulses. Thus, the circuit shown in Fig. 5A changes state when the set and reset lines alternately go high. This flip-flop can be made by cross-coupling any two CMOS NOR gates. Since there are two gates, the outputs are complementary.

Sometimes, negative-going inputs are available to store input timing information with a latch flip-flop. Rather than invert these negative inputs to drive a NOR latch, it is simpler to use a NAND latch as shown in Fig. 5B. The function of this circuit is exactly the same except that its inputs are sensitive to negative-going transitions. This latch can be made up of any two CMOS NAND gates, and it also has complementary outputs. For both the NOR and NAND latch-input flip-flop functions, there are also standard devices which offer multiple circuits. The CD4043AE is a quad NOR latch, and the CD4044AE is a quad NAND latch. Both of these units have built-in transmission gates which can be used to enable the output.

Type D Flip-Flops. Using latching flip-flops and transmission gates in a master/slave arrangement, the type D flip-flop is clocked, meaning that its outputs do not respond to input data until the clock line goes from low to high. A typical CMOS type D flip-flop is the CD4013AE as shown in Fig. 6.

The key to the operation of this flip-flop is the transmission gates, which are controlled by the clock input. There are two sets of gates, driven in opposition. In the master section, data is entered and held, then transferred into the slave section when the clock line goes from low to high. The slave (output) section has separate set and reset inputs which can be used to latch it upon application of a high input, regardless of the state of the clock.

JK Flip-Flop. The standard CMOS JK flip-flop is the CD4027AE, a dual device with set and reset capability. This flip-flop circuit is similar to the type D, with additional gating for the J and K inputs. Like the CD4013, the CD4027 changes states synchronously with the positive transition of the clock pulse. It also has set and reset inputs, which override the clock and respond to high-level inputs. The CD4027AE is useful in counters, registers, and control circuits and will typically clock at 8 MHz with a 10-volt supply.

Counters and Registers. There are many CMOS high-order devices. They are multiple stages of the basic CMOS functions and many of them are MSI or LSI. Circuits with large component density are ideally suited to CMOS because its all-transistor circuit allows high packing densities.

There are a number of multiple-stage counters available. The CD4024AE is a 7-stage unit, allowing counts up to 128, with buffered taps at each of the seven stages. A common line resets all stages together. The CD4040AE is similar, but has twelve stages (counts up to 4096). Fourteen stages are available in the CD4020AE, which counts up to 16,384.

A watch can be made with the CD4045AE, a 21-stage counter, which can count to 2,097,152. It also has output pulse shaping for motor drive and a stage for an oscillator. With this one device, it is possible to have a crystal-controlled source with 1-second outputs.

There are a number of CMOS registers with various input/output formats. The CD4015AE is a 4-stage device; CD4014AE has 8 stages; and CD4006AE 18 stages. The versatile CD4034AD is an 8-stage register which can be used serial in and parallel out, parallel in and out, bidirectionally, and either synchronously or asynchronously.

Display Decoders and Drivers. To use with the counters and registers, a number of display drivers and decoders are available. The most basic are the CD4026A and CD4033A, decade counters with seven-segment decoders. Outputs can be interfaced to LED and other popular 7-segment displays with a high-current buffer.

The low-power display to go with low-power CMOS is the liquid-crystal type, and there are several decoder/driver combinations which can drive liquid-crystal displays directly. The CD4054AE is the basic unit, a 4-line input (with latches) and display drivers. The CD4055AE is a BCD input unit with 7-segment decoder and drivers. The CD4055AE is a BCD input unit with 7-segment decoder and drivers. The CD4056AE is basically the same, but it has a latch with strobe on each input line.

Other CMOS Variations. What has been described so far are the basic elements of the RCA 4000A COS/MOS line. RCA was a pioneer in the field and the 4000A series is now manufactured by many other companies. However, in addition to the 4000A devices, several manufacturers offer their own highly useful versions of CMOS logic elements.

Motorola Semiconductor has a very broad line of CMOS devices—both 4000A types and its own variety. Motorola's CMOS line (which it calls McMOS) is similar in concept to those we have discussed but they have a greater power supply range. Military devices (denoted by an AL suffix) operate from 3 to 18 V and the CL or CP types operate from 3 to 16 V at −40 to +85°C. The numbering of the 4000A devices is slightly different—the 4007A, for instance, is Motorola's type MC14007AP.

In addition to the MC14000 series, Motorola has an MC14500 series, with many special features. The most interesting devices are in the MSI category. For instance the MC14517CP is a dual, 64-

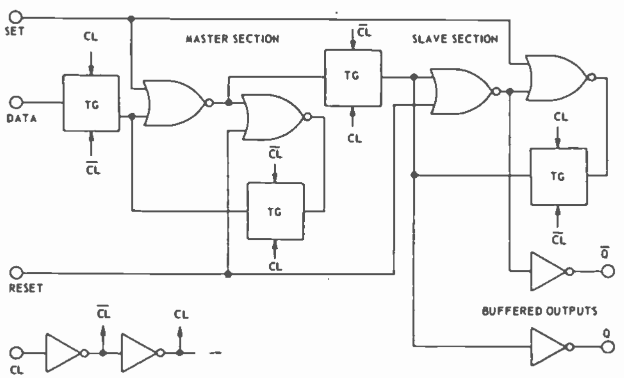
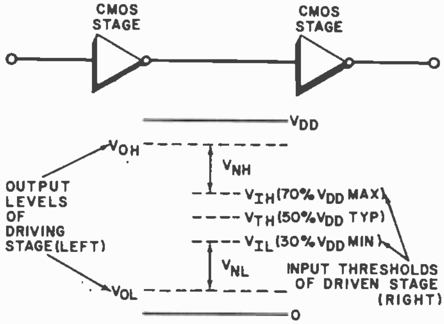


Fig. 6. Block diagram of one section of an RCA CD4013AE COS/MOS type D flip-flop unit.

CMOS NOISE IMMUNITY



In Part 1 of this article we mentioned the fact that CMOS stages switch at approximately half of the supply voltage. This transfer characteristic and the fact that the high and low logic levels approach the values of the supplies provide the very high noise immunity that is typical of CMOS. Typically the noise immunity is specified as 45% of V_{DD}.

Noise immunity is basically the difference between the high and low states of the output voltages and the high and low states of the input thresholds. This is shown graphically in the accompanying sketch. In general, an output voltage (V_{OH}) greater than the next stage's high input threshold (V_{IH}) guarantees that the driven stage will recognize the input level as a valid high level and switch properly. Similarly, an output low voltage (V_{OL}) lower than the stage's low input threshold (V_{IL}) guarantees recognition of a valid low level. The difference between the actual V_{OH} and necessary V_{IH} is the high-state noise margin (V_{NH}) since a noise pulse of this amplitude can exist without disturbing the validity of a one logic state. In like manner, the difference between V_{OL} and V_{IL} is the low-state noise margin (V_{NL}).

The highest noise margins (V_{NH} and V_{NL} maximum) occur when V_{OH} approaches V_{DD}, V_{OL} approaches 0, and V_{IH} and V_{IL} are nearly centered between V_{DD} and 0. These factors are all characteristic of CMOS stages. V_{OH} and V_{OL} are typically within 10 mV of V_{DD} and 0, and the input thresholds are centered around $\frac{1}{2}V_{DD}$. CMOS noise margins at room temperature are typically 45% of V_{DD}—at a minimum, 30%. This makes the worst-case upper and lower input thresholds 30% and 70% of the supply.

stage shift register, with taps at 16, 32, 48, and 64 bits. The MC14511CP is a BCD-to-7-segment latch/decoder/driver which can supply up to 25 mA of output current. The MC14514CL and MC14515CL are combination 4-bit latches and 4-line to 16-line decoders.

An interesting counter set is the MC14522CP and MC14526CP, BCD and binary (respectively) programmable "divide-by-N" counters. The BCD unit can divide by 1 to 999 at up to 5 MHz.

The standard monostable is also available in the MC14528CP, a dual one-shot. Its two sections can be triggered with either pulse edge, and pulse width is set by external resistance and capacitance.

National Semiconductor has two CMOS lines—one a 4000A series and the other a series with "74-type" pin configurations. The latter, the much broader of the two lines, are pin-for-pin functional equivalents of 7400 TTL. In this, a 74C00 is a quad 2-input NAND gate just as is a 7400. The rest of the series is the same, including gates, inverters, flip-flops, counters, registers, decoders, and so on. The line is still being expanded. All 74C outputs are designed to drive two 74L loads, making interfacing easy.

National's MM4600A series is equivalent to the 4000A CMOS lines for −55 to 125°C operation; and the MM5600A line is for −25 to 70°C. So, the National part number for a CD4007AE is MM5607AN.

Harris Semiconductor has made a unique contribution to CMOS technology with its process of "dielectric isolation" which yields both higher speed and even lower power than regular CMOS. Harris also has 4000A types as well as its own proprietary devices. All are made with the DI-CMOS process. The 4000A devices are designated simply as HD-4000 types. For instance, an HDI-4007-9 is a 4007A in a ceramic package. The other Harris series is the HD4800; and it includes buffers, flip-flops, transmission gates, etc.

Summary. We have covered the important aspects of the operation and application of CMOS IC's. The important thing now is for the reader to try them in his own circuits and come up with new ideas. ◈

ELECTRONICS IN MODERN SOUND STUDIOS

HOW ELECTRONICS HAS REFINED AND ADDED NEW DIMENSIONS TO THE ART OF SOUND RECORDING

BY CRAIG ANDERTON

ELECTRONICS has changed the professional recording studio just as it has changed many other specialized areas over the past few years. Much of the increased sophistication in sound can be traced to a corresponding sophistication in electronics in general. Specifically, linear and digital integrated circuits have opened up an entirely new era in the art of recording, making possible machines that create sounds which attract listener attention and save precious time and money in the studio.

It is interesting to look into a modern recording studio. By comparing the relatively unsophisticated studio of only a decade ago to a modern studio, one can get an inkling of what the studio of the future is likely to be.

Inside a Typical Studio. Before discussing what is new, let us review the basics of studio recording. The heart of the whole process is usually a tape system that can record 16 independent tracks of audio information. This independence allows individual tracks to be electronically adjusted to provide the best possible effect. Sometimes the sound engineer will erase one track to get a better performance from a musician while leaving the other tracks alone.

In this modern studio at RCA Records, the audio engineers can alter, electronically, studio size and reverberation time to obtain desired effects.

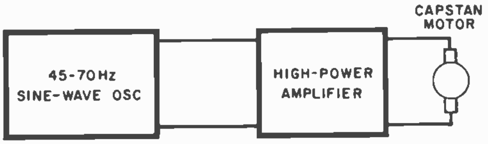
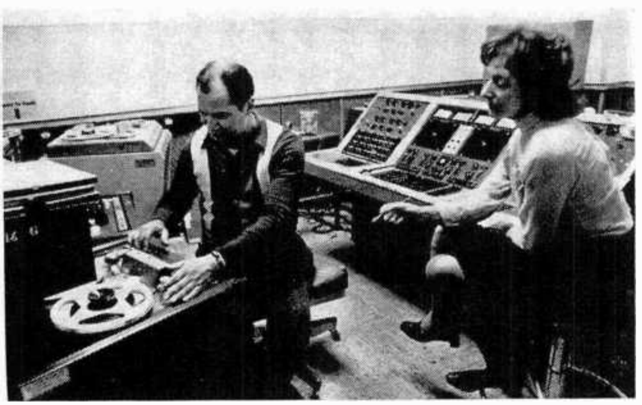


Fig. 1. A sine-wave oscillator and amplifier circuit control speed of tape recorder motor.

To end up with the final stereo master, the 16 tracks, each individually optimized for best level and tonal balance, are mixed down into a 2-track machine. Just to accomplish this basic function requires sophisticated electronics, usually found only in sound studios, for both recording and playing back. Limiters are used to keep audio signal peaks from overdriving the tape recorder by electronically keeping the signal level within a range that can be handled by the recorder. Panpots are used to place the signal "source" at a position anywhere between the extreme left and extreme right of a stereo "spread." Artificial reverberation might be used to provide a realistic depth to the signal that the studio acoustics may lack. And equalizers can be used to cut or boost any tonal range, making thin basses full, strident voices mellow, and dull sounds bright.

In addition to the specialized devices, a studio requires monitor amplifiers and speakers, cueing devices, microphone preamplifiers, etc. Working together, these various items make up a basic studio.

New Sound Machines. Since studio time is expensive ($100-$150 per hour), it is no wonder that the promise of electronics to do a better and faster job has led to the rapid acceptance of a number of innovative devices. The new devices either modify the sounds of existing instruments and voices to produce a novel effect, or solve a particular problem.


Many tracks are equalized, enhanced and mixed electronically to make master tape.

The pitch problem is only one area in which electronics has helped. For example, suppose someone records a piano and a voice track in the studio and, a week later, decides to overdub an electronic organ that is not quite in tune with the piano. Before electronic speed control, the out-of-tune organ might have been put on with the hope that no one would notice the discrepancy, or the organ was retuned and the overdub was remade, neither approach being satisfactory. With speed control, however, the recording engineer can now adjust the speed of the entire 16-track master tape until the pitch of the old track exactly matches the tuning of the new instrumental overdub. If the track is slightly higher in pitch than the instrument to be overdubbed, a slight reduction in the recorder's speed can bring the two into line.

There are two other popular applications to which speed control can be put. If a selection drags a bit, the whole number can be sped up by a small but noticeable amount; conversely, too fast a tempo can be dealt with by slowing down the recorder. Secondly, with drastic speed changes, instruments become almost unrecognizable. Slowed-down drums can sound like thunder, while a sped-up guitar's sound resembles the sounds produced by a harpsichord. Hence, speed control can be used to introduce special effects.

Since most tape recorder motors use the 60-Hz power-line frequency as a reference for speed, speed controls are basically variable-frequency devices. They consist of a variable sine-wave oscillator feeding a high-power, heavy-duty power amplifier, the output of which is used to drive the motor (see Fig. 1). It should be noted that too great a speed deviation can strain a recorder motor, causing it to heat or stall. This restricts the maximum deviation in frequency to about ±25 percent, which is satisfactory for all but the most unusual effects.

Phasing, defined as the sound produced by playing back two identical signals at the same time with a slight time difference between them, is another example of electronics making a tough job easy. The composite signal acquires a very popular "spacey" type of sound due to the subtle phase and frequency changes that occur. This process

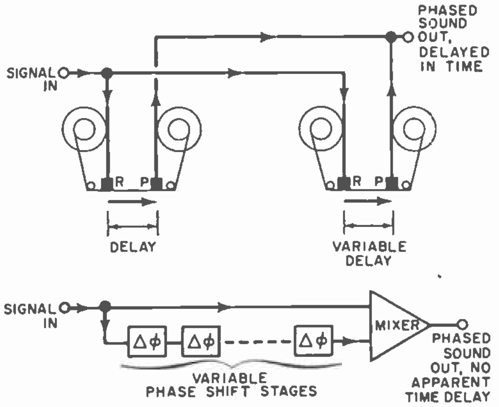


Fig. 2. Phasing (to get "spacey" effects) was formerly accomplished by running the signal through two tape decks, with different delays (top diagram). Now, a series of electronic stages with variable shifts accomplishes same thing (bottom diagram).

formerly required the use of two tape decks, one with variable speed to produce variable time delays, and could be done only during mixdown since recording the signal was a prerequisite to any processing.

Now, electronic phasing units accomplish virtually the same thing by cascading a series of phase-shifting stages. As the phase shifts, the signal picks up a simulated time delay which, combined with the original unshifted signal present at the input of the phasing unit, produces phased sound at the output (see Fig. 2). This avoids tying up an extra machine and setting up a variable-speed system and offers the advantage of being able to be used while the musician is recording. Also, this helps the engineer by reducing the number of tasks to be accomplished during mixdown, while permitting the musician to tailor his playing to the effect.

A close but considerably more complex relative of the phasing unit is a device called the "digital delay line" (DDL). It consists of an analog-to-digital (a/d) converter, a large number of shift registers, and a digital-to-analog (d/a) converter. The a/d converter (see Fig. 3) changes the analog signal at the input of the DDL into a binary, or digital, signal that is then shifted many times to pick up a small but useful time delay on the order of a few hundred milliseconds. The d/a converter then changes the delayed digital coded signal back into an analog signal that is identical to the signal at the input but delayed in time.

A DDL unit has many uses. It can produce the phasing effect. It can produce an echo or "reverb" effect without using the usual tape process or mechanical springs. It can also multiply the sound of an instrument. To accomplish the last, a violin re-

A typical professional mixing console such as those employed in modern recording studios.

(All photos courtesy of RCA Records)

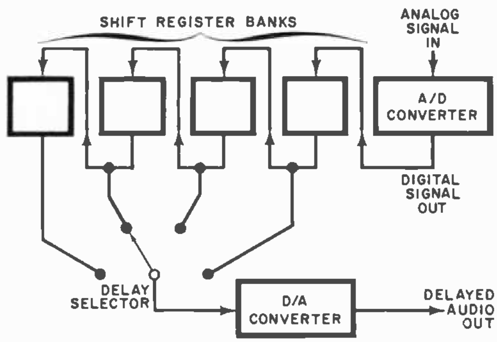


Fig. 3. Schematic of digital delay line that is used for phasing and effects such as reverb.

corded through a slight time shift of, say, 5 ms, sounds like two violins. Recording the composite sound into one track of a 16-track recorder and playing the new track back through a DDL again yields a sound like four violins. Repeating the process, it is possible to create an entire string section from one violin, one DDL, and a multitrack tape recorder.

The problem of leakage between adjacent microphones in a studio is yet another event that lends itself to solution through electronics. A device called the "Kepex" effectively cancels leakage by being, in effect, an expander with a programmable threshold level. All signals below the threshold are attenuated by a controllable amount of up to 60 dB, while signals above the threshold are left untouched (see Fig. 4). Some studios use a Kepex for each of the 16 recorder tracks to control leakage. Other applications for the Kepex include eliminating excessive reverberation in a room and eliminating objectionable outside sounds such as air conditioning, sirens, etc.

Silencers. Tape hiss has always been a problem in the studio. Many techniques have been used to cut back on noise: running a tape at 30 ips instead of 15 ips, while expensive on the tape bill, helps to some extent. So does using tapes with special oxide formulations. High-output microphones help by improving the overall signal-to-noise ratio. But nothing does quite so much to cut out tape hiss as the Dolby™ noise reduction system (and other related systems) that electronically controls the recorded signal to minimize noise. The Dolby system boasts the highs during recording to bring low-level passages above the ambient noise. During playback, the system compresses the signal to restore the dynamic range—but without the noise. Several other companies, among them dbx and Burwens, have also developed noise reduction systems that help in cleaning up a record.

Looking To The Future. In the recording industry, new advances are almost immediately put to practical use. The exploitation of digital equipment and techniques is just one example. Some control boards now use switching logic to replace the traditional patching system found in older consoles.

Various programmable expansion and compression devices are now available. So are digital accessories like timers and tuning standards. Some manufacturers are even perfecting a computerized mixing console. Such a console allows the programming of fade-outs, fade-ins, stereo image placement, and so on. There is no doubt that extensive automation will be a key to studio work in the future.

Another trend to watch is the tendency for people to build their own 4- or 8-track studios at home rather than pay the going rate for 16-track recorder time. Several consumer-oriented companies like Teac are making home-studio oriented 4-channel synchronizable tape decks and relatively inexpensive (less than $2000) mixing consoles.

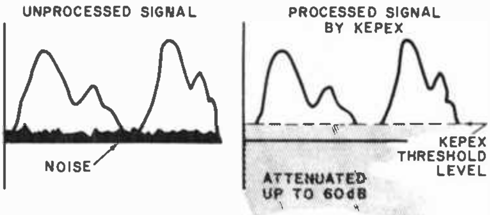


Fig. 4. Waveforms show how Kepex device effectively cancels leakage between mikes.

There are a few catches to having advanced studio equipment available. For one thing, just to use it properly requires the services of an engineer with equal musical and electronics knowledge. There is also a shortage of people capable of maintaining the highly complex equipment in peak operating order. Considering the high cost of studio time and the fact that many studios are booked around the clock, equipment down-time must be kept to an absolute minimum. Hence, the extra automation comes at the expense of more to learn and more to maintain. ◈

Build a Shirt-Pocket METRONOME

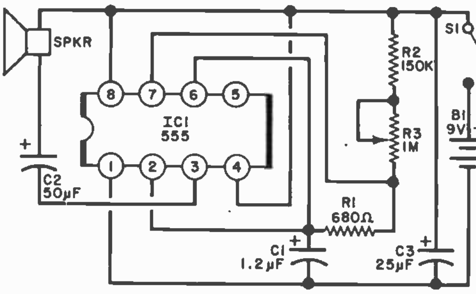
PROVIDES PRECISION AUDIBLE COUNT OF 40 to 220 BEATS PER MINUTE

BY A. A. MANGIERI

THE ubiquitous 555 IC is proving to be the answer to many timing problems. Here, for example, it is used as the heart of a precision shirt-pocket electronic metronome having an adjustable range from 40 to 220 beats per minute. It costs less than $5 to build.

About the Circuit. The timer (*IC1*) is operated as an astable oscillator whose period is determined by capacitor *C1* and timing resistors *R1* through *R3*. When the voltage across *C1* reaches ⅔ of V_{cc}, *C1* discharges rapidly through *R1* and the internal circuit of the IC to ⅓ of V_{cc}, and then the cycle repeats. With the IC trigger terminal (pin 2) connected as shown, the IC retriggers itself to initiate the next cycle.

The output of *IC1* (pin 3) is a pulse which drives a small speaker voice coil



PARTS LIST

B1—9-volt transistor battery
C1—1.2-µF, 12-volt disc capacitor (see text)
C2—50-µF, 15-volt electrolytic capacitor
C3—25-µF, 15-volt electrolytic capacitor
IC1—555 IC timer
R1—680-ohm, ½-watt resistor
R2—150,000-ohm, ½-watt resistor (see text)
R3—1-megohm miniature linear-taper potentiometer
S1—Spst slide switch
SPKR—Miniature speaker
Misc.—Case, perf board, IC socket, push-in terminals, battery clip, knob, etc.

The clock rate, generated by IC1 is determined by C1 and the associated resistors. A small speaker converts the current pulses to audible clicks.

through coupling capacitor *C2*. Using small resistance values for *R1* and large values for *R2* and *R3* produces brief pulses at moderate time intervals, with potentiometer *R3* determining the repetition rate.

Since the trigger levels of the IC depend on the ratio of some "on-the-chip" resistors, timing is not affected by changes in the supply voltage. Also, because the 555 delivers sufficient current, a much higher audio volume will result than in the conventional UJT approach.

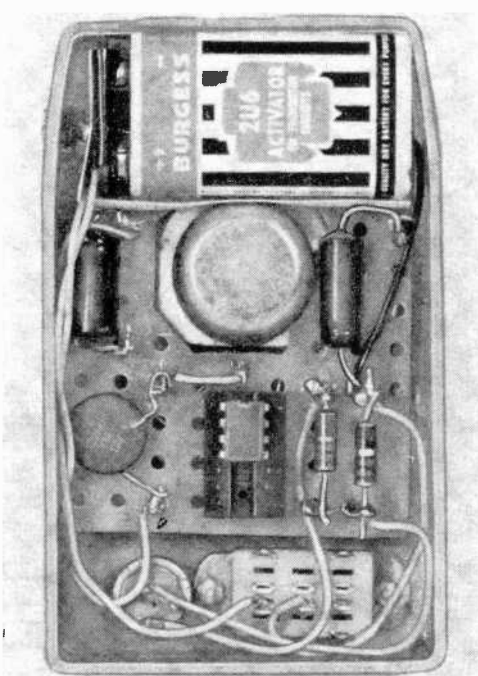


Photo shows how author's prototype, using perf board, fits in transistor radio case.

Construction. Using a socket for *IC1*, the complete circuit can be assembled on a small piece of perf board and installed in almost any type of chassis. The prototype, as shown in the photos, was built in a plastic transistor radio case.

The metronome should deliver 40 to 220 beats per minute, so set *R3* at maximum resistance and pick a capacitance for *C1* that will provide slightly less than 40 beats per minute. This is done by using five 0.22-µF disc capacitors and padding them until the desired 40 beats is obtained. Then set *R3* to minimum resistance and pick a resistance for *R2* that will provide slightly more than 220 beats. You can count the beats over a 5- or 10-second interval.

The impedance of the speaker limits the peak current surges through the output stage transistors. The prototype has been used with six-inch speakers having only several ohms of resistance and also with a 16-ohm speaker. So pick a speaker that will fit the selected enclosure.

Use a dial scale on *R3*, and calibrate it at the most frequently used rates. For photographic work, make the one-per-second beat calibration the most accurate.

Application. Turn on the metronome and adjust *R3* for the desired beat rate. After *S1* is first turned on, a few moments will elapse before the first click is heard while the dc voltage levels become established. Replace the battery when the audio level drops below a satisfactory level. The average current drain is about four milliamperes, so battery life should be long. ◈

VOLTAGE INDICATOR USING LED's

Two light-emitting diodes indicate polarity and level of voltage

BY CALVIN R. GRAF

A SIMPLE dc voltage polarity indicator that can also reveal the presence of ac voltages and provide a rough estimate of ac and dc voltage levels is a handy item to have on a workbench. As shown in the schematic diagram, such an instrument can be built from very few components, making your investment minimal.

The polarity indicator provides testing capability for ac and dc voltages between 1.5 and 150 volts. This range covers just about every voltage level you are likely to encounter in solid-state electronics, the automotive field, and the standard 117-volt ac line power that is so important to modern electronics.

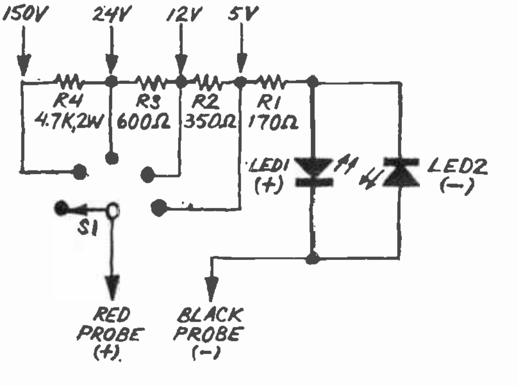
Light-emitting diodes *LED1* and *LED2* indicate both the polarity and level of voltages under test. For dc voltages, only one LED will illuminate, while ac voltages will turn on both LED's. (When both LED's come on, it is a sure indication that ac is present.) Level indication is a function of the value of the series resistance (*R1* through *R4*) switched into the circuit via rotary range switch *S1*. Resistor *R1* is always in the circuit, limiting the current through the LED's to about 30 mA on the 5-volt range. As *S1* is rotated through the 12-, 24-, and 150-volt positions, resistors *R2*, *R3*, and *R4*, respectively, add to *R1* to maintain a safe current limit (20 to 30 mA) through the LED's.

Polarity indication is a function of which of the LED's illuminates and the manner in which the test probes are connected to the unknown voltage buses. To illustrate, assume that the red (+) test probe were connected to the "high" bus and the black (−) test probe were connected to the "low" bus. Under these conditions, *LED1* would illuminate, indicating that the red test probe is indeed touching the high bus. If the probes were transposed so that red is touching low and black is touching high, *LED2* would come on to indicate that the black probe is connected to high. (For ac voltage indications, no matter how the test probes are connected to the buses, both LED's would illuminate.)

Use LED's rated at 50 mA or greater forward current. Two good choices are Motorola's HEP P2000 and P2003 LED's, both of which are rated at 50 mA.

To use the polarity/level indicator, always start with *S1* in the "off" position. Connect the test probes to the buses of the unknown voltage and switch to the 150-volt range. If neither LED glows, proceed downrange until you see one or both LED's glow. Stop at the first range that yields an indication. If you switch to a lower range, you might pass excessive current through the series circuit and destroy one or both LED's.

With practice, you will learn not only how to determine polarity and the range into which test voltages fall, but you will also get the knack of refining voltage level readings within each range by the intensity of the glow. ◈



WHAT DO YOU KNOW ABOUT RESISTORS?

BY ROBERT P. BALIN

The electronics technician and hobbyist must know a great deal about resistors. Besides being able to read the resistor color code, they should be able to identify some of the common applications of resistors, know how to use a resistance bridge, and know how to combine resistors to obtain a desired equivalent resistance or power rating.

To test your knowledge of resistors, see how many of the following problems you can solve. The numbers on the problems correspond to numbers on the diagrams below. The answers are at the bottom of the page.

1. The color code on the axial-lead resistor shown indicates that it has a rating of how many ohms and what tolerance percentage?

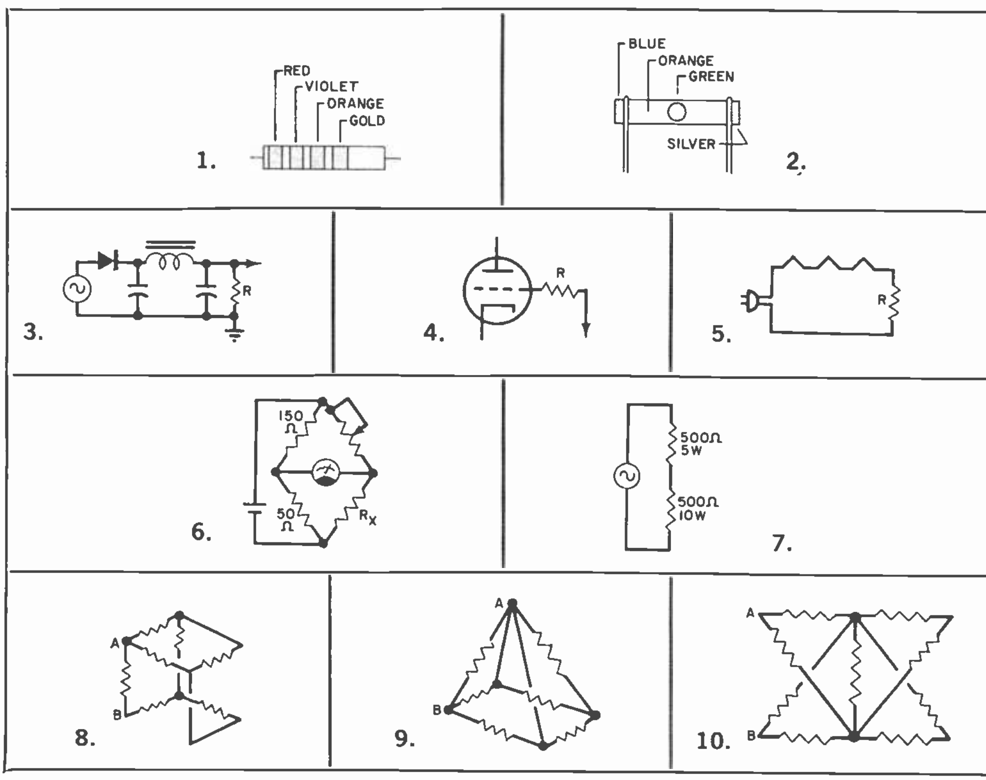
2. The color code on the radial-lead resistor shown indicates that it has a rating of how many ohms and what tolerance percentage?

3. 4. 5. What is the function of the resistor (R) in each of these three circuits?

6. If the bridge circuit shown is balanced when the adjustable resistor is set for 60 ohms, what is the value of the unknown resistor, Rx?

7. If a 500-ohm, 5-watt resistor and a 500-ohm, 10-watt resistor are connected in series, the combination is the equivalent of a resistor of how many ohms and what wattage rating?

8. 9. 10. What is the total equivalent resistance between points A and B for each of these three circuits? All of the resistors are identical and rated at 6 ohms.

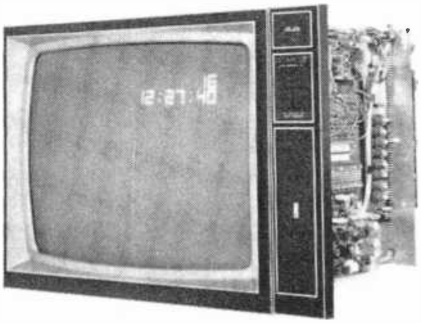


ANSWERS

1. 27,000 ohms, ±5% 6. 20 ohms
2. 3.6 megohms, ±10% 7. 1000 ohms, 10 watts
3. Bleeder 8. 4 ohms
4. Parasitic suppressor 9. 2 ohms
5. Ballast or dropper 10. 6 ohms

Product Test Reports

HEATHKIT MODEL GR-2000 DIGITAL COLOR TV RECEIVER WITH OPTIONAL REMOTE CONTROL AND CLOCK



IT HAS been a long time since anything novel as far as electronics is concerned has been introduced to the color TV receiver market. Advertised "new" models are really mostly older models with cosmetic changes and perhaps a minor alteration or two in the circuitry. But now there really is something new in color TV receivers: digital, non-mechanical tuning is just one innovation. You can find it in the Heathkit Model GR-2000 color TV receiver chassis kit that retails for $650. For another $80 and $30, respectively, you can add the convenience of wireless remote control and a 6-digit, 12/24-hour clock accessory.

The receiver features a digital read-out display of the selected vhf or uhf channel on the picture tube screen (also used for displaying the time); an i-f system that uses a filter, factory preset for optimum response —without traps—while having a response curve that rivals the best systems currently available; and a black-matrix, ultra-rectangular CRT with 25-in. diagonal measurement.

For kit builders who do not wish to "custom install" the GR-2000, four handsome floor-standing cabinets, from $140 to $180, are available to house the chassis. Style choice of Early American, Mediterranean and Contemporary, constructed of hardwoods or oak solids and veneers, with metal hardware, simplifies matching to any decor. All cabinets accept a second speaker.

Technical Features. The TV tuner employs variable-capacitance (Varactor) diodes as the tuning elements. The capacitance of these diodes is determined by an applied dc voltage so that, when used with an appropriate inductance, they can be used to tune a circuit to eliminate moving parts.

The tuning system is shown in Fig. 1. The circuit begins with a 2-Hz clock oscillator *(Q217* and *Q218)* whose output pulses are gated into a four-bit up/down counter *(IC202)*, depending on which latching gate formed by sections of *IC201* is turned on by its respective front-panel touch switch. The counter produces 16 binary numbers and can be commanded to continue in either the up or the down mode.

The four-bit output is applied to *IC203*, a 16-line decoder. Only one of the 16 outputs is low at any given clock interval, the other outputs remaining high. The low cycles around the 16 outputs, depending on the input count. Let us assume that output 1 is low while all others are high. Each *IC203* output drives a separate transistor *(Q201-Q216)*. Only *Q201*, connected to the low 1 output, is turned off and *Q202-Q216* are saturated and act as closed switches, shorting their respective diode anodes to ground.

The Varactor tuning voltage for each channel is derived from the setting of preset tuning controls *R276-R293* which are calibrated for each tuner via *R294*. The tuning voltage at the rotor of each preset control is fed via isolating resistors *R213-R246* and diodes *D249-D264* to the tuning voltage input in the tuner. Only *Q201* is cut off so the positive voltage from *R213*, the only "on" circuit, passes through *D249* to the tuner. Simultaneously, the other diodes

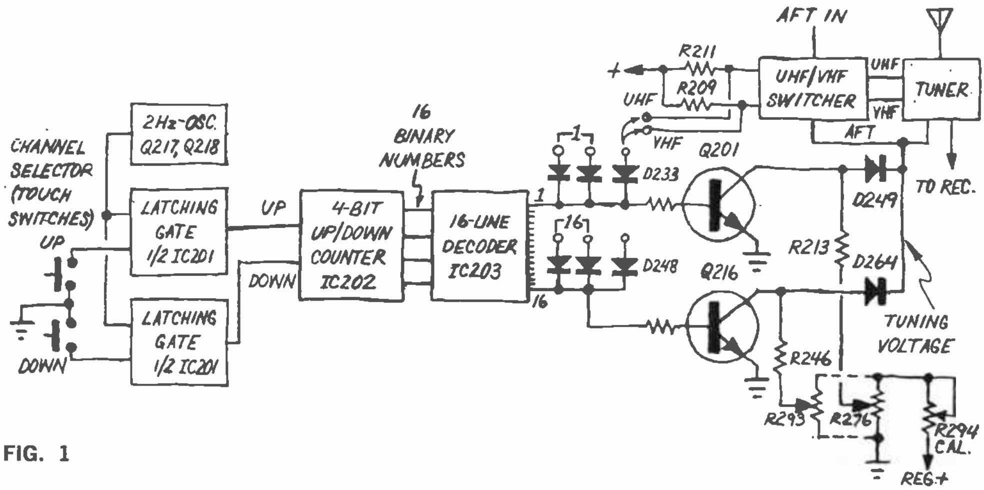


FIG. 1

are automatically reverse biased. As the low output of *IC203* cycles with channel selection, each transistor in turn is "opened" while all others are saturated. Hence, *IC203* automatically selects the preset Varactor tuning voltage for each channel.

Each channel-selecting transistor circuit has provisions for vhf or uhf strapping. When the selected channel is uhf, strapping automatically develops a voltage drop across *R211*, which causes the vhf/uhf switcher module to apply the correct voltage to the tuner to convert it to uhf for that selection. The switcher also accepts the automatic fine tuning (aft) voltage and applies it to the Varactor input of the tuner to which the channel-control voltage is applied.

The preselected channels, totalling 16 in all, can be any combination of vhf and/or uhf channels in your viewing area. The same channel can even be programmed into more than one selection slot.

The basic circuit for the digital channel readout system is shown in Fig. 2. (Lacking a mechanically operated tuner, the GR-2000 has no control-panel channel indicator.) The vhf/uhf channel numbers automatically appear at any preset position on the TV screen whenever the channel is changed or when the channel number is called for by the user. The seven-segment display differs from other such displays in that the segments overlap each other at their extremities to produce unbroken figures. The channel identifier can be programmed to remain on over a period of time ranging from a few seconds to 1½ minutes.

The display chip *(IC301)* is a CMOS device that generates numerical characters on demand. It uses the horizontal and vertical pulses for timing. The 4.5-MHz gated oscillator that forms the "clock" for the character generator is gated only when the horizontal and vertical pulses are simultaneously present. The horizontal pulses are fed directly into *IC301*, while the vertical pulses arrive via a gate and time-delay circuit. The delay keeps the vertical gate on for the programmed-in period, after which the gate opens, no vertical pulses appear at *IC301*, and the digit display disappears. The time delay is activated automatically with channel up/down or recall signals.

Facilities are provided in *IC301* for generating either a 4- or a 6-digit display when using the optional Model GRA-2000-1 clock module, or to display either the channel number and time or the channel number only. Each time or channel digit is generated in accordance with the *IC301* inputs from the tuner or optional clock. The IC output is passed through a display/dot switch to emitter follower *Q221*. Three chroma amplifiers accept the red, green, and blue video from the receiver, while the luminance signal is inserted via transistor *Q426*. Transistor *Q427*, in parallel with the luminance input, accepts the numeric display or dots for parallel display on the CRT screen. Potentiometer *R445* determines the brightness of the digital display.

The optional clock module accepts the digit address code from *IC301* and uses it to generate the time's numeric characters.

Positioning controls for both the horizontal and vertical directions enable the user to place the digital display almost anywhere on the TV screen.

The dot generator (not illustrated) consists of conventional digital logic using the horizontal and vertical pulses as timing to generate the pattern required. The output of the dot generator is passed to *Q221* through the display/dots switch.

The unique bandpass filter used in the video i-f module is a predistorted transitional gaussian design made up of ten sections. This computer-designed module is enclosed in a double-shielded enclosure and never requires adjustment. When coupled with its associated amplifiers, it creates an i-f that is at least the equal of most top-of-the-line performance for commercial color TV receivers.

There are no tunable traps in this unique filter-type video i-f amplifier. The curve skirts are very steep on both sides immediately above the picture carrier and below the chroma carrier. This means that the 10-to-15-dB "comeback" problem typical of the conventional trap is nonexistent in the GR-2000 and, hence, no "herringbone" patterns will appear in the picture.

Remote Control Option. The main option for the GR-2000 is the GRA-2000-6 TV Remote Control which consists of two sections—a hand-held ultrasonic transmitter and a two-part ultrasonic receiver that is mounted in the receiver.

The hand-held transmitter has four finger-operated rocker switches that provide the eight signals that turn the TV receiver on and off, adjust the audio volume (increase and decrease), change TV channels (up and down), and give complete control of both tint and color intensity. A touch on either the volume or channel selector control will also recall the digital on-screen channel number or time readout. The usable range is at least 20 feet. The single-transistor transmitter is powered by a conventional 9-volt battery and is enclosed in a beige plastic case.

The two-part ultrasonic receiver, which is mounted in the TV chassis, senses the eight ultrasonic signals through a microphone concealed in the front panel of the set. The circuit of the receiver uses 28 transistors, 12 IC's, and 8 diodes. One portion detects the signal presence, and the second "remembers" what was remotely commanded.

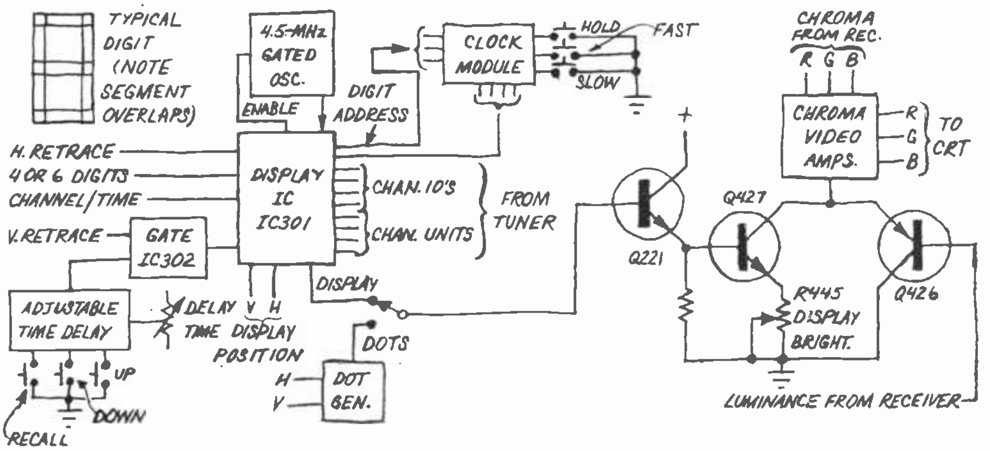
The color and tint circuits each have an 8-bit up/down counter, an associated clock-pulse latching gate, and a digital-to-analog converter. The volume control circuit consists of a 4-bit up/down counter, an associated clock-pulse latching gate, and a digital-to-analog converter with additional circuits for controlling an ac power on/off relay.

When installed in the GR-2000, the remote control is paralleled with the similar elements in the receiver.

User Report. The receiver is assembled in module fashion. First come the 20 glass-epoxy circuit boards. (Each board is packed with its own components so that there can be no errors.) Assembling the boards is easy if the excellent instructions in the manual are followed. Each step is clearly identified and there are sufficient illustrations to satisfy even the most fastidious assembler.

Once the boards are complete, the receiver subchassis is assembled, with other elements following. Total time taken for our assembly of the receiver was 52 hours. If this seems a little long, we must point out that we were not racing against time and took some care to make sure that the as-

FIG. 2



sembly, when complete, would work properly—a procedure that we find usually pays good dividends.

The receiver contains 19 IC's (33 if the remote control and clock are included) and 71 transistors. Each semiconductor has its own socket and there are 12 factory-fabricated interconnecting cables. The 25-in. CRT is enclosed in a sturdy Magna-Shield metal container with the circuit elements mounted on the rear apron. The preset tuning controls, remote control, readout board, convergence board, and clock module are all mounted on a slide-out service drawer, which is mounted beside the CRT enclosure.

Once the set is completely assembled, it can be converged. For the GR-2000, convergence is far easier than with most color sets. The built-in dot generator produces rock-steady, *small* dots that make adjustment much easier. The complete color adjustments can be performed in less than one hour. The tuner and i-f circuits are preset in the factory and require no alignment.

Programming the channels is simply a matter of determining which channels will be most frequently used, and in what order. There is a choice of any 16 channels—high or low vhf and uhf. The same channel can also be programmed to appear in more than one selected position.

The CRT-displayed channel identifier is programmed at the same time. This on-screen identifier is used because the set does not have a mechanical front end. The digital readout appears automatically when the channel is changed or when the volume is turned down by pressing the appropriate switch on the receiver or remote control. The channel number display can be set to remain on for a few seconds or as long as 1½ minutes. It can also be set to be displayed at all times; its brightness can be adjusted; and it can be adjusted to appear anywhere on the CRT screen.

The clock module also fits in the slide-out drawer and is provided with the usual pushbutton controls. The time display can be set to provide either four or six digits, and it appears just below and at the same time as the channel identifier.

The picture obtained on the GR-2000 can only be described as superb. The Black (Negative) Matrix CRT, the tuner and i-f strip, and the video amplifier provide a picture equal to that of many studio color monitors. (We used the GR-2000 with a broadband log-period antenna and coaxial transmission line, in a good signal area.) Blacks are intense and vivid and high-frequency outlines are very clean with no evident ringing. The color "fit" is excellent and the overall chroma spans the range from a light pastel to excessive coloration. The i-f produces no herringbones, no adjacent-channel interference, and no moiré patterns. Best of all, no more alignments.

The touch-switch system of tuning and sound control takes some "getting used to." To change channels, for example, the front panel (or remote) touch switch is operated for either up or down. Since there is no mechanical movement involved, the channels skip by quite rapidly. The key to the operation is just to *touch* the switch and then release it—a procedure that one adjusts to quickly. In the remote mode, changing the audio level has a similar operation. When the sound is reduced to a minimum, the set will go off if the switch is touched again. Touching the switch for increased sound, will turn it back on and start to raise the volume.

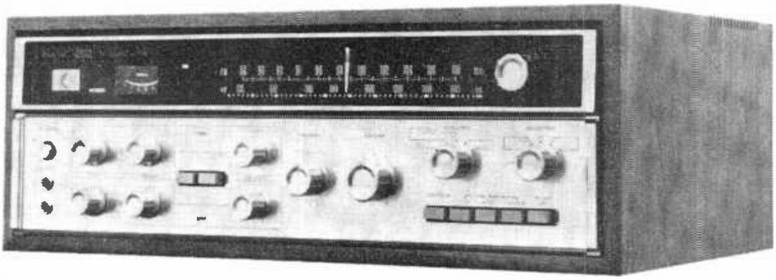
The GR-2000 has an "instant-on" feature, which means the CRT heater is on all the time, making the picture available as soon as the set is turned on—without warm-up. Instant-on also permits the remote control module to remember all of the previous settings (being digital, the settings are lost if power is removed) and the digital clock is supplied with power so that it keeps time when the set is not in use. There is a master on-off switch which can be used to turn off the power completely.

We have taken a close look at the solid-state circuits used in the GR-2000 and were pleased to find that they use all of the latest IC's. Digital logic experimenters will find many fascinating circuits to analyze—and possibly modify for other uses. The remote control itself has more IC's and transistors than some complete TV sets.

This outstanding, large-screen TV receiver combines peerless reception, anticipated ultra-reliability (due to the elimination of mechanical switching and solid-state design) and all the optional convenience features one could wish for (electronic digital clock, remote control, and "hi-fi" audio tap). In our view, the color TV of the future is here—and Heath's GR-2000 is it!

Circle No. 5 on Reader Service Card

SANSUI MODEL QRX-3500 4-CHANNEL RECEIVER
(A Hirsch-Houck Labs Report)



THE Model QRX-3500 4-channel stereo receiver is one of the new line of products made by Sansui which uses their Vario-Matrix (a logic controller that enhances the stereo separation inherent in the QS system). The Vario-Matrix compares the phases of the two input channels and controls the matrix coefficients to accentuate separation without "pumping" or other audible side effects encountered with other decoding systems.

The receiver's amplifiers are rated at 15 watts/channel into 8-ohm loads with all channels driven (22 watts when only one channel is driven). The power amplifiers are direct-coupled right out to the speaker outputs. Thorough protection against damage to the output transistors is provided by fuses, electronic circuits, and a relay that disconnects the speakers in the event of a short circuit or other malfunction.

The FM tuner has a rated 2.2-μV IHF sensitivity, better than 25 dB of midrange stereo separation, and less than 0.4 and 0.6 percent distortion in mono and stereo, respectively. Most other tuner specifications reflect a good-quality tuner that is easily able to meet the needs of the vast majority of listeners.

The receiver measures 20⅜ in. wide by 13¾₁₆ in. deep by 7⅛ in. high. It weighs about 41 pounds, including wood cabinet. The front panel, its upper third dominated by a black-out dial window, is finished in satin gold with matching control knobs.

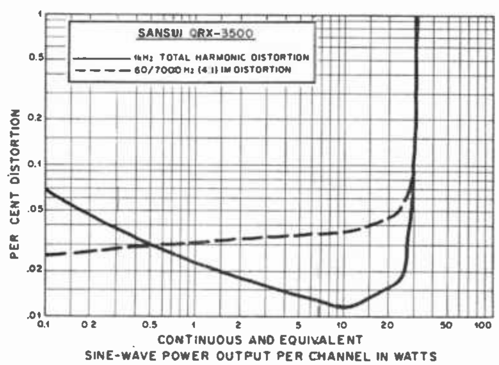
Separate bass and treble controls, each with 11 detented positions, are provided for the front and rear channels. The front and rear channels can be separately balanced left to right, and the filters operate on all four channels. There is also a front-to-rear balance control. A master volume control permits all four channel gains to be adjusted simultaneously.

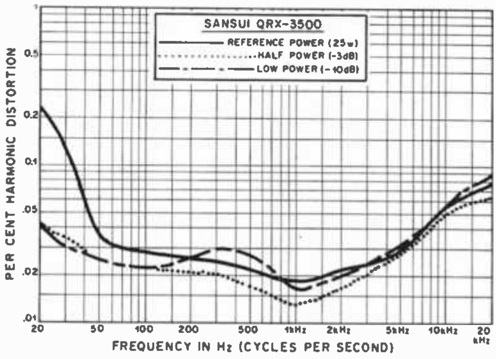
The FUNCTION switch establishes the operating mode from among 2 CH, SQ SYNTHESIZER, QS REGULAR MATRIX with both SURROUND and HALL characteristics (each supplying different amounts of rear left-to-right separation), PHASE MATRIX for SQ-encoded discs, and DISCRETE. Illuminated legends to the left of the dial scales identify the mode in use.

Another SELECTOR switch establishes the program source in use from among PHONO, FM AUTO, FM MONO, AM, and two 4 CH AUX.

Pushbutton switches are provided for switching in and out of use loudness compensation, FM muting, and tape monitoring for any of three tape recorders (one 2-channel and two 4-channel decks). Completing the front-panel features are separate headphone jacks for front and rear channels and a pushbutton power switch.

The rear apron of the receiver contains the inputs and outputs. The 2-channel tape monitoring jacks are paralleled by a DIN connector. Spring-loaded insulated terminals are used for the speaker and antenna hook-





ups. There is also a socket for an optional remote-control accessory, the Model QBL-100 ($35), that consists of a "joystick" balance control and a volume control for the 4-channel setup. One of the two ac outlets provided is switched. An input voltage selector plug adapts the receiver to line voltages between 100 and 240 volts ac. The ferrite AM antenna pulls out about 2 in. from the receiver; it does not rotate or pivot.

The retail price of the Sansui Model QRX-3500 4-channel receiver is $500.

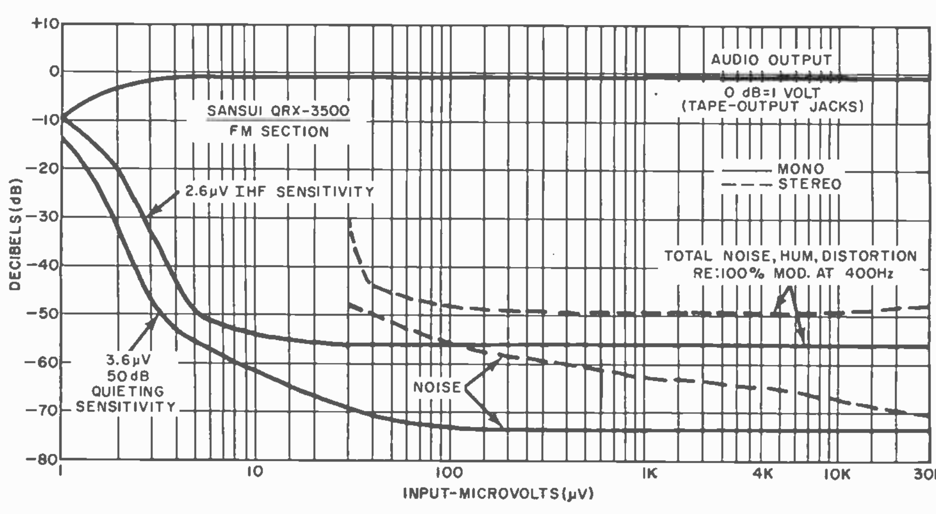
Laboratory Measurements. With all four channels driven at 1000 Hz into 8-ohm loads, the output clipped at 24.2 watts/channel. Driving only two channels, the available power rose to 29 watts/channel. With 4-ohm loads, the power jumped to 41 watts, while into 16-ohm loads it was 12 watts/channel. Our subsequent measurements were made with two channels driven into 8-ohm loads.

The 1000-Hz total harmonic distortion was 0.023 percent at 1 watt, 0.012 percent at 10 watts, and 0.1 percent at 30 watts. Using 25 watts/channel as a reference power output, the THD was 0.23 percent at 20 Hz and less than 0.08 percent between 45 and 20,000 Hz. At half power or less, the distortion was less than 0.88 percent between 20 and 20,000 Hz and was typically less than 0.03 percent.

To drive the amplifiers to 10 watts output, an input of 92 mV on AUX or 1.45 mV on PHONO was required. The S/N ratio through any input was a very good 75 dB referred to 10 watts. Phono overload was at 120 mV, exceptionally high. RIAA equalization was accurate within ±0.5 dB over the defined 30-to-15,000-Hz range (actually the full 20-to-20,000-Hz measurement range).

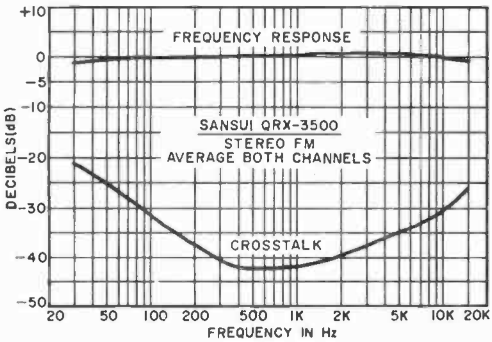
The tone-control characteristics were good, with a sliding turnover frequency on the bass controls and a hinged characteristic on the treble controls. The filters had gradual 6-dB/octave slopes, and their responses were down 3 dB at 120 and 3000 Hz. The loudness contours were boosted at low and high frequencies when the volume level was reduced.

The FM tuner's usable IHF sensitivity was 2.6 μV. A 50-dB S/N ratio was measured at 3.6 μV (with 1.35 percent THD). The ultimate distortion, at a 1000-μV input, was 0.16 percent in mono (0.36 in stereo)—well below the specified values. The ultimate S/N ratio was 73.5 dB in mono and 63 dB in stereo. The automatic transition from stereo to mono took place gradually as the input was reduced from 40 μV to 25 μV, and the FM muting threshold was 12 μV.



The FM capture ratio was 1.75 dB, and AM rejection was 49 dB. Image rejection was better than rated, measuring 77 dB. The receiver proved to be slightly better than its rated 50-dB alternate-channel selectivity figure, measuring 51.5 dB on one side of the signal and 65 dB on the other side.

The stereo FM frequency response was ±1 dB from 30 Hz to 15,000 Hz, and 19-



kHz pilot-carrier leakage was 69.5 dB down. Channel separation was better than 21 dB from 30 Hz to 15,000 Hz and exceeded 40 dB through a wide range of middle frequencies. The AM frequency response was down 6 dB at 50 and 3300 Hz.

Although most of our evaluation of the Vario-Matrix was done by ear, we checked its separation with a QS-encoded Sansui test record. On the sides, the front-to-rear separation was 7 to 10 dB, and across the front and rear, respectively, it was 12 and 14 dB. Across the diagonals, it was 15 to 20 dB, and from the center of each side to the opposite center or to any corner it was 10 to 20 dB.

User Comments. Judged by its published specifications, the QRX-3500 might appear to be a fairly low-powered receiver. As our tests show, however, it is rated most conservatively. It can actually deliver about 100 watts of total continuous power. Similarly, although the tuner ratings are modest, sensitivity is more than adequate, and the low distortion is comparable to that of some very expensive separate-component tuners. As the very low distortion demonstrates, the audio amplifiers are among the cleanest we have found in any receiver.

The Vario-Matrix proved to be a fascinating and impressive device. With QS-encoded discs, it produced virtually "discrete" 4-channel sound with none of the sudden cutting off of sound from one speaker by the action of a gain-riding logic system. With SQ discs, the system was almost as good—not as good as the latest full-logic SQ decoders, but strikingly better than other receivers equipped with the basic SQ matrix.

We most appreciated the QS SYNTHESIZER that gave better "4-channel" sound from 2-channel programs than we have gotten from 4-channel records played through ordinary matrix decoders. Any matrix decoder can create an "ambience" enhancement via the rear speakers from 2-channel material, but this is usually totally lacking in solid directionality. In contrast, the Vario-Matrix creates four distinctly different channels from two and does it in a way that most of the time does not sound awkward or excessively artificial.

Circle No. 65 on Reader Service Card

CARINGELLA MODEL TCG-1 SEMICONDUCTOR CURVE TRACER

AS THE electronics experimenter and service technician begin to use more sophisticated solid-state devices, he must look beyond simple go/no-go semiconductor testers. At this time, he usually investigates curve tracing and its advantages, especially the capability of testing a great variety of semiconductor devices both in and out of the circuit. And, in using a curve tracer he becomes familiar with operating parameters of semiconductor devices. Of course, a curve tracer must be used in conjunction with an oscilloscope, on the screen of which are displayed the curves.

One such tracer is the Model TCG-1 made by Caringella Electronics, Inc. It is a fine example of a well-designed and easy-to-use curve tracer. The price of the TCG-1 in kit form is $80; wired, it is $100.

How It Is Used. The TCG-1 tracer is used with almost any type of ac or dc oscilloscope. It features two collector voltage modes: one of ±10 volts operating at 550 Hz provides a flicker-free conventional family of five curves display, and the other of ±200 volts is for checking voltage breakdowns. A built-in step generator produces a total of ten base-current steps (five positive and five negative) that allows both npn and pnp transistors to be tested consecutively without having to touch control settings or flipping switches to change polarity.

A three-position lever switch permits the selection of either of two test sockets or a set of three color-coded binding posts (into which test leads are plugged) for out-of-circuit and odd-based transistor tests.

The beta of the transistor under test is indicated on a clearly marked front-panel control after making a simple CRT adjustment. To eliminate guesswork, a built-in calibrator is used to set up the scope's vertical and horizontal amplifier channels.

The instrument measures 6 in. high by 4 in. wide by 2½ in. deep. It has an attractive two-tone case with a brushed aluminum front panel. The adjustable carrying handle doubles as a tilt bench stand.

We have been using the curve tracer for several months now. In comparing it to another (more expensive) semiconductor curve tracer, we have found that the TCG-1 is more comfortable to use, primarily because of its ease of oscilloscope calibration and the capability of testing both types of transistors without having to switch around. All in all, this is a good, reliable test instrument accessory that should see a lot of use by the serious experimenter or the busy service technician involved in solid-state circuitry.

Circle No. 66 on Reader Service Card

MICRO ELECTRONIC SYSTEMS MINI DRILL

LAYING out and etching a printed circuit board is not difficult once you know how to go about it. But the trouble starts for most of us when we have to drill the considerable number of holes, sometimes several hundred in an IC project, required for component mounting. These holes are usually very small in diameter, necessitating the use of somewhat fragile No. 61 and No. 64 bits. Unfortunately, most of us own ¼-in. or ⅜-in. hand drills that were never designed for the delicate touch needed when working with pc-type bits. The result is usually the destruction of one bit after another as each snaps or twists under the pressure of the drill. In extreme cases, the bit might break and damage the pc board beyond repair.

If you have gone this route and are considering chucking the whole idea of pc boards in favor of point-to-point wiring, don't make a hasty decision. We recently obtained a Mini-Drill made by Micro Electronic Systems Inc. that promises to solve pc drilling woes. It costs only $17.50 and comes with a chuck tool, four AA cells, and a 0.03937- in. bit that is ideal for pc mounting holes. The battery-powered drill measures only 1⅝ in. in diameter and 7 in. in length. It weighs a negligible few ounces; so, it is easy to handle and maneuver and reduces operator fatigue to a minimum.

The chuck of the Mini-Drill is designed to accommodate drill bit sizes ranging from 0.8 mm to 1.4 mm (0.0135 in. to 0.0551 in.), which just about covers the entire range of hole sizes you will ever need for pc work. Although the drill is usually battery powered, it can also be operated from a 6-volt, 600-mA source (available as optional Model AD-660 accessory).

In use, the Mini-Drill is comfortable to handle. Having made several test runs, each consisting of 100-plus holes, we can honestly say that there is virtually no user fatigue. The bit pierces easily through phenolic, polyester, and G-10 epoxy pc board. Although we didn't time ourselves during a test run in which we drilled 250 holes, one after the other, we would estimate that the entire job didn't consume more than ten minutes. We didn't bend or break one drill bit in well over a thousand holes drilled. (We were lucky to average 25 holes per bit with our clumsy hand drill during similar test runs.)

Circle No. 67 on Reader Service Card

CIRCUIT SPOTLIGHT

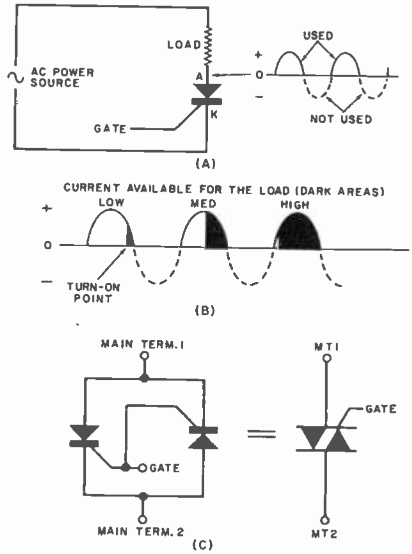
WHY USE A TRIAC?

BY LESLIE SOLOMON, Technical Editor

THE USE of the triac in various power control systems may not be particularly innovative; but, in looking at the circuit, one tends to wonder just why a triac was used instead of some other component—or components. Many hobbyists are not really that familiar with the triac.

Since a triac can be considered to be a second-generation silicon controlled rectifier, it is necessary to understand how the latter works before getting into details on the former. An SCR is a four-layer pnpn semiconductor device having three electrodes—cathode, anode, and gate. With a forward bias (positive voltage on the anode, cathode connected to common), an SCR should behave like a conventional diode. In that case, current would flow through the junction and through any load in series.

However, the construction of an SCR is such that current cannot flow through the junction unless both the anode and gate are simultaneously positive with respect to the cathode. As soon as this happens, the SCR conducts fully, after which the signal on the gate no longer has any effect. Thus, if pure dc (rectified and filtered) is used as the power source, the SCR will not turn off as long as the anode voltage is applied.



But in most SCR circuits, either raw ac or rectified but not filtered dc is applied to the SCR. This means that only the positive half cycle has any effect on the SCR since the negative half cycle reverse biases the SCR and can't be used (see sketch A). The amount of power controlled by the SCR depends on how long the positive voltage is allowed to remain on the anode, thus supplying current to the load. The SCR turns off automatically when its anode voltage drops to zero.

If the SCR is turned on late in the positive half cycle (sketch B), only a small amount of current is available for the load; but when the gate signal is used to turn the SCR on earlier in the positive half cycle, the current through the load is increased. Keep in mind that the SCR turns off at each zero crossing and must be retriggered in each positive half cycle. Varying the triggering is usually the job of a phase-shift network which drives the gate (a circuit found quite commonly in home light dimmers, power tool controllers, etc.).

Obviously, no matter how early in each positive half cycle the SCR is triggered, the best it can do is pass half of the available power in each cycle—hardly a profitable arrangement. To remedy the situation, bridge rectifiers are sometimes used for full-wave rectification. (The negative half cycle gets "folded up" to become a positive half cycle.) This approach permits using more of the available power; but the rectifiers cost money too.

Now back to the triac, which is essentially a pair of SCR's connected as shown in sketch C, with just one common gate for the two junctions. But the two junctions are, so to speak, back-to-back so that the other two terminals can't be marked anode and cathode. Instead they are called simply Main Terminal 1 and Main Terminal 2 (MT1 and MT2).

Unlike the SCR, the triac can conduct on both halves of the cycle—with MT1 positive on one half cycle and MT2 positive on the other half cycle. Thus the triac can deliver more power than a single SCR, without a special power supply circuit. ◈

MAC'S SERVICE SHOP

Electronics And the Energy Crisis

By John T. Frye, W9EGV, KHD4167

WHEN Barney entered the service department, blinking from the bright April sunshine, he found Mac frowning in concentration and scribbling on a note pad.

"Writing a spring poem, Boss?" the youth asked flippantly.

"Hardly," Mac replied. "I'm preparing a brief on the electronics industry's place in the sun during the long-haul energy crisis. As things have been going, I'm afraid the loudly squeaking wheels—truckers, commercial aviation, farmers, owners of private planes, teachers, boat owners, etc.—are going to get most of the grease, or oil, and leave little for the rest of us who do not have a government department, a strong union, or a powerful Washington lobby to open the spigot for us.

"Electronics is so all-pervasive in our society, it plays such a quiet but essential part in our lives, that it's easy to take its services for granted and forget that it, too, must have its fair share of energy to continue and expand those services. *Unlike most other industries, electronics returns manyfold every calorie it consumes!* It has played and will continue to play a major role on three fronts in the energy crisis: (1) the locating of new sources of present forms of energy, (2) the conservation of all forms of energy, and (3) the development and control of new kinds of energy."

Locating New Energy Sources. "I guess electronics helps locate new oil and gas fields, huh?"

"You guess right. If all the oil wells discovered through the use of electronics were suddenly taken out of production and we had left only those wells brought in guessing or using a divining rod, we would have only a small fraction of the 17 million barrels of oil we consume daily in this country. While electronics plays an essential part in most forms of modern geophysical prospecting, it is the heart of the seismic type on which the oil industry spends many millions of dollars each year in field work and laboratory research.

"You know how this works: explosive charges are detonated in shot holes drilled in the earth, and the refracted or reflected shock waves are picked up by special chart-drawing receivers in the vicinity. The accurate measuring of the times that elapse between the detonation and the reception of the ground-travelling waves at several receiver points indicates the presence of anticlines, salt domes, and faults beneath the surface, formations expected to be oil-bearing. In underwater prospecting from a surface vessel, detonating charges are often replaced by bursts of compressed air. When new oil fields are discovered, you can bet that electronics will have pointed the finger."

Conservation of Energy. "How does electronics conserve energy?"

"Dozens of ways. First, let's talk about what electronics has already done to save electrical energy in the home, office, and industry. Replacement of tube-type radios, TV receivers, and hi-fi sets with semiconductor equipment has saved up to 80% of the energy consumed by these entertainment devices. The same goes for computers and calculators. And don't forget the saving in the huge air-conditioning energy requirements for keeping those early tube-type computers cool. The replacement of older energy-consuming relays with newly developed semiconductor products is just getting off the ground in the telephone industry, and in the future this will represent a very substantial saving in energy. Humidity sensors that automatically shut off clothes dryers when the clothes are dry, rather than at the end of an arbitrary, energy-wasting time interval, are already saving both gas and electricity.

"But more is on the way. IC microprocessors will be used to monitor and program heating, lighting, and air-conditioning in office buildings and factories of the future. By tailoring these quantities precisely to actual needs—for example, lighting only areas actually occupied by people and maintaining a uniform temperature during all seasons—it is estimated a 30% saving in energy can be achieved. Back in the home, electronic equipment will calculate the total heat produced by an oven from turn-on and eliminate the need for wasteful preheating. You'll be glad to know the electronics industry is constantly scrutinizing its own uses of energy and trying to make savings. Core memories in computers will be replaced with semiconductor circuits; CMOS logic circuits will be substituted for TTL."

"How about transportation? Don't tell me electronics can't help save some energy there."

"It most assuredly can, and this is very important because transportation consumes 24.8% of all the energy we use, making its consumption second only to that of industry, which takes 37.3%. Actually, electronics is already doing a good job of conserving fuel used in cars. A good electronic ignition system can add up to 2 miles per gallon over a period of time by eliminating misfires and providing stable ignition timing that does not change because of wear. Automatic speed control devices can increase mileage 20% on highway travel. It's claimed that the substitution of electronic fuel injection for carburetion can, on average, increase mileage in stop-start driving from 4 to 16 miles per gallon. All in all, Floyd Kvamme of National Semiconductor says that electronics can provide up to 40% savings in automobile fuel.

"Don't forget that the car of the future is going to come equipped with an on-board computer to provide separate digital readouts for the speedometer, gas gauge, electric clock, tachometer, etc. At the same time, as we have discussed before, this computer will provide, by means of pulse modulation, exactly the amount of power—no more and no less—needed for braking, steering, window control, windshield wiping, and other mechanical jobs. It will do this over the single-cable wiring system that will replace the rat's nest of wiring found in today's cars. The saving in dc power from the battery, of course, means a saving in fuel required to recharge that battery. But that brings me to my 'invention' that I was working on when you came in."

"What invention?" Barney asked.

"A really accurate miles-per-gallon digital readout meter controlled by the on-board computer. All we need to do is provide that computer with two inputs from digital sensors, one of which will indicate distance travelled per unit of time and another which will indicate gasoline consumed per identical unit of time. The computer will sample inputs from both the flowmeter installed in the gas line and the speedometer at very short time intervals, compare them, and provide a constantly updated digital readout in miles per gallon."

"Hey, I like that!" Barney exclaimed. "It certainly would be a vast improvement over those so-called mileage meters that are nothing more than intake manifold pressure indicators. That thing would really give religion to some of our lead-footed brethren, especially if you modified the readout to indicate cost-per-mile for the high-priced fuel we're going to be using."

Mac grinned as he nodded agreement. "All of us would be better drivers if we were made instantly and irrefutably aware of the effect of our driving performance on fuel consumption—and our pocketbooks. The installation of such meters on all cars would probably do more to save gasoline than would all the dire predictions and exhortations coming out of Washington. And there would be other advantages. You'd not need to take the salesman's word about the gas mileage you could expect from the car he was trying to sell you. It would be right there on the dash in little glowing numbers at any speed you chose to drive; furthermore, after you got a tune-up, if you couldn't see an immediate improvement in gas mileage, you could ask some very pointed questions of the mechanic."

New Forms of Energy. "You said something about how electronics would help with the development and control of new forms of energy," Barney pointed out.

"That's right. Electronics really shines in the areas of precise measurement, tireless monitoring, remote control, almost instantaneous communication, adjusting output to demand, and elephant-like memory. No matter what kind of energy source we use in the future—whether it is solar energy from sun farms in the Southwest or from circling satellites, breeder reactors, 'laser energy' resulting from continuous controlled nuclear fusion triggered by a laser beam, shale oil extraction, the gasification of coal, or some as yet undreamed of source—all of these functions of electronics will be sorely needed to design the hardware for the new energy source, to harness and control its output, and to make sure that it does no harm to man or his ecological environment."

"Well," Barney observed, "you've done a pretty good job of convincing me that electronics is the key to man's survival during the approaching period of exhaustion of the earth's supply of fossil energy. It helps him locate and extract fossil energy deposits still left, it's absolutely essential to stretching those supplies as far as they will go, and it's the best hope of discovering and using new sources of energy. Depriving the electronics industry of the energy it needs to do the work it is already doing and to expand its potential would be suicidally short-sighted. How could energy-alloting bureaucrats fail to understand that?"

"Never underestimate the ability of a bureaucrat or a politician to overlook something until it is forcefully pointed out to him by a powerful lobby or voting block," Mac warned. "Electronics has no voice of its own because it speaks through the languages of medicine, science, industry, entertainment, research, computation, and communication. There are some who will not appreciate the contribution of electronics to our way of living until pacemaker-stimulated hearts quit beating, space vehicles never leave the launching pad, or TV and radio sets go dead."

"You don't really expect that to happen, do you?"

"Not unless we continue the policy of greasing only the wheels that squeak the loudest. In our highly organized, specialized, and interdependent society, it's difficult to judge the essentiality of any segment. Certainly, you can't base that judgment on which group bellows the loudest when it is asked to conserve energy. Some of the gears in our society are large and some are small, but remove any one gear and the whole clock stops. This is no time for any one group to claim it should not be asked to join in energy conservation on the grounds that its work is absolutely essential to the welfare of the whole nation. ◈

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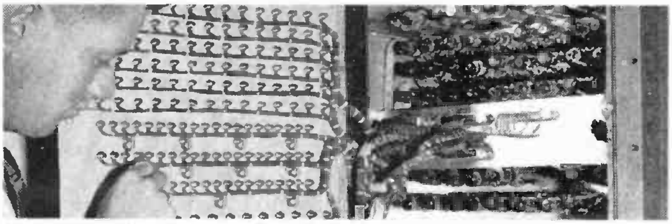

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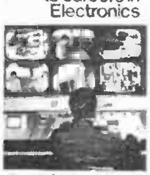

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Understanding

HERE ARE SOME SIMPLE RULES OF THUMB THAT

LEARNING to understand the decibel—really understanding it—can be very confusing. Actually, a decibel is nothing more than the logarithm of the ratio of two power levels; but the problem gets complex when the term is used in such diverse areas as antenna gain or microphone voltage. As a result, the only people who toss off decibel ratings with apparent confidence are salesmen and others who have memorized the values without knowing what they really mean.

Actually, understanding decibels requires just a slight amount of general knowledge and two simple rules of thumb. There is no "higher" math involved. The basic expression is

$$G_{dB} = 10 \log_{10} (P_2/P_1)$$

The power ratio has no units since the two powers cancel each other.

The output power, P_2, is some multiple of the input power, P_1. For example, with a power ratio of 2 and an input power of 5 watts, the output power is twice the input, or 10 watts. This power ratio of 2 expressed in decibels is 3 dB. (The output is 3 dB greater than the input.) The input power, then, is usually the starting point or reference level to which the output power is compared. Knowing the reference level defines what the dB measures.

The concept of reference level is not found only in the use of decibels. Voltages are usually referenced to one volt. Multiples of one volt can then be used to define all voltage levels. Similarly, the power ratio in decibels defines the power level in multiples of the reference level. The difference is that the reference for voltage is one volt, while the reference for dB could be any defined power or just an arbitrary test input.

These references are usually understood for each type of measurement. Typically, in measuring acoustical energy, 10^{-6} watt/cm^2 is used as a reference. In antenna measurements, everything is compared to a simple dipole. Hopefully, if the reference is not standard, it is abbreviated as a letter following the dB value. Audio power, dBm, is referenced to 1 milliwatt. Other common references are dBW (1 watt reference) and dBn (thermal noise). There is no set rule for the derivation of these abbreviations; they are originated for special cases.

Why Are They Used? The beauty of using the decibel system is that decibel figures can be added (as can any logarithm) rather than multiplied, as must be done with regular gain figures. The circuit gains in dB from one stage to the next can simply be added or subtracted from the input reference level. For example, assume that a microphone has an output of 0.00001 mW (−50 dBm) which is attenuated by a factor of 1/10 (−10 dB) in the cable to the amplifier. The amplifier has a power gain of 10,000,000,000 (100 dB). The output of the amplifier can be found in one of two ways:

(1) 0.00001 mW × 1/10 × 10,000,000,000 = 10,000 mW = 10 W

(2) −50 dBm − 10 dB + 100 dB = 40 dBm = 10 W

Using the dB figures requires an additional step to convert the answer to watts, but the rest of the calculation is much easier. The numbers are of a more manageable size and addition is easier than multiplication.

Any signal level or known characteristic can be used as a reference as long as it is related to power. The power measurements, however, are seldom taken directly. That would require a calorimeter or a direct-reading wattmeter. Usually the voltage or current through a known resistance is measured and the power is calculated from

$$P=V^2/R=I^2R=VI$$

Input and Output Resistances. The power ratio is simplified when both the input and output resistances are equal. By cancelling the like resistance terms, it is only necessary

Decibels

BY GEORGE BOARD

MAKE IT EASY TO USE AND UNDERSTAND dB's

to measure voltage or resistance and square it to obtain the power ratio. The logarithm of the voltage ratio squared is twice the logarithm of the voltage ratio unsquared. Thus,

$$G_{dB} = 20 \log_{10} V_2/V_1$$

The special case of having equal input and output resistances is not unusual. Equipment requiring many signal interconnections usually has input and output resistances of 50 ohms. In such a system, the formula 20 $\log_{10} V_2/V_1$ is always usable in finding the dB gain.

Instant chaos develops if the input and output resistances are not equal. The voltage ratio squared would then not be equivalent to the power ratio. In this case the power ratio must be calculated using the proper resistance values.

Rules of Thumb. Knowing what decibel ratings are, the next thing to learn is how they are used. When a salesman says, "Instead of the beam, why not get this new kW rig," he knows that the beam antenna gain in dB cannot be directly compared to the power ratio between your old transmitter and a kilowatt. To figure out what he means, using algebra and logarithm tables, would take too long and making a guess is difficult with decibels. Being logarithmic, they don't increase in a normal fashion. A power ratio of 5, for instance, represents 7 dB, but increasing the ratio to 10 only increases the decibels by 3. So some rules of thumb are useful.

The first rule of thumb pertaining to the decibel scale is that adding 3 dB doubles the power ratio. (The factor is actually 1.9953 . . . , but doubling is close enough.) Thus the gain represented by 6 dB is twice that of 3 dB just as a gain of 58 dB is twice that of 55 dB. Similarly, a gain of 55 dB is half that of 58 dB and −3 dB is a power ratio of one half.

If powers of two were so easy to remember, things would be easy. But it wouldn't be worth the effort to figure out that 30 dB is 10 times 3 dB for a power ratio of 2^{10}.

The second rule of thumb is that each 10 dB represents a power-of-ten change in the power ratio. Or, add 10 dB for each zero in the power ratio. If the power ratio is less than one, subtract 10 dB for each zero, including the zero to the left of the decimal. A ratio of 1000 is 30 dB (3 zeros), and a ratio of 0.001 is −30 dB (3 zeros).

Combining the counting of zeros and the multiples of two, the simplified system expands to provide a handy reference for all decibel levels. A power ratio of 20,000 is 40 dB (4 zeros) plus 3 dB for the factor of two, totalling 43 dB. Half (−3 dB) of 100 (20 dB) is 50; so 50 is 20 dB minus 3 dB or 17 dB. Interpolating, 0.0001875 is between 0.0001 (−40 dB) and 0.0002 (−37 dB). But the number is much closer to 0.0002, so it must be −38 dB. A closer figure could only be obtained by using logarithm tables and many calculations.

The two rules of thumb for power ratios can also be used for voltage ratios. Remember that the voltage ratio in dB is 20 $\log_{10} V_2/V_1$ and the power ratio is the square of the voltage ratio. Thus a power ratio of 16 (12 dB) is the same as a voltage ratio of 4. Now, 4 would be 6 dB as a power ratio—one half of the 12 dB for 16. So, the voltage ratio in dB is twice what the rules for the power ratio would make it. In other words, a voltage ratio of 2 is 6 dB, 4 is 12 dB, and 0.01 is −40 dB.

Summary. (1) Adding decibels is like multiplying power ratios. (2) The reference level must be known. (3) The voltage ratio in dB (resistances equal) is twice what the power ratio would be. (4) Doubling the power ratio adds 3 dB (6 dB for the voltage ratio). (5) Multiplying the power ratio by 10 adds 10 dB (20 dB for the voltage ratio). ◈

Tips & Techniques

CORK SLAB AND STRAIGHT PINS MAKE DANDY BREADBOARD

One of the fastest and least expensive methods for breadboarding electronic circuits can be had with a slab of close-grain cork and some of those straight pins in your wife's sewing basket. Perhaps the best cork base to use is the self-adhering variety that can be purchased from any hardware store. Place it on a nonconducting surface when breadboarding a circuit. To lay out the circuit, push the component leads into the cork. The leads will be readily accessible for tack soldering. Use straight pins for solder terminals and lugs where several wires are to be joined in common. You will find that the cork base can be used many times before replacement is required. Also, it is a good idea to use only a low-wattage soldering iron for the tacking operations. *—Robert Oliver*

SPACER PREVENTS EXCESSIVE HEAT FROM DAMAGING PRINTED CIRCUIT BOARD

Before soldering power-handling components like resistors and axial-lead inductors and diodes to a printed circuit board, it is good practice to space them away from the board's surface by a small distance. This is an expedient that will obviate excessive heat damage to the board should the component fail during operation and overheat. A piece of scrap phenolic board, plastic, or wood measuring about 1/16 in. thick by about ⅜ in. at its widest will do fine. Taper one end of the spacer to permit easy insertion and removal. The spacer goes between component and board. When soldering is complete, it is removed.

—Richard A. Walton

HOW TO DEAL WITH TARNISH ON UHF AND BNC CONNECTORS

Uhf and BNC connectors removed from surplus equipment are often tarnished by oxidation to the point where poor electrical contact results. The easiest and most effective way to clean away the tarnish is to dip the connectors into jewelry cleaner. This cleaning solution works equally well on gold- and silver-plated connectors and contacts; so, it can be used on pc board edge connectors, rotary switches, transistor and IC sockets, etc.

—Steven R. Flick

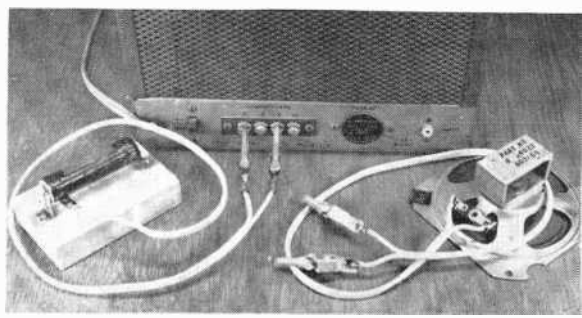
RESISTOR AIDS IN TRANSMISSION LINE CONTINUITY TESTS

Many of today's antenna arrays contain no folded dipole and, therefore, exhibit an open circuit when the conventional continuity test is performed. Hence, a continuity test of the transmission line cannot be made with an ohmmeter. However, by placing a 100,000-ohm resistor across the transmission line terminals at the antenna, one can check the continuity of the line at any time. The resistor will not interfere with antenna operation due to the relatively low impedance of the antenna at r-f.

—Thomas A. Singletary

DUMMY LOAD AND SPEAKER FOR AMPLIFIER TESTING

If you do a lot of amplifier testing, you will find that it's convenient to have on hand a dummy load and a test speaker. The load con-



sists of an 8-ohm 50-watt resistor mounted on a block of wood with an 18-in. length of zip cord terminated with two alligator clips. The clips are much more convenient than spade lugs or raw wire ends, and you should not chisel on the length of the zip cord. You may want to tip the amplifier over for access to the under-chassis area so the long zip cord is a necessity. It's also useful to have on hand a test speaker. Use any 5- or 6-in. speaker to which you have attached an 18-in. length of zip cord terminated again with the convenient alligator clips.

—Lewis A. Harlow

TIPS WANTED

Do you have a "tip" or "technique" that might help your fellow readers? It may be worth money to you. Send it in (about 100 words, with a rough drawing and/or clear photograph, if needed) and you'll receive payment if accepted. Amount depends on originality and practicality. Material not accepted will be returned if accompanied by a stamped, self-addressed envelope. Send material to: Tips and Techniques Editor, POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016.

CB Scene

Patches Come to CB

By Len Buckwalter, KQA5012

A REMARKABLE number of accessories —from field-strength and SWR meters, to coaxial switches and antennas—are nearly interchangeable between CB and amateur radio. So it's no surprise that CB, the younger medium, leans heavily on the tools and technology of ham radio. Latest item to bridge the gap is the *phone patch*. It is an attachment to a telephone that can send your CB voice by landline to just about any other phone in the world. In reverse fashion, you can speak on a phone and be heard by a mobile CB station on the road. Since the number of manufacturers offering phone patches is increasing, it's timely to consider just what this accessory offers a CB operator. About three manufacturers now make patches in the $20 category.

Phone patching has been done for years on the ham bands for several reasons. It enables thousands of servicemen to place low-cost phone calls from overseas posts to the folks back home. In a typical case, the soldier goes to a station on his military base and asks the operator to contact a stateside ham close to the soldier's home. After radio contact is accomplished, the U.S. ham turns on his patch and feeds the soldier's voice into the landline. The advantage is no charge for the transoceanic hop by ham radio—only for toll charges within the U.S. Phone patching is also enjoyed by scientists on expeditions to remote parts of the globe. Finally, patching provides vital communications for victims of natural disasters when phone lines are knocked out.

That last category holds the most promise for CB phone patching. If you're on the scene of an emergency, you (or anyone else) can speak directly from your car to police, civil defense or other authorities by telephone. Of course you could do the same without a patch by asking a base station to make the call for you, but the patch is vastly more efficient. You speak directly with the party on the phone line without the verbal repetition and misunderstanding possible with a go-between.

How It Works. You can see how the whole system works in Fig. 1. Let's say the CB'er at an accident scene wants to speak by telephone to a distant party. He first contacts another CB'er known to have a base station fitted with a patch. The operator on base responds by dialing the phone number and turning on his patch.

When the party at the other end of the line answers, the base operator lets the two parties speak directly with each other. The only difference between talking on a patch and an ordinary phone is that only one person talks at a time. In actual operation, though, you can speak quite normally and be only faintly aware of the send-receive switching. After a few moments it has the feeling of an ordinary phone call. During one test I witnessed, voices went back and forth with normal intelligibility, even though the mobile CB'er was in a moving car. Only when the car moved out of normal communicating distance did quality deteriorate.

Installing a phone patch isn't difficult if you're willing to remove the CB set from

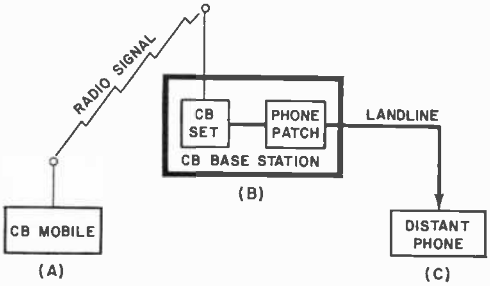


Fig. 1. How phone patch works. Mobile CB (A) talks directly to any phone (C) by going through base station and patch at (B).

its cabinet and locate tie-in points. There are usually two circuit connections (Fig. 2): a shielded cable to the microphone input; and a pair of wires to the loudspeaker. With these cables in place, the CB loudspeaker feeds incoming voices (from over the air) into the telephone line. The

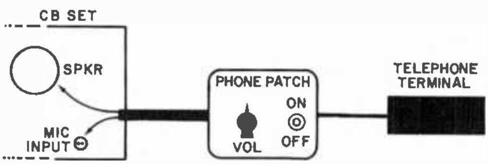


Fig. 2. Diagram of how a phone-patch installation is connected at CB base station.

telephone signal reaches the microphone input so the landline voice goes out over the air. The circuit inside the phone patch typically has a transformer to match various impedances, provides a method for adjusting audio levels, and has a disconnect switch.

The Technicalities. What does Ma Bell have to say about all this? The situation surrounding attachments to the phone line is not yet completely resolved. During decades of ham patching, the phone company looked the other way. Speculation has it that hams deliver a valuable public service to men in uniform and stopping the practice could cause bad feelings toward the phone company. Other observers believe that phone patching actually generates *more* revenue for the company by encouraging servicemen to make calls they'd never consider under normal toll rates. The company, at least, gains revenue on the stateside part of the circuit.

The legal tide changed in 1968 when a private manufacturer won a momentous decision against the phone company. In the celebrated Carterfone case, the FCC declared the Bell System too restrictive about attachments to the line. The result of that decision was an outpouring of accessories that do everything from answering the phone and recording messages, to diverting incoming calls to another number or dialing preset numbers at the touch of a button. It's estimated that more than 6 million telephone answerers have already been sold and the end is nowhere in sight. It's common knowledge that just about all of these accessories can be connected directly to the phone line. The phone patch between a CB set and the phone line connects the same way. However, the phone company demands that any attachment be connected to its line through an interconnect device. Bell argues that its device protects the line against interference and other disturbances. There is a charge, though, for using an interconnect (installation fee and monthly rental).

A phone patch can be an excellent addition for CB clubs and other groups bent on rendering public service, especially when normal communications are disrupted or aren't available in the field. At little cost, a patch provides communications with fewest intrusions in between. ◈

"I'd suggest the next signals you transmit to the YL of yours be RIP."

Test Equipment Scene

By Leslie Solomon, Technical Editor

4-Channel CRT Viewing

ALTHOUGH we, as serious electronics experimenters and service technicians, have access to the latest in test equipment, quite often our needs are one step ahead of the available instruments. Take the case of waveform analysis as an example.

Although two-channel scopes are readily available, as are dual-trace converters for single-trace scopes, there are many occasions when even two traces are not enough. This is especially true when observing several signals in a digital counter, aligning an i-f strip, servicing audio systems—any occasion when it is necessary that a number of signals have certain specific and accurate relationships in order for the complete system to operate properly.

Since multiple trace displays are not readily available now, we have cooked up a small circuit that does the job at reasonable cost. Because 5-inch scopes seem to be so popular and since four traces fit nicely on such a scope, the circuit is designed for four traces. (Most of the readers we have contacted on this subject seem to be interested in displaying four traces.) The circuit (Fig. 1) uses CMOS IC's so the power requirements are minimal. Only the circuit is shown —the serious instrument builder can readily design his own pc or perf board layout.

The heart of the 4-channel switcher is the 4016 transmission gate, also known as a quad bilateral switch—which has no equivalent in any other type of logic. Essentially, each transmission gate (TG) consists of a CMOS device that is connected in series with an input signal and the scope. (There are four such gates in a 4016).

Each TG acts as a conventional mechanical switch, in that, when its control element is driven one way, the CMOS device looks like an open circuit; and when the control element is driven the other way, the device looks like a short circuit. Also, like a mechanical switch, either end of a TG can be the input or output.

The circuit uses a pair of flip-flops (4013) and a set of two-input NOR gates (4001) used as a decoder and arranged to deliver four independent successive gate signals—one for each input trigger signal (pin 3 of the 4013). Each NOR output turns on its pair of associated TG's in sequence, with only one pair of TG's operating at the same time.

The four audio inputs are passed through their own gain controls and then to one of the four lower TG's. The four outputs are connected to the common summing output through isolation resistors. In this way, each audio channel is sampled successively and presented to the scope.

Each audio TG has an associated bias TG (upper 4016) which is turned on simultaneously. The bias TG's deliver a predetermined dc voltage (set by the associated positioning control) to the summing output. In this way, each channel can be independently positioned on the scope. By keeping the audio input level low and properly spacing the four traces, they will easily fit on a 5-inch scope.

Trigger Source. The 4013 requires a positive going input trigger on pin 3. This can be provided in one of two ways—either in a

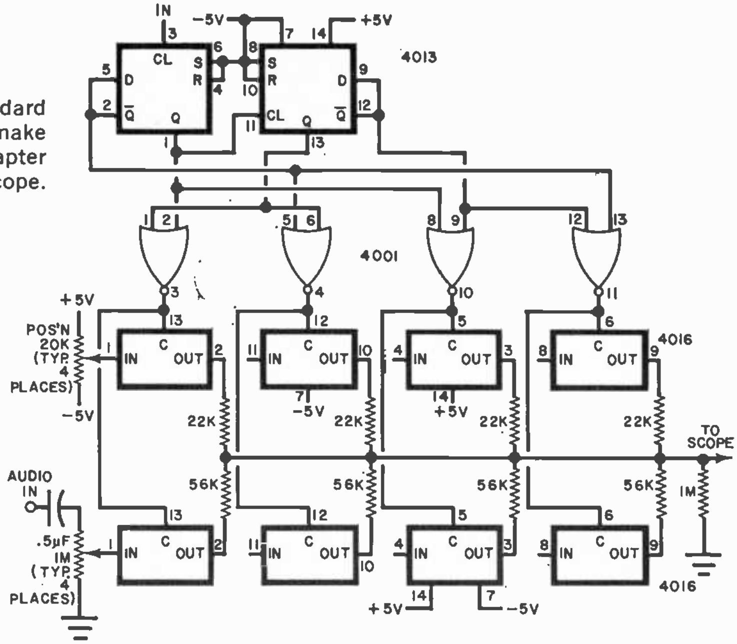


Fig. 1. Just four standard CMOS IC's are used to make a handy four-trace adapter for a single-channel scope.

chopped mode or an alternate mode. Both arrangements are shown in Fig. 2.

In Fig. 2A, the chopped mode, a 4009 CMOS chip is arranged as a free-running multivibrator whose frequency is dependent on the value of *R* and *C*. The buffered output is connected to pin 3 of the 4013.

For alternate-mode triggering, with one channel for each sweep of the scope CRT, it is necessary to get to the scope's horizontal oscillator and pick off a pulse that occurs during the retrace. (The particular scope that we used had such an output provided on the rear apron.) The way in which this pulse is processed to drive the flip-flops depends on the pulse from the scope. In our case, we had a 2-volt negative-going pulse from the scope. The circuit is shown in Fig. 2B. Another transistor will provide phase inversion if necessary.

Keep in mind that, in the alternate mode, the four traces will follow each other in time. Thus they will be dimmer than usual. However, we found that there was enough brightness left in the scope intensity control to compensate.

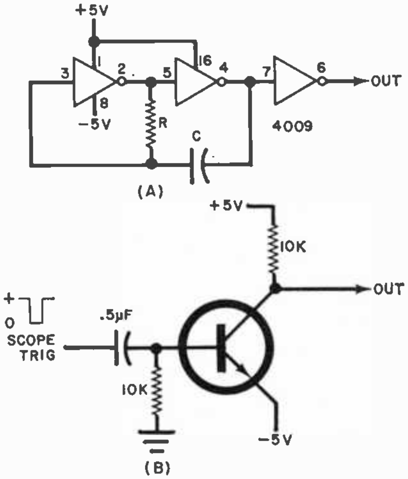


Fig. 2. Chopped mode of triggering uses a CMOS oscillator (A). Simpler circuit (B) is for alternate trigger.

Generating Sync Pulse. Figure 3 shows one approach to generating a sync pulse for the scope. Here, the selected audio channel is coupled into an inverter (4009) through an isolation resistor, and the output is taken from a pair of inverters in parallel to provide a heftier output signal to drive the scope sync. ◈

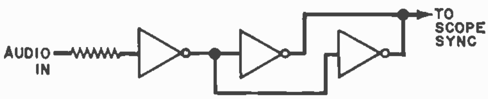


Fig. 3. Three CMOS inverters are used to make a sync generator for four-channel trace. Output inverters are in parallel.

Solid State

By Lou Garner

Using MOS Devices

IF YOU'RE not using MOS (metal oxide semiconductor) devices as yet, there's a good chance you'll be doing so in the near future. Not only are these devices being specified more frequently in experimenter and hobbyist projects, they are being used in ever increasing numbers in commercial, industrial and consumer products. Typically, you'll find MOS devices in digital wristwatches, clocks, counters and calculators—in hi-fi equipment, receivers, and TV sets—and in much of the electronic control and safety equipment installed in new automobiles.

Certainly, MOS technology has much to recommend it compared to more familiar and older techniques. MOS devices have extremely low power consumption (in the nanowatt range for some circuit functions), high input impedances, high noise immunity, wide supply voltage tolerances, liquid crystal readout compatibility, minute leakage currents (often specified in picoamperes), and fantastic versatility. MOS techniques, for example, can be used for the fabrication of discrete devices, such as individual field effect transistors (known, variously, as MOSFET's or IGFET's), multiple device arrays, and both MSI and LSI circuits as well as standard IC's. They are easily adapted to the manufacture of either linear or digital circuits.

There are, basically, three general types of MOS devices: PMOS (p-channel), NMOS (n-channel), and CMOS (complementary or complementary-symmetry, a combination of both p- and n-channel devices on a single substrate).

Regardless of type, virtually all MOS devices utilize a very thin film of oxide insulation between their control (gate) and output (source/drain) electrodes. Because of this, MOS devices are inherently sensitive to damage by electrostatic discharges, despite the fact that most commercial units incorporate input protection networks to minimize accidental damage. Excessive static discharges can break through the oxide film and cause such failures as shorted or leaky input protection diodes, shorted or open gates, open circuit paths, and a degradation of device characteristics. With improper handling, such failures can occur before a device is actually used in a circuit.

For maximum safety and minimum damage, then, it's best to adopt special handling methods when working with these versatile devices. The following procedures, suggested by the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051) in their *National 74C Times*, should enable you to get the MOST from your MOS:

1. The leads of MOS devices should be kept in contact with conductive materials to avoid the buildup of static charges when handled. Manufacturers generally use special containers lined with conductive films for packaging, transporting and storing MOS devices. *In no case should MOS devices be inserted into polystyrene plastic foam or other high dielectric materials.* (So that's what happened to my expensive MOS alarm clock circuit!)

2. MOS devices and/or circuit boards containing MOS units *should not be inserted into or removed from circuits with power "on"* because transient voltage spikes may cause permanent damage.

3. *Do not apply signal voltages to the*

inputs of MOS devices when a circuit's power is off.

4. All unused MOS device inputs should be connected either to the power supply source or to ground (as appropriate to the device).

5. All electrical equipment used for circuit assembly and wiring should be hard-wired to ground, including soldering iron tips and the metal parts of fixtures and tools. A strap of flat tinned copper braid equipped with alligator clips is handy for this operation.

6. Where possible, avoid touching the input terminals of MOS devices except with a grounded tool.

7. When checking equipment using MOS devices, avoid the use of "circuit disturbance" tests which involve opening lead connections or the application of excessive voltages.

8. When breadboarding circuits using MOS devices, double-check all lead connections *before* applying power and *always* check the output setting of variable voltage bench power supplies *before* switching on. Be sure, too, that you observe procedures "2" and "3," above.

9. Most important—*use common sense.*

Don't be frightened by our rather imposing list of "dos" and "don'ts" into avoiding projects using MOS devices. In the final analysis, they are as easy to use as more familiar junction units once you've learned to observe the ground rules. As a coach might say to his team, follow the rules and you'll have no trouble playing the game. After a while, the rules will become more or less second nature and you'll follow proper MOS handling procedures as easily as you handle a screwdriver, soldering iron, or pair of long nose pliers.

Simple SCR Circuits. With all the publicity MSI and LSI devices have received recently, some of us are likely to forget that there are many interesting circuits and useful projects that can be assembled using discrete devices. As examples, three relatively simple, although quite versatile, SCR circuits are illustrated in Figs. 1, 2 and 3. All three circuits were abstracted from *Thyristor New Design Ideas*, a 50-page, 8½" × 11" booklet published by the Unitrode Corporation (590 Pleasant Street, Watertown, MA 02172). In addition to the schematics shown, the booklet features a variety of practical lamp and motor control circuits, temperature and light sensor controls, electronic switches, drivers, and counting circuit designs, together with condensed product specifications for Unitrode SCR's PUT's, LASCR's, and GTO's. Mathematics is kept to a minimum and most of the schematics include typical component values.

With a pair of SCR's, the interval timer circuit illustrated in Fig. 1 is designed for operation on a 22-to-40-volt (nominally, 28-

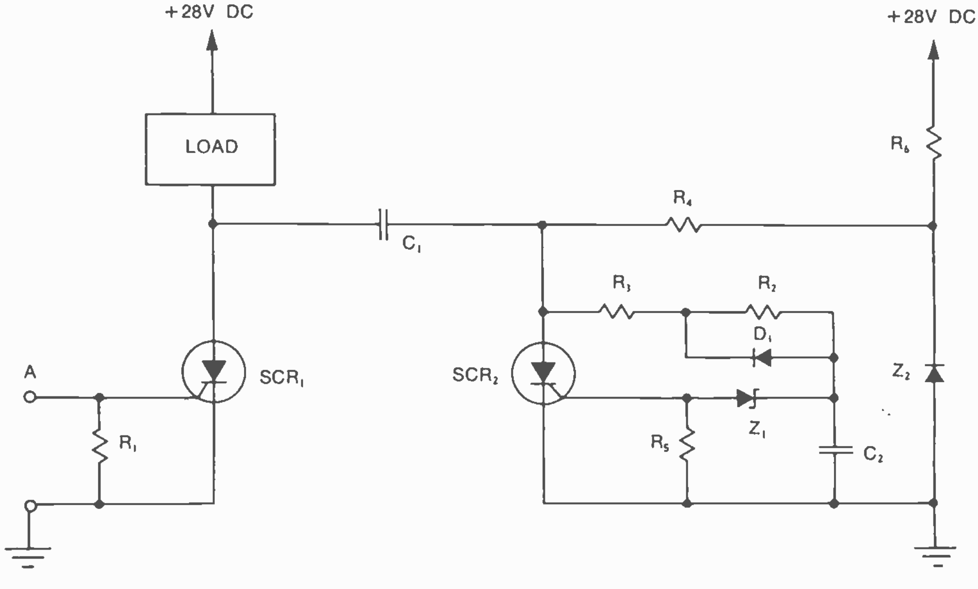


Fig. 1. Unitrode thyristor circuit for high-power interval timer.

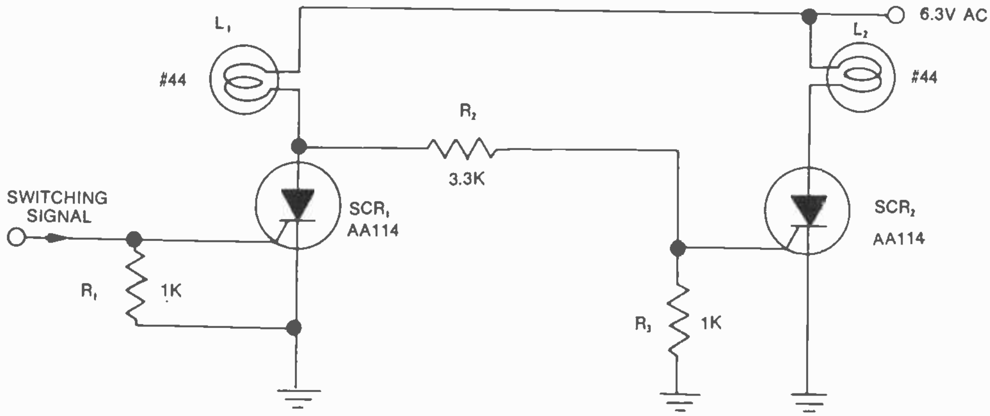


Fig. 2. Circuit for a complementary ac power switch using SCR's.

volt) dc power source and will furnish up to 3 amperes load current for a period of one second each time operation is triggered by the application of a 1-volt signal pulse. It can be used for actuating animated displays, special effect lighting, process cycling, or in any similar application requiring short-interval electrical equipment control.

In operation, the timing cycle is initiated by applying a one-volt (minimum), 5-microsecond (or longer) positive pulse to the gate of *SCR1* (point A). This pulse switches *SCR1* to a conducting state, supplying power to the load, and turning *SCR2* off by the action of commutating capacitor *C1*. At this point, timing capacitor *C2* starts charging through *R2, R3* and *R4* from a regulated dc source provided by *R6* in conjunction with zener diode *Z2*. When *C2*'s charge reaches approximately 7.5 volts, diode *Z1* will conduct sufficiently to apply a firing current to *SCR2*'s gate, switching this device to a conducting state and turning *SCR1* off through *C1*'s commutation action, thus removing load power. Simultaneously, *C2* is discharged rapidly (in about 1 millisecond) through *D1* and *R3*, resetting the circuit for another cycle.

Standard components are used in the interval timer. *SCR1* and *SCR2* are types 2N2324 and AA100, respectively, while *Z1* is a 6.8-volt zener, and *Z2* an 18-volt unit. The capacitors are electrolytic units, with *C1* rated at 6 μF, 30 volts and *C2* 40 μF, 10 volts. All the resistors are ¼ watt units, with *R1*—1k, *R2*—50k, *R3*—10 ohms, *R4*—2.2k, *R5*—6.8k, and *R6*—2.2k.

The specified component values provide an "on" time of approximately 1 second. This interval can be increased by using a larger value for *C2* or shortened by using a smaller value. If multiple timing intervals are needed, several different timing capacitor values can be used, with the desired value for *C2* selected by a simple rotary switch.

Equivalent, in some respects, to a spdt electronic switch, the circuit given in Fig. 2 is used to switch power to two loads in complementary fashion. That is, one load or the other is always energized, but not both at the same time. With incandescent lamp loads (as shown), the circuit may be used to actuate equipment or circuit status indicators, such as GO-NO-GO, START-STOP, HIGH-LOW, SAFE-DANGER, or UP-DOWN. The lamps may be replaced by relays, solenoids, or other electrical devices for a variety of other practical applications.

In operation, a steady positive input signal of about 1 volt at a little less than 1 mA applied to *SCR1*'s gate will maintain this device in a conducting or "on" state, permitting it to conduct on positive half-cycles and energizing the load with half-wave rectified dc. During this period, *SCR2* remains in a nonconducting state, since the small voltage at *SCR1*'s anode, further reduced by voltage-divider *R2-R3*, is not sufficient to drive *SCR2*'s gate. When the external signal is removed, *SCR1* turns off and its peak anode voltage rises, furnishing a trigger voltage to *SCR2*'s gate and turning the second device on during positive half-cycles, thereby energizing load *L2*. During this period, there is a very small current through *L1*, as needed to drive *SCR2*'s gate, but not enough to energize the load. If the switch signal is applied again, the original condition is restored. Thus, *L1* is energized when the switching signal is applied and *L2* de-energized while, with the signal removed, $L1$ is de-energized and $L2$ energized.

In practical installations, the input switching signal can be obtained from various sources, depending on the required control function. Typically, the signal could be derived from a thermistor bridge for temperature indication or heater control or, in another case, from a photoresistive cell for annunciator, burglar alarm, or safety control applications.

The final circuit, Fig. 3, can be used as a high-speed, low-level ac static switch or, with a time-variable pulse generator furnishing the input signal, as an ac proportional control. In effect, the circuit is the SCR "equivalent" of a bi-directional triac control, but with the advantage of being able to handle load currents from as little as 1 mA to as much as 1 A. In contrast, most commercial triacs require a minimum load current of 30 mA for turn-on and as much as 150 mA for latch-on.

In operation, the application of a positive signal of 2 to 3 mA to *SCR1*'s gate causes

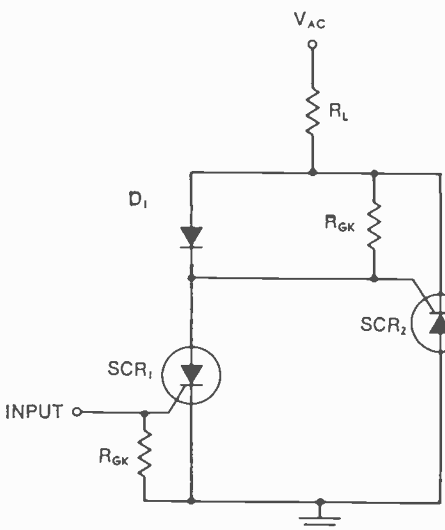


Fig. 3. SCR triac replacement circuit.

this device to switch on during positive half-cycles, energizing load *RL*. During negative half-cycles, *SCR2* is energized by *SCR1*'s reverse anode current, which is blocked by diode *D1* and forced to flow into *SCR2's* gate, thus again energizing the load and providing full bi-directional performance.

Relatively few parts are required for circuit assembly. *SCR1* is type AA109, *SCR2*, type AA102, and *D1*, type UT113. The gate-cathode resistors (R_{GK}) are 1000-ohm, ½-watt types.

The basic circuit is designed to operate on a standard 117-volt ac source at from 60 Hz to 20 kHz. It may be used as an ac static switch by applying a dc voltage to the input (enough to supply 2 to 3 mA), positive with respect to circuit ground, or as a proportional control by applying positive-going time-variable pulses. The control pulses may be obtained from any variable frequency PUT or UJT oscillator circuit.

Device/Product News. Shades of *Star Trek*! According to an item in *MONOgram*, a publication issued by Interdesign, Inc. (1255 Reamwood Ave., Sunnyvale, CA 94086), R. W. Enterprises (P.O. Box 735, Independence, IA 50644) is now marketing a digital alarm clock which will obey an oral command to "shut up." In operation, the clock first tries to awaken you with a soft beep-beep-beep. If you want to snooze a little longer, you just tell it to be quiet—a grunt, yell, or even a cuss word will work. The clock, obedient to your wishes, then shuts its alarm off and tries again five minutes later. Naturally, the clock is solid state, with all the electronic circuitry contained on a single IC chip.

Intended for reference oscillator and clock applications, two new crystal oscillators have been introduced by Motorola Semiconductor Products Inc. (P.O. Box 20924, Phoenix, AZ 85036). Featuring a choice of complementary sine-wave, single-ended MTTL, and complementary MECL outputs from a single MSI IC chip, each device comprises a voltage regulator, an oscillator, an amplifier/automatic gain control, a sine-to-MECL translator, and a MECL-to-TTL translator. The only external components required to produce a highly stable oscillator are a series-mode crystal, two bypass capacitors, and, of course, a power supply. Output voltages range from 800 mV p-p (no load) to 500 mV p-p at full load. Type MC12060/12560 is intended for operation from 100 kHz to 2.0 MHz, while type MC12061/12561 covers the 2.0-to-20.0-MHz range. Both types are offered in 16-pin ceramic DIP's.

RCA's Solid State Division (Route 202, Somerville, NJ 08876) has introducted a new device which should be of interest to serious experimenters and hams: an AM radio receiver IC.

Designated type CA3123E, RCA's linear

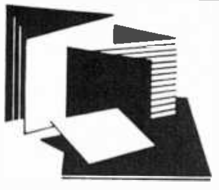
radio receiver subsystem provides an r-f amplifier, i-f amplifier, mixer, oscillator, agc detector, and voltage regulator on a single chip. Designed for use in superhet AM radio receivers, the new device is supplied in a 14-lead dual-in-line plastic package.

If you're an advanced experimenter, student, or ham working with uhf and vhf circuits, you should be interested in two new offerings from the Amperex Electronic Corporation (Hicksville Division, Hicksville, NY 11802)—a series of uhf amplifier modules and a 50-watt r-f power transistor.

Consisting of three units, Amperex's new uhf amplifier modules are designed for operation in the 380-512-MHz band on 12.5-volt power supplies. Designated types BGY22, BGY23 and BGY24, the devices can furnish output powers of 2.5, 7, and 17 watts, respectively. The BGY22 requires 50 mW drive power while the BGY23 and BGY24 each requires 2.5 watts. If desired, the BGY22 can be used as a driver for either the BGY23 or BGY24. The only external matching required to use these modules are 50-ohm input and output lines. The units are offered with either ceramic or plastic caps.

GE's Semiconductor Products Department (Electronics Park, Building 7, Mail Drop #49, Syracuse, NY 13201) has introduced two sets of inexpensive, matched LED/detector pairs for use in interrupter applications. Each pair consists of a gallium arsenide LED and a silicon detector housed separately in side-looking TO-92 plastic packages. Type H17A1 features a transistor detector, while type H17B1 employs a Darlington detector. The new units may be used for such applications as level detectors, counters, position sensing, etc.

Reader Idea. If you are looking for a novel chess set, reader Richard A. Picard has this suggestion: obtain some translucent chess pieces and drill out a small portion at the bottom, just large enough to accommodate a small low-voltage pilot lamp or LED. Insert the light and attach it to a two-terminal electrical connector which will form the new bottom of the piece. Then drill a hole in the middle of each square of a checkerboard, just large enough to accommodate a socket matching the connector on the chess piece. Wire all of the sockets to a common low-voltage supply. If the chessmen are clear, you can use lights of two different colors. If they are already tinted, clear lights can be used. ◈



New Literature

SAMS BOOK CATALOG

Contained in the 88 pages that make up this new catalog are more than 400 book listings (hard and soft cover) from Howard W. Sams. Of particular interest are the numerous listings for audio and hi-fi, electricity and electronics, communications and computers. In fact, the electronics-related books occupy the lion's share of the catalog. Address: Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268.

HEATHKIT GENERAL CATALOG FOR 1974

Included in the 1974 Heathkit catalog are color TV receivers, the latest in audio/hi-fi equipment, marine gear, communication gear, automotive test devices, test equipment, etc. Many of the items listed and fully described are accompanied by full-color photos of the finished project. Address: Heath Co., Benton Harbor, MI 49022.

NBS METRIC SYSTEM BOOKLET

Publication of a new consumer booklet that outlines the essential details of the metric system of measurement has been announced by the National Bureau of Standards. The 16-page "What About Metric" booklet was written to give consumers the few terms and relationships they need to use the metric system and relate it to the system they have been accustomed to using. The booklet is largely two-color illustrations and a minimum of text. It gives visual comparisons and simple illustrations. Copies are available for 80¢ each from: Supt. of Documents, U.S. Govt. Printing Office, Washington, DC 20402. Specify NBS Consumer Information Series 7 or GPO stock No. 0303-01191.

GILFER SWL'ING CATALOG

"The World of SWL'ing" is the title of the latest catalog from Gilfer Associates, Inc. It lists and fully describes many items of interest to beginner and old-timer alike—receivers, preselectors, antennas and antenna matchers, headphones, etc. Also listed are a Franklin 24-hour wall clock and a digital electronic six-digit 12/24-hour desk clock. Address: Gilfer Associates, Inc., P.O. Box 239, Park Ridge, NJ 05676.

SWTPC PRODUCT CATALOG

Featured in the latest Southwest Technical Products catalog are kits ranging from hi-fi equipment to electronic music devices, test gear, and light displays. Each item listed is fully described and is accompanied by a photo and full technical description. Address: Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, TX 78216.

JOHN WILEY BOOK ORDER CATALOG

A new catalog that lists and describes 19 electronics engineering books is available from John Wiley. Except for the cover, the entire catalog is divided into 20 post card order forms (no postage necessary). Address: John Wiley & Sons, Inc., 605 Third Ave., New York, NY 10016.

IEEE STANDARDS CATALOG

This new catalog lists more than 350 standards publications by subject as well as in numerical sequence. Included in the new set of listings are the many American National Standards published by IEEE. Address: IEEE Standards Dept., 345 East 47 St., New York, NY 10017.

GR GUIDE TO COAXIAL COMPONENTS

Components and accessories for high-frequency applications (to 9 GHz) are described in a 32-page pamphlet from General Radio. Included are detailed specifications for general-purpose and precision 50-ohm and 75-ohm connectors, adapters, attenuators, terminations, coupling elements, cables, air lines, and a unique low-cost r-f bridge. Address: General Radio, 300 Baker Ave., Concord, MA 01742.

SANYO CONSUMER ELECTRONICS CATALOG

The complete line of Sanyo consumer items is described in a new 52-page booklet. Full-color photos, descriptions, and important features are outlined for such items as color and monochrome TV receivers; portable and clock radio receivers; tape recorders; stereo systems (2- and 4-channel); and automotive radios and stereo equipment. Address: Sanyo Electric Inc., 1200 W. Artesia Blvd., Compton, CA 90220.

RCA LINEAR IC REPLACEMENT GUIDE

An updated "Linear IC Direct-Replacement Guide" (No. CRG-110A) is available from RCA Solid State Division. It includes the solid-state devices of 13 industry manufacturers and reflects the change in RCA linear-IC type designations. To simplify the recognition of second-source IC's in the linear line, type numbers have been changed to include the exact source manufacturer's type number, except for the CA prefix and package identification suffix letters. (Address: Box 3200, Somerville, NJ 08876).

MAXELL TAPE GUIDE

Maxell Corp. of America dealers have a 24-page Tape Guide that tells the complete story about magnetic recording tapes. It describes how tapes are manufactured for specific recording devices and provides a basic understanding of recording bias, record and playback equalization, etc. (Address: 130 W. Commercial Ave., Moonachie, NJ 07074).

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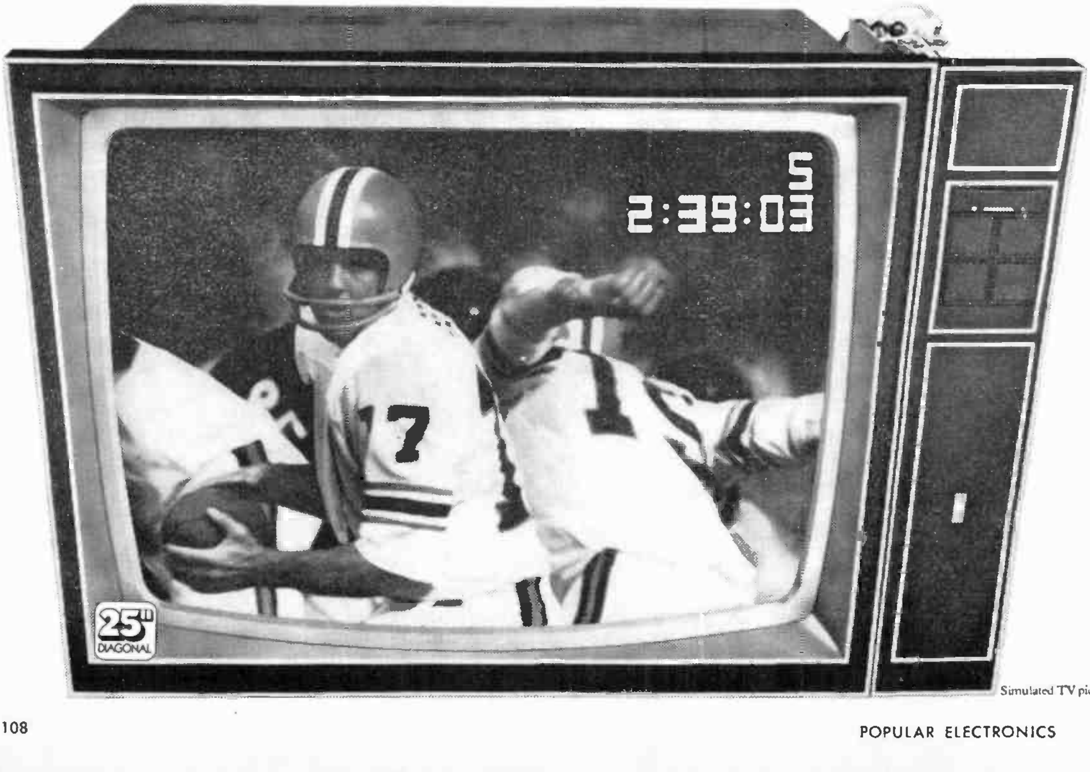

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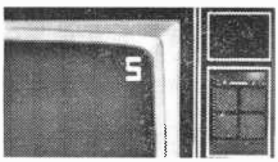
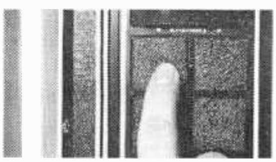
Channel numbers that flash on the screen



Wait until the neighbors see that *your* TV has channel numbers that actually flash on the screen! You can even pre-set how long you want them to stay on before fading.

Automatic pre-set channel selector



With just the push of a button, your favorite channels come on in the sequence you pre-set. All "dead" channels are skipped over. You can even intermix UHF and VHF channels!

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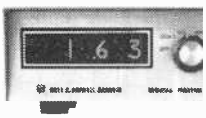

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Electronics Library

UNDERSTANDING AND USING THE OSCILLOSCOPE

by Clayton Hallmark

Presupposing no prior knowledge whatever on the part of the reader, this book tells how to set up any type of oscilloscope, calibrate it, and use it for small- and large-signal voltage, frequency, phase, time, response, gain, modulation percentage, and a host of other applications. It covers scope construction, sweep circuits, timebase circuitry, sync circuits, blanking and unblanking, probes, how and why of linearity, checks for distortion within a scope, intensity modulation, interpretation of Lissajous figures, direct and indirect phase measurement, and electronic switching for dual-trace displays. Covered also are special-purpose devices in which CRT's are used.

Published by Tab Books, Blue Ridge Summit, PA 17214. 256 pages. Hard cover $7.95; soft cover $4.95.

ELECTRONIC TROUBLESHOOTING: A MANUAL FOR ENGINEERS AND TECHNICIANS

by Clyde N. Herrick

The theory of electronics is kept to a minimum with emphasis on troubleshooting techniques. A broad spectrum of topics has been chosen for instruction, including AM and FM broadcast radio receivers, stereo/hi-fi equipment, tape recorders, color and monochrome TV receivers, TV cameras, tape recorders, radio transmitters, electronic organs, digital computers, etc. Solid-state circuit analysis and testing are stressed, as are the standard and specialized test equipment needed for troubleshooting today's electronic equipment.

Published by Reston Publishing Co., Inc., P.O. Box 547, Reston, VA 22090. Hard cover. 306 pages. $15.95.

QUESTIONS AND ANSWERS ABOUT NOISE IN ELECTRONICS

by Courtney Hall

Why is noise important? What is "shot" noise? How can noise figures be measured using a signal generator? These and many more pertinent questions are answered in this book for the engineer, technician, and experimenter. The Q & A approach provides a quick basic understanding of noise characteristics and noise measurement techniques for practical applications in electronics. Discussed are white, pink, man-made, atmospheric, and galactic noises and their importance. Next come discussions on thermal and shot noise, noise bandwidth, special considerations for noise, S/N ratio, noise figure, etc.

Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Soft cover. 96 pages. $3.95.

ELECTRONICS FOR MODERN COMMUNICATIONS

by George A. Angerbauer

If you are seeking an amateur or a commercial FCC license, this book contains the latest information that you need to prepare for taking the licensing exam. It presents all of the material in a step-by-step method, progressing from basic simple concepts to the more complex ones, while establishing a valuable continuity from one element to the next. Material included on transistors and other solid-state devices reflects the latest FCC questions asked. The questions following most chapters have been compiled in full accordance with the latest FCC Study Guide Revisions. Hundreds of drawings illustrate all of the material throughout the book.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hard cover. 662 pages. $15.95.

ILLUSTRATIONS IN APPLIED NETWORK THEORY

by F.E. Rogers

Although this book is intended for intermediate college-level engineering courses, its math level rarely rises above simple algebra and trigonometry. The text emphasizes the importance of natural frequencies that correspond to the poles and zeros of synthesis specification through illustration of their roles in time and frequency domains, in specification of characteristics at real frequencies, and the behavior of amplifiers with various feedback arrangements. The reader is introduced in simple ways to the indefinite admittance matrix as a nodal-voltage analysis tool and the basis of Darlington's transfer function procedure for a terminated-reactance two-port network, to the scattering coefficient, and to the concept of a scattering matrix.

Published by Crane, Russak & Co., Inc., 52 Vanderbilt Ave., New York, NY 10017. Hard cover. 228 pages. $11.75.

New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

TI SLIDE-RULE CALCULATOR

A new full-function slide-rule calculator from Texas Instruments Inc. costs only $169.95. The Model SR-50 calculator features an easy-to-use algebraic keyboard with circuitry that permits numbers and functions to be entered in the same order as they are written. It performs the four basic arithmetic functions, reciprocals, squares, square roots, nth powers, nth roots, factorials, trigonometric and hyperbolic functions (sine, cosine, tangent), inverse trig and hyperbolic functions, common and natural log functions, and e^x. Answers to problems are calculated to 13 significant digits, with the answer automatically converted to scientific notation when it exceeds 10^{10} or is less than 10^{-10}.

Circle No. 68 on Reader Service Card

SCHOBER BASIC POWER AMPLIFIER

The Model TR-3 basic power amplifier from Schober Organ Corp. is offered in both stereo and mono versions at outputs of 70 watts/channel. Unusual features include push-pull operation of all stages and direct coupling throughout. At a steady-state 70 watts into 8 ohms, the power bandwidth is 5 to 40,000 Hz ±0.5 dB. THD is less than 0.1 percent, and IM distortion is less than 0.07 percent. Sensitivity can be set

with a special control so that only 150 mV is needed at the input for full output power. The Model TR-3D 2-channel kit sells for $194.90; the Model TR-3M mono kit sells for $142. A model TCK-3 mono-to-stereo conversion kit is also available for $59.20.

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TRIPLETT "3-IN-1" TESTER KIT

Triplett Corporation's versatile new Model 615 VOM for appliance, industrial, commercial, and residential maintenance jobs is now available in kit form. The Model 615-K kit provides a single package containing the Model 615 VOM, the Model 20-A clamp-on ac ammeter adapter, the Model 101 ac line separator, 48-in. test leads, a 6-ft thermocouple probe, alligator clips, batteries, and instruction manual—all in a rugged carrying case that is lined with shock-isolating plastic form. (Price is $180).

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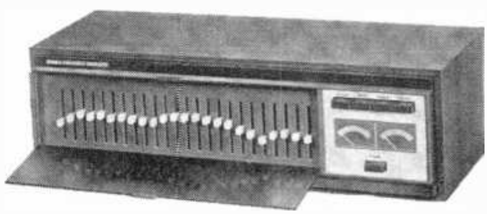
BSR 12-OCTAVE FREQUENCY EQUALIZER

The Model FEW-3 frequency analyzer from BSR Electronics Inc. covers 12 full octaves with 24 individual controls for complete and pre-



cise adjustment of each of two stereo channels. It is equipped with two VU meters for use with calibrated sound level meters. Unlike other equalizers, it is designed to permit convenient equalization while making a recording. Distortion is less than 0.007 percent and noise is 80 dB down. A translucent flip-down front panel protects the slide controls from accidental movement that would upset the equalization.

Circle No. 71 on Reader Service Card

LAFAYETTE 4-WAY SPEAKER SYSTEM

The Lafayette Radio Electronics Corp. top-of-the-line floor-standing speaker system (stock No. 21-05054HWX) has a nominal impedance of 8 ohms and will handle 100 watts of input power. The four-speaker, four-way system is housed in a 5.4-cu ft acoustic-suspension enclosure. Its overall frequency range is 18 to 22,000 Hz, with crossovers at 400, 900, and 7000 Hz. The driver complement includes a 15-in. woofer with 12-lb magnet structure, 8-in. midrange driver with 2½-lb magnet structure, 5-in. upper midrange driver with 2-lb magnet structure, and 2-in. direct-radiator super tweeter. Separate high, upper-midrange, and lower-midrange controls are provided for tailoring the system's response to the listening environment. (Price is $199.95).

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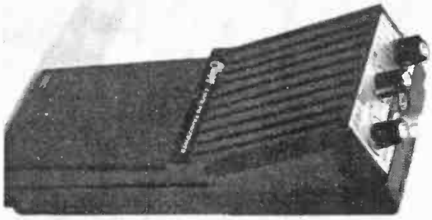
CLEGG HAND-HELD 2-METER TRANSCEIVER

A new solid-state portable 2-meter FM transceiver designed to provide the ham with reliable performance at low price ($289) is available



from the Clegg Division of International Signal and Control Corp. The Model HT-146 transceiver meets all FCC type-acceptance requirements. It is a 2-watt, five-channel unit that draws only 5 mA of standby current. The receiver section features single conversion, a crystal filter, and solid-state T/R switching. Plug-in crystals make channel changing fast and easy. Jacks for external microphone, speaker, and earphone are included along with a BNC antenna connector and a heliflex antenna. The transceiver measures 8⁵⁄₁₆ in. by 3¹⁄₁₆ in. by 1⁹⁄₁₆ in. and weighs about 1 lb 10 oz.

Circle No. 73 on Reader Service Card

EDMUND SCIENTIFIC BIOFEEDBACK MONITOR

A portable biofeedback system, the "Biosone" (No. 71,809) is available for only $49.95 from Edmund Scientific Co. It picks up alpha and theta brainwaves and provides an audio signal for monitoring their increase and decrease. The Biosone contains narrow-band filters that isolate the brainwaves and a high-gain, low-noise amplifier with a 5-μV sensitivity. The unit includes stethoscope earphones, a headband with permanent electrodes, a neckband that eliminates the need to hold the unit, electrode cream, complete instructions, and a one-year warranty.

Circle No. 74 on Reader Service Card

DATA TECHNOLOGY DMM MEASURES C

A new 3½-digit bench-type digital multimeter that measures ac and dc voltages, resistance,

and capacitance has been introduced by Data Technology Corp. The Model 20 DMM is said to be the first precision, easy-to-use capacitance meter that sells for less than $300. It has a resolution of 1 pF and an accuracy of 2 percent of reading. There are four dc voltage ranges (to 2000 V) with 1-mV resolution and 0.1-percent accuracy; four ac voltage ranges (also to 2000 V) with 1-mV resolution and 0.5-percent accuracy; and four resistance ranges with 1-ohm resolution and 0.2-percent accuracy. The instrument consumes 3.5 watts of power and employs ⅓-in. Sperry gas-discharge readouts. (Price is $269).

Circle No. 75 on Reader Service Card

PIONEER OPEN-REEL TAPE DECK

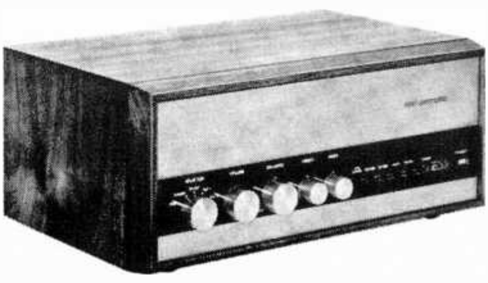
The U.S. Pioneer Electronics Corp. Model RT-1020 tape deck is a three-motor/three-head unit that features a 2/4-channel stereo playback head. The 15- and 7½-ips deck will accom-

modate professional 10½-in. tape reels. It offers unique two-step equalizer and three-step bias selection that permits its use with all available tape formulations. The deck will record and play back in the standard 2-channel/4-track stereo format. Additionally, the playback head permits playback of discrete 4-channel stereo tapes.

Circle No. 76 on Reader Service Card

ESS STEREO PREAMPLIFIER

The ESS Stereo Preamplifier has harmonic and intermodulation distortion figures of 0.0075 and 0.005 percent, respectively. Noise is down



100 dB in the high-level section, 96 dB in the tone control section, and 80 dB (referenced to a 10-mV, 1000-Hz input signal) in the phono preamplifier section. The bandwidth and frequency response in the high-level section at ±0.025 dB is 10 to 40,000 Hz, becoming 2 to 2,000,000 Hz at ±1.0 dB. In the tone control section, the response is 10 to 25,000 Hz ±0.025 dB or 2 to 150,000 Hz ±1.0 dB. And in the phono preamp section, it is ±0.25 dB from the RIAA curve, 20-20,000 Hz.

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XCELITE METRIC DRIVER SET

A compact convertible hex socket screwdriver set, the Model PS-90MM, manufactured precisely to metric dimensions is now available from Xcelite Inc. The set includes eight hex socket drivers plus the company's original "piggyback" torque amplifier handle that slips over the tops of the midget tools to provide longer reach and greater driving power. Hex tip drivers on the 4-in. long shanks range in size from 0.89 mm to 5.0 mm. The drivers and handle are supplied in a flexible plastic see-through case with integral molded-in snap lock.

Circle No. 78 on Reader Service Card

REGENCY HAND-HELD MONITOR/SCANNER

The introduction of a hand-held, four-channel scanning monitor receiver—the Model ACT-P-4H—has been announced by Regency Electronics,, Inc. The compact receiver features pushbutton control for each of its four frequencies, fast/slow scan operation, and stop-scan for listening to any one channel. It has a telescoping antenna and external provisions for powering from an optional ac power supply and battery charging accessory. (Price is $119, plus crystals).

Circle No. 79 on Reader Service Card

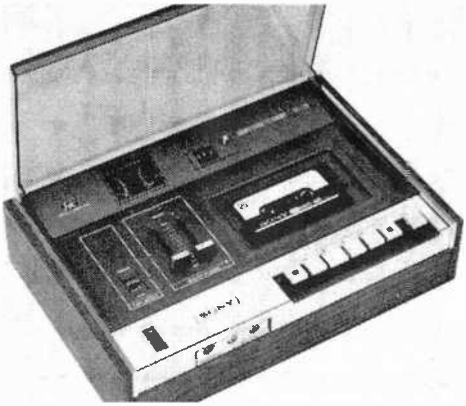
COLE-FLEX AEROSOL SOLVENT & CLEANER

The all-purpose CD-240 solvent and cleaner from Cole-Flex Corp. is most effective on printed circuits, pc boards, and general bench use. It is said to have no flash or fire point, low resisdue, low toxicity, good solvency, and excellent electrical properties. The spray will leave no visible effect on most materials and insulations commonly found in the electronics/electrical industries, with the exception of polystyrene. (Price is $2.10).

Circle No. 80 on Reader Service Card

SONY CASSETTE DECK

The new Sony Model TC-129 stereo cassette deck available from Superscope offers many features for a $149.95 unit. In its design, are Sony's Ferrite head for extended life, automatic shut-off at tape's end in both the record and



playback modes, a tape selector switch for selecting the proper equalization for standard and chromium dioxide tape, illuminated dual VU meter, and straight-line record level controls. Other features include a built-in dust cover, three-digit tape counter, locking pause control, a stereo headphone jack, and a walnut base.

Circle No. 81 on Reader Service Card

GOLD LINE MULTI-BAND ANTENNA COUPLER

The Model GLC 1079 multi-band antenna coupler from Gold Line allows you to use the standard radio antenna in your car to monitor the 20-70-MHz, 148-174-MHz, and 250-470-MHz bands (with the appropriate receiver) as well as the AM and FM broadcast bands. The coupler installs, via two cables provided, between the antenna and receiver being used. The receiver's antenna input plugs into or screws onto the appropriate connector mounted on the coupler's housing. (Price is $12.95).

Circle No. 82 on Reader Service Card

TECHNICS BY PANASONIC RECEIVER

The Model SA-6700X Technics by Panasonic 4-channel AM/stereo FM receiver generates 92 watts of total continuous rms power when all four channels are driven simultaneously into 8-ohm speakers. The receiver offers a 1.8-μV FM sensitivity. Built into the receiver is a multi-function oscilloscope that visually displays signal distribution in all channels simultaneously.

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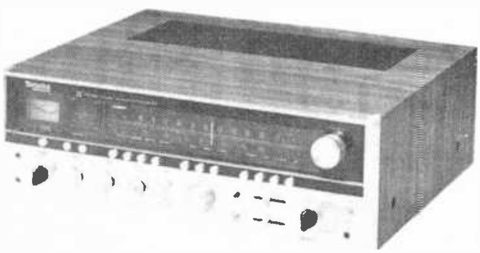

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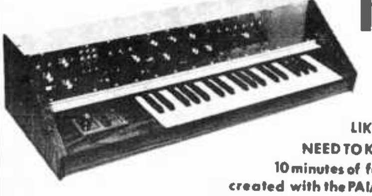

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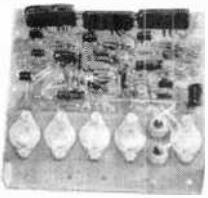

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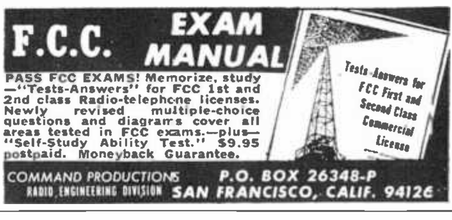

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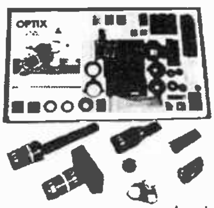

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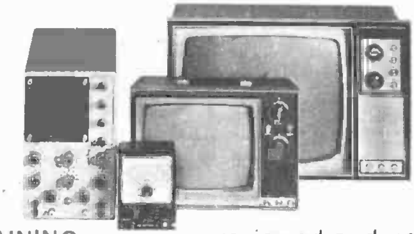

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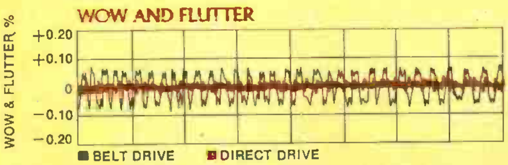

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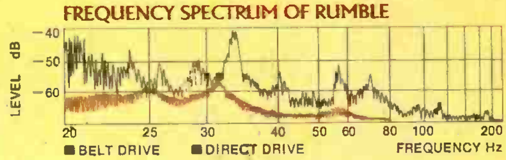

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