HOW TO INSTALL A NEW CAR AUDIO SYSTEM

MARCH 1994

48783

Electronics NOW®

Combined with Radio-Electronics®

BUILD THIS PC-BASED FUNCTION GENERATOR

Build This
Distinctive Ring Detector
and get the benefits of a second phone line at a fraction of the costs

Trace back to the
Roots Of Radio
with regenerative receivers

Send control signals over your house wiring with this
Power Line Modem

A GERNSBACK PUBLICATION

$3.50 U.S
$3.95 CAN

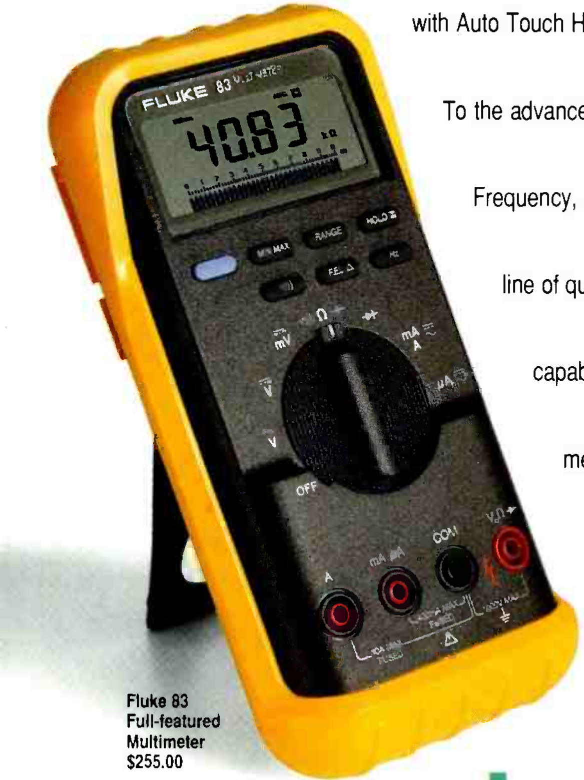
All about transistor-based
Audio Preamplifiers

PLUS: Hardware Hacker • Audio Upda[te] • Video News • And Lots More!

Multi-Choice.

Whether you're doing first-level troubleshooting or component-level diagnosis, Fluke meters offer you one of the widest choice of capabilities and price ranges in the industry. Choices ranging from the basic Fluke 12 with auto function V-Chek™ and Continuity Capture™. To the classic Fluke 77 with Auto Touch Hold® and current measurements. To the advanced Fluke 83 with Min/Max/Average recording, Frequency, Duty Cycle and Input Alert™. Plus a full line of quality accessories to extend those capabilities even further. No matter which Fluke meter you choose, you can count on precise, reliable, consistent performance year in and year out. Plus, strong customer support and product warranties that measure up to any in the industry. Make the choice that gives you the most choices.

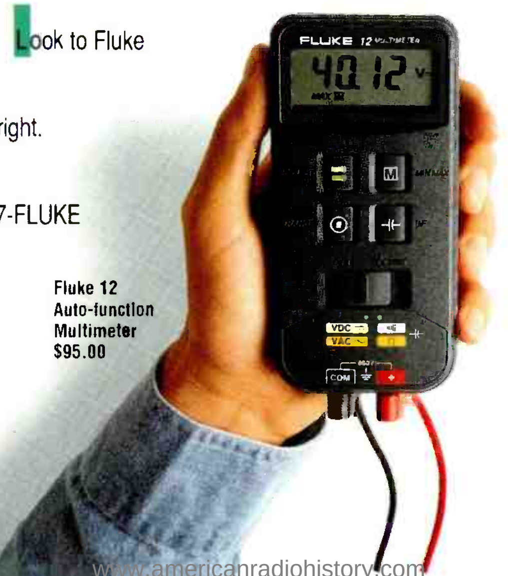
Fluke 77
The classic
Multimeter
$169.00



Fluke 83
Full-featured
Multimeter
$255.00

Look to Fluke for the tools you need to get the job done right.

See your Fluke distributor, or call 1-800-87-FLUKE for a catalog and the name of the distributor nearest you.



Fluke 12
Auto-function
Multimeter
$95.00

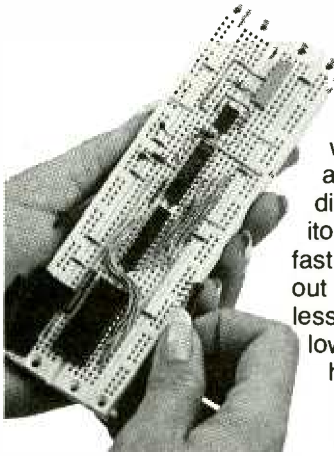
FLUKE 12	FLUKE 77	FLUKE 83
The Fluke meters listed above feature DC/AC voltage, resistance, audible continuity and diode test.		
Capacitance measurements	Auto Touch Hold®	Auto Touch Hold® and Relative modes
V Chek™ (auto function)	Current measurements	Current measurements
Min/Max Record with Relative Time Stamp	Analog/Digital display	Analog/Digital display
Two-year warranty	Three-year warranty	Three-year warranty
Continuity Capture™	Yellow holster with Flex Stand™	Yellow holster with Flex Stand™
Basic accuracy 0.9%	Basic accuracy 0.3%	Input Alert™
	For measurements to 4800 V·A	Capacitance measurements
		Frequency and Duty Cycle
		Min/Max/Avg. Recording
		Basic Accuracy 0.3%

John Fluke Mfg. Co., Inc.
P.O. Box 9090, Everett, WA 98206
For more information call:
(416) 890-7600 in Canada
(206) 356-5500 from other countries

FLUKE®

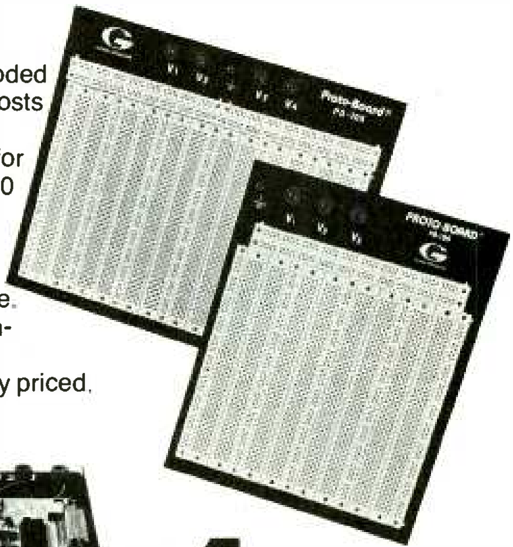
CIRCLE 121 ON FREE INFORMATION CARD

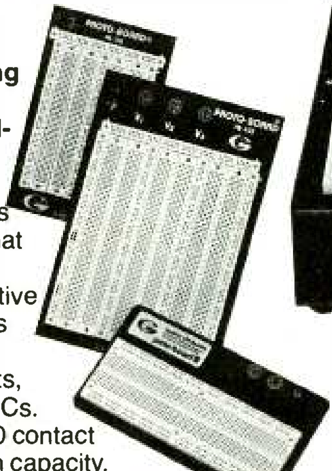
5 WAYS TO STOP WASTING TIME IN ELECTRONICS.



Stop wasting your time soldering. Save hours of soldering, desoldering, resoldering with Quick Test™ sockets and bus strips. Connect/disconnect resistors, capacitors, transistors, ICs, etc. as fast as you can push in/pull out leads. Interlock for limitless expandability. Priced as low as $1.60, you'll wonder how you've done without them!

5-color coded binding posts and 17 sockets, for over 4,560 contact points. Lifetime guarantee. American-made. Affordably priced.





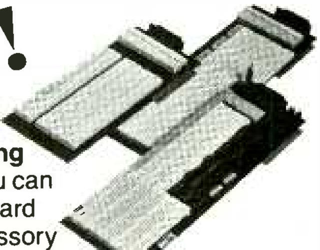
2. Stop wasting your time breadboarding. Here are three popular PROTO BOARD® Brand solderless breadboarding systems that meet any budget or time schedule. First the diminutive PB-10's 840 contact points and 3-color binding posts. PB-102 has 1,240 tie points, accepting up to 12 16-pin ICs. Finally, PB-103, with 2,250 contact points, and up to 24 16-pin capacity. They're affordable, American-made, lifetime guaranteed. You'll soon see why PROTO BOARD Brand is Today's Standard for Quality in Breadboarding.

4. Stop wasting your time plugging-in external power. We've added the power to the breadboard. And, what power! Up to triple voltage power, +5V, +12V, −12V, regulated/current limited and DC. Up to 2,250 tie points, with 24 IC capacity and 14 pin DIPs. Now you can create, test and modify TTL, CMOS, Op-Amps and even microprocessor circuits. Plus, there is the standard Global Lifetime Guarantee on the sockets. And, wait 'til you see the modest prices!

FIRST PROTO BOARD BRAND

3. Stop wasting your time jury-rigging large numbers of circuits. Here are two oversized PROTO BOARDS Brand, with expanded area, tie points, and more to keep your ideas together. PB-104 features 3,060 tie points, which can handle to 32 16-pin ICs with ease. Four color coded binding posts, and roomy 9.2" x 8" metal panel make it big...but simple. The humungous PB-105 lets you load up to 48 16-pin ICs, and much more onto its

5. NEW!



Stop wasting time designing computer circuits. Now you can use your solderless breadboard concepts for designing accessory circuits. PROTOCARD® is a PROTO BOARD Brand which fits any standard slot in your IBM, PC/XT or PC/AT computer. Some modules even include built-in basic decoder circuits for memory and I/O addressing. Breadboard areas up to 3,360 contact points. Buffered versions eliminate loading of pc buses.

Easy does it!™

Call toll-free for details
1-800-572-1028

GLOBAL SPECIALTIES

Global Specialties. An Interplex Electronics Company.
70 Fulton Terrace. New Haven, CT 06512.
Telephone: (203) 624-3103.
All Global Specialties breadboarding products made in USA.

CIRCLE 177 ON FREE INFORMATION CARD

A0011

March 1994

Electronics NOW®

Vol. 65 No. 3

BUILD THIS

TECHNOLOGY


THE LOST ART OF REGENERATION

Look again at classic regenerative receivers and their importance in radio history, and build these modernized, transistorized versions

PAGE 66


UPGRADE YOUR CAR STEREO

Install a stereo in your car or remove one for servicing. It is easy to do and will save you money if you follow this procedure.

PAGE 52

DEPARTMENTS

AND MORE

ON THE COVER

If you design radio circuits, an RF (radio-frequency) signal generator is a must-have on your workbench. This month we introduce the TG2000, a PC-based synthesized signal generator. The 2-GHz RF signal generator is an IBM-PC compatible card that can be installed in an 8-bit slot or, with an external power supply, interfaced to a parallel port. Software for the TG2000 is available on the Electronics Now BBS. Turn to page 35 for all the design details.

COMING NEXT MONTH

THE APRIL ISSUE GOES ON SALE MARCH 3.

THE NEW AGE OF SATELLITE TV
A look at the new Direct Broadcast Satellite service.

CIRCUIT COOKBOOK
Audio power amplifier principles.

BUILD THE AUDIO WIZARD
A function generator for testing audio equipment.

ELECTRONICS NOW, (ISSN 1067-9294) March 1994. Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735. Second-Class Postage paid at Farmingdale, NY and additional mailing offices. Canada Post IPM Agreement No. 334103, authorized at Mississauga, Canada. One-year subscription rate U.S.A. and possessions $19.97, Canada $27.79 (includes G.S.T. Canadian Goods and Services Tax, Registration No. R125166280), all other countries $28.97. All subscription orders payable in U.S.A. funds only, via international postal money order or check drawn on a U.S.A. bank. Single copies $3.50. © 1994 by Gernsback Publications, Inc. All rights reserved. Printed in U.S.A.

POSTMASTER: Please send address changes to ELECTRONICS NOW, Subscription Dept., Box 55115, Boulder, CO 80321-5115.

Electronics NOW®

Hugo Gernsback (1884-1967) founder

Larry Steckler, EHF, CET, editor-in-chief and publisher

EDITORIAL DEPARTMENT
Brian C. Fenton, editor
Marc Spiwak, associate editor
Neil Sclater, associate editor
Teri Scaduto, assistant editor
Jeffrey K. Holtzman computer editor
Robert Grossblatt, circuits editor
Larry Klein, audio editor
David Lachenbruch contributing editor
Don Lancaster contributing editor
Evelyn Rose, editorial assistant

ART DEPARTMENT
Andre Duzant, art director
Injae Lee, illustrator
Russell C. Truelson, illustrator

PRODUCTION DEPARTMENT
Ruby M. Yee, production director
Karen S. Brown advertising production
Kathryn R. Campbell production assistant
Lisa Rachowitz editorial production

CIRCULATION DEPARTMENT
Jacqueline P. Cheeseboro circulation director
Wendy Alanko circulation analyst
Theresa Lombardo circulation assistant
Michele Torrillo reprint bookstore

Typography by Mates Graphics
Cover design by David Loewy
Photograph by Bill Westheimer

Electronics Now is indexed in *Applied Science & Technology Index*, and *Readers Guide to Periodical Literature*, *Academic Abstracts*, and *Magazine Article Summaries*. Microfilm & Microfiche editions are available. Contact circulation department for details.

Advertising Sales Offices listed on page 98.
Electronics Now Executive and Administrative Offices
1-516-293-3000.
Subscriber Customer Service:
1-800-288-0652.
Order Entry for New Subscribers:
1-800-999-7139.

Audit Bureau of Circulations Member

EDITORIAL

Keeping Up Your Technical Skills

The Electronic industries Foundation, a division of the Electronics Industries Association (EIA), is developing standards for evaluating electronic technicians' skills. To gain a background for its plans, the Foundation sent questionnaires to working electronics technicians asking them about the strengths and weakness of their formal and informal training. Responses were received for 95 of the questionnaires. The highlights of that survey are:

- Most responding technicians were between 25 and 45 years old, with the majority under 35.

- The respondents were overwhelmingly male—by a margin of 89 to 2. (This suggests that electronics repair is not yet a very attractive occupation for women.)

- All respondents had high school diplomas or equivalency certificates, and 33.3% of those reported that they had Associate in Electronics Engineering or Technology degrees. Another 30% reported that they had attended college.

- Nearly two-thirds of the respondents had participated in on-the-job training on such subjects as microprocessors and personal computers, maintenance of consumer electronics products, and circuit troubleshooting and upgrading.

- In performing their daily work assignments, 92% reported that they used multimeters, 90% used oscilloscopes, and 88% needed a power supply.

However, in my view, the most revealing findings in this survey were the respondents' comments on the value of the courses they studied and their relevance in preparing them for entry-level jobs. Theory was found to be most important, with practical circuit analysis and troubleshooting in second place. Hands-on repair techniques showed up in third place.

What does this mean? It tells me that **Electronics Now** has a very important role in the basic and ongoing training of electronics professionals. It has long provided coverage of the subjects most technicians want and need to know more about—electronic theory, practical circuitry, and the operation of electronic devices and test instruments.

But we could and should improve our coverage of trouble-shooting techniques and problem solving. To do this right we need your help. After all, you are out there doing this on a daily basis. We want case histories, descriptions of your on-the-job learning experiences, and the details on how you solved tough repair problems in a timely and economical manner.

The subjects of your personal experiences can range across the board from servicing computers, communications equipment, and instruments to to the maintenance of consumer electronics products.

What's your reward? If you send us ideas for interesting and informative articles that we can publish, you'll be trebly rewarded: First, you'll get a check; second, you'll have the pleasure of seeing your name and experience in print; and third, you'll gain the satisfaction of knowing that you've helped others like yourself who are keeping up-to-date in a constantly changing and ever challenging field.

Flood my mailbox! Send your suggestions directly to me, Larry Steckler, CET/EHF, **Electronics Now**, 500-B Bi-County Blvd., Farmingdale, NY 11735. We'll work with you to develop some terrific articles. Do it now!

Larry Steckler

Larry Steckler, EHF/CET
Editor-in-Chief and Publisher

WHAT'S NEWS

A review of the latest happenings in electronics.

RF signals deter auto theft.

An ignition key with an embedded transponder that emits a unique digital code and a radio-frequency reader on a car's steering column form a new automobile theft deterrent. This vehicle-immobilization system, based on Texas Instruments' technology, is slated for installation in Ford cars this year.

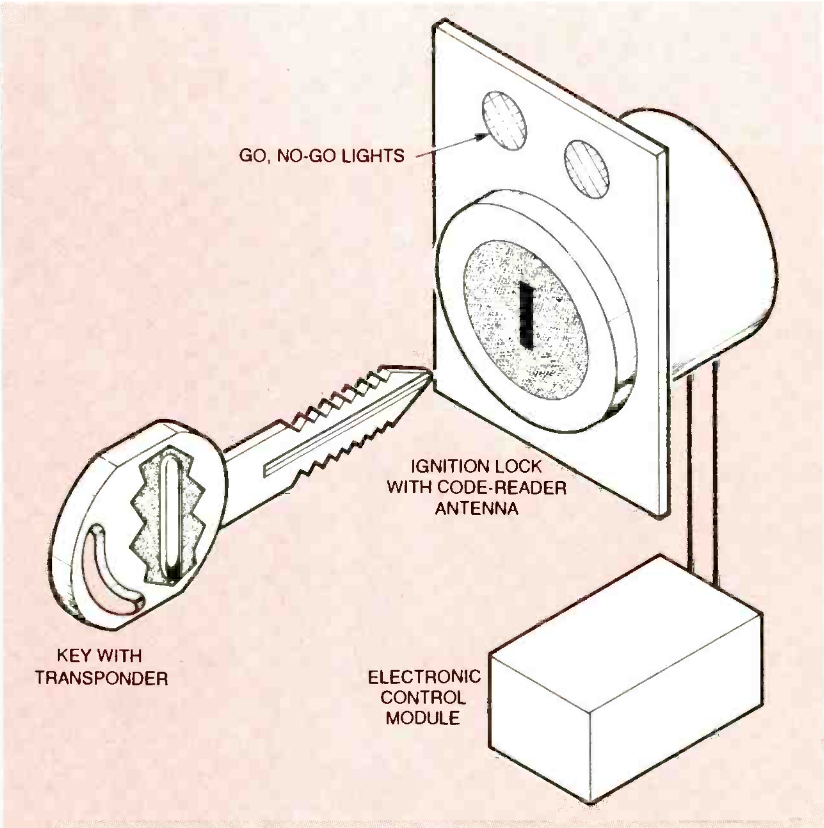
A miniature transponder embedded in the ignition key contains an unalterable factory-programmed 64-bit identification code that is uniquely identified by the system's FM receiver. The transponder consists of a small antenna, an integrated circuit that contains the code, and a capacitor encapsulated in a glass tube. The capacitor is charged by a burst sent from the radio frequency reader.

The code reader's antenna is integrated with the ignition system through the lock barrel in the steering column, and its transceiver is connected to a control module in the engine compartment.

When a key is inserted in the ignition lock and turned, the reader is automatically activated. It transmits a signal that charges the key's transponder. The transponder then transmits its code which is compared to the code stored in the car's control module.

If the codes match, the module enables either the fuel-pump relays or the module itself. However, if the wrong code (or no code) is detected, the car cannot be started. The system might also include go-no-go lamps to indicate if the wrong key was inserted by mistake so the driver would know instantly why the car does not start.

Ford claims that the system is durable, tamper-proof, and virtually transparent to users. It is said to be easier to use than PIN-based systems that require drivers to remember and punch in a security code. According to Ford, it cannot be overridden as can infrared-energy- based security systems.



TEXAS INSTRUMENTS' TIRIS SECURITY SYSTEM FOR FORD CARS includes an ignition key that contains a microminiature FM transponder, a lock in the steering column integrated with a reader receiving antenna, and an electronic control module. The code reader charges a capacitor in the key's transponder so that it emits a 64-bit ID code. The ignition system is activated only if the reader antenna receives the correct ID code.

Ford Motor Company's Electronics Division based the system on Texas Instruments (Attleboro, MA) registration and identification system (Tiris) technology. The security system will be available in Europe in two of Ford's most popular cars, the Escort and the Fiesta this year, and it might be introduced in some U.S. models in 1995.

Future applications for Tiris are seen in automatic car-entry and locking systems, personalized seating and climate control, and for automated access to garages and parking lots. Tiris technology can also identify vehicles in automatic toll-collecting systems.

Kyoto Prize goes to IC pioneer

Dr. Jack St. Clair Kilby, an inventor of the integrated circuit, has been awarded the Inamori Foundation's 1993 Kyoto Prize in Advanced Technology. Kyoto Prizes, established in 1984 by Kyocera Corporation's Chairman Kazuo Inamori, recognize outstanding achievements in disciplines not recognized by Nobel Prize awards. Each 1993 laureate received academic honors and a cash award equal to about $425,000.

Dr. Kilby proposed and confirmed the fundamental concept of monolithic semiconductor integrated circuit, the basis for today's advanced

DR. JACK KILBY WINS THE 1993 KYOTO prize in advanced technology for his pioneering work in monolithic integrated circuits.

microelectronics technology. In 1958 Dr. Kilby integrated a transistor with resistors and capacitors on a semiconductor substrate, creating the world's first known monolithic IC.

A year later, he designed, built, and tested a monolithic flip-flop circuit. Then he became active in the promotion of applications for monolithic ICs. His team was the first to develop a calculator IC and design a compact calculator to use it. Dr. Kilby is now a consultant to Texas Instruments, Inc.

HDTV Grand Alliance announces key technology decisions

A group called the digital high-definition television (HDTV) Grand Alliance presented its decisions on four key digital high-definition TV technologies to the Technical Subgroup of the Federal Communication Commission's (FCC) Advisory Committee on Advanced Television Service.

The four technologies covered in the presentation are: digital video compression, transport, scanning formats, and audio technology. They include modifications of the Grand Alliance system that had been recommended earlier by the Technical Subgroup which endorsed the technology decisions.

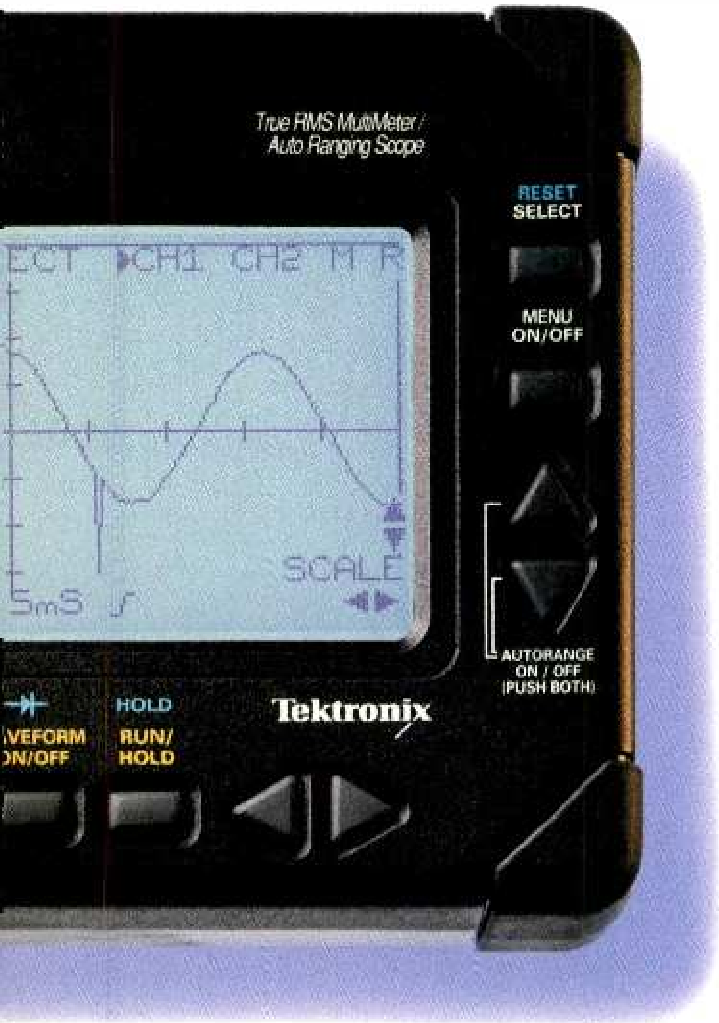
The Grand Alliance represents the merger of three formerly competing groups—AT&T and Zenith, General Instruments and MIT, and a group consisting of Thomson Consumer Electronics, Philips Consumer Electronics, and the David Sarnoff Research Center.

The proposed digital HDTV system is compatible with existing NTSC television broadcasting standards, popular computer operating systems, and accepted telecommunications technology. This compatibility is expected to ensure its place on the much discussed Information Superhighway.

The selected digital video-compression technology is based on international standard MPEG-2 from the Moving Picture Experts Group. It includes the use of "B-Frames," bi-directional frame-motion compensation, a compression technique that improves picture quality.

A packetized data-transport system will permit most combinations of video, audio, and data to be transmitted in packets similar to those formed for advanced telecommunications networks. The system will concentrate on the features of MPEG-2 that are applicable to HDTV and are included in the MPEG-2 transport layer. Ω

l of the trades.



push of a button, you'll see exactly what you're measuring.

Easy to afford, too.

At only 2.2 pounds, TekMeter won't weigh heavily on your belt, and it won't do much damage to your wallet, either. Starting at $859,* the TekMeter packages a remarkable set of capabilities that will enhance your productivity and will be easy to justify.

Put one in your hands today.

Of course, the best way to take full measure of TekMeter is to try it for yourself. For the name of your nearest authorized Tektronix distributor, call 1-800-426-2200, ext. 800 and put one to the test.

Once you've seen everything TekMeter can do—and how easily it does it—we think you'll agree it's the one tool you won't want to trade for anything else.

Come test drive the TekMeter at your local distributor and judge for yourself.

Tektronix

*Suggested retail price

CIRCLE 92 ON FREE INFORMATION CARD

VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• **Video LP CD's.** Although standards have now been set for Video CD's—full-motion video on five-inch compact discs—there's growing pressure to move quickly to a longer playing system that could accommodate a full movie on the same size disc. While the Video CD will accommodate up to 74 minutes of compressed video, a behind-the-scenes movement is exerting pressure to develop a system that can squeeze up to 135 minutes—two hours and 15 minutes—on a disc.

It's understood that Philips Electronics is spearheading the effort to develop a standard long-playing system with laserdisc picture quality to replace tape as a carrier for recorded video. Philips is seeking to mesh the many systems under development into a single, cohesive world standard, for commercialization as early as 1996. Philips has declined to comment.

Japanese manufacturers confirm that developments are on a fast track in their laboratories. The general feeling is that the next carrier of prerecorded video must have a life of at least 10 years. It's generally conceded that the standards must take into account such factors as ease of handling and suitability for production at existing hardware and software factories. Some manufacturers say that green or blue lasers now under development could increase the recording density of a CD enough to accommodate virtually all feature films.

Although many companies, including Sony in Japan, have stated that they will introduce Video CD players and discs using the currently contemplated short-playing system, Michael Schulhof, president of Sony Corporation of America, said recently that the existing Video CD standards have neither the quality nor the playing time to accommodate feature films. The current picture quality, he said, "is a step backward from VHS," and, "packaged video really has to encompass a full movie on one side." He noted that any packaged media to succeed "has to offer an improvement in picture quality."

• **Cable compatibility standards.** The FCC followed up its report to Congress (*Video News*, **Electronics Now**, January 1994) with a proposal to assure compatibility between cable systems and consumer electronic equipment such as TV sets and VCR's. As directed by the Cable Act of 1992, the Commission proposed rather stern rules. The rules are designed to discourage scrambling by cable systems, and they mandate the use of standard channel numbers, and a back-of-set interface that would permit use of the TV or VCR's tuner. Such an arrangement would permit consumers to use such features as picture-in-picture and the capability to watch one channel while taping another.

The FCC's proposed rules are tough on both cable systems and consumer-electronic products. They lay down specific requirements that any product must meet to be advertised as "cable ready." Those include the incorporation of a new standard back-of-set interface, capability to tune all standard cable channels with frequencies up to 1 GHZ, and improved receiver performance—rejection of adjacent channel interface and direct pickup, along with standards to minimize tuner overload and signal leakage. The FCC proposes that the new standards go into effect for all products made or imported after December 31, 1996 that are advertised as being compatible with cable systems.

Under the Cable Act, the FCC must adopt strict rules for compatibility by April 4. The Commission's proposed rules contain some that would go into effect as early as next October. Those would eliminate scrambling of basic-tier channels, require cable systems to give subscribers the option of receiving unscrambled channels directly over the air, bypassing cable boxes. Cable companies would also be required to provide boxes that permit consumers the full use of their TV and VCR features on request, as well as requiring systems to inform consumers about all of their options.

• **Widescreen TV sales slow.** Although several companies have introduced widescreen TV sets with 16:9 aspect ratios, sales have been quite slow, presumably due to high price and the shortage of available widescreen programming. Philips, which had announced that it would offer a 34-inch widescreen set to the American consumer market at a suggested retail price of about $6000, changed its mind and decided that the set would be aimed at the broadcast and special commercial-monitor market instead.

Thomson, which started marketing 34-inch sets under the RCA and ProScan brands last April, conceded that sales had fallen short of the 10,000–15,000-set goal it had said it would like to see in 1993, but blamed the shortfall on the shortage of picture tubes of all kinds last year. The company has introduced new widescreen models for both brand lines and cut the price so that they could be sold for less than $4000. It added such inducements as $500 worth of free laserdiscs or a $749-value laserdisc player as premiums with the purchase of the sets.

Although there is very little widescreen programming being broadcast, there is a large variety of laserdiscs that use letterbox aspect ratios, and Thomson thinks that laserdisc owners are the prime prospects for widescreen sets. Ω

Experience The New Technology Behind Today's Advanced Computer Systems With...

McGraw-Hill's Computer Electronics Series

NEW! Now you have a fast, easy, low-cost way to meet the challenges of today's computer electronics. McGraw-Hill's unique new learning series is as innovative as the technology it explains, as fascinating as the experiments you perform.

From circuit theory to the Pentium chip, you master one subject at a time with the McGraw-Hill Computer Electronics Series. Twelve unique modules, sent to you one every 4-6 weeks, give you a thorough understanding of such subjects as digital logic, microcomputer operation, data storage devices, data communications, PC servicing, local area networks, and more.

Each module goes right to the heart of the matter. You waste no time on extraneous material or dry history. Instead, you get a fast, efficient, and lively learning experience...a nontraditional approach to the most modern of subject matter.

Unique interactive instruction

Your learning experience is reinforced through the integration of vividly illustrated text with actual electronic experiments. In fact, by the time you complete your sixth module, you will have assembled the McGraw-Hill Prototyping Design Lab, a breadboarding lab you'll use long after you complete the series for building up and testing prototype circuits. Your modules also feature indexed binders to preserve your text, backup materials, and notes for convenient referral.

Your adventure begins with Module 1

With your very first module, you'll begin to understand the technology behind today's most advanced computer systems.

You'll be introduced to basic electronics principles and discover the role of key electronic components, including resistors, capacitors, and transistors.

Before long, you'll be recognizing symbols and know how to construct circuits using schematic diagrams. Best of all, you'll actually build up live circuits as you begin the assembly of the McGraw-Hill Prototyping Design Lab.

Each module adds more to your expanding knowledge of computer electronics

Step by step, each module builds your knowledge and confidence. In all, 12 modules take you quickly from the basics to today's sophisticated computer concepts:

- Electronic Circuits and Components
- Semiconductors and Linear Applications
- Digital Logic Fundamentals
- Flip-Flops, Counters, and Registers
- Microcomputer Fundamentals
- Mass Data Storage Systems
- Data Communications
- Graphics Display Systems
- Embedded Microprocessor Controllers
- Print Technologies
- PC Servicing
- Local Area Networks

For anyone interested in computer electronics

McGraw-Hill's Computer Electronics Series is designed for anyone from hobbyist to professional. It's for you if you're finding that computers are playing an increasingly important role in your work...if you're a teacher or trainer who wants an update in contemporary computer circuits...or if you're simply fascinated by today's computer technology and want to know more about it.

It's even for electronics engineers or computer technicians who want to refresh their skills.

In short, McGraw-Hill's Computer Electronics Series is an ideal way to understand the technology at work in today's computers... and it's the quickest, most convenient, and probably the least expensive way to do it. And the only one that gives you hands-on experience.

15-day no-risk trial

We invite you to prove to yourself that McGraw-Hill's Computer Electronics Series is all we say it is...without risk and without committing yourself in any way. Order today, and we'll send you your first module — Electronic Circuits and Components — for a free, 15-day examination. If you're not absolutely certain that this is an enjoyable as well as highly effective way to learn, simply return the module to us.

If you wish to continue, we'll ship the remaining modules automatically, about once a month, on the same Free Examination basis.

Send for your first module today! And let McGraw-Hill guide you into the fascinating world of Computer Electronics.

FREE 15-DAY TRIAL! SEND TODAY!

Computer Electronics Series
McGraw-Hill Continuing Education Center
4401 Connecticut Avenue, NW, Washington, DC 20008

YES! I'm interested in learning computer electronics and would like to examine the first module in the series. If I decide to keep it, I will pay just $24.95 plus $2.25 shipping and handling. I will then receive future modules automatically, one every 4 to 6 weeks, at the same low price and on the same 15-day Free Examination basis. There is no minimum number of modules I must buy, and I may cancel at any time simply by notifying you.

Name ______________________
(please print)
Address ______________________
City/State/Zip ______________________
Telephone(______) ______________________ 2001-0394

All orders subject to approval and payable in U.S. funds only. Available in U.S. and Canada only.

AUDIO UPDATE

The dynamics of music and the evolution of audio instrumentation

LARRY KLEIN

As I indicated last month, I didn't find much of interest at the recent Audio Engineering Convention (AES) in New York City. But that is more a reflection of my perhaps overly narrow focus on home audio than of the presentations and exhibits at the convention. The exhibitor directory listed over 350 manufacturers of professional audio equipment, with booths displaying everything from cassette loaders and music synthesizers to broadcast and recording consoles. A home-audio person scanning the list would find only about two dozen familiar names (including Denon, Sony, Carver, Shure, Panasonic, Audio Technica, and Yamaha) representing home-audio equipment manufacturers that had professional products.

One of the presented papers that caught my eye was "The Dynamics of Recorded Music" by McManus, Evens, and Mitchell (AES preprint 3701 B1-AM-1). Before discussing the paper, some background is in order. When I first became involved in audio—I guess it was shortly after the invention of the wheel—it was difficult, if not impossible, to find out exactly what recorded music demanded of the playback equipment. Manufacturers' claims about recorded rise times, frequency bandwidths, or dynamic ranges were difficult to confirm because the available measuring equipment wasn't up to the task.

Instrumentation advances

About 25 years ago—when the appropriate instrumentation became available—I participated in an investigation of the rise-time characteristics of live music waveforms. We used a B&K microphone with a 30-kHz response feeding a triggered Tektronix scope. Because storage scopes were not yet available, we arranged for the camera shutter to be triggered at the same time as the scope sweep. This provided photographic storage of the initial waveforms produced by cymbals, temple blocks, and chimes. I don't remember the waveforms we obtained, but it was quite clear that, despite the claims, an amplifier's ability to pass a 50-kHz square wave had no real-world significance for music reproduction.

Then there was the question of exactly what frequencies were present on the widest range LPs. Claims ranged from 16 Hz on the low end to 20 kHz on the high end. Perhaps needless to say, the advent of the real-time analyzer did a lot for truth in recorded frequency advertising.

Some of you may remember the big speaker versus little speaker arguments that used to clutter the pages of hi-fi magazines. One of the claims in favor of the big speakers was that the heavy cones in the comparatively small acoustic suspension systems made it difficult for them to deliver bass at low drive levels. Inertia was said to be the culprit since it obviously took more energy to get a heavier cone moving than a light one.

I borrowed one of the new General Radio real-time analyzers and a pink-noise generator and had one of my technical writers run tests on an Altec A-7 (big!) and an Acoustic Research AR3 (little). The real-time analyzer clearly showed that the frequency responses of both speakers were independent of their playing level; from soft to loud the responses were unaltered.

So how come the Altec sounded better at low playing levels than the AR? The RTA curve of the Altec showed a broad hump centered (as I recall) at about 200 Hz at all playing levels. I was later told that in the speaker's original commercial application as a movie-house speaker this helped to project its sound through the screen. In the home environment, the 200-Hz hump lent a full, sonorous quality to the A-7's sound that attracted many audiophiles in its day. And at low playing levels, the low-end bump served as sort of a Fletcher-Munson loudness compensation to compensate for the ear's normal loss of low-bass response at low listening levels.

The AR speaker, on the other hand, being reasonably flat over the same range by comparison, seemed bass shy at low levels. (Do I need to point out that it makes more sense to start with a flat-response speaker and add equalization as needed than to have a speaker with a built-in bump that comes through on all program material whether it's musically helpful or not?) After I wrote up the results in *Stereo Review*, I received—as expected—a number of outraged letters from A-7 owners.

Dynamic headroom

The AES paper mentioned earlier addresses the question of the dynamic range of music and its relationship to the current Electronic Industries Association's Dynamic Headroom measurement standard. The first edition of the current EIA amplifier standard stated: "Particularly noteworthy is the introduction of a new measurement, Amplifier Dynamic Headroom, that addresses itself to the power output capability of an amplifier when that amplifier is called upon to handle music-waveform signals rather than continuous sine-wave signals."

Not noted were the lengthy behind-the-scenes debates that preceded the adoption of the new standard. Some of the engineers on the standards committee needed to be convinced that the Dynamic Headroom rating would not open the door to more of the wildly exaggerated amplifier-power numbers that were an unhappy fact of hi-fi life in the early 70's. Others simply had difficulty accepting that unregulated power supplies could have special merit in hi-fi applications.

Briefly, the story is this: Music is

mostly moderate in level with substantial, but short-lived, peaks of 10 to 20 dB. An amplifier designed to deliver continuous power at the anticipated peak levels (say, 200 watts) is likely to have large heat sinks, a substantial power transformer, and a price that reflects its very heavy duty construction.

If, instead, an amplifier is designed to provide, say, 100 watts, and a substantial dynamic headroom of, say, 3 to 6 dB to handle the peaks, worthwhile savings are realized in size, weight, and cost, without significant tradeoffs in performance.

In short, given two quality amplifiers with the same continuous power, the one with the highest headroom is preferred; given two amplifiers with the same dynamic headroom, the one with the highest continuous power is preferred.

Dynamic duration

When the amplifier committee finalized the standard on dynamic-headroom measurements in 1976, we specified 20 milliseconds as a plausible headroom duration that was also within the capabilities of the amplifier-design technology of the day. The AES paper that prompted this long digression argues that 20 milliseconds does not encompass the actual waveform peaks of music and details a very sophisticated series of tests carried out to prove the point.

The authors used a custom-built, PC-based data-acquisition system that could sample a music input 200 times per second! Each reading consisted of two values: peak and mean-square (average). About 150 tracks of a wide variety of musical recordings were analyzed, yielding over 100 computer-drawn graphs.

I found no surprises in the authors' conclusions that an amplifier is a more efficient reproducer of music if designed to have a high dynamic headroom that extends up to 200 milliseconds or more. They add that when an amplifier is intended to handle the most demanding musical signals at live-music levels, a high steady-state power is a necessary complement to its dynamic headroom. I couldn't agree more! Ω

LETTERS

Write to Letters, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

WORLD BAND RECEIVER UPDATE

My "World Band Receiver" article, which first appeared in the January 1993 issue of **Electronics Now** and was reprinted in the 1993 issue of *Radio Craft*, has been so popular with builders that one supplier of the variable tuning capacitor, C49, Fair Radio Sales No. C12/T784, has completely sold out his stock! It is the source listed in the article.

For those still planning to build the receiver, I recommend the following changes:

1. Substitute capacitor No. P7761569-7 from Fair Radio Sales, Lima, OH 45802, for No. C12/T784 in the parts list. It is variable from 14 to 62 picofarads and it is priced at $4. Although it is larger than the C12/T784, it will fit in the location

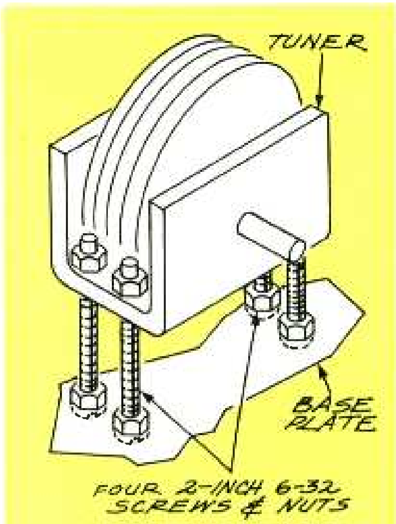


FIG. 1—FOUR STANDOFF POSTS for the World Band Receiver tuning capacitor are 6-32 × 2-inch screws.

on the metal case shown in the article. A surplus capacitor, it has a ¼-inch dial-mounting shaft. Mount it with the stator plates above the shaft by fastening it with four 6-32 × 2-inch machine screws through the sheet metal, as shown in Fig. 1.

2. Replace 735-picofarad capacitor C43 in the tuning circuit with a 330-picofarad unit. (Fair Radio Sales has these in stock.) The coil specified, L1, must be replaced by one with 17 turns of No. 20 enameled-copper wire with a tap located four turns from the ground end. This will still leave room to mount the 2 × 3-inch circuit board for the VFO circuit under the capacitor between the 2-inch mounting screws.

JOHN PIVNICHNY
Vestal, NY

MODIFIED DIVERSITY CIRCUIT

I love the diversity circuit ("Build a Diversity Antenna System and Improve the Performance of Any Car Stereo," **Electronics Now**, November 1993) because out here in the sticks where I live, the "picket fence" effect is especially severe. There are many water, amateur radio, transmission and other towers around here.

However, I had a some problems adapting the circuit to my car stereo. I own a 1975 Mercedes Benz with a removable 1987 Clarion stereo. A few years ago, after I got tired of resetting the memory, I installed a nickel-cadmium rechargeable battery pack from an old cordless phone along with a diode and a pair of resistors.

I found I had trouble setting the 20

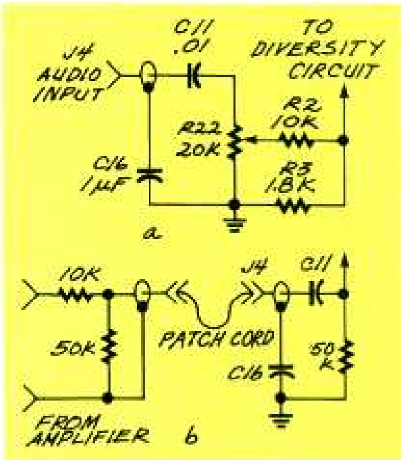


FIG. 2—INPUT STAGE for the Diversity Circuit (*a*) was altered to accommodate a stereo auto-level control (*b*).

K trimmer potentiometer R22 in the diversity circuit because my stereo has an auto-level control. To solve this problem, I changed the input of the diversity circuit, as shown in Fig. 2. Now I feed R22 through another resistor directly from the amplifier, and the circuit works like a charm. I was able to connect the radio to the diversity circuit with a two-conductor patchcord because I installed an RCA jack at the back of the radio.

CRAIG S. SHIPPEE
Shirley, MA

MICRO TV TRANSMITTER APPLICATIONS

I enjoyed the article "Build a Micro TV Transmitter" (**Electronics Now**, December 1993). Charge-coupled devices (CCD find applications in aerial reconnaissance, machine vision, astronomy, photography, and medical imaging. When I was at school, I looked forward to reading your magazine and thinking about how to apply what I learned. I'd like to suggest that you publish an article on building a CCD camera module which would complement the Micro TV Transmitter article. Keep up the good work!

MANUEL DAYENIAN
Grayslake, IL

PARTS SEARCH

Where did Mr. Eady find the 28-pin ribbon headers for his "Static ROM" project (**Electronics Now**, December 1993)? I needed a ribbon-cable jumper and I couldn't find a source, so I built my own.

One way to do this is to cut two 14-pin headers in half lengthwise. I put four bottom halves into a 28-pin DIP socket and swaged the tops onto the bottoms. Then I bonded the pieces together with hot-melt glue.

I also accomplished the same result with a disgarded 28-pin EPROM DIP. I punched out the mica window and cut the fine wires from the lead frame to the die. (You'll need a large magnifying lens or a binocular microscope to see the fine wires). Then I soldered the ribbon wires to the sides of the EPROM DIP pins.

These methods might not be elegant, but they are effective..
LAWRENCE T. MAZZA
Mayfield Heights, OH

Mr. Eady purchased his headers from JDR Microdevices, but many other **Electronics Now** *advertisers offer them too. Fill in and send the Reader Service Card to request information and catalogs. Or you could telephone the advertiser directly.—Editor*

FILE TRANSFER METHODS

I have the same problem that reader K.G. Pratt described in *Letters*, **Electronics Now**, January 1994—how to transfer ASCII files that I did not want to retype from a Timex/Sinclair TS-2068 to an IBM PC or compatible with an Intel 486 processor. Here is my method:

First, connect the two modem cords that normally go to the telephone outlet with a two-line plug having no connection to the phone line. Turn on both modems and load the modem software. Then set the PC to its TERMINAL MODE and the TS-2068 computer to its ASCI SEND MODE.

With the PC's Hayes-compatible modem, enter the ATA command (it answers phones without a ring or a carrier). The PC modem recognizes the signal from the other modem and connects at 300 baud.

Set the PC's modem to receive on Xmodem file receive mode. From the TS-2068, select SEND FILE NAME. The PC acknowledges and receives the file.

To the best of my knowledge, this file-transfer method will work for any two computers.
ABED KAHALE
The Timex/Sinclair NorthAmerican User Groups
Hoffman Estates, IL 60195-3106

MAC—AHEAD OF THE IBM PACK

I've been reading your magazine for more than 20 years, but I've never felt compelled to write until now. In two recent *Computer Connections* columns, Jeff Holtzman wrote about computer architecture.

One column explained how Microsoft was trying to gain acceptance for a communications standard so that IBM PC and compatible users could send faxes and E-mail as well as regular ("snail") mail from their computers. The column reminded me that I have all of those capabilities right now. I was going to respond to the article with all three methods, but **Electronics Now** apparently is not "now" enough to have an E-mail address!

Holtzman's second column discussed problems in computer configuration. I have added an internal modem and an extra 240-MB internal hard drive to my computer, increased my RAM and video RAM, and added an external Syquest drive. All I had to do was turn off the computer, add the cards and ICs, turn on my computer, and install the required software simply by double-clicking on the installer icon.

Of course, my computer is a Macintosh—you know, that *other* computer that your magazine almost never mentions. I hope that all you IBM types get those capabilities soon, just to catch up with those of us with Macs.
ELMER BATAITIS
Rochester, NY

DIGITAL AUDIO BROADCASTING SYMPOSIUM

Readers of **Electronics Now** will be interested to know that the Second International Symposium on Digital Audio Broadcasting (DAB) will be held March 14 to 17, 1994 at the Sheraton Centre Hotel and Towers in Toronto, Ontario, Canada. More than 400 people representing international broadcasting will participate.

Presentations will cover the latest developments in DAB. These include programming opportunities and challenges, transition scenarios, value-added services, and systems technology and standards.

Additional information can be obtained by contacting:
DAB SYMPOSIUM '94
126 York Street #401
Ottawa, Ontario
K1N 5T5, Canada
Phone: 613-594-8226
Fax: 613-565-2173

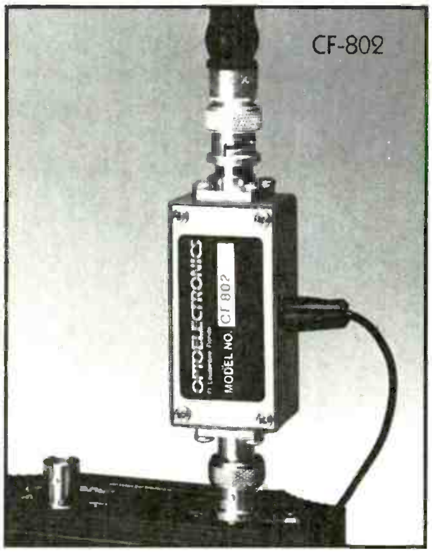
Ω

Model DC440 Decoder $259.

- 50 Sub-Audible (CTCSS)tones
- 106 Digital (DCS) Codes
- 16 Touch Tone (DTMF) characters/126 character recall
- Serial Data Interface
- Update older service monitors
- Ideal for testing two way radios
- Tone log software available
- Exceptional 2x16 character backlit display
- Small size - 1.8" x 4.5" x 4" deep

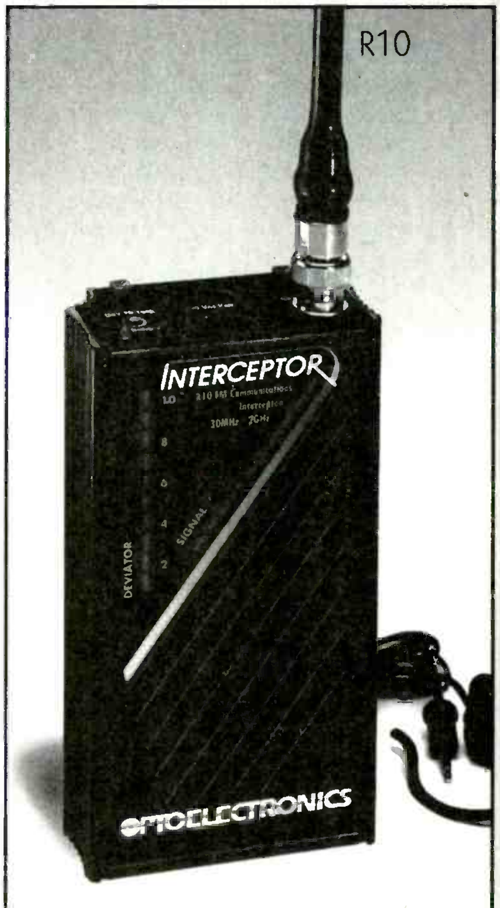
Model 3300 MiniCounter $129.

- Super Compact
- 10 digit LCD - longer battery life
- 1 MHz to 250 MHz direct count for high resolution (1 Hz/Second)
- Maximized Sensitivity
- Hold Switch to lock display
- Ni-Cad plugs into board - no soldering to change outpack



Model CF-802 $149.

835 MHz ± 10 MHz filter/amplifier. 10 times the pick-up distance when used with our counters or R-10.



Model R-10 $359.

The R-10 is a unique FM Communication Test Receiver with security and surveillance applications. 30 MHz to 2 GHz. Measures deviation and relative signal strength. Demodulates FM

Model APS104 $995.

Tunable band pass filter covers 10 MHz to 1,000 MHz. Tunes continuously over more than 5 octaves. Increase pickup distance 10 times. Ultimate Security Sweeper.

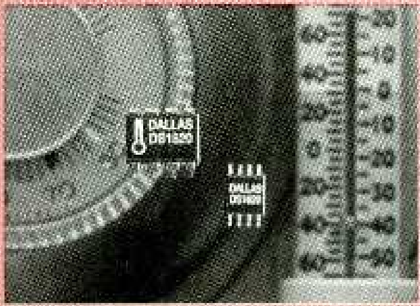
5% Ship/Handling (Max $10) U.S. & Canada. 15% outside continental U.S. Visa Master Caed, C.O.D., Cash or Money Orders only. All specifications and prices are subject to change without notice or obligation.

MADE IN THE U.S.A

CIRCLE 182 ON FREE INFORMATION CARD

Dallas Semiconductor DS1620 Demonstration Kit

An all-silicon thermometer and thermostat.



A new integrated circuit promises to simplify the task of temperature measurement and control. The DS1620 thermometer/thermostat from Dallas Semiconductor (4401 South Beltwood Parkway, Dallas, TX 75244-3219; 214-450-0448) has both a temperature-sensing circuit and an analog-to-digital (A/D) converter on-chip. A demonstration kit that is designed to teach how the device works and how it can be included in new circuit designs is available for $25.

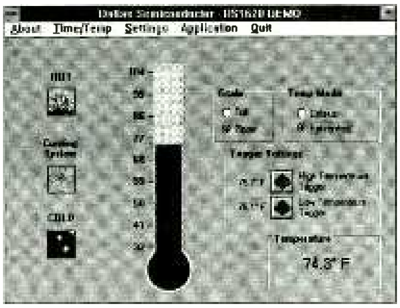
The DS1620 offers advantages over existing temperature-sensing devices in digital systems. Its most important advantage is that it requires no external components. Because of its on-chip A/D converter, the device provides a digital output. Conventional temperature-measurement devices provide an analog output that must be converted to a digital signal for use in digital systems.

The on-chip A/D converter can also provide more accurate readings than conventional temperature measurement circuits. Because the DS1620 is calibrated at the factory, a designer does not need to be concerned with A/D converter noise pickup or A/D offset that can introduce inaccuracies in analog measurements. The DS1620 is factory-calibrated to provide readings accurate to ½°C in the range from 0°C to 70°C.

Conventional temperature sensors develop a voltage drop across a non-linear temperature-sensitive element (such as a PN junction) and measure the output with an external A/D converter. The DS1620 is based on a different technique. It contains two oscillators whose frequencies are determined by different temperature-sensitive resistive elements. The DS1620 compares the frequencies of the two oscillators to determine the temperature.

The DS1620 can also function as a stand-alone thermostat with two user-defined set points. With minimal external circuitry, the device can be programmed to turn on a cooling fan when its temperature reaches a preset level.

That would be an advantage, for example, in a notebook computer that ran too hot. The thermostatic control of the fan or other cooling device would keep the computer at a safe temperature while saving battery power.



THIS SCREEN CAPTURE shows the Windows version of the DS1620 demonstration software.

High- and low-temperature set points (T_H and T_L) can be stored in the device's non-volatile memory. When the temperature is less than or equal to the user-defined T_L, the T_{low} output is driven high. When the temperature is greater than or equal to the user-defined T_H, the T_{high} output is driven high. A third output, T_{com}, is a combination trigger that is driven high when the temperature exceeds T_H and it stays high until the temperature falls below T_L.

The DS1620 Demonstration Kit provides an easy way to try out the capabilities of the digital thermometer and thermostat IC. The kit includes a postage-stamp sized circuit board that contains the 8-pin DS1620 device, protective diodes, and a couple of capacitors and resistors. A ribbon cable that is terminated with a DB-25 plug extends from the circuit board for connection to the parallel port of an IBM-standard personal computer.

Two versions of control software are supplied: The first runs under Microsoft Windows, and the other is an MS-DOS application. The software displays the measured temperature, and provides an easy way to set the high- and low-temperature triggers. Three icons display the status of the triggers; a "cooling fan" spins in accordance with the output of T_{com}

The DS1620 Demonstration Kit offers an ideal way to learn how to put the silicon thermometer/thermostat to work in your applications. It is available from Dallas Semiconductor distributers. The DS1620 chip is available in 8-pin DIP or SOIC packages, and costs $2.50 when it is purchased in 5000-piece quantities. Ω

Countersurveillance

Never before has so much professional information on the art of detecting and eliminating electronic snooping devices—and how to defend against experienced information thieves—been placed in one VHS video. If you are a Fortune 500 CEO, an executive in any hi-tech industry, or a novice seeking entry into an honorable, rewarding field of work in countersurveillance, you must view this video presentation again and again.

CALL NOW!

1-516-293-3751

HAVE YOUR VISA or MC CARD AVAILABLE

Wake up! You may be the victim of stolen words—precious ideas that would have made you very wealthy! Yes, professionals, even rank amateurs, may be listening to your most private conversations.

Wake up! If you are not the victim, then you are surrounded by countless victims who need your help if you know how to discover telephone taps, locate bugs, or "sweep" a room clean.

There is a thriving professional service steeped in high-tech techniques that you can become a part of! But first, you must know and understand Countersurveilance Technology. Your very first insight into this highly rewarding field is made possible by a video VHS presentation that you cannot view on broadcast television, satellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

Foiling Information Thieves

Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

CLAGGK INC. EN
P.O. Box 4099 • Farmingdale, NY 11735

Please rush my copy of the Countersurveillance Techniques Video VHS Cassette for a total cost of $53.95 each (which includes $4.00 postage and handling).

No. of Cassettes ordered ________.
Amount of payment $________.
Sales tax (N.Y.S. only) ________.
Total enclosed ________
Bill my ☐ VISA ☐ MasterCard
Card No. ________
Expire Date ____ / ____
Signature ________
Name ________
Address ________
City ________ State ____ ZIP ____

All payments in U.S.A. funds. Canadians add $4.00 per VHS cassette No foreign orders.

The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

The Dollars You Save

To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

NEW PRODUCTS

Use the Free Information Card for more details on these products.

COMBINATION DMM/OSCILLOSCOPE. *Tektronix* has introduced a new line of combination digital multimeters and oscilloscopes that it calls *TekMeters*. Palm-sized and weighing just two pounds, each battery-powered *TekMeter* measures 8.5 × 5.5 × 1.6 inches.

These test instruments are capable of automating power measurement and monitoring line voltage automatically. The products include the single-channel *THM 550*, the dual-channel *THM 560*, and the backlit, dual-channel *THM 565*.

A *TekMeter* is both a true-rms digital multimeter and a 5-MHz oscilloscope. The DMMs perform autoranging DC and true-rms measurement from 400 millivolts to 600 volts AC or 850 volts DC. They can measure resistance over the range from 400 ohms to 40 megohms. The instruments can also check diodes and perform audible continuity tests. The autoranging oscilloscope includes signal-tracking circuitry that automatically finds, scales, and displays signals continuously without any manipulation.

CIRCLE 16 ON FREE INFORMATION CARD

Described as easy to use, *TekMeters* automate the setup of routine measurements made by service technicians. It is only necessary to attach the lead to the test point and the *TekMeter* can automatically make power calculation measurements, determine transformer harmonic derating factor (THDF), and provide triggering for variable speed AC motor control.

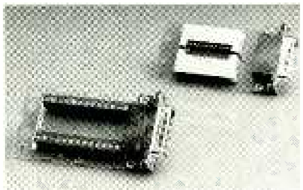
Optional accessories for *TekMeters* include current probes, a carrying case, a nickel-cadmium rechargeable battery pack with charger, and an AC/DC adapter with an RS-232C interface.

The pricing of *TekMeters* is: THM 550—$859, THM 560—$999, and THM *565—$1259.*

Tektronix, Inc.
P. O. Box 1520
Pittsfield, MA 01202
Phone: 1-800-426-2200

SIGNAL-TERMINATION BOARD. *Analogic* is offering its *Qwik Connect* signal-termination boards as an alternative to a breakout box and cables. The board serves as an interface between external signals and Analogic's PC/AT data-acquisition boards.

Qwik Connect boards are available with either screw terminals or ribbon cable connectors. The



CIRCLE 17 ON FREE INFORMATION CARD

Qwik Connect-ST is a 1.5 × 3.0-inch circuit board with screw-terminal strips for field wiring and a 26-pin, D-style connector that interfaces directly with the data acquisition board. A cover assembly protects the screw terminal.

A *Qwik Connect-RC* performs the same functions, but it is terminated with ribbon-cable connectors. A pair of *Qwik Connects* can be used to access all the analog and digital I/O circuity on a data-acquisition board.

Both *Qwik Connect* signal-termination boards are priced at $75.

Analogic Corporation
360 Audubon Road
Wakefield, MA 01880
Phone: 508-977-3000
Fax: 617-245-1274

CLAMP METER. The *Fluke Model 30* is a new, low-cost, rugged, general purpose clamp meter capable of measuring AC voltage up to 600 volts, AC current up to 400 amperes, resistance, and continuity. Its tapered jaws with a centered opening make it easy for the user to access conductors in crowded junction boxes.

The *Model 30* has a hold button that "freezes" the display to values can be read conveniently. It conforms to the safety standards of IEC 1010 and has UL, CSA and TUV certification. *Fluke* states that the *Model 30's* accuracy of 1.3% will be retained for at least one year after calibra-

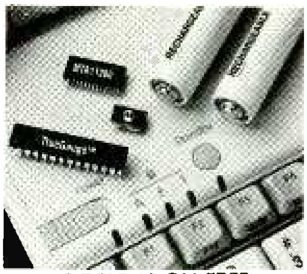
CIRCLE 18 ON FREE INFORMATION CARD

tion. The unit operates over the temerature range of 14°F to 122°F and is powered with a standard 9-volt transistor battery. It has been tested to withstand a six-foot drop without breaking.

The *Model 30* clamp meter is priced at $99.

Fluke Corporation
P. O. Box 9090
Everett, WA 98206
Phone: 800-87-FLUKE
Fax: 206-356-5116

BATTERY-MONITORING IC. *Microchip Technology's*, *TrueGauge MTA11200* is a low-power CMOS, 28-pin integrated circuit for monitoring batteries and controlling charging rates. Intended for applications where a battery gauge is required, it is capable of predicting imminent battery failure and providing real-time battery-capacity measurement and charge control.



CIRCLE 19 ON FREE INFORMATION CARD

The *TrueGauge MTA11200* can monitor nickel-cadmium, nickel-metal-hydride, or lead-acid battery packs. It is expected to find sockets in laptop and notebook computers, camcorders, hand-held transceivers, cellular telephones, and other products that are usually powered by rechargeable batteries.

The *TrueGauge* IC is located in the battery pack where it continuously monitors battery condition. It calibrates itself automatically and continuously to maintain its high accuracy level.

The manufacturer explains that unlike conventional battery-monitoring devices which estimate the battery capacity based on the charging rate, *TrueGauge* measures the battery's total capacity during automatic calibration. It then provides the data for a calculation of charge that determines the remaining battery capacity.

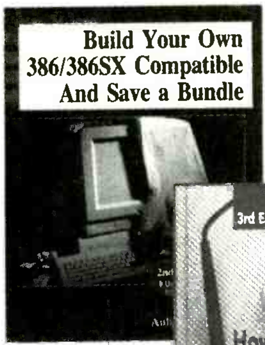
To extend battery life, *TrueGauge* requests conditioning cycles at regular intervals based on battery usage. It can provide measurements of the battery's remaining and total capacity, voltage, current, and temperature over a single wire.

A *TrueGauge* IC in a 28-lead plastic DIP, SOIC, or SSOP package is priced at $3.75 each in 10,000 quantity. A development system for designers engaged in the design and prototyping of battery gauges is priced at $499.

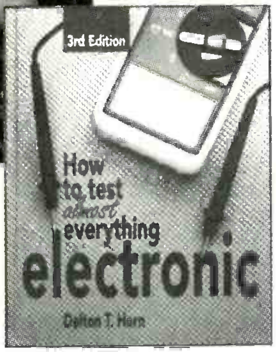
Microchip Technology, Inc.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Phone: 602-786-7200
Fax: 602-899-9210

19,200-BPS MODEMS. *Intelligent Modem Corp.* has introduced two 19.2 Kbps, full-duplex, dial-up modems with compression speeds of up to 75,000 bps, the stand-alone *SA19.2* and the internal *IM19.2*. The modems are compatible with IBM PCs or compatibles, Macintosh computers, and also workstations.

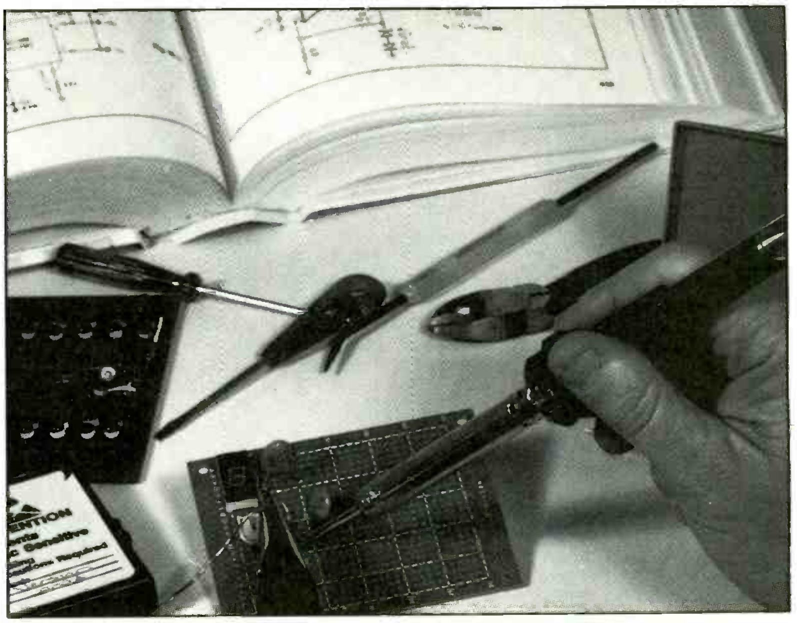
Although there is no CCITT standard for

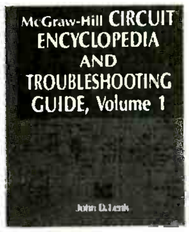


4089P $18.95
Softcover

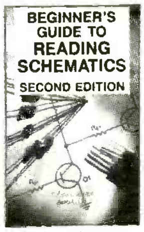


4227H $24.95

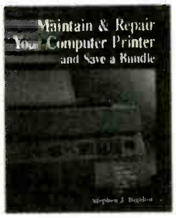




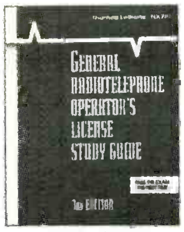
037603H-XXX $59.50
Counts as 3



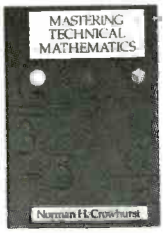
3632P $10.95
Softcover



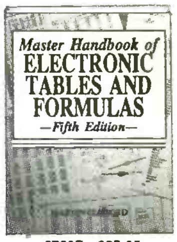
3922P $16.95
Softcover



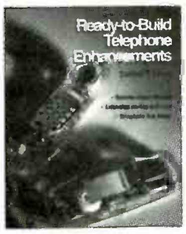
4075P $17.95
Softcover



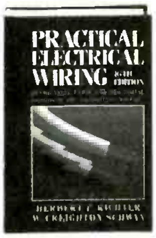
3438H-XX $39.95
Counts as 2



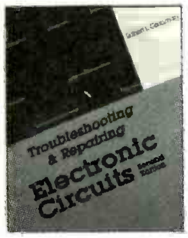
3739P $22.95
Softcover



4362P $16.95
Softcover



052394H-XX $35.00
Counts as 2

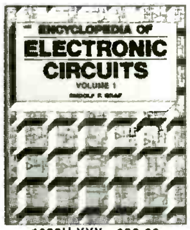


3258P $19.95
Softcover

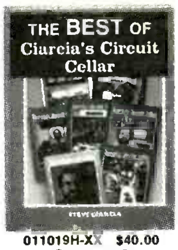
2724P $17.95
Softcover

3274H $25.95

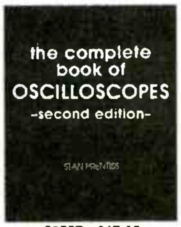
4111H $27.95



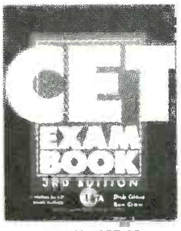
1938H-XXX $60.00
Counts as 3



011019H-XX $40.00
Counts as 2

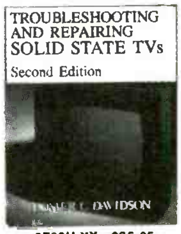


3825P $17.95
Softcover

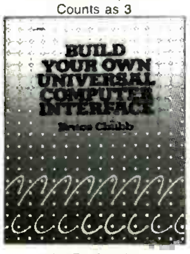


4199H $27.95

2790P $15.95
Softcover



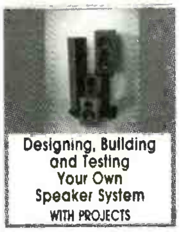
3700H-XX $36.95
Counts as 2



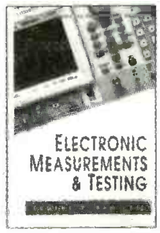
3122P $21.95
Softcover

586354H-XX $30.00
Counts as 2

3765P $19.95
Softcover

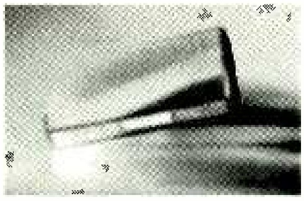


3374P $16.95
Softcover



003961H-XX $40.00
Counts as 2

3887H $26.95



CIRCLE 20 ON FREE INFORMATION CARD

19,200-bps throughput, called "V.32terbo," the two modems can be modified to meet future CCITT and as yet unannounced standards with software. This will eliminate the need for swapping chip sets or returning the modem for an upgrade. Both models support all other existing industry standards for data compression and error control as well as fallback speeds from 16,800 bps all the way down to a very slow 300 bps.

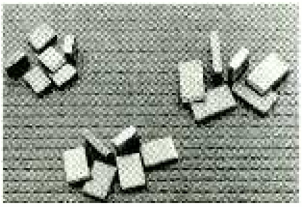
The modem's standard features include echo cancellation (to sort incoming data from the modem's own signal), line equalization (to improve performance over low-quality phone lines), autodialing, and auto-answering. Other features include pulse or tone dialing, call progress monitoring, and a supervisory tone-detection system. On-board diagnostics include power-up, loopback self tests, as well as local analog and remote digital tests.

The *SA19.2* modem is priced at $995, and the *IM19.2* modem is priced at $945. These prices include a user's manual, a standard phone cable, and the "Communications by Crosstalk" modem software package.

Intelligent Modem Corporation
435 West Universal Circle
Sandy, UT 84070
Phone: 801-561-8080
Fax: 801-561-0117

SURFACE-MOUNT CERAMIC CHIP CAPACITORS. New ceramic multilayer chip capacitors extend *Rohm's* range of available values in surface-mount components. The *MCS* MLC series is available with capacitance values from 10,000 to 6.8 million picofarads.

The terminations of the *MCS* MLCs are applied to the ceramic in a dry-film process. This is in contrast to the standard industry practice of applying solder plating to the terminations. According to *Rohm*, this



CIRCLE 21 ON FREE INFORMATION CARD

process change eliminates the usual step of immersing ceramic capacitors in a plating solution that leaves a conductive deposit on its surface that can cause insulation-resistance breakdown.

The bond between the thin-film termination and the ceramic of the *MCS* capacitors increases adhesion and resilience. This is said to improve the chip's ability to withstand stress, especially important if the capacitors are mounted on flexible substrates. The improved adhesion is said to increase pull strength and push resistance. According to Rohm, thin-film bonding eliminates the cracking problems that often occur in the larger MLCs because of differences in the thermal coefficient of expansion between the ceramic dielectric body and the intermediate silver film. The thin-film process gives the MLCs the ability to withstand the soldering temperatures that are as high as 400°C.

Each capacitor size is available in a wide capacitance range: The *MCS32* (0.12 × 0.10-inch) ranges from 10,000 to 3.3-million picofarads. The *MCS43* (0.17 × 0.12-inch) ranges from 22,000 to 6.8-million picofarads, and the *MCS53* (0.22 × 0.12-inch) ranges from 33,000 to 6.8-million picofarads.

The prices of *MCS32*, *MCS43*, and *MCS53* chip capacitors are $0.018 to $0.67 each in quantities of 10,000.

Rohm Corporation
3034 Owen Drive
Antioch, TN 37013
Phone: 615-641-2020
Fax: 615-641-2022

INSTANT BONDING KIT. A new kit of fast-acting cyanoacrylate adhesive is intended specifically for electronics packaging. The *Planned Products' 4300 Circuit Works Quick-Bond Gel Kit* bonds metal, rubber and plastic. The kit includes an accelerator that can be applied directly over the adhesive to assure instant bonding.

The adhesive is recommended for such applications as bonding jumper wires to circuit boards, temporarily holding surface-mount components before soldering, mounting conventional leaded components, and as a shallow potting material.

Quick-Bond gel will adhere by itself or it can be mixed with the accelerator supplied. The accelerator can be brushed directly over the gel adhesive with the brush furnished or it

CIRCLE 22 ON FREE INFORMATION CARD

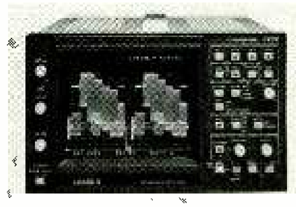
can be applied to hard-to-reach surfaces with pipette included.

Bonding is said to be instantaneous as the accelerator contacts the adhesive, assuring reliable adhesion despite wide variations in temperature or humidity. When cured, the gel forms a colorless solid material that resists shock, impact and temperature cycling.

The *4300 Circuit Works Quick-Bond Gel Kit* with adhesive, accelerator, applicator brush, and pipette, is priced at $6.95.

Planned Products
303 Potrero Street, Suite 53
Santa Cruz, CA 95060
Phone: 408-459-8088
Fax: 408-459-0426

NTSC/PAL/SECAM WAVEFORM MONITOR. *Leader Instruments'* new *Model 5222* waveform monitor operates in the NTSC,



CIRCLE 23 ON FREE INFORMATION CARD

PAL, and SECAM systems and handles composite and component signals simultaneously. Eight input channels are divided into A/B groups of four, with sync selected from two of each group plus external reference.

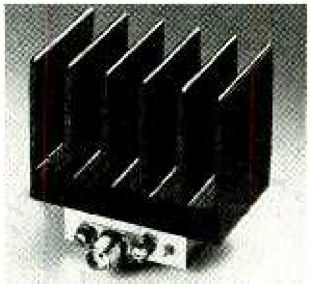
Both overlay and parade displays are provided. Picture display can be selected, and the selected line is highlighted during line-select steps. Full-line selection is provided with on-screen NTSC, PAL, or SECAM notation of selected lines.

On-screen cursors read out level, voltage ratio, delay time, time ratio, or frequency. The *Model 5222* can store up to 10 front-panel setups for routine checks, with local or remote recall, and remote control of panel settings. Menu selections offer a wide range of setup conditions and readout options, including clamp speed, volts or IRE units, and voltage ratio.

The *Model 5222* waveform monitor is priced at $3665.

Leader Instruments Corporation
380 Oser Avenue
Hauppauge, NY 11788
Phone: 516-231-6900 (in NY)
Toll free: 800-645-5104

MICROWAVE AMPLIFIER. This new medium-power amplifier from *Mini-Circuits'* covers the 2- to 8-GHz frequency range. The



CIRCLE 24 ON FREE INFORMATION CARD

ZRON-8G amplifier can have an output up to 100 milliwatts with 20-dB linear gain over its entire frequency range.

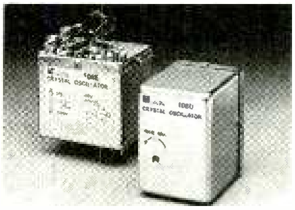
The amplifier is suited for wideband test instrumentation, S- and C-band radar, spread-spectrum and optical communications. It can also be installed in satellite uplinks and in line-of-site transmission and reception communication systems.

The ZRON-8G microwave amplifier is priced at $495.

Mini-Circuits
P. O. Box 350166
Brooklyn, NY 11235-0003
Phone: 718-934-4500
Fax: 718-332-4661

OVEN-CONTROLLED CRYSTAL OSCILLATORS. The *108D* and *108E* are new oven-controlled crystal oscillators from *NEL Frequency Controls* are intended for communication, navigation, and instrumentation applications.

The *108D* is mounted on a printed-circuit connector board. It has two internally-threaded mounting studs on its bottom cover. The *108E* has filter feed-through terminals for its power connection, an oven monitor, and SMB snap-on type RF connectors for its



CIRCLE 25 ON FREE INFORMATION CARD

10-MHz output and EFC input. It has one stud on its bottom cover and two on the top for mounting vibration isolators.

The *108D* crystal oscillator is priced at $650 and the *108E* is priced at $775.

NEL Frequency Controls, Inc.
357 Beloit Street
P. O. Box 457
Burlington, WI 53105-0457
Phone: 414-763-3591
Fax: 414-763-2881

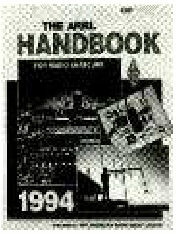
Ω

NEW LITERATURE

Use The Free Information Card for fast response.

The ARRL Handbook for Radio Amateurs 1994. The American Radio Relay League, 225 Main Street, Newington, CT 06111; Phone: 203-666-1541; Fax: 203-665-7531; $25.

This latest edition of the ARRL Handbook is a one-volume, 1100-page reference book that contains a wealth of practical information on electronics and related subjects. It covers the basics of amateur radio, electricity, and radio design as well as the principles of solid-state and vacuum-tube devices.



CIRCLE 40 ON FREE INFORMATION CARD

The handbook contains detailed information on radio principles, modulation methods, frequencies, and propagation. Included are schematics and parts placement diagrams for building such projects as power supplies, audio and video equipment, circuits that operate at high, very-high, ultra-high and microwave frequencies, antennas, and amateur radio station accessories.

New projects in this edition include an add-on circuit that converts an amateur station's fixed-voltage power supply into a variable-voltage supply, a high-frequency "Ugly Weekender" transceiver, a five-band quad antenna that works all bands from 20 to 10 meters, and an active attenuator that will find hidden transmitters.

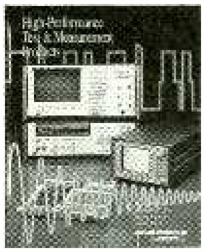
You are given advice in how to set up and operate an amateur radio station. Subject coverage includes operating aids, advice on monitoring and direction finding, and tips for avoiding radio interference. The handbook contains more than 2100 charts and illustrations.

The ARRL Handbook is updated every year to include technical advancements in amateur radio. This 71st edition includes topics not discussed in earlier editions: digital signal processing (DSP) and RF power amplifiers. A revised section on digital-logic ID timers will help you to improve the operation of your repeater continuous-wave ID circuit.

High-Performance Test & Measurement Products: Calibration, Acquisition, Synthesis & Analysis. Analogic Corporation, 8 Centennial Drive, Peabody, MA 01960-9901; Phone: 508-977-3000; Fax: 508-532-6097; free.

This Analogic catalog features the company's complete line of waveform generators, analyzers, and digitizers for automotive, home-entertainment, defense, communications, medical-research, and computer applications.

Among the eleven new product, described in the catalog are several function generators and an improved universal waveform



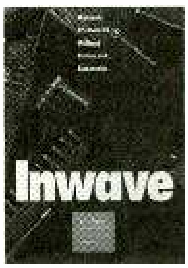
CIRCLE 39 ON FREE INFORMATION CARD

analyzer. A two-page selection guide provides a technical summary of Analogic's products for rapid reader review and convenient selection.

Four sections devoted to specific products include detailed product descriptions, photographs, waveform patterns, and complete technical specifications. Included in the catalog are a glossary, information about other Analogic products, and a description of Analogic's software support for its instrumentation products.

Communications Catalog. Inwave, 29 West Milwaukee Street, P. O. Box 5113, Janesville, WI 53547-5113; Phone: 800-304-1000; free.

Inwave, the communications equipment distributor, offers this new catalog describing its line of two-way radios, pagers, and accessories. The 32-page catalog describes the equipment from Motorola, Ericsson GE, and Midland, as well as accessories that it carries in stock. Inwave's own technicians and programmers will assist buyers with systems design and licensing problems, and they are able to answer technical questions. A communications equipment rental program is available for those with temporary or overload communications needs.



CIRCLE 38 ON FREE INFORMATION CARD

Practical Filter Design; by Jack Middlehurst. Prentice Hall Inc., Englewood Cliffs, NJ; $35, including diskette.

Practical Filter Design offers a non-mathematical approach to filter design that will be attractive to hobbyists, technicians and engineers whose background in the mathematics of filters is weak or rusty. The book includes filter-design software that will bypass much of the dog work in designing filters from scratch.

CIRCLE 37 ON FREE INFORMATION CARD

Middlehurst's book describes situations that call for filters and offers guidance on appropriate filter selection for specific applications. He discusses the benefits and limitations of various filters. His book includes information on filter circuits, the construction and tuning of LC filters, simple active filters, state-variable filters, and switched capacitor filters.

Subjects include Butterworth, Chebychev, and elliptic forms of low-pass, high-pass, bandpass, and band-reject filters, as well as active and passive crossover and notch filters among others.

The diskette included contains computer programs in GW BASIC. This software will permit the reader with a personal computer to design filters and predict their properties without having to solve many complex mathematical equations .

Silicon Photodiodes 1994 Catalog. Centronic Inc., 2088 Anchor Court, Newbury Park, CA 91320; Phone: 805-499-5902; Fax: 805-499-7770; free to all qualified specifiers.

Centronic's 1994 catalog describes its line of photodiodes and related products. The 50-page catalog includes product photographs, package outline

CIRCLE 36 ON FREE INFORMATION CARD

drawings, and specifications for standard and specialized photodiodes. A selection guide is included as a short cut in the process of selecting the right photodiode for a specific application. In addition, a tutorial overview offers a refresher course on photodiode technology. Ω

What Do These Prestigious Companies Have In Common?

Aerovox
DC Film and RFI Suppression Capacitors, AC Oil Capacitors, EMI Filters

AMP
Electrical/Electronic Connectors, IC Sockets, PCB Switches

AVX CORPORATION
A KYOCERA GROUP COMPANY
MLC, Tantalum and Thin Film Capacitors, Resistors, Networks, Trimmers, Oscillators, Resonators, Filters and Piezo Devices

BERG ELECTRONICS
High Density and Industry Standard Connectors/Subsystems

BURNDY an FCI Company
Electronic Connectors

CAROL
CAROL CABLE COMPANY INC
Electronic and Electrical Wire and Cable and Power Supply Cords

COLE FLEX
Tubing, Conduits, Hose, Sleevings, Splices, Insulation and Cable Harness Products

Communications Instruments, Inc.
Relays and Solenoid Relays

COOPER Belden
Multi Conductor, Paired, Coaxial, Flat, Fiber Optic, Instrumentation/Process Control, LAN, Special Application Cables, Power Supply Cords & Molded Cable Assemblies

COOPER Bussmann
Fuses, Fuseholders, Fuse Blocks, and Fuse Accessories

CORNELL DUBILIER
Capacitors-Aluminum Electrolytics, Mica, AC Oil, Film, MICA Paper and Relays

A COMPANY OF VISHAY
Dale Electronics, Inc.
Resistors, Networks, Oscillators, Displays, Inductors & Thermistors

DANTONA INDUSTRIES, INC.
BATTERIES: Computer, Cordless Phone, Scanner & R/C.
ANTENNAS: Cordless Phone (metal & rubber), Scanner Bumpers, Grommets and Stik-On Feet

DEARBORN WIRE AND CABLE L.P.

EATON
Eaton Corporation, Commercial & Military Controls Operation
Switches, Relays, Displays and Keyboards

A **GERNSBACK** PUBLICATION
Electronics Now Magazine

KOA SPEER ELECTRONICS, INC.
Resistors, SMT Tantalum Capacitors Inductors, Resistor Networks, SMT Thermistors

MALLORY
North American Capacitor Company
Tantalums, Aluminums, Sonalerts® Ceramics, Films and AC's

M-tron
Quartz Crystal Clock Oscillators and Special Hybrid Products

muRata ERIE®
MURATA ERIE NORTH AMERICA
Monolithics, Discs, Variable Capacitors, Oscillators, Potentiometers, RFI/EMI Filters, Microwave, Surface Mount Capacitors

NTE ELECTRONICS, INC.
A WORLDWIDE REPUTATION FOR QUALITY, SERVICE AND VALUE
Semiconductors, Resistors, Capacitors, Relays

Philips ECG
A North American Philips Company
Semiconductors, Test Equipment, Relays, A/V Parts and Chemicals

Quam
Loudspeakers and Commercial Sound Products

ROHM
Rohm Electronics Division
Resistors, Ceramic Capacitors, Transistors/Diodes, Opto Components and IC's

SELECTA
Electrical Electronic Products
Switches, Relays, Terminals, Indicator/Pilot Lights, LED Indicators, Test Clips, Test Leads, Cable Ties and Heat Shrinkable Tubing

A COMPANY OF VISHAY
SPRAGUE
Tantalum Capacitors, Wet & Foil Capacitors, Resistor Networks, Resistor Capacitors Networks, Filters

Switchcraft
A Raytheon Company
Switches, Connectors, Jacks, Plugs, Jackfields & Audio Accessories

TECH SPRAY
Non-CFC Cleaners/Degreasers, UV Cured Compounds, Swabs, Wipes, Brushes, Wick, Cleanroom Supplies, and Static Control Products.

They sell through distributors. They belong to the E.I.A. They belong on your vendor list.

Leadership in electronics is not just a matter of designing products better and manufacturing them better, but also of marketing them better. And the sponsors of this message understand that better service to customers *requires* effectively involving distributors as part of their marketing teams.

Distributor involvement means lower prices, quicker deliveries, better service over-all. The Buyer wins. . . the Seller wins.

Distributors help achieve marketing leadership. So does the manufacturer's involvement in the Components Group of the Electronic Industries Association. EIA fosters better industry relations, coherent industry standards, and the sharing of ideas, which helps one another *and* serves customers better.

In choosing your component supplier, look for the marks of leadership —

availability through distribution
membership in the E.I.A.

ELECTRONIC INDUSTRIES ASSOCIATION
EIA
EST. 1924

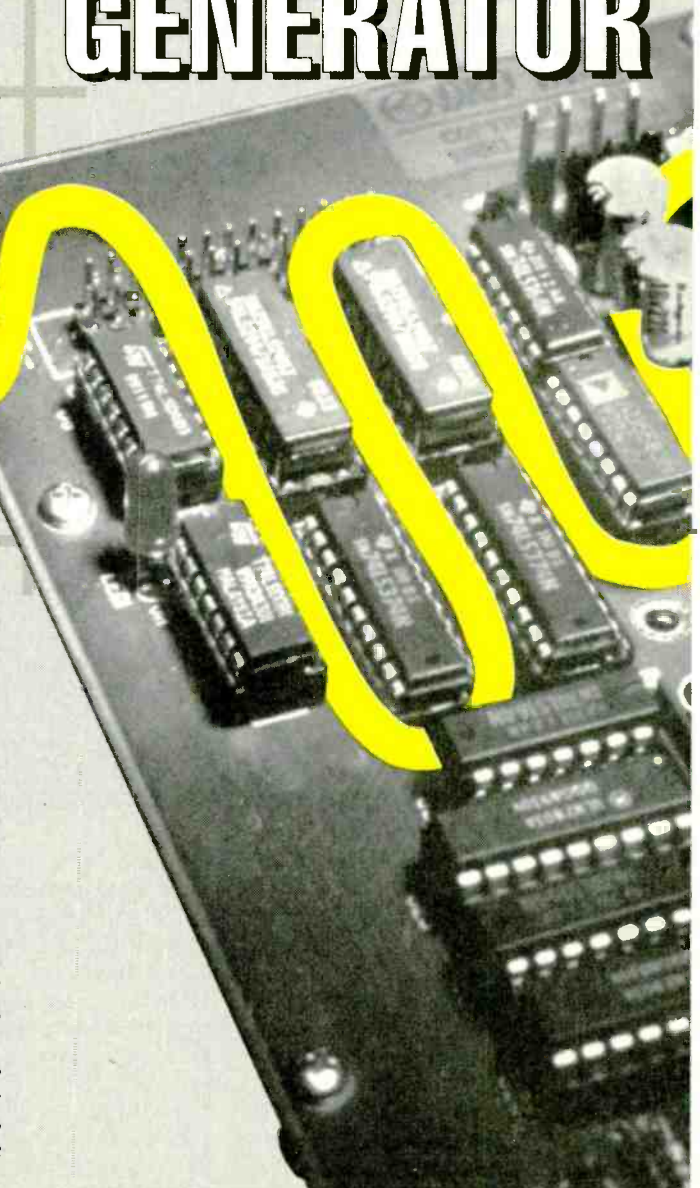
Electronic Industries Association/Components Group
2001 Pennsylvania Avenue, N.W. 11th Floor
Washington, D.C. 20006
Phone: (202) 457-4930 Fax: (202) 457-4985

Committed to the competitiveness of the American electronics producer

A look at the design of a 2-GHz RF signal generator.

PC-BASED RF SIGNAL GENERATOR

DAN DOBERSTEIN



RF (RADIO FREQUENCY) SIGNAL GENERATORS ARE ESsential equipment for radio-frequency design. The TG2000 described in this article is a PC-based synthesized signal generator. It can also function as a tracking generator for DKD Instruments' Models 810B and 1800C/H PC-based spectrum analyzers. The model 810 spectrum analyzer was the subject of an article in **Radio-Electronics**, August and September 1991.

The TG2000 is a IBM-PC compatible card that can be installed in an 8-bit slot on the PC bus. (Alternatively, it can be interfaced to a parallel port, although an external power supply is needed for that.) Software for the TG2000 is a stand-alone package that is available on the *Electronics Now* BBS (516-293-2283, 9600, V.32, V.42bis).

By reviewing the key specifications shown in Table 1, it can be seen that the TG2000 covers the band from 4 to more than 2048 MHz in progressive octave bandwidths. Its output is phase-locked to a 4-MHz crystal reference and its output power ranges from −5 dBm to 0 dBm. Output impedance is nominally 50 ohms and is provided via an F-connector. An optional output connector provides an attenuated output. External FM modulation is supported via an AC-coupled RCA jack input. A sync pulse is provided at another RCA jack for triggering scopes and other equipment. System requirements are very modest for stand-alone operation: a PC/XT or better with CGA or better monitor, 512K RAM, and one floppy drive are all you need.

RF generator basics

Figure 1 shows the RF output spectrum from an "ideal" generator that produces a single frequency or tone with infinite purity. The real world is more complex than Fig. 2 shows. An actual spectrum consists of the fundamental frequency, as well as other undesirable frequency components.

The unwanted frequency components are broken down into three categories: Harmonically related, spurious (or non-harmonically related), and residual modulation close to the fundamental frequency that are due to noise and phase-locked loop (PLL) processes. Harmonics pose the least problems, and at times could be desired, as in frequency multiplication or mixing. Spurious response is generally never useful, and it's best to minimize its content and power. Subharmonics or outputs at whole number fractions of the fundamental are almost always undesired output.

To understand the third group of unwanted outputs "zoom in" on the fundamental line (see Fig. 3), where the small residual modulations can be seen. Of all the unwanted components, this one is the toughest to eliminate. It consists of phase noise and residual FM sidebands. Residual FM is generally caused by the PLL process and cannot be completely eliminated. Phase noise is caused by random fluctuations or noise, and it cannot be completely eliminated.

One way to visualize residual modulations is to

TABLE 1
MODEL TG2000 SPECS

Frequency coverage: 4 to 2100 MHz, Single Output, F/SMA Connector.

Power output: 0 dBm to −10dBm
w/Option P-01 ; +7 dBm to −10dBm,
Total power Flatness; ±2 dB over the band 10 to 2000 MHz

Frequency step sizes:

Step	**Band**
250.00000 Khz	1024 to 2048 MHz
125.00000 KHZ	512 to 1024 MHz
62.50000 KHz	256 to 512 MHz
31.25000 KHz	128 to 256 MHz
15.62500 KHz	64 to 128 MHz
7.81250 KHz	32 to 64 MHz
3.90625 KHz	16 to 32 MHZ
1.95312 KHz	8 to 16 MHz
0.97656 KHz	4 to 8 MHz

With option DDS-01 step sizes are reduced by:
Max step size (@ top of band); Take above step sizes divide by 238
Min step size (@ bot of band); Take above step sizes divide by 476

VSWR of Output (50 ohm): < 1.3 all bands.

Frequency Output Spec's:
Primary Oscillator Phase locked to Crystal or DDS reference.
Reference Sidebands; > -50 dBc typ. @ 1000 MHz
Phase Noise; > -70 dBc/Hz @ 10KHz offset @ 1000 MHz
Harmonics;
2nd; > -10dBc 68 to 2200 MHz
> -5dBc 5 to 68 MHz
All others > -10dBc 5 to 2200 MHz
Spuruous; > -50dBc TYP to to 2200 MHz
Subharmonics, LO/2; > -20dBc, -30dBc typ. 1100 to 2200 MHz
5 to 1100 MHz no subharmonic content.

Frequency Accuracy; +/- 30Khz All bands @ room temp.
+/- 200Hz w/ Optional TCXO reference.

EXT. FM Modulation Input:	**(Optional) Ext. AM Pulse Modulation:**
Impedance; >10K ohm	Impedance; TTL
Bandwidth; >5KHz	Bandwidth; 5KHz
Max Sensitivity; 1v/100MHz	ON/OFF Ratio; >30db
Coupling; AC	Copuling; TTL Levels

Power Requirements: +5 VDC @ 0.5 amps, +12 VDC @ 0.2 amps, -12VDC @ 0.1 amps
Interfaces: PC Bus or Parallel Interface (Centronics).
System Requirements: 360K Disk Drive, VGA, EGA or CGA graphics adapter, 512k Ram, DOS 3.0 orhigher.

imagine a perfect FM radio receiver. If the output of a perfect RF generator were fed into the perfect radio, nothing would be heard from the speaker. If a signal containing phase noise and residual FM were fed into our perfect radio receiver, the phase noise would be heard as a hiss, and the PLL sidebands would be heard as a single tone (assuming that the sidebands were audio frequencies within the human ear's frequency response range).

Synthesized vs. non-synthesized

RF signal generators can be classified into two categories: synthesized and non-synthesized, or open-loop. Non-synthesized generators tend be less expensive, and for that reason you will still find them in consumer receivers. An example of a non-synthesized RF generator is a voltage-controlled oscillator (VCO). Synthesized generators such as the TG2000 are more accurate and frequency-stable than non-synthesized generators.

A VCO can be converted into a synthesizer with the addition of a PLL. This turns the open-loop VCO into a closed-loop control system in which frequency can be controlled with much greater precision. There is a price for this accuracy though: VCOs essentially have infinite frequency resolution and fast settling

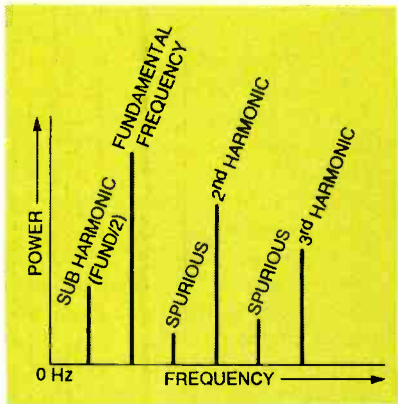


FIG. 1—IDEAL RF OUTPUT SPECTRUM from an ideal generator. The ideal generator produces a single frequency or tone with infinite purity.

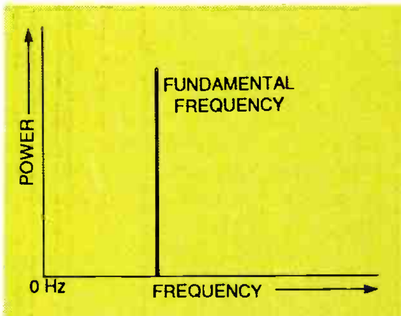


FIG. 2—THE PRACTICAL GENERATOR is considerably more complex than an ideal one. The actual spectrum consists of the fundamental frequency that we want, and other frequency components which we don't want.

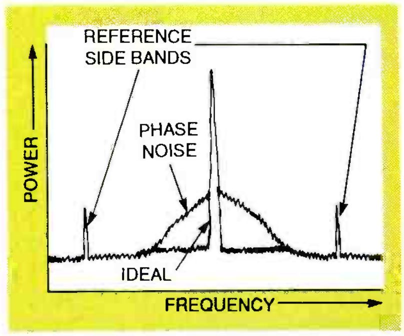


FIG. 3—TO SEE THE THIRD GROUP of unwanted outputs you can "zoom in" on the fundamental line.

times. Once a PLL is coupled to the VCO, the oscillator has fixed-frequency steps and, in general, slower settling time. A benefit to PLL control of a VCO is that the phase noise declines dramatically over that of the open-loop VCO.

The PLL

The minimum number of components for a common PLL-based synthesizer are a VCO, a phase/frequency detector, a loop filter, and a crystal reference (see Fig. 4). The PLL divides the crystal reference down to form the reference frequency, typically on the order of 10 to 500 kilohertz (kHz). The output of the VCO is also divided down and then compared with the reference frequency at the phase/frequency detector. This generates an error voltage that, when filtered and fed to the VCO, forces the VCO frequency to be an exact multiple of the reference frequency. The filter for the error voltage is called the loop filter. The time constants of this filter and other characteristics will greatly effect PLL performance. Phase noise, reference sideband levels, and settling time will all be influenced by the loop filter.

As already mentioned, the reference frequency is found in the RF output as sidebands that are symmetrical about the fundamental. This is the approach used in the TG2000.

Another common element found in RF PLL synthesizers is the prescaler, which reduces the frequency of a VCO to one that can be handled by the programmable dividers. Prescalers come in many divide ratios, and some have multiple divide ratios. Dual-modulus prescalers are a special class of prescalers. These dividers have two divide ratios, typically N and N + 1. The active divide ratio depends on a separate control input. Dual-modulus prescalers allow finer step sizes for a given divide ratio than fixed prescalers.

A trade off

Ideally, a synthesizer has infinitely small step sizes and no phase noise. Unfortunately as step size is reduced, phase noise increases. There are some exceptions to this rule but, in general, to obtain the cleanest possible output in terms of phase noise, larger step sizes or equivalently larger reference frequencies are needed. As a rule of thumb, every time the reference frequency is reduced by a factor of 2, the phase noise increases by 6 dB. A technique that's just starting to be widely used, called fractional synthesis or arithmetically locked loops, offers some relief in the phase noise/step size trade off.

The 125-kHz reference frequency is the highest that can be accepted by the TG2000 while providing its complete frequency range. This limitation on frequency range is caused by the dual modulus characteristic of the MB1501 prescaler.

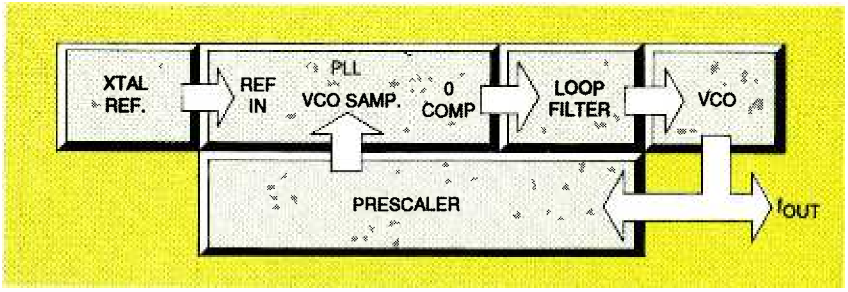


FIG. 4—THE COMPONENTS for common PLL-based synthesizer are a VCO, a phase/frequency detector, a loop filter, and a crystal reference.

Multiple octaves

A typical VCO can span, at best, a frequency range roughly double that of the VCO's lowest operating frequency. This is called its octave bandwidth. For example, a VCO with a 0- to 28-volt control voltage range that outputs 1 GHz with zero volts at its control point will output 2 GHz with 28 volts of control voltage. It becomes obvious that to cover 4 to 2048 MHz with one VCO is not practical. To overcome this limitation, many strategies are used in RF generators. They usually involve mixing a VCO octave band down or up.

The TG2000 uses a progressive-division technique. A 1024- to 2048-MHz VCO is phase locked, and then a series of divide-by-2 prescaler ICs creates the frequencies between 4 and 1024 MHz in progressively smaller octave bandwidths. To cover the 4- to 8-MHz band, for example, the 1024- to 2048-MHz VCO output is divided by 256, or 2^8. One advantage of progressive division is that phase noise improves with each increase in divide ratio. The power of two relation also applies to the minimum step size available in each octave band.

Each divide-by-2 divides this minimum step size in half. A disadvantage of this method is the relatively high harmonic content caused by the dividers and higher frequency bleed-through due to limitations in high frequency RF isolation.

Another disadvantage of the progressive-division technique is a relatively large step size. The TG2000 uses a reference frequency of 125 kHz, which the divide-by-2 prescaler translates as a 250-kHz step for the 1024- to 2048-MHz bands. Provision has been made in the design of the TG2000 for the addition of an optional direct digital synthesis (DDS) reference. The DDS reference, which can replace the fixed crystal reference, has the ability to select frequency with approximately 2-hertz (Hz) resolution. This would permit much finer steps for the combined system with virtually no loss in phase-noise performance.

The MB1501 PLL

The Fujitsu MB1501 PLL IC is the heart of the TG2000 generator. The block diagram of the 1501 is shown in Fig. 5. The MB1501 incorporates a built in serial interface for loading the programmable reference divider, two counter registers (A and N), a high-speed, dual-modulus divider (64/65 or 128/129), and two phase/frequency detectors.

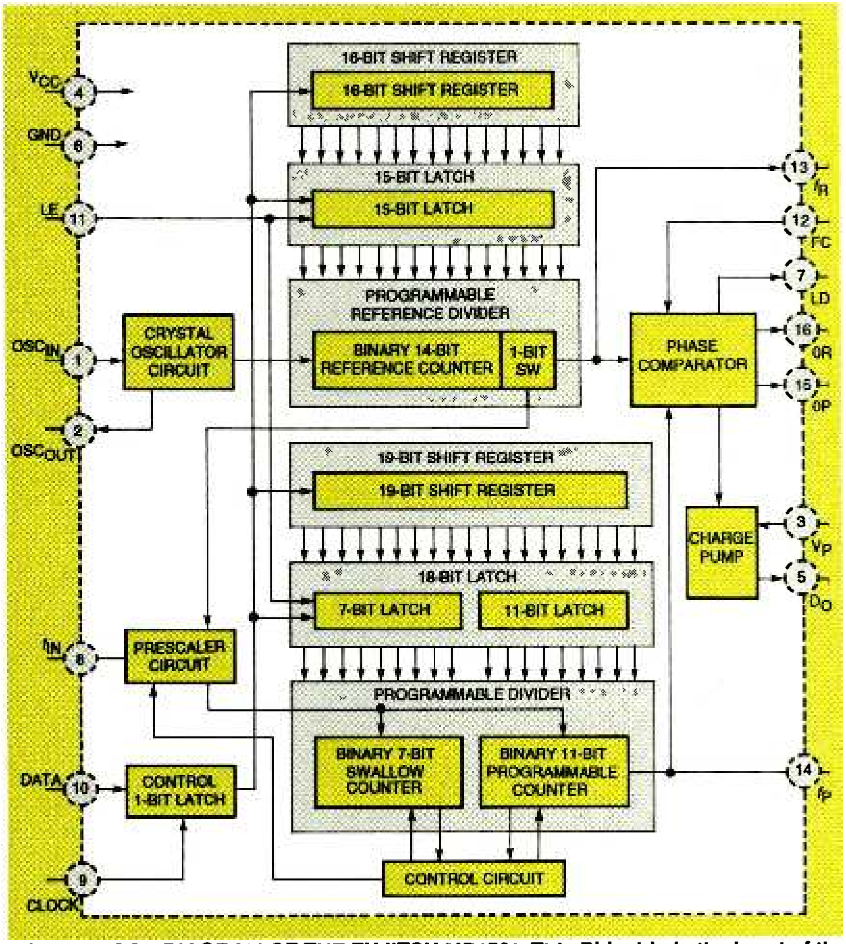


FIG. 5—BLOCK DIAGRAM OF THE FUJITSU MB1501. This PLL chip is the heart of the TG2000 generator.

The output frequency of the VCO is determined by the integers loaded into the R, A and N registers by the following formula:

$$f_{VCO} = [(P^N)+A]^2[f_{OSC}/R]$$

where P = 64 or 128

The TG2000 uses the dual-modulus prescaler in the divide by 64/65 mode, or P=64. The VCO can oscillate only at frequencies that are integer multiples of the reference frequency, f_{OSC}. The factor of two accounts for the fixed divide-by-2 operation (done by an NEC584 prescaler) that the VCO output carries out before it reaches the VCO input which has a maximum frequency of 1100 MHz (refer to Fig. 4).

The MB1501's internal dual-modulus prescaler is needed to reduce the input frequency of the VCO to the point where the N and A counters can operate. This dual-modulus ability overcomes the effect of a fixed-modulus prescaler—step-size multiplication. For example, for a fixed-modulus prescaler of 64, the minimum step sizes would be multiplied by 64. That would translate to a 16-MHz step size in the 1024 to 2048 MHz band for the TG2000. The N/A counter in combination with the dual-modulus divider avoids this problem with the limitation that N must always be greater than or equal to A.

The restriction that N be greater than or equal to A has some not-so-obvious ramifications, such as placing limits on frequency range versus reference frequency, as discussed earlier. Essentially, for a given reference frequency (f_{OSC}/R), the generator is limited to a minimum frequency that can be synthesized while still providing full coverage at minimum step size. For P=64, R=32, and f_{OSC} =4 MHz, the minimum frequency is 512 MHz. Since the generator has a fixed divide-by-2 prescaler, that results in 1024 MHz at the VCO. Below that frequency, not all integer multiples of the reference frequency are possible due to the N>=A restriction. In other words, you could not sweep the VCO frequency from 900 to 1024 MHz at step sizes of 250 kHz.

While all this might seem confusing, a general rule is that if you want a large step size for improved phase noise, *and* your PLL uses a dual-modulus approach, the dual-modulus divide ratio should be as small as possible.

All fixed divide ratios, step sizes, and prescalers are a power or multiple of two. Other numbers could be used, but when it is time to compute A, N, and band switching points for a given output frequency, the power/multiple-of-two relationships pay off.

Two phase/frequency detectors are included with the MB1501 PLL. The bipolar on-chip charge pump permits a minimum number external components for the loop filter. The differential phase-comparator outputs require an external charge pump, usually an op-amp. In the TG2000, an external LM358A op-amp (IC1-a) boosts the bipolar charge pump voltage from 0 to 5 volts to −0.5 to 28 volts. In addition, the op-amp and its associated feedback network acts as an active loop filter. Polarity of the phase-detector output can be inverted by the PLL's FC input. This input is required to compensate for op-amp inversions or VCOs with a negative voltage-versus-frequency slope.

The digital interface to the MB1501 is serial—a block diagram of it is shown in Fig. 6. Three lines are used; CLOCK, DATA, and LOAD ENABLE. Data is clocked in serially, and after an appropriate number of bits (determined by what you are loading) a LOAD ENABLE is sent. A 15-bit word serves as the reference divider, and a 19-bit word holds both the A- and the N-count values. The C source code for the routines that send the N-, A-, and R-register values to the

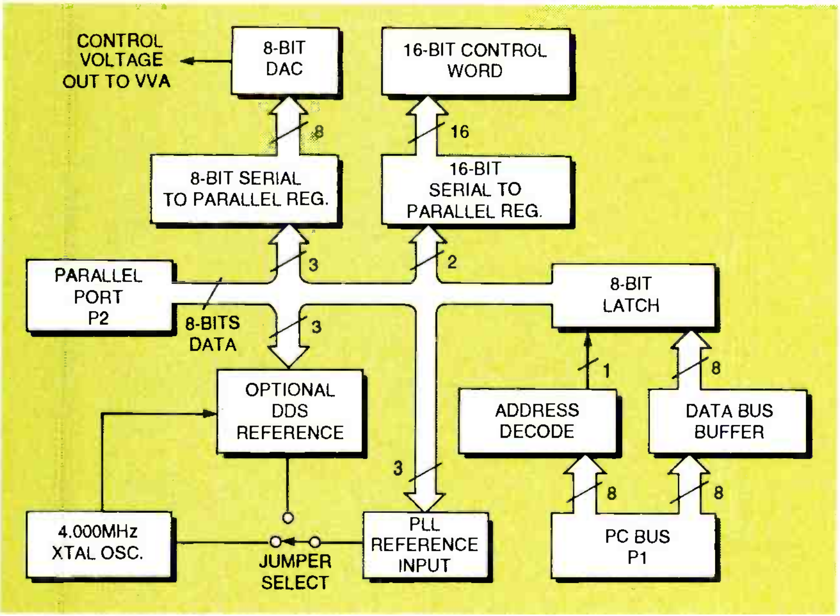


FIG. 6—MB1501 DIGITAL INTERFACE block diagram.

MB1501 are provided on the *Electronics Now BBS* as part of a file called TG2000.ZIP.

Overall operation

As already discussed, the synthesis technique used in the TG2000 is successive division. Every band except the one from 1024–2048 is the output of a divide-by-2 divider. The computer determines the band being used and turns on the appropriate dividers and a single output amplifier path is activated; the other amplifiers are turned off. Five paths cover the 4–2048 MHz band. The band from 256 to 2048 is covered in three paths, with each path covering one octave. The band from 4 to 256 MHz is covered with two paths, each covering 3 octaves. A total of nine octaves are covered in this fashion from 4 to 2048 MHz. The three octave paths are possible due to the divider used which has selectable 2/4/8 divide ratios available. See the block diagram in Fig. 7.

The summed signal is passed through a voltage-variable attenuator (VVA) pin-diode array (a Seimens BAR60), which can be seen in Fig. 8 as D12. The VVA corrects output power variations and provides variable output power. An 8-bit DAC controls the VVA. The signal then passes through a final amplification stage and out to the RF output connector. The VVA requires a 0- to 10-volt control signal and bias voltage for proper operation. The device has a non-linear attenuation versus control-voltage response. These nonlinearities do not affect attenuation control because the computer uses a look-up table to control it.

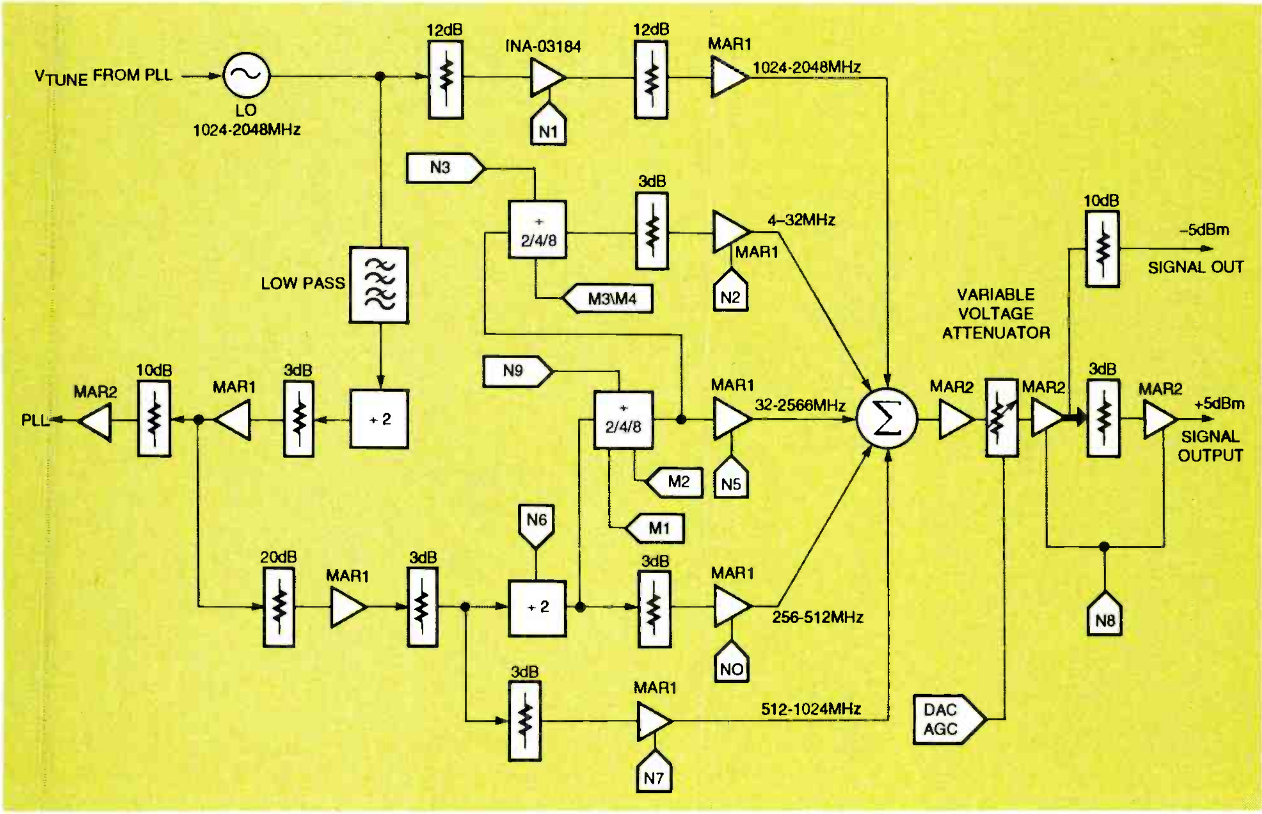


FIG. 7—DIVIDER BLOCK DIAGRAM. The TG2000 uses a successive division technique for synthesis.

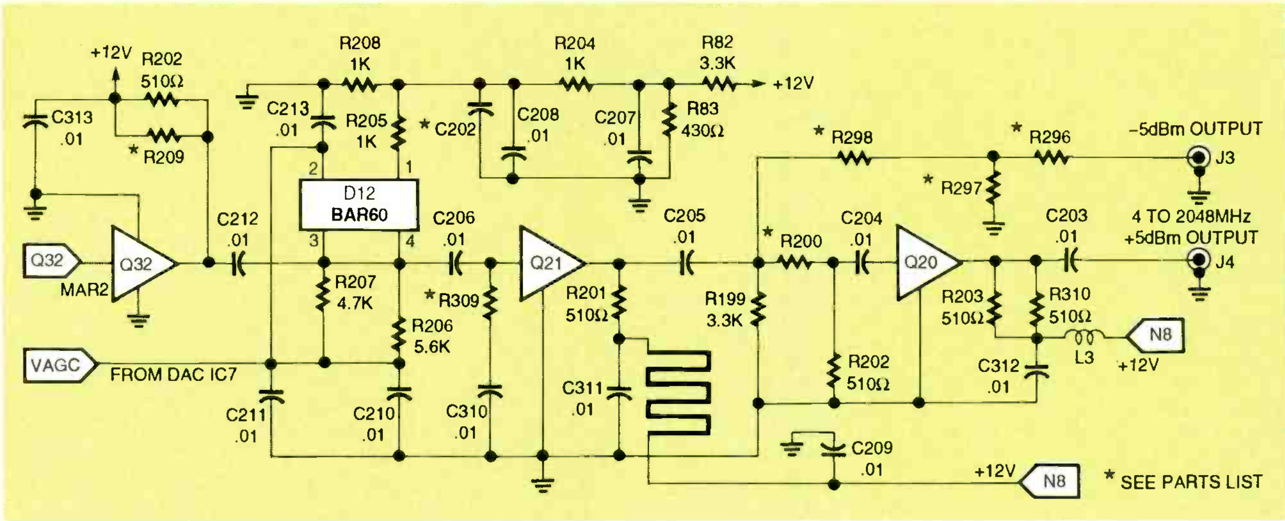


FIG. 8—THE SUMMED SIGNAL is passed through a voltage-variable attenuator pin-diode array (D12), which corrects output power variations and provides variable output power.

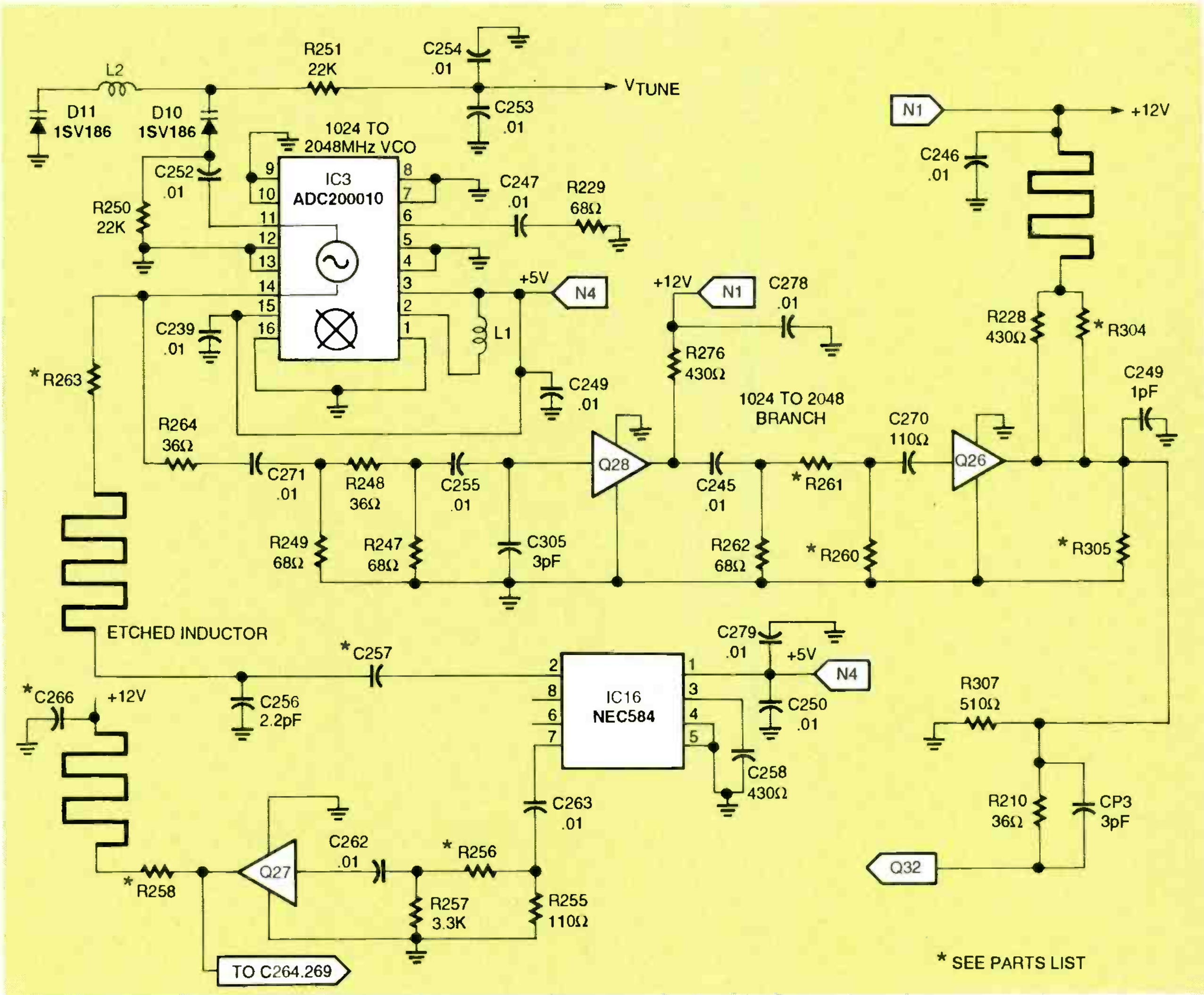


FIG. 9—THE FIRST NEC548G (IC16) acts as a prescaler, reducing the output frequency of the VCO by a factor of 2. It becomes the 512-to-1024 divider when this band amplifier is switched on.

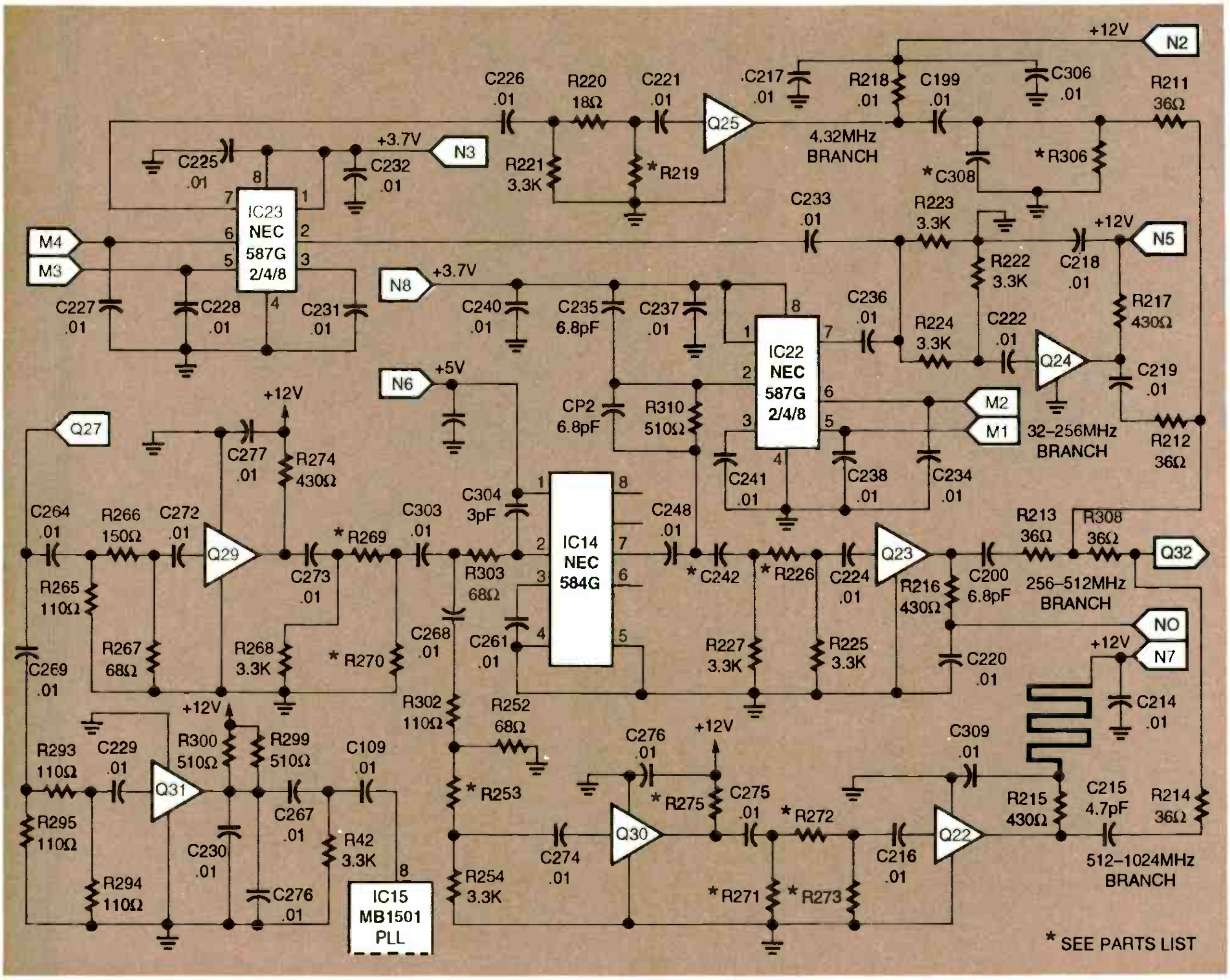


FIG. 10—AFTER THE SIGNAL IS SPLIT, one half is sent to the 512-to-1024 path. Splitting again occurs with half going to the 512 to 1024 amplifier and the other half to the 256 to 512 MHz divider.

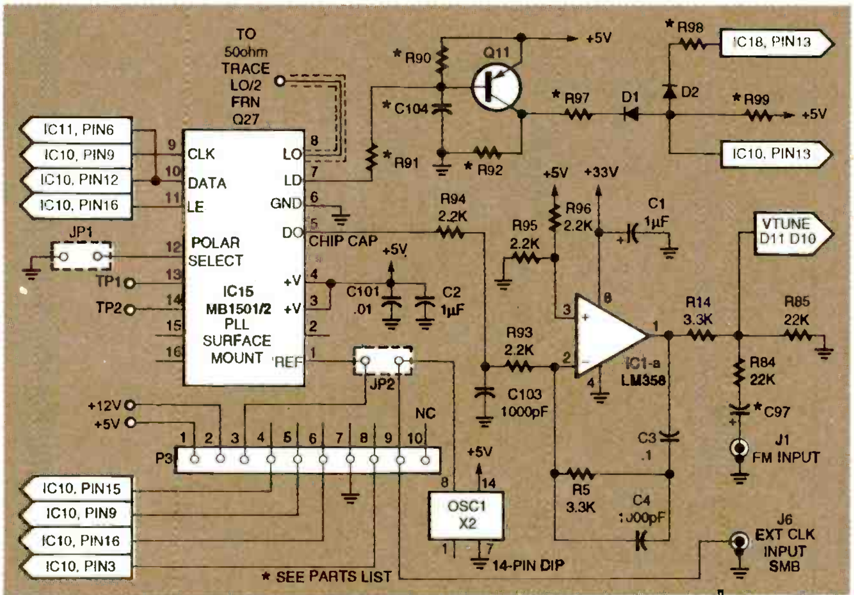


FIG. 11—THE FM INPUT (J1) is AC-coupled and directly modulates the VCO control point.

The dividers

The two divide-by-2 dividers are NEC584Gs, and the two divide-by-2/4/8 dividers are NEC587Gs (see Figs. 9 and 10). The first NEC548G (IC16) acts as a prescaler, reducing the output frequency of the VCO by two. It becomes the 512-to-1024 divider when this band amplifier is switched on. This signal is the split; one half is sent to the PLL and the other half is sent to the 512-to-1024 path. Splitting again occurs with half going to the 512–1024 amplifier and the other half to the 256–512 MHz divider. The output the 256–512 MHz divider is sent to the 256–512 MHz amplifier and the 32–256 MHz 2/4/8 divider. The 4–32 MHz band is handled by the last 2/4/8 divider.

The VCO

Three different voltage-controlled oscillators can be installed in the TG2000. The

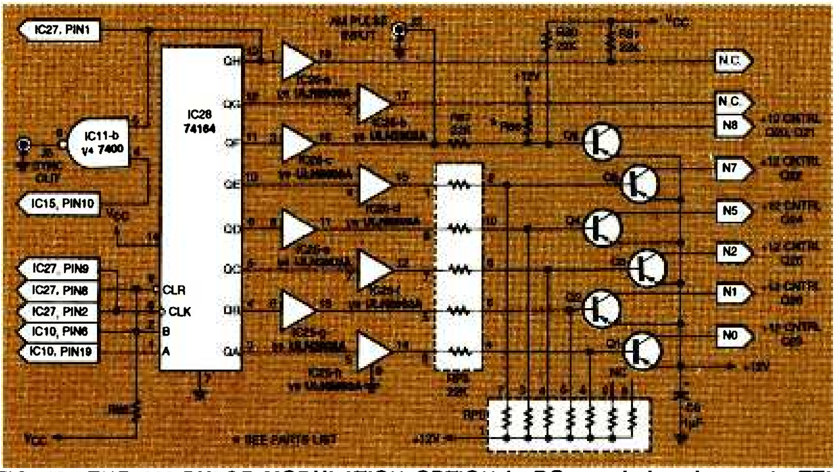


FIG. 12—THE AM PULSE MODULATION OPTION is DC-coupled and accepts TTL control signals.

standard VCO is an ADC20010 made by Anadigics. The device is actually both a VCO and mixer combined in a single module, but just the VCO is used here.

Power/frequency calibration

The combination DAC/VVA automatically adjusts output power so that it's flat within ±2 dB over the 10 to 2000 MHz band. The computer uses calibration data from the TGCAL0.DAT, TGCAL5.DAT, and TGCAL10.DAT files, which are sent to the DAC to linearize power output. Those files represent 0dBm, −5dBm, and −10dBm, respectively.

Readers will not be able to achieve the same calibration accuracy obtained with a factory-assembled product; a slight degradation will be seen because kit builders must depend on generic calibration files.

Frequency accuracy is determined primarily by the 4-MHz crystal TTL oscillator (OSC1 in Fig. 11). The standard oscillator is accurate to ±50 ppm. More accurate frequency references improve the accuracy of the frequency output.

External modulation inputs

FM and optional pulse-AM modulation is obtained with RCA jacks. The AC-coupled FM input (J1 in Fig. 11) modulates the VCO control point. Sensitivity decreases as DC control voltage increases. The maximum sensitivity is about 1V/100MHz. Both the amplitude and frequency content must be limited for this input to prevent the PLL from breaking lock.

The AM pulse modulation option (see Fig. 12) is DC-coupled and accepts TTL control signals. Maximum frequency of on/off toggling is limited by the response time of the amplifier voltage supply. A TTL sync-pulse output is available at RCA jack (J5). The sync pulse is produced at the end of a sweep and can be the external trigger for an oscilloscope. A wide-band oscilloscope (or an RF detector probe and a lower performing scope) can display these frequency response curves.

Digital interface

PC-bus and parallel-port interfaces are supported (see Fig. 13). The PC-bus interface comprises an address/strobe decoder made up of a 74688 (IC20) and two 74138s (IC18 and IC19). The PC data bus is bidirectionally buffered by the 74245 (IC21). Two eight-bit 74374 latches (IC9 and IC10) hold two eight-bit PC-bus bytes for control of the TG2000.

The simpler parallel interface has two octal 74244 buffers (IC4 and IC5) and part of a hex 7404 inverter (IC6). The connection to the parallel interface is provided by header P2. A cable terminated with a 26-pin IDC connector on one end and a DB-25 on the other is all that's needed to complete the interface.

When the TG2000 is connected to the parallel interface and external to the host PC, an external source of power is needed. A supply of +5 volts at 1 ampere, +12 volts at 0.5 ampere, and −12 volts at 0.1 ampere is recommended.

The remainder of the digital interface is made up of the 16-bit serial-to-parallel control register and the 8-bit serial-to-parallel converter for the DAC. The 16-bit control register switches the various dividers and RF amplifiers for the different bands on and off. Two 74164s (IC27 in Fig. 14 and IC28 in Fig. 12) convert a serial data stream to 16-bit parallel words for the control register. Two UNL2803A open-collector octal buffers (IC25 and IC26) provide the control voltages or currents needed for proper switching. Transistors Q1 to Q7 and Q9 and Q10 provide additional level and buffer current for the +5- and +12-volt switching. Transistor Q8 is not used so it is jumpered across its emitter and collector.

A 74164 (IC8) provides the serial-to-parallel conversion for the 8-bit DAC (IC7). The 8-bit DAC provides a 0- to 10-volt control signal to the VVA for AGC purposes, as already discussed.

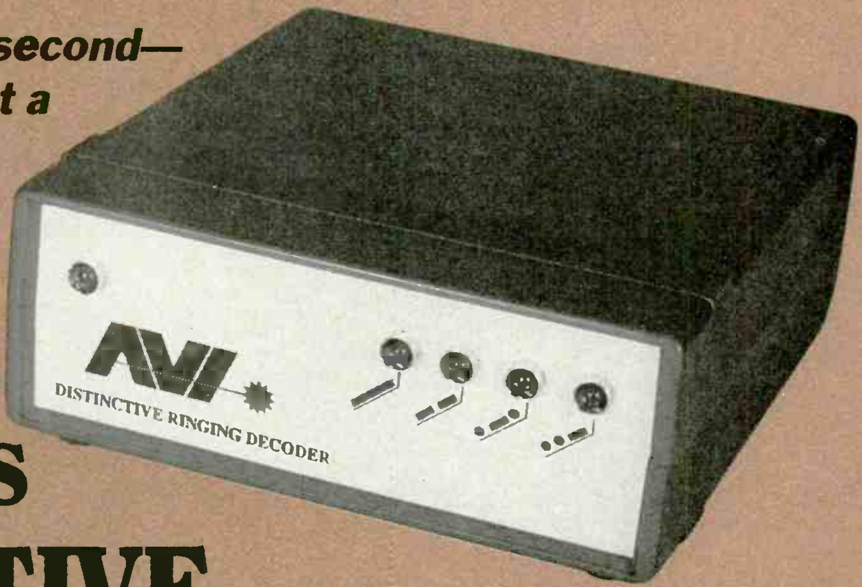
An MC34063A +12- to 28-volt converter (IC3) provides the higher voltage needed to drive the VCO across its full range (see Fig. 15). It is essentially a small switching power supply capable of delivering a few milliamperes at 28 volts. The −1-volt bias for the LM358A (IC1-a) is derived from a voltage divider across or connected to the −12-volt supply. This bias allows the LM358A to operate at or near ground potential.

Software

Two programs provide software support for the TG2000. Version 4.0 of the Series-800 spectrum analyzers provides the tracking-generator capability. A separate DOS-based program called TG2000.EXE operates the TG2000 as a general-purpose signal generator. Only the TG2000.EXE software will be discussed here. It is

Continued on page 88

Get the benefits of a second—or third—phone line at a fraction of the cost.



BUILD THIS DISTINCTIVE RING DECODER

EDWARD J. KEEFE

IN RECENT YEARS, MANY NEW FEAtures have been added to the telephone system. One of them, a distinctive ringing service, assigns more than one phone number to a single line. Each number generates a distinctive ringing pattern so that family members can answer only the calls that are intended for them. The monthly charge for distinctive ringing service is much less than for a separate line. Typically three additional numbers can be added for a low monthly fee of about $3 to $5.

Normally, if you subscribe to distinctive ringing, calls are identified by unique ringing patterns that are easy to distinguish, although all the phones in the house will ring. However, if you build the Distinctive Ringing Decoder (DRD) presented here, calls can be redirected to the intended phone without ringing all the other phones in the house. Calls for a fax machine or modem can be routed automatically. You might want to have a separate number for your home office, a separate phone number for the kid's room, and so on. Figure 1 is a block diagram of the system.

With a little imagination, you can find many uses for DRD. One of the best is for a home-based business. There are commercial devices available that will intercept a call and send it to a FAX, modem, or answering machine, but all of them must share the same phone number. With the DRD, each of these devices can be assigned a different phone number, thus providing convenience and the illusion of a larger company. Numbers can be assigned in categories so the phone can be answered differently for friends, co-workers, or bill collectors. The possibilities are endless.

Ringing theory

An AC ring signal is sent by the central office of the phone company to signal an incoming call. The ring signal varies from 40 to 130 volts and from 15.3 to 68 hertz. The Distinctive Ringing Decoder detects every cycle of the ring signal, and determines the frequency and cadence of that signal. However, only the pattern of the ring is important, so the device ignores

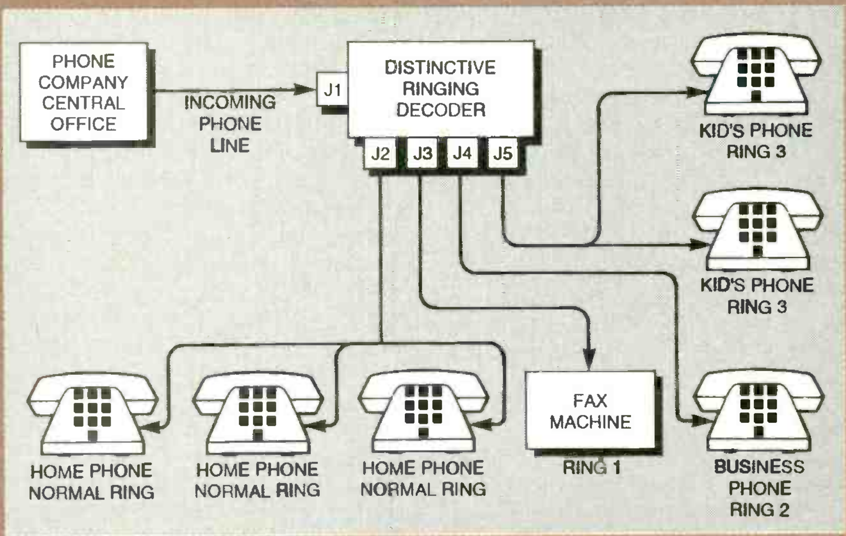


FIG. 1—BLOCK DIAGRAM OF THE DRD SYSTEM. Calls can be intercepted and redirected automatically, without ringing all the phones in the house. You can use a separate phone number for a FAX machine or modem, a separate number for your home office, a separate phone number for the kid's room, and so on.

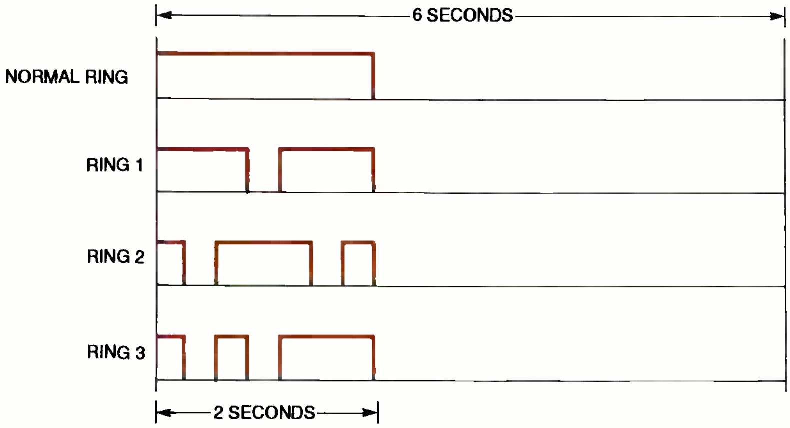


FIG. 2—FOUR DIFFERENT RING PATTERNS can be decoded with the Distinctive Ringing Decoder.

the frequency. The four different ring patterns are shown in Fig. 2.

The circuit

Figure 3 is a complete schematic of the DRD circuit. An Intel 8031 microcontroller simplifies the design. It contains a full-duplex serial port, 2 timers, and 128 bytes of RAM. Two lines on port 3 are used for input; port 1 is used for output. The software for the DRD is contained in a 2764 EPROM. Alternatively, a single-chip microcontroller with built-in EPROM (an Intel 8751) can be substituted in the design. (Note that software for the DRD is available from the source mentioned in the Parts List and from the *Electronics Now BBS* (516-293-2283, 9600, V.32/V.42bis) as a file called RINGER.ZIP.

The microcontroller's clock source is a 12-MHz crystal (XTAL1) with two 30-pF capacitors (C1 and C2). At power up, a small reset circuit, formed by R3 and C3, initializes the microcontroller. Because the software that controls the DRD can be in an EPROM or contained internally in a single-chip microcontroller, the EXTERNAL ADDRESSING (EA) line must be connected correctly. If the software is contained in an external EPROM, EA must go to ground; if the software is loaded in the single-chip microcontroller, EA must go to +5 volts.

It is less expensive to build the DRD with the 8031 microprocessor and an external EPROM. However, it is easier to build it with an 8751 microcontroller (basically an 8031 with built-in EPROM) because the external EPROM and 74HC573 latch are not required. Therefore, wiring is simplified. The choice is up to you—the software is identical for either method.

The tip and ring lines from the phone company are connected to a metal-oxide varistor (MOV1). If a surge enters the device from the phone line, the MOV will absorb it. The ringing signal is monitored by R6, C4, and optocoupler IC7, whose output goes low for each cycle of the ring signal. The output of IC7 is normally pulled high through R7, and is connected to the microcontroller on pin 12.

When the device detects a ring signal, it responds by energizing all the relays through the 2813A relay-driver chip (IC5). That disables all of the phones in the system. After the DRD decodes the ring signal, it deactivates the corresponding relay so that the intended phone will ring, and it turns on the LED that matches the pattern received. Then the DRD waits for the ringing to stop or the call to be answered. If the call is not answered, the unit resets. If the line is picked up, it is held until the extension hangs up. To detect when the line is in use, its voltage is monitored; when the phone is on-hook, the voltage on the phone line is about 48 volts DC, and when it goes off-hook, the voltage drops to about 6 volts. A bridge rectifier (BR1) eliminates any phone-line polarity problems.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R2, R4, R5, R10—220 ohms
R3—10,000 ohms
R6—22,000 ohms
R7—15,000 ohms
R8—10 megohms
R9—1 megohm
Capacitors
C1, C2—30 pF, mica
C3—10 µF, 16 volts, tantalum
C4—0.47 µF, 250 volts, mylar
C5—4.7 µF, 16 volts, electrolytic
C6—0.0047 µF, mica
C7—10 µF, 16 volts, electrolytic
Semiconductors
IC1—8031 microcontroller (Intel)
IC2—4093 quad NAND gate
IC3—27C64 EPROM
IC4—74HC573 latch
IC5—ULN2813A relay driver
IC6—7805 5-volt regulator
IC7—H11AA1 optocoupler
BR1—200-volt, 1-ampere bridge rectifier
MOV1—300-volt metal-oxide varistor
LED1–LED4—red light-emitting diode
LED5—green light-emitting diode
Other components
XTAL1—12 MHz crystal
J1–J5—4 pin RJ-11 modular phone jack
J6—Coaxial power connector
RY1–RY4—DPDT 5-volt DIP relay
Miscellaneous: 9-volt DC 500 mA wall transformer, project case, bezel, solder, etc.
Note: The following items are available from Audio Visual Imagery, P.O. Box 332, Randolph, MA 02368:
- **PC board—$30.00**
- **Pre-Programmed 2764 EPROM—$10.00**
- **Pre-Programmed 8751 microcontroller—$35.00**

(If you're using the 8751, you do not need the 74HC573 or EPROM, just remember to move the EA jumper on pin 31 of the microcontroller to +5 volts)
Please add $3.00 shipping and handling to any order. MA residents must add 5% sales tax to all orders.

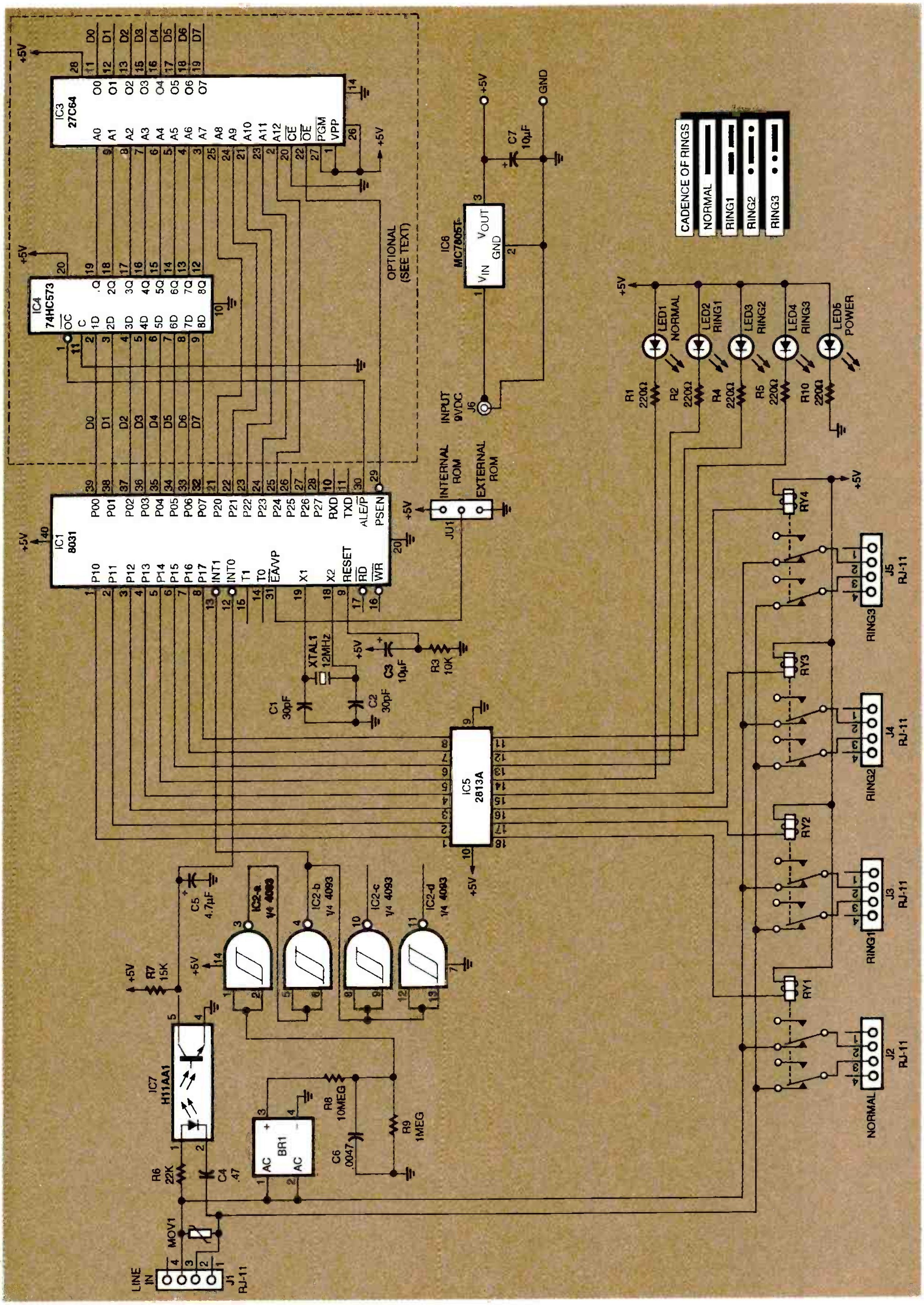


FIG. 3—COMPLETE SCHEMATIC OF THE DRD CIRCUIT. An Intel 8031 microcontroller consists of a full-duplex serial port, 2 timers, and 128 bytes of RAM.

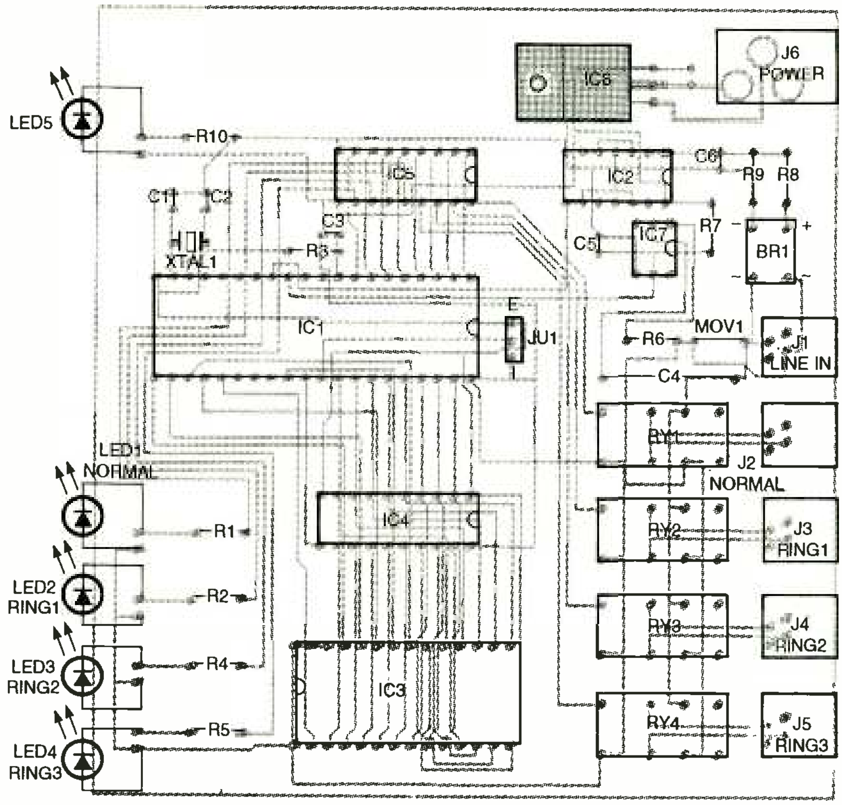


FIG. 4—PARTS-PLACEMENT DIAGRAM. Install all the small components first, and then add the rest of the components.

zero, the relays and LEDs are reset. and the unit goes back into the main loop to wait for rings.

Construction

Assembly of the DRD is straightforward. Point-to-point wiring is practical because of the low parts count. However, foil patterns for making your own PC board are provided here, and finished boards are available from the supplier listed in the Parts List. Sockets for the ICs are recommended but certainly are not required.

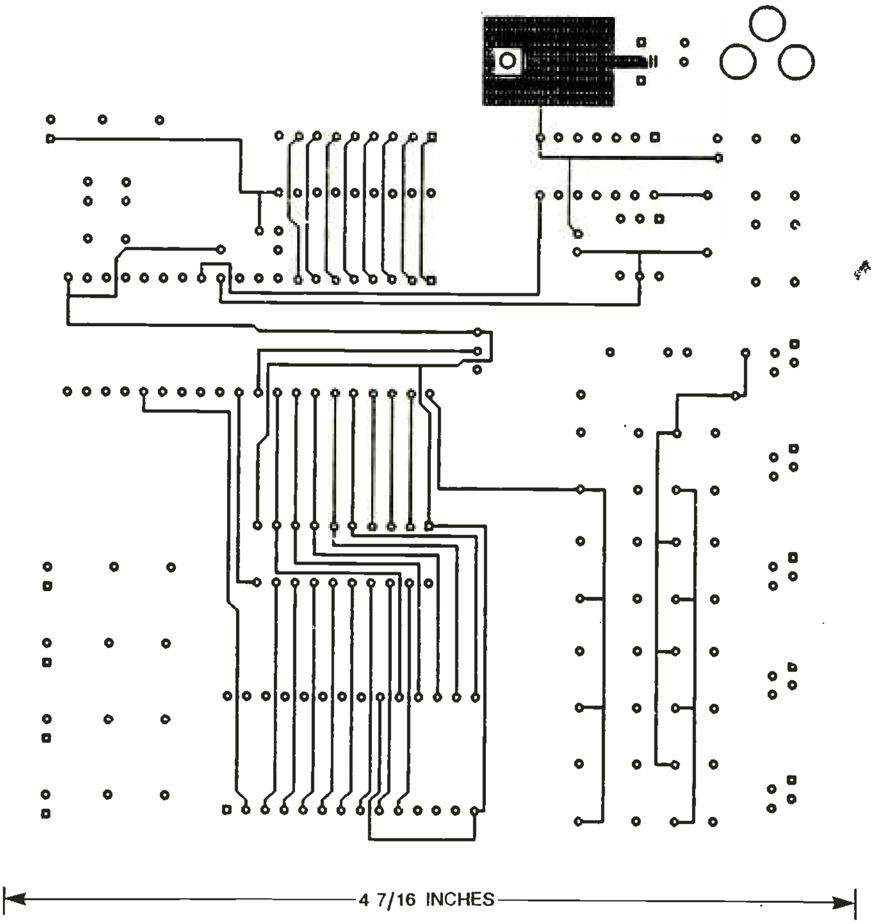
Figure 3 is the parts-placement diagram. Install all the small components first (resistors, capacitors, and crystal), and then add the rest of the components (relays, regulator, connectors, MOV1, and ICs).

The finished board should be mounted in a suitable case like the wire-wrapped prototype shown in Fig. 4.

Software

The software for the DRD is written entirely in assembly language. At reset, the internal RAM is cleared and the timers are initialized. The interrupt priority is set, and the LEDs are scanned twice to confirm that the unit has reset properly and is ready to decode ring signals. After initialization, the main program loop is started. The only function performed by the main program loop is waiting for rings.

When a ring is received, a short delay begins that allows verification of the ring. The cadence of the ring is matched to the ringing patterns stored in memory. When a match is found, the proper relay and LED are activated and the software goes into an IN—USE loop, and a timer is started. This loop monitors the RING input and the IN-USE input from the 4093. As long as the RING input or the IN-USE input are low, the DRD remains in this loop and the timer is reset. When both of those lines go high, the timer times down. When the timer reaches



COMPONENT SIDE FOIL PATTERN.

Operation

Note that you must first subscribe to a distinctive-ringing service for the DRD to work. For the most flexible installation, the DRD should be connected to the phone line at the point where it enters the house. This will allow all calls to be redirected to their correct locations.

Plug the extension phones into the device and apply 9-volts DC to the unit with a wall-outlet mounted adapter. The DRD will respond by energizing, and then de-energizing the relays. The LEDs will scan back and forth twice, and the unit is then ready to receive and decode incoming calls.

If the unit doesn't respond, first make sure that all cables are installed correctly. Check for 9 volts DC at the input to the regulator, and 5 volts DC at its output. If no voltage is present, check for the proper polarity of the wall adapter.

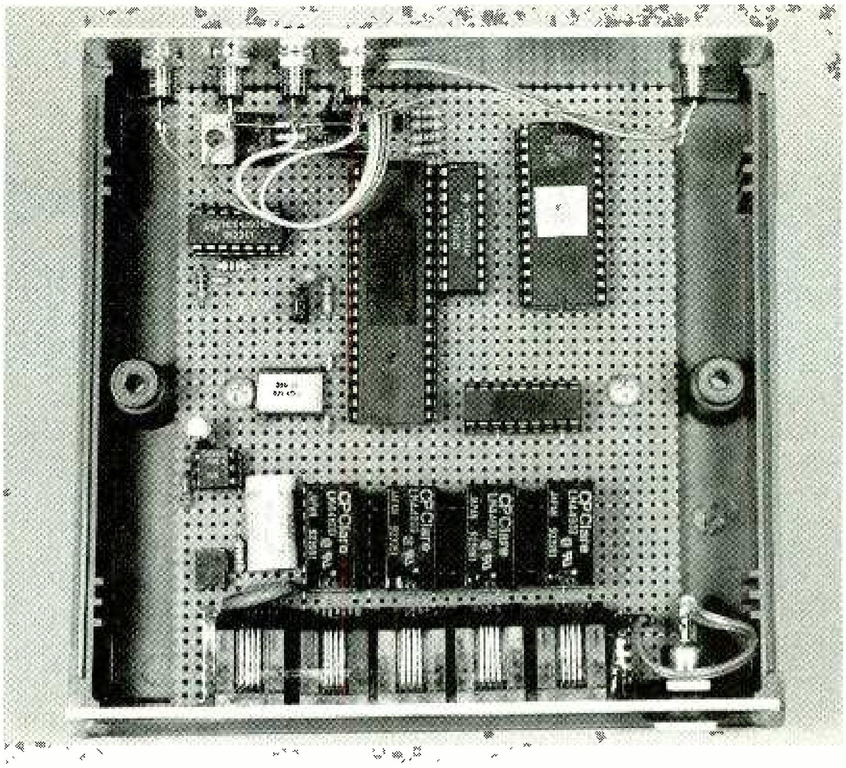
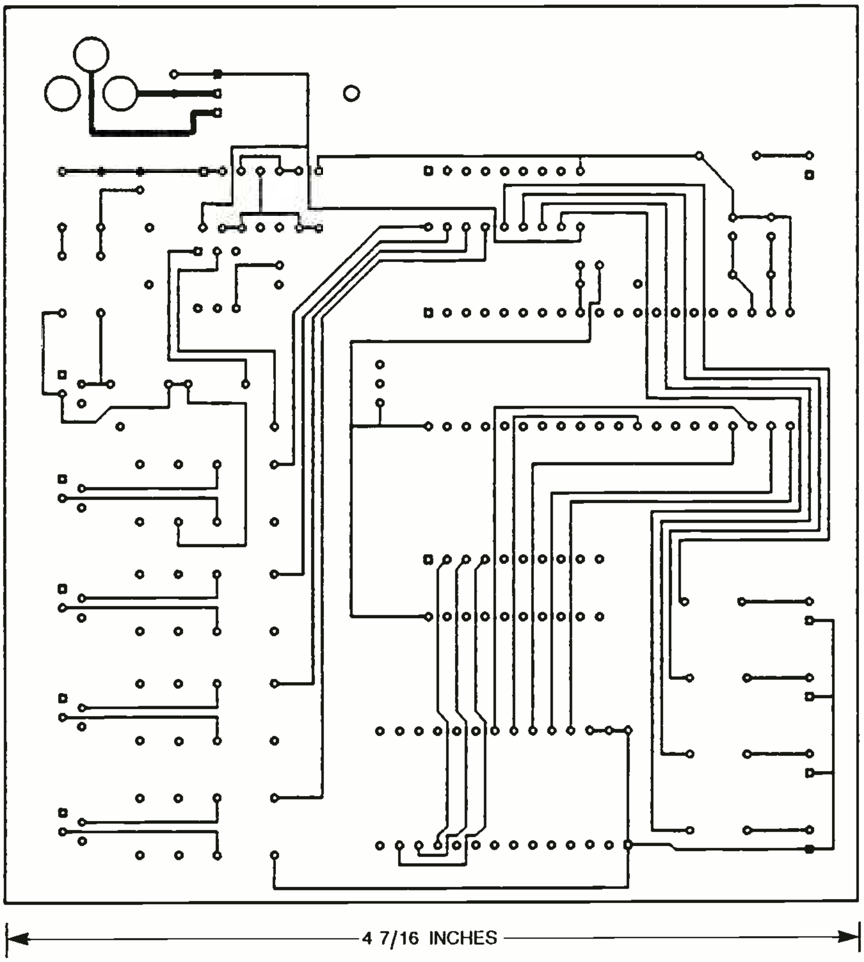


FIG. 5—COMPLETED PROTOTYPE. This one was made using point-to-point wiring.



SOLDER SIDE FOIL PATTERN.

If you use an EPROM and latch chip, make sure the EA line of the microcontroller is jumpered to ground. If you use the single-chip microcontroller, make sure the microcontroller is connected to 5 volts. Also place a scope probe on pin 18 or 19 of the microcontroller and measure to be sure the oscillator is running. Check pin 30 of the microcontroller for a signal that is approximately one-sixth that of the oscillator frequency.

If all the signals are present but the LEDs don't scan back and forth, check the wiring of the LEDs, the 2813A chip, and the reset circuit (C3 and R3). If the unit resets but won't respond to the ringing signal, check the positioning of IC7. When the phone is ringing, the output of the optocoupler should pull low for each cycle of the ring. If the optocoupler's output does not do that, check R6, R7, and C4. If the unit decodes the rings correctly but will not reset the relays at the end of a call, verifyt that pin 4 of the 4093 goes low when an extension phone goes off-hook. Ω

UPGRADE YOUR CAR STEREO

Install a stereo in your car or remove one for servicing. It is easy to do and will save you money if you follow this procedure.

MARC SPIWAK

IF YOU'VE HELD OFF FROM BUYING the car stereo you always wanted because of the high cost of custom installation work, you don't have to wait any longer. This article will take you step by step through a straightforward procedure. All you'll need to tackle the installation is basic knowledge of a car's electrical system, hand-tool skills, patience, and common sense. These requirements also apply equally if you want to remove your car's present radio or stereo system for repairs or upgrading to a better system, perhaps with a CD player in place of a tape cassette deck.

Standard installation

The circuitry in a car stereo is, as you might expect, quite complex. The manufacturer has squeezed a receiver, amplifier, a tape cassette or compact-disc (CD) deck, and a lot of support circuitry into a small metal box. Its high component density and high percentage of parts that are not user serviceable suggest that internal servicing should be left to professionals. However, do-it-yourself installation is another story.

The external wiring required for installation is relatively simple. A typical external wiring scheme consists of four or more color-coded wires and an antenna cable. Your first task will be to identify the functions of all of the wires unless you are fortunate enough to find them labeled or called out in a service manual. Start by locating the power and antenna terminals.

Most automotive stereo systems can be powered from any 12-volt DC source. However, be warned that you can encounter some units that are powered by +6 volts and −12 volts. The power wiring typically consists of a red wire for +12-volt DC and a black wire for chassis ground. The red wire must be connected to the car's accessory voltage terminal, which is activated by turning on the ignition switch. This scheme prevents inadvertent battery drain if you forget to turn off the radio.

The accessory voltage terminal and a ground connection can most easily be found in most cars by tracing the wiring from the car's factory installed radio, or from the fusebox. As a practical matter, any bare metal

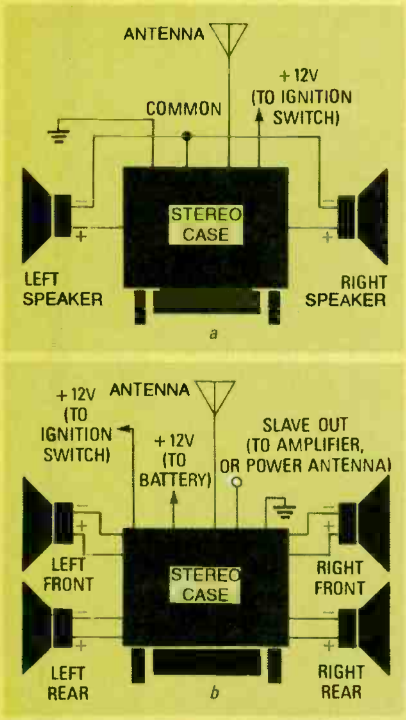


FIG. 1—BASIC STEREO WIRING schemes. A two-speaker stereo system *a*, and a four-speaker stereo system *b*.

part of the dashboard can be a satisfactory chassis ground.

Car stereos typically have two pairs of speaker-output wires, left and right. Nevertheless, you might encounter systems with only one wire for each channel and one common wire shared by both. But you'll find that most up-scale, expensive car stereos have four pairs of wires—left and right and front and rear. By convention speaker wires are typically colored green, brown, white, or gray—rarely red or black.

All car radios have an antenna cable terminated by a Motorola-type plug. The chances are that your car was equipped at the factory with an antenna for an installed radio. The cable from that antenna can be plugged into any new stereo system. In the unlikely event that your car was delivered without an antenna, you are faced with the task of installing one. This usually calls for drilling a hole in your car's fender, trunk, or roof for mounting the antenna. This a separate task that won't be discussed here.

Without labels or a manual, the identifying all of the wires coming out of a replacement stereo or radio can be puzzling. Typically a car radio with digital tuning, memory presets, and perhaps even a clock, will have two power leads. It is common practice to use a red wire as the connection to the car's ignition switch. An orange or yellow wire is usually connected to an unswitched 12-volt DC source to preserve the radio's memory.

A connection to the terminal at the back of the cigarette lighter will usually meet this requirement. The lighter in most cars is permanently connected to the

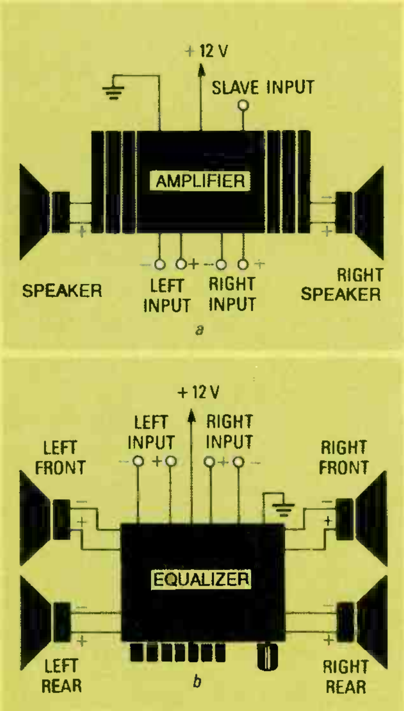


FIG. 2—AMPLIFIER AND EQUALIZER wiring. Amplifier wiring is shown in (*a*) and equalizer wiring is shown in (*b*). Both have wires for +12 volts, ground, and speaker input and output. An amplifier might also have a remote turn-on wire.

12-volt battery, and the lighter will work even if the ignition switch is off. Moreover, that terminal is usually easily accessible. However, if you are uncertain about that connection, try it out with the ignition switch off. If the lighter heats up, you have found a suitable terminal for the memory wire.

If the lighter does not heat up (or is inaccessible), search for an alternative with a voltmeter at the fuse box. If you are unsuccessful, you can always run the memory wire directly to your car battery's positive terminal through an opening in the fire wall. If your car has a radio that can be removed and taken with you when you leave the car, it will have an internal memory-backup battery.

Some radios have a slave output wire that goes high when the radio is switched on. That wire can turn on an amplifier or activate a power antenna when the radio is switched on. There's a good chance that this wire will be colored blue.

The identification process can be complicated if your car has DIN-plug outputs specifically intended for connecting to other equipment. DIN is the abbreviation for *Deutsche Industrie Normenausschuss*, a German standards organization that sets standards for Germany that are recognized by most European countries.

If you are not sure about the functions of some of the wires

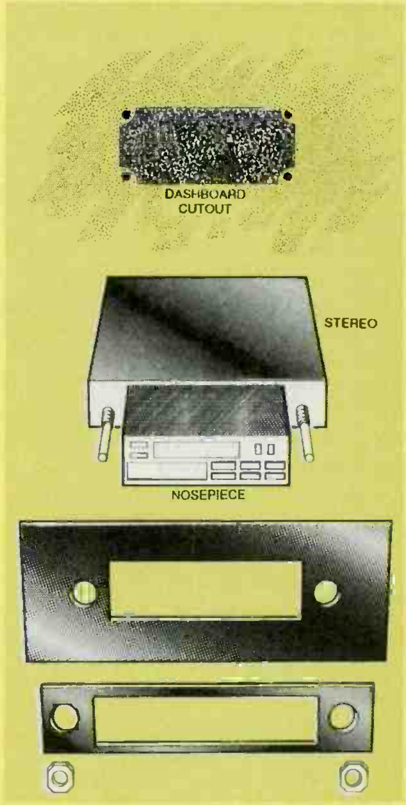


FIG. 3—INSTALLATION OF A TYPICAL radio/stereo. The two threaded control shafts that project through the dashboard mounting plate hold the case in position when fastened with nuts. A rear bracket might secure the back of the case to the dashboard.

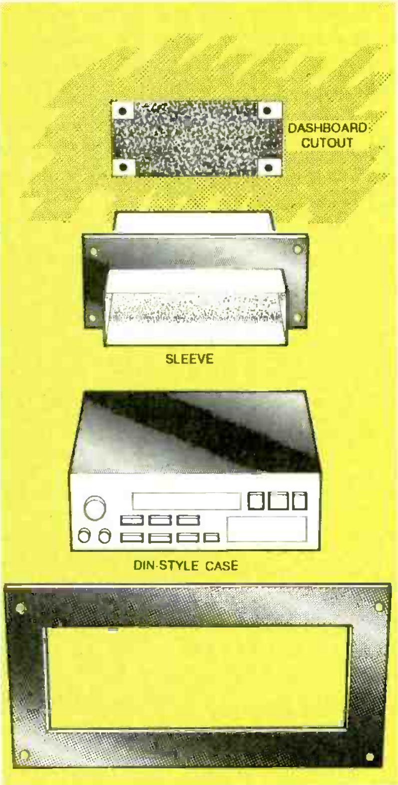


FIG. 4—INSTALLATION OF A DIN-style radio/stereo case. A standard case slides into a mounting sleeve designed to fit specific car models.

from your stereo, it is a good idea to set it up on a bench and test it before installing it in your car. In that way you can identify any mystery wires. You'll need a 12-volt battery or DC power supply, two speakers, and an antenna. Be certain to identify the +12-volt supply and the chassis ground wires first; after that, the others will be easier to identify. Figure 1 illustrates some standard automotive wiring schemes to help you.

Amplifiers and equalizers

Car stereos can be purchased in a wide range of price and performance. Premium quality stereos often have low audio output power so they need an amplifier to boost their output. But it is not wise to connect an amplifier to a radio or stereo that does not need amplification; the output could be overdriven and the sound degraded—and you could damage either the amplifier, speakers, or both!

Most amplifiers are designed to be impedance matched with specific input circuitry and should be fed at the input level specified by the manufacturer. If you connect the speaker outputs from a car stereo to an amplifier that is designed to accept standard 1-volt, line-level inputs, you can overload and possibly damage the system.

Some stereos require two amplifiers—one for the car's front speakers and one for the rear speakers. Other automotive stereo systems are designed so that the receiver's output drives the front speakers and a separate amplifier drives the rear speakers. Automotive stereo amplifiers are usually mounted out-of-sight of the driver and passengers, typically behind the dashboard, in the glove box, or even in the trunk. They are turned on by the slave output from the stereo.

An equalizer capable of enhancing the system's output power can usually be connected to any automotive stereo system. The purchase of an equalizer is a sound investment, especially for a system whose output is weak. The output power can be greatly enhanced even by an inexpensive equalizer that might sell for as little

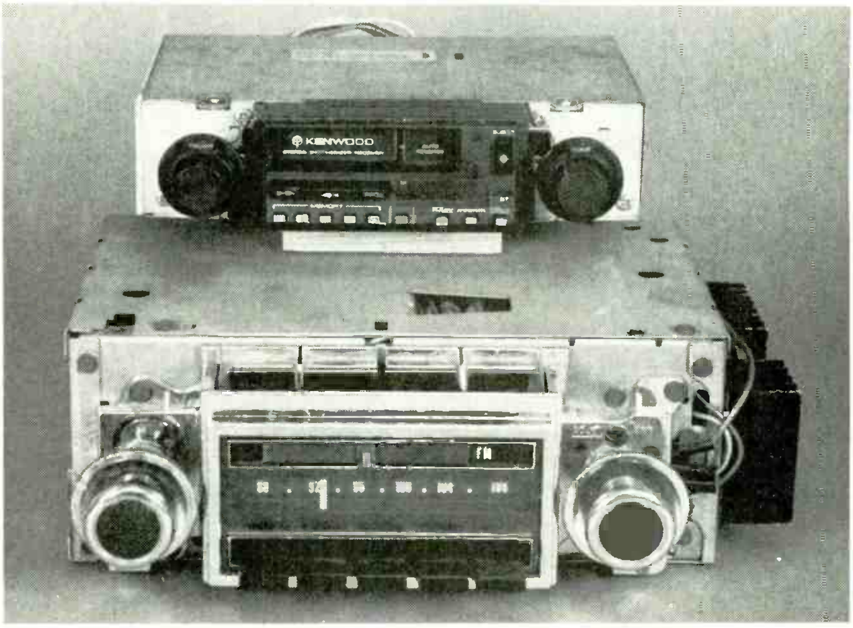


FIG. 5—CONTRAST IN CASE SIZE. A modern automotive AM/FM stereo case with an audio tape deck atop a 23-year old AM/FM radio.

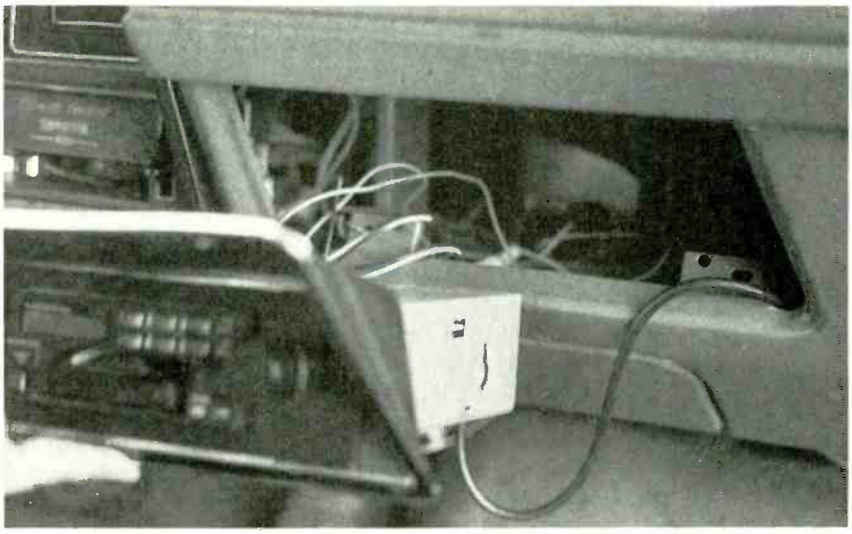


FIG. 6—MODERN CAR STEREO REPLACES A RADIO in an old car. Both are shown in Fig. 5. The stereo offers digital tuning, memory presets, a clock, a cassette deck, four speakers, and an equalizer.

as $30.

If your original radio had only two speakers rather than a pair for the front and back of the car, an equalizer will give you two more outputs. Equalizers can be mounted behind the dashboard, but the easiest place to install it is under the dashboard. Equalizers are sold with all the necessary mounting hardware. The ON/OFF switch on an equalizer's front panel doubles as a bypass switch when the equalizer is turned off.

Amplifiers and equalizers must be connected to the +12-volt source, chassis ground, speaker input and output wires, and a remote turn-on wire as shown in Fig. 2. Be warned, however, that as you increase the number of components in a car-stereo system, the task of wiring it becomes more complicated. *Do not make any connections unless you are sure of what you are doing. Mistakes can be costly!*

Installation and removal

The first task that you must do when installing a new stereo is to remove the existing radio; this job calls for patience. Try to avoid damaging your car while making the installation. Consider taping protective cardboard or paper around any installation site to avoid scratching or scoring the finish during any material cutting or drilling operations. Separate all wire connectors carefully to avoid damaging them. The use of excessive force or tugging on the wires can rip them from their terminals and lead to costly repairs which might be beyond your skill level.

There are two different radio chassis styles, and they must be installed in different ways. A conventional car radio, as shown in Fig. 3, has two control shafts and a middle "nosepiece." The other more modern style, called a DIN chassis, has a flat, rectangular face with no control shafts, as shown in Fig. 4. In this instance, DIN refers to the case shape, size, and mounting requirements.

You might have to remove knobs from either style before a

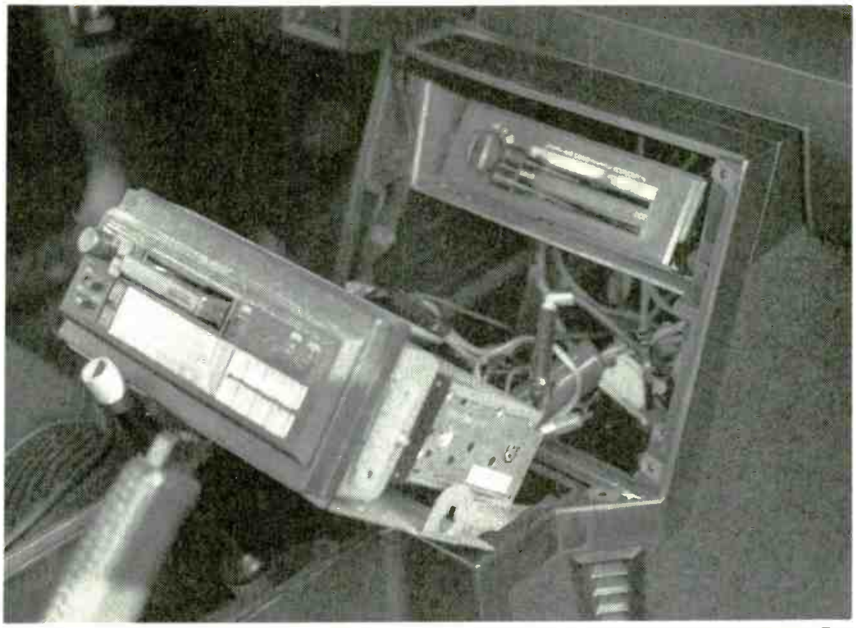


FIG. 7—DIN-STYLE STEREO requires a mounting kit to secure it in the console. Be sure that the mounting kit will fit your car.

FIG. 8—FRONT SPEAKERS can usually be mounted under the dashboard cover.

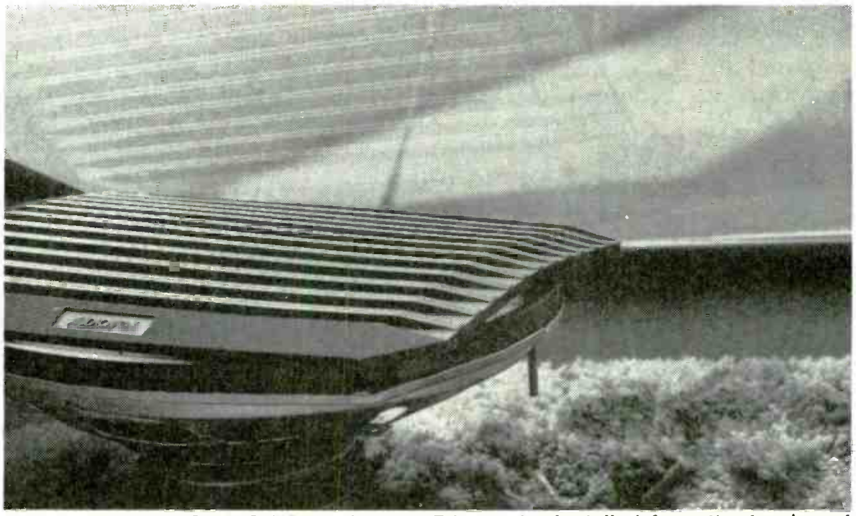


FIG. 9—REAR-DECK MOUNTED SPEAKERS can be installed from the trunk and positioned against the rear deck or mounted from above. Carpeting can cover the rear panel if it is soiled or warped.

dashboard installation can be removed. When you are working on late-model cars, you might need some special tools to fit unusual fasteners. You can usually obtain these from most automobile parts supply stores.

Most radios are installed with a bracket that is bolted to both the underside of the dashboard and to the back of the radio case. You can gain access to the bracket from under the dashboard, but you might have to remove covers or panels to get at the unit. Remove the bracket from the radio—not from the dash panel.

If it is not possible or practical to remove the radio through the front opening of the dashboard because of its size or interfering hardware, the radio must be removed from behind the dashboard. Oversize radios are more likely to be encountered in older cars that still have their original equipment in place.

Figure 5 shows a 23-year old Delco AM/FM monophonic radio with a more modern Kenwood AM/FM stereo with a cassette deck on top of it. This clearly illustrates the progress in miniaturization of automotive radios over the years—even with many additional features added.

It might be necessary to remove ventilation ducts and other interfering hardware to complete a job. The removal of a center-console-mounted radio, for example, might require the partial or complete removal of the console itself.

When all of the mechanical fasteners have been removed, permitting the radio to be pulled from its cutout, the next step is to disconnect any attached wires. Factory-installed radios typically have one or more connectors that can simply be unsnapped, and the antenna cable can be unplugged. You might want to identify the power supply wires that you will need at the connector with a voltmeter at this time.

The other wires connect the factory-installed speakers which you will probably discard. There might also be a separate power wire attached to the car's headlight switch. Power from that wire illuminates the radio's dial only when the car's headlights are on. The automobile's ignition switch must be on on to enable the radio's ON/OFF switch. Many modern automotive stereos also have lights that illuminate the stereo's control buttons when the headlights are turned on, even if the radio is off.

FIG. 10—REAR SPEAKERS can be mounted behind the back-seat side panels—if space permits.

FIG. 11—IN A HATCHBACK CAR, rear speakers can be mounted on the panels in the hatch area.

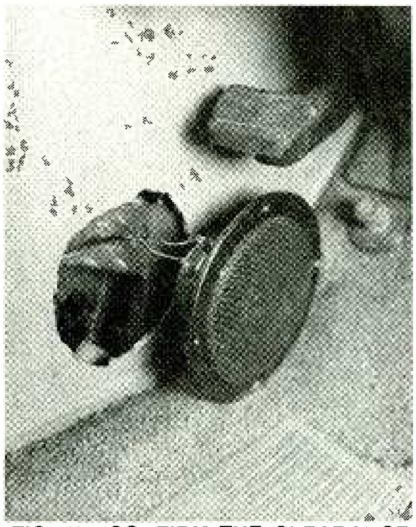


FIG. 12—CONFIRM THE CLEARANCE space when mounting speakers in door panels or front kick panels by removing the panel and making a measurement.

When installing your new stereo system, avoid wherever possible, any unnecessary alteration of your car's interior. You might have to cut away some metal or plastic around the mounting hole in the dash panel to accommodate the new unit. Double check your measurements before you do any cutting that might be incorrect and irreversible, leaving the dashboard defaced.

The control-shaft spacing on conventional automotive stereos can usually be adjusted so that the case will fit through the original opening in the dashboard. Most of those radios are sold with bezels that fit securely over the dash panel's original trim plate.

The bezel might have grooves molded into its frame that allows pieces of it to be snapped off to adjust its size, as shown in Fig. 6. However, a DIN-type stereo usually requires a mounting kit to secure it in its intended location, as shown in Fig. 7. The installation of a removable radio is similar, but only the radio's mounting sleeve is installed. The radio then slides into the sleeve.

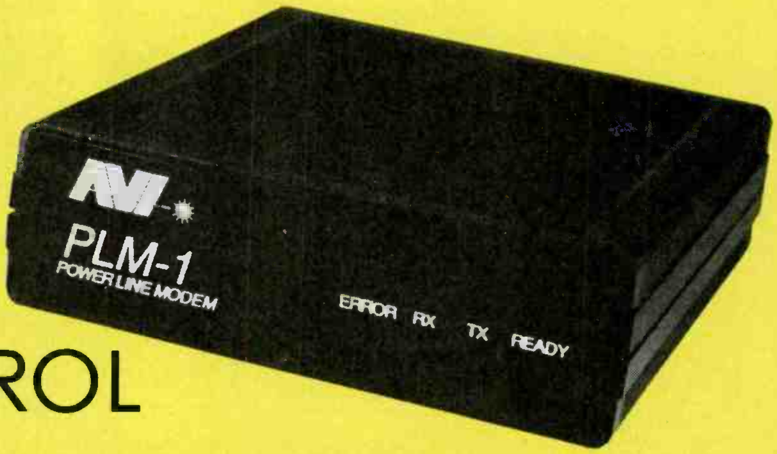
Speaker installation

Assume that you have removed your old radio successfully and are ready to install your new system. Now is the time to install the speakers. However, you first must decide if you want two speakers or four. The interior space in some cars is so restricted that it has room for only two speakers, so the decision has been made for you.

Unless you have some compelling reason for installing new speakers in another location, it makes sense to put them in the

Continued on page 90

POWER LINE MODEM FOR HOME CONTROL



This power-line modem lets your personal computer send signals over your home's wiring to control lights and appliances.

EDWARD J. KEEFE, JR.

THE PERSONAL COMPUTER MAKES it possible to control just about anything these days—if you have the right hardware and software. This article tells you how to build the PLM-1, a power-line modem that, under the control of a personal computer, will let you operate and monitor your home lighting and appliances over a network formed by your home's power wiring. This system provides a more comprehensive and versatile control than commercially available controllers.

In 1978 a power-line carrier (PLC) code format called X-10 was introduced for the control of household lights and appliances by means of remote modules plugged into AC electrical outlets. Then as now, those interface and transmit-receive modules, as well as a simple controller for the X-10 systems, are sold by retail hardware stores and home improvement centers as consumer-installable items.

These products, which include remote modules, command center/ controllers, handheld controllers, and remote wall switches are sold under the trade name "Plug'n Power." Table 1 is a listing of fourteen different kinds of X-10-compatible receiver and transceiver modules such photocell light-control sensors, appliance modules, and wall switches made by many different manufacturers. Only one module is required at each outlet where a light or appliance is to be controlled.

Figure 1 is a diagram of a complete light and appliance control system. It includes the PLM-1 power-line modem, a personal computer, a purchased TW-523 transmitter-receiver module, and a selection of receive modules. The TW-523 module plugs into an AC power outlet and acts as the interface with the power wiring. The personal computer-to-PLM-1 connection is made with a three-wire serial communications cable, and the PLM-1-to-TW-523 connection is made with a four-conductor, straight-through telephone cord.

In addition to acting as the interface with the household power line, the purchased TW-523 transmit-receive module is capable of controlling as many as 256 purchased receive or transmit-receive modules that can be plugged or wired into the home power wiring. It includes three optocoupled lines for the *transmit*, *receive*, and *zero-cross* signals. The optocoupled circuitry within the TW-523 that isolates it from the AC line meets UL and CSA safety standards.

All the codes in the X-10 protocol are synchronized to the AC voltage zero-crossings of the household power wiring. The personal computer generates X-10 code packets that are sent to the PLM-1 modem for the timing and message formatting required by the TW-523. The TW-523, in turn, modulate the power line with 120-KHz pulses. The PLM-1 modem permits all existing and future X-10 codes to be sent.

A string of ASCII characters sent from the PC's serial port to the PLM-1 modem will cause it to generate the correct X-10 signal envelope for the TW-523. The PLM-1 "listens" to the AC power line, receives all valid X-10 commands and sends back a serial message in ASCII form to the PC that indicates which plugged-in appliance was "talking."

The PLM-1 also offers a feature called transmit "collision detection." When an X-10 signal is requested for transmission, the PLM-1 sends the correct envelope to the TW-523. Simultaneously, the PLM-1 "listens" to its own transmit signal. If any of the required data is missing, the PLM-1 will retry the entire message. After two unsuccessful attempts, the PLM-1 relays a *collision* message to the PC that can trigger remedial responses in the system.

The software related to this article is on a 5-1/2-inch diskette available from the source given in the Parts list and on the

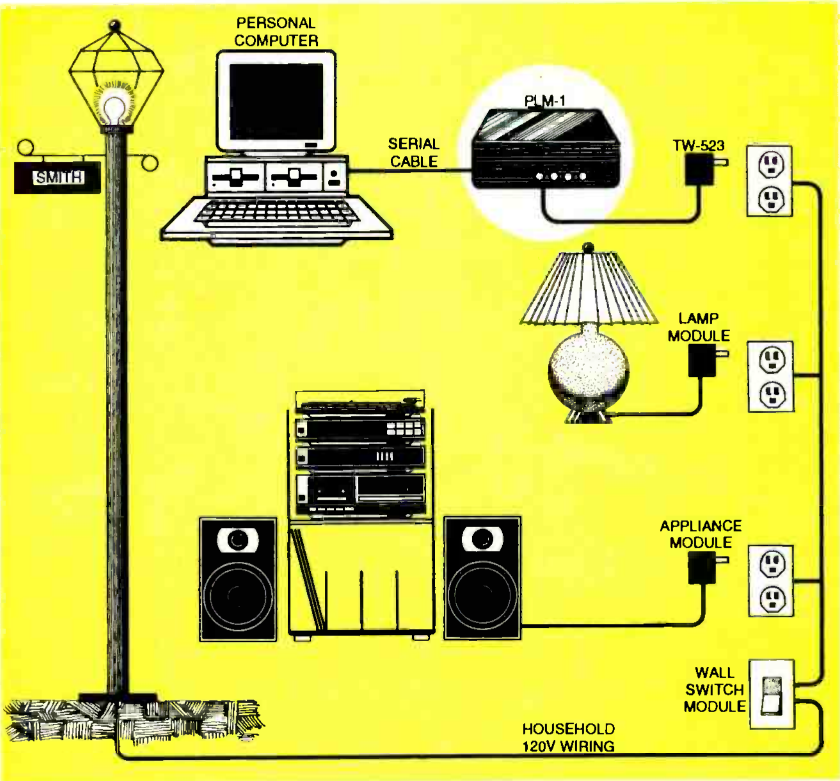


FIG. 1—A PERSONAL COMPUTER-BASED X-10 system for the control of lights and appliances. Household power wiring serves as the communications bus.

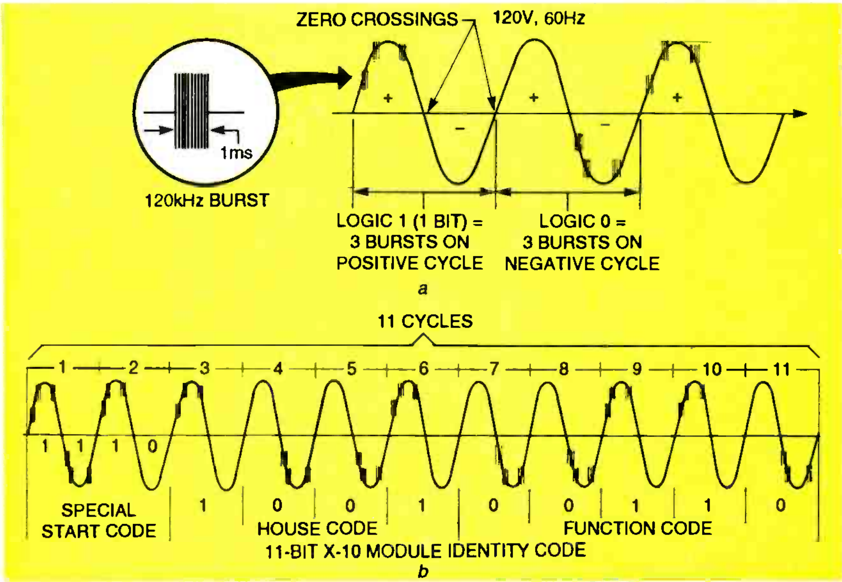


FIG. 2—THE POSITION OF THREE 120-kHz BURSTS on the 120-volt, AC waveform establishes the logic code of each cycle (*a*). An X-10 receive module is identified by 11 start, house, and function bits (*b*).

Electronics Now BBS (516-293-2283) as PLM1.ZIP. Included on the disk are the source code and hex code for programming the microcontroller within the PLM-1, sample programs for interfacing the PLM-1 to a personal computer, and samples of C, Pascal, and Visual BASIC.

X-10 protocol theory

All X-10 transmissions are synchronized to AC-voltage zero crossings as illustrated in Fig. 2. All signals must be transmitted as closely as possible to the AC-line voltage zero cross, and their durations must be no longer than 200 microseconds. The TW-523 interface provides 60-Hz square waves as shown in Fig. 2 with a maximum delay of 100 microseconds from the zero-crossing point.

The maximum delay between the transmit request from the personal computer and the generation of the 120-kHz burst by the TW-523 is 50 microseconds. This means that the transmit request must be made within 50 microseconds of the zero-crossing square wave.

A *1* is represented by a 1 millisecond burst of 120-KHz signal at the zero crossing. A *0* is formed by the absence of the burst. The 120-kHz burst is generated by the TW-523, so only a *1* need be sent for 1 millisecond.

As shown in Fig. 2, eleven cycles of the 60-Hz power line are required to transmit a complete message in X-10 code. The first two cycles represent the start code. The next four are assigned as *house* codes, and the last five are the *number* or *function* codes. With the exception of *bright* and *dim* functions which must be transmitted continuously, all complete blocks must be sent in groups of two, with three complete power-line cycles between them.

CYCLES	CODE
2	Start
4	House
5	Function (number)

A data check is performed by sending the house and function (number) codes in complimentary form on alternate half cycles of the AC line. The start code does not conform to this rule; it must always be in the "1110" form to distinguish it from the house and function codes.

Circuit description

Figure 3 is the schematic for the PLM-1. It is designed around a 87C51 CMOS, single-chip microcontroller (MCU) designated IC1. It is a CMOS version of Intel's 8751 MCU selected because of its lower power consumption. The 4 kilobytes of internal one-time programmable EPROM

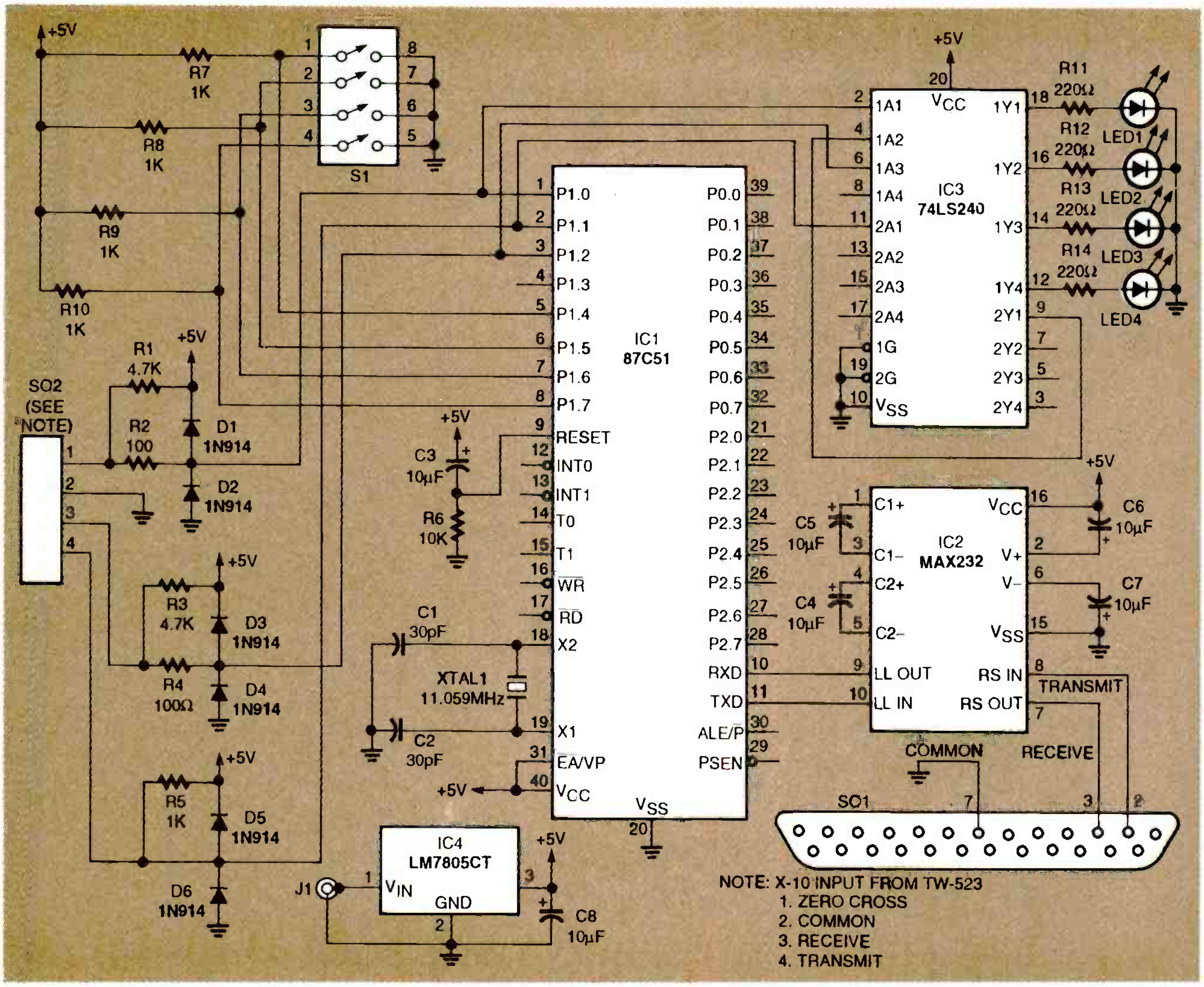


FIG. 3—SCHEMATIC FOR THE PLM-1 MODEM that conditions X-10 codes from a personal computer for use by an X-10 two-way power-line interface in a home light and appliance control system.

must contain the complete program required for X-10 interfacing. The 87C51 also has a full duplex serial port, two timers, and 128 bytes of RAM. The PLM-1 modem depends on IC1's port 1 for all input/output functions except those specified for the serial port.

The clock oscillator for IC1 is the 11.059-MHz crystal XTAL1 with 30 picofarad capacitors C1 and C2 across its electrodes. When power is applied, a reset circuit, formed by resistor R6 and electrolytic capacitor C3, initializes IC1. Because the program that controls the interface is internal, pin 31 of IC1 must be held at +5 volts.

The interface to the TW-523, RJ-11 telephone socket SO2, is provided by three simple clamping circuits consisting of diodes D1 through D6 and resistors R1 through R5. The signals from IC1 are sent to SO2 from pins 1, 2 and 3 (P1.0, P1.1, and P1.2, respectively). These three signals are also connected to the 74LS240AN bus transceiver IC3 that drives the status-indicating light-emitting diodes LEDs 1 through 4. These LEDs indicate the presence of the zero-crossing signal from the TW-523, X-10 transmit and receive, and entry errors from the serial port.

The RS-232C serial interfacing is performed by IC2, a MAX232, which generates the negative voltage required by the RS-232C specification. Four 10µF capacitors, C4 through C7, function as charge pumps and filters. For a standard three-wire interface, pins 7 and 8 of IC2 are connected to pins 2 and 3, respectively, of D-type DB-25 socket SO1, and pin 7 of SO1 is grounded. A cable from socket SO1 couples the PLM-1 to the personal computer.

The four-position DIP switch S1, shown in Fig. 3, permits communications and message options to be selected. Before applying power to the PLM-1, the correct baud rate must be selected. Fig. 4 shows the front face of S1 schematically and it includes a table of settings for the baud rates supported. (The location of switch S1 is shown in the parts placement diagram, Fig. 5.)

The switch in Fig. 4-*a* is shown set for 1200 baud. The format is no parity, 8 data bits, 1 stop bit. *The software terminal program must be set to the values given in Fig. 4-b for the system to work.* Switch position 3 is not used, and switch position

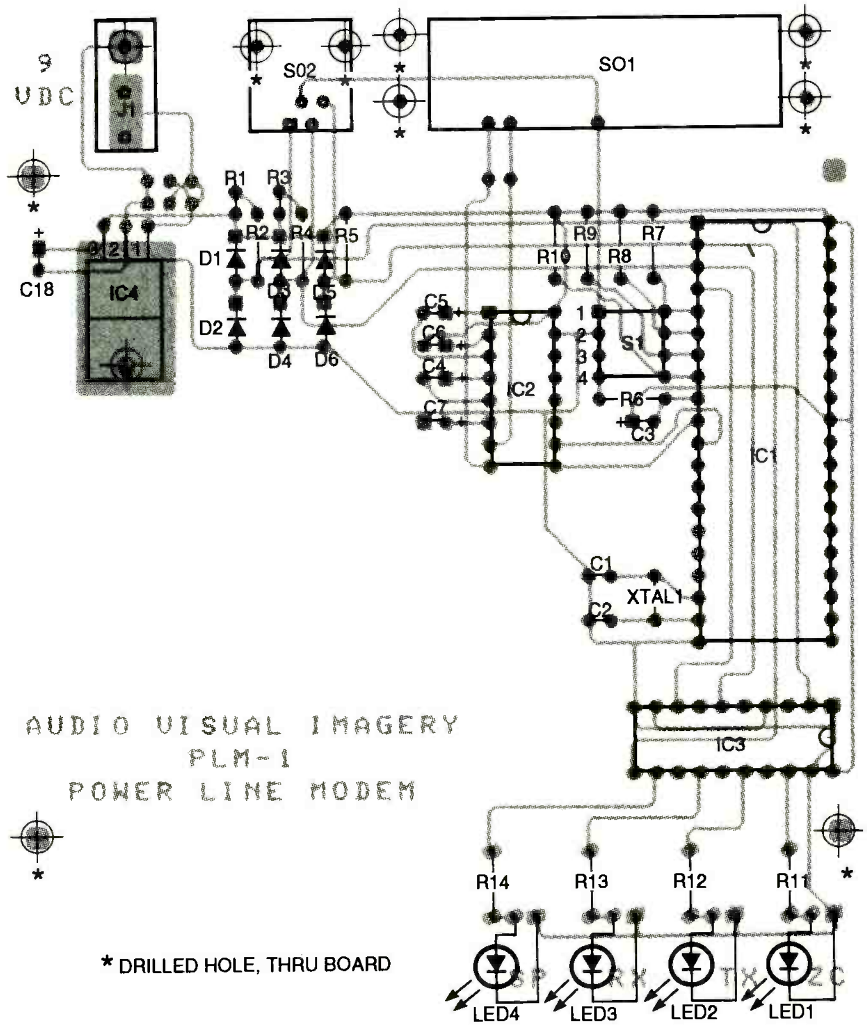


FIG. 4—PARTS PLACEMENT DIAGRAM for the PLM-1 modem. LEDs can be mounted off the board and inserted in formed holes in the end panel.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise specified.

R1, R3—4,700 ohms
R2, R4—100 ohms
R5, R7, R8, R9, R10—1000 ohms
R6—10,000 ohms
R11, R12, R13, R14—220 ohms

Capacitors

C1, C2—30 pF, mica
C3, C4, C5, C6, C7—10µF, 16 volts, tantalum
C8—10µF, 16 volts, aluminum

Semiconductors

IC1—P87C51, microcontroller, CMOS, Intel or equivalent
IC2—MAX232, line transceiver Maxim or equivalent
IC3—74LS240, octal buffer/line driver, Motorola or equivalent
IC4—7805CT positive 5-volt regulator, 1.5 ampere, TO-220 package, Motorola or equivalent
D1, D2, D3, D4, D5, D6—1N914 silicon diode
LED1, LED2, LED3, LED4 —Light-emitting diode, T1¾, red

Other components

XTAL1—crystal holder, 11.059 MHz, two-pin case
S1—4-position digital DIP switch, PCB mount, Digi-Key A5204 or equivalent
J1—DC jack, PCB mount (see text)
SO1—DB-25, 25-pin D-style socket, PCB mount
SO2—4-pin RJ-11 modular phone jack

Miscellaneous PC board or 0.1-inch-grid punched circuit board, two-piece plastic case (see text), DIP-style IC sockets: one 60-pin, one 20-pin, and one 16-pin, 120-volt AC-to-9-volt DC adapter rated for at least 0.5 amperes (see text), plastic two-piece case (see text), solder, TW-523 interface module, length of telephone

TABLE 1
X-10 DEVICES AVAILABLE

Lamp modules (dimmable)
2-pin Appliance modules
3-pin Appliance modules
Wall-switch modules
Three-way wall-switch modules
Screw-in lamp modules
Drapery controllers
Chime modules
Universal modules (contact closure & beeper)
Thermostat set-back modules
Alarm interface
Flood lamps
Motion sensors
Barking-dog alarms

4 controls message format.

When power is first applied to the PLM-1, the word READY is sent to the computer. ENTRY ERROR is sent whenever the message from the serial port is not in the correct PLM-1 format. If a transmit collision happens, COLLISION DETECTED is sent.

These messages might take too much time in critical systems, so they can be removed by setting position 4 of switch S1 in the up (ON) position. This will transform each message into a single ASCII numeric character so that X-10 receive messages will not be affected. Position 4 of switch S1 in Fig. 4-*a* is shown set for word messages.

After the PLM-1 completes its requested task, it responds with an alphabetic or numeric message as described. Table 1 lists the numeric responses and gives their alphabetic or word equivalents.

Software explanation

The program within microcontroller IC1 is interrupt activated. At reset, the internal RAM is cleared and the timers are initialized. The interrupt priority is set and the main loop is started. The main loop confirms that a TW-523 is connected to the the modem, checks for new received X-10 messages, and expedites retries resulting from collisions.

The serial interrupt routine is responsible for all serial communications between the host and the PLM-1. The X-10 interface is basically five timing loops. When a *1* is required for X-10 transmission, the TXD cord terminated with RJ-11 plugs, length of 3-wire cable terminated by DB-25 plugs, solder, nuts and bolts.

Note: The following companies are sources for the manufactured modules and accessories in the system:

TW-523 interface modules and transmit/receive modules:

- **X-10 (USA) Inc., Northvale, NJ 07647**
- **Home Automation Labs, Smyrna, GA 30080**
- **Home Control Concepts, San Diago, CA 92126**

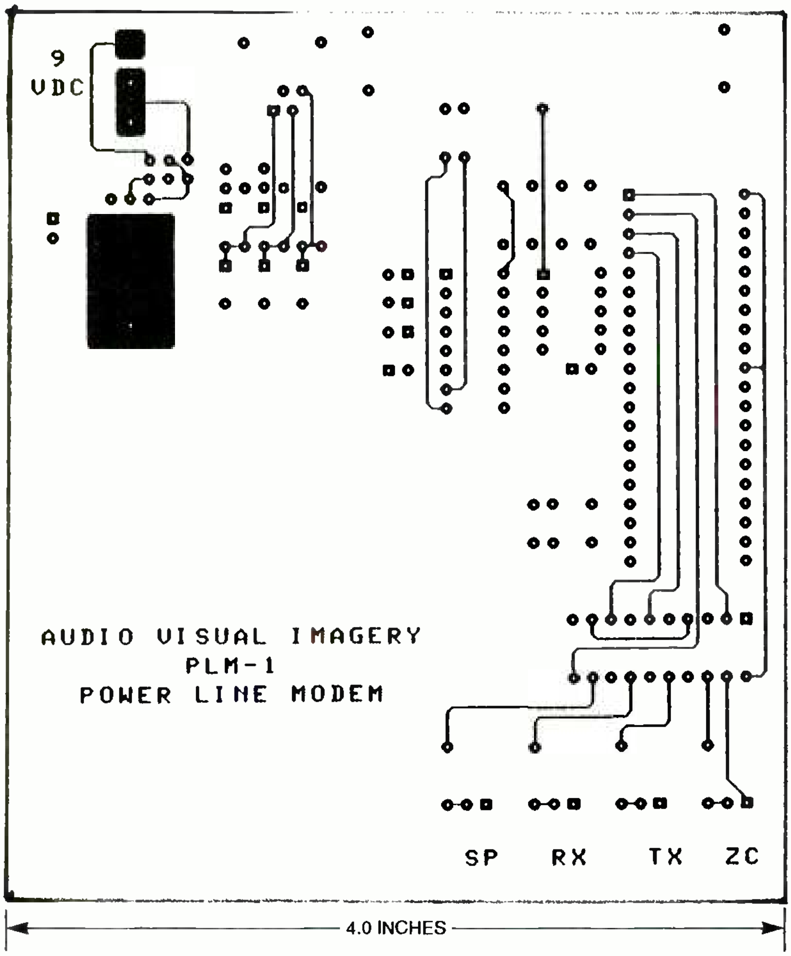
Two-piece case:

- **Pac-Tec, Philadelphia, PA 19104**

The following selection is available from Audio Visual Imagery, P.O. Box 332, Randolph, MA 02368

- **Assembled and tested PLM-1 modem, one TW-523 interface module, plug-terminated phone cord, and D-style connector terminated cable—$149.95**
- **Complete kit of all active and passive components and printed circuit board, less case and TW-523 X-10 interface module—$99.95**
- **Programmed 87C51 microcontroller—$34.95**
- **TW-523 X-10 interface module—$34.95**
- **Printed circuit board—$29.95**

A diskette with sample files will be included with all orders. Add $3.00 for shipping and handling to all orders. Massachusetts residents add 5% sales tax.



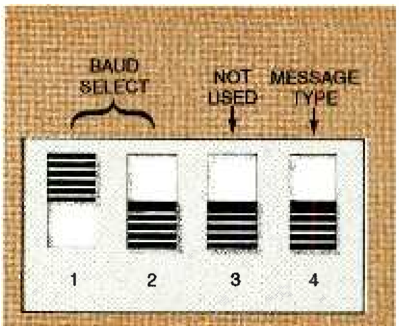
FOIL PATTERN FOR COMPONENT side of PC board.

output port pin 11 of IC1 is set high, and the timer delays the output 1 millisecond. The TXD port pin is then set low and a delay of 1.778 milliseconds is introduced. This sequence is repeated two more times.

The compliment of this delay is then sent. This simple error-checking function is part of the X-10 protocol specification. The bits of each transmission are rotated out the TXD port pin 11, each synchronized to an AC zero-crossing.

As stated earlier, the main loop also checks for received X-10 messages. It does this by polling P1.2 pin 3 of IC1. Because IC1 runs significantly faster than X-10, the chances of it missing a message are remote. The received data is then processed to accept its core information and formed into an ASCII message that is loaded into the serial-transmit buffer of IC1. The serial-interrupt routine then performs the RS-232C transmission. The X-10 receive section of the code also permits the PLM-1 to carry out collision detection.

The data on the power line can be degraded by noise or other X-10 transmissions in the



a

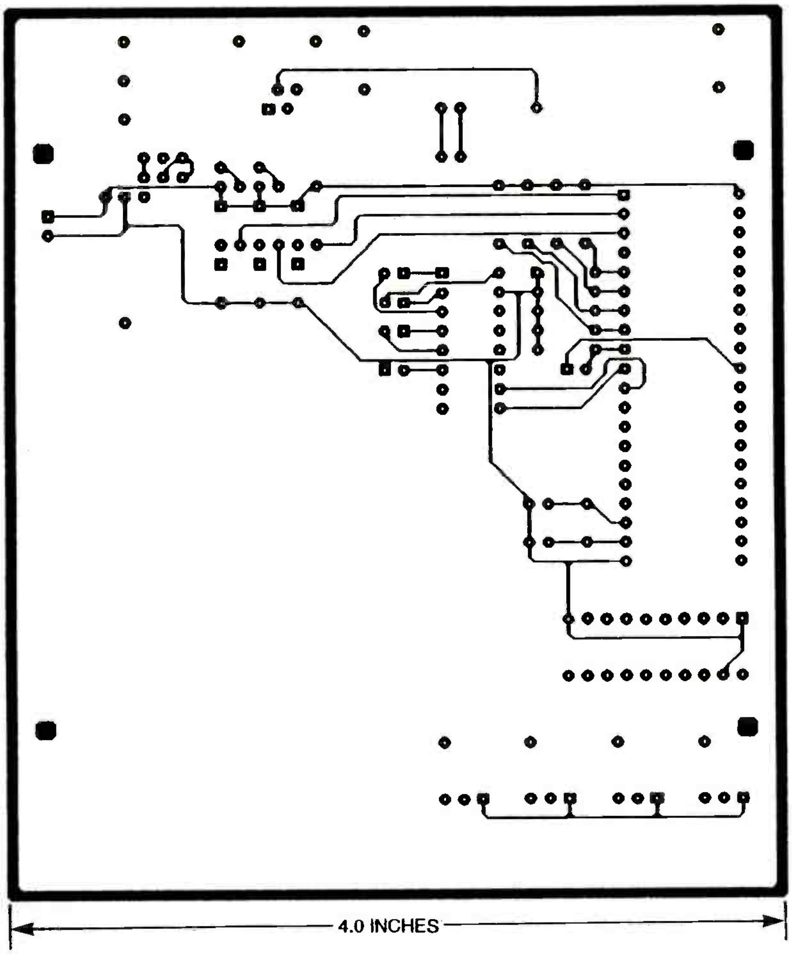
BAUD RATE	SWITCH 1	SWITCH 2
9600	DOWN	DOWN
2400	DOWN	UP
1200	UP	DOWN
300	UP	UP

b

FIG. 5—DIAGRAM OF FOUR-POSITION DIP switch S1 (*a*), and a table for setting baud-rate with switches 1 and 2 (*b*).

TABLE 1
ALPHA AND NUMERIC RESPONSE EQUIVALENTS

Numeric Response	Alpha Response
0	READY
1	ENTRY ERROR
2	COLLISION DETECTED
3	CHECK TW-523
4	TW-523 OK



FOIL PATTERN FOR SOLDER side of PC board.

TABLE 2
PLM-1 CODE EQUIVALENTS

PLM-1 Code	House Code	Unit Code	Function Code	Relative Brightness (Percent)
0	A	1	ALL UNITS OFF	100.00
1	B	2	ALL LIGHTS ON	93.75
2	C	3	ON	87.50
3	D	4	OFF	81.25
4	E	5	DIM	75.00
5	F	6	BRIGHT	68.75
6	G	7	ALL LIGHTS OFF	62.50
7	H	8	EXTENDED CODE	56.25
8	I	9	HAIL REQUEST	50.00
9	J	10	HAIL ACKNOWLEDGE	43.75
A	K	11	PRESET DIM (1-8)	37.50
B	L	12	PRESET DIM (9-F)	31.25
C	M	13	EXTENDED DATA	25.00
D	N	14	STATUS = ON	18.75
E	O	15	STATUS = OFF	12.50
F	P	16	STATUS REQUEST	6.25

system. However, the TW-523 transmit-receive interface can "hear" anything it "says," so the PLM-1 can ensure data integrity by comparing transmission requests with what was sent.

Other routines are included for Hex and ASCII conversion, LED display and blink, message parsing, and ROM date and version information. The complete source code for IC1 is available from the source in the Parts List, and it is on the **Electronics Now** BBS, 516-293-2283.

Building the PLM-1

Refer to the parts placement diagram Fig. 5. The circuitry of the PLM-1 is so simple that it can be built on stock 0.10-inch grid punched circuit board by point-to-point wiring. However, construction will be faster and the end result will look more professional if a two-sided printed-circuit board is used. A circuit board is available from the source given in the Parts List, but if you prefer to make your own, component- and solder-side foil patterns are included in this article.

All conventional methods for electronic component insertion and soldering on a circuit board apply to this project. The circuit board layout calls for the axial-leaded resistors R1 through R5 and diodes D1 through D6 to be inserted vertically on the circuit board. Carefully bend one lead of each of those resistors and the cathode lead of those diodes 180° so they effectively become radial-leaded components.

Insert, solder, and trim the leads of all the diodes, resistors and capacitors at the locations shown in Fig. 4. Verify that the correct polarities of all diodes and electrolytic capacitors have been observed. Insert and solder sockets for ICs 1 through 3 after verifying the correct locations for pin 1 of each IC.

The way you mount the four LEDs will depend on your PLM-1 packaging preference. If you want to view the LEDs through a translucent red filter at one end of the case, grasp the LED leads close to the lens with needle-nose pliers and bend their ends 90° so that the LEDs lie flat on the PC board when they are inserted. Then solder and trim the leads.

However, if you prefer that ends of the LED lenses project through holes in an opaque plastic end panel, insert the leads in the board so that their ends are flush with the solder side of the board, and solder them in position. (The LED leads can then be bent later so that the lens ends will project through the end-panel holes after the circuit board has been attached to the bottom half of the case.)

Bend the ends of the leads of the TO-220-packaged voltage regulator IC4 90° and insert them on the board so that the heat sink tab lies flat against the heat sink patch on the circuit board. Fasten the heatsink tab of IC4 to the board with a nut and bolt through the hole in the tab to mount the voltage regulator more securely to the board and improve its heat-sinking properties. Solder and trim the leads.

Assemble and solder DIP switch S1. Unless the D-type connector S1 has only leads 2, 3 and 7 exposed, trim all the other leads close to the connector body. Insert those three pins of SO1 in the circuit board as shown in Fig. 4, and fasten the socket with nuts and bolts. Then solder and trim leads 2, 3, and 7 close to the solder side of the PC board.

Insert the four leads of RJ-11 socket SO2 through the PC board and seat it by inserting the plastic mounting pins through the formed holes. Solder and trim the leads, and melt the ends of the plastic pins on the solder side with a soldering iron to secure it in position. Insert the pins of coaxial DC jack J1 in the board and seat it. Solder and trim the leads.

Finally, after rechecking the polarities of the diodes and capacitors for proper orientation and making certain there are no inadvertent solder bridges or cold solder joints, insert the DIP-packaged ICs 1, 2 and 3.

Packaging the PLM-1

The prototype PLM-1 was packaged in a two-piece plastic case that measures $5 \times 5\frac{1}{4} \times 1\frac{1}{2}$ inches. The halves can be separated by removing two screws. In the prototype, a red translucent filter was substituted for one of the two opaque plastic $4\frac{3}{4} \times 1\frac{5}{16}$-inch end panels included. Identification markings for the four LEDs—ERROR, RX, TX and READY—were silk screened

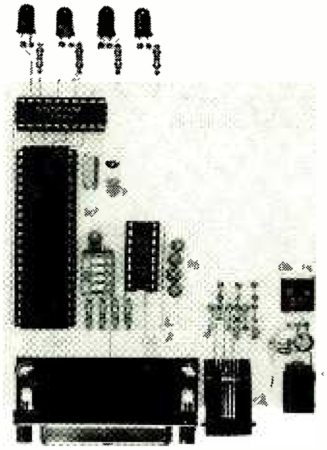


FIG. 6—COMPLETE PLM-1 CIRCUIT board.

on the filter. The socket end of the case was left open.

Alternatively, you can form four holes in one of the two opaque plastic end panels so that the ends of the four LEDs can be press fit into those holes. The holes should be sized so that only the ends of the tapered lenses project from the end panel. Determine the size by measuring the actual LEDs precisely. The holes can be labeled with the four functions stated earlier.

After the complete circuit board is fastened to the bottom of the case with four screws, the LED leads can be carefully bent in pairs so that the ends of their lenses project through the corresponding holes formed in the end-panel.

Monitor operation

Connect the TW-523 interface module to the PLM-1 with a length of telephone cord terminated with RJ-11 plugs, and connect the PLM-1 to your PC with a three-wire serial cable terminated with matching plugs. Start any communications program that you prefer on your personal computer. Any communications software that offers a terminal mode can be used (Procomm, Bitcomm, QModem, Windows Terminal).

After verifying that the center conductor of the cord from the 120-volt AC-to-9-volt DC wall outlet adapter has a negative polarity (see the diagram on the adapter's label), plug it into jack J1 on the PLM-1 circuit board.

A "READY" message should appear on the PC monitor. Refer to the the commands given in the Message Structure section that follows, and then send the desired command to the TW-523 interface.

Message structure

Note: All serial data sent to the interface must be transmitted as upper case characters; lower case characters will be interpreted as errors. All commands must be terminated by pressing the RETURN key. Six different X-10 starting characters are used:

* Send normal commands
# Send multiple dim and bright commands
$ Direct unit control
@ Direct function control
& Send multiple direct function controls
? Obtain software date and its revision

Each character has its own specific format.

The normal message format is *HUF where * is the start character, H is the *house* code, U is the *unit* code, F is the *function* code. To send a command that will turn unit A-1 on, refer to Table 3 and organize the command as follows:

* Start character
0 House code A
0 Unit 1
2 ON

To send the ON command, key *002, then hit RETURN.

To send the OFF command, key *003, then hit RETURN.

To send the DIM A-1 command, key *004, then hit RETURN.

To send the BRIGHTEN A-1 command, key *005, then hit RETURN.

Here are some sample commands:

*A02 K-1 ON
*A03 K-1 OFF
*A04 K-1 DIM
*A05 K-1 BRIGHT
*C42 M-5 ON
*C43 M-5 OFF
*C44 M-5 DIM
*C45 M-5 BRIGHT

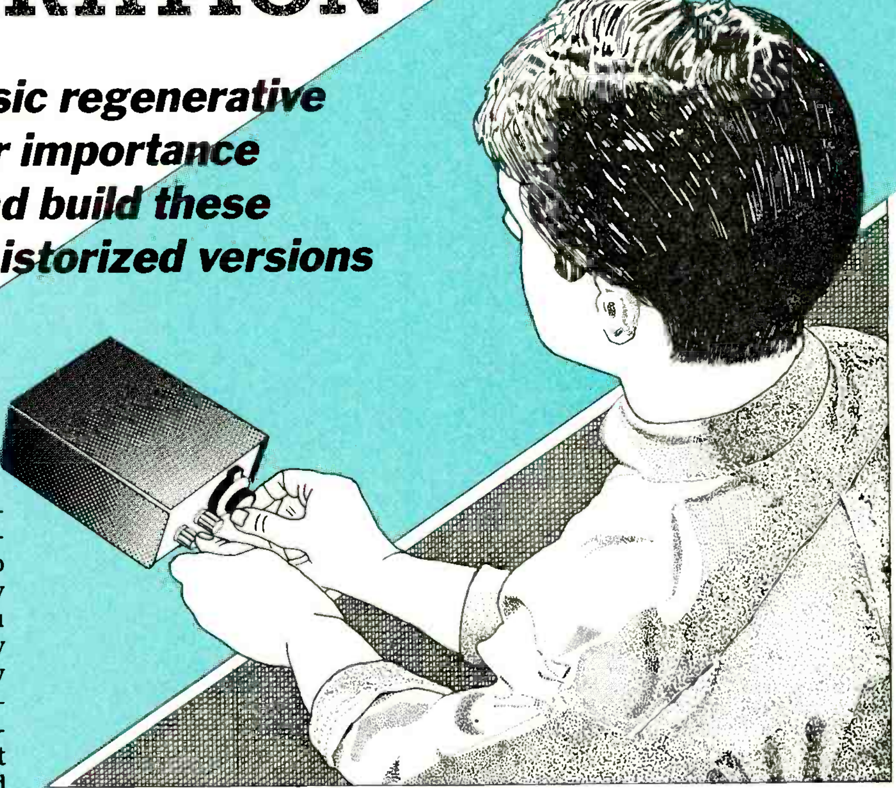
To send multiple dim or brighten commands, use the start character #. The format is

Continued on page 74

THE LOST ART OF REGENERATION

Look again at classic regenerative receivers and their importance in radio history, and build these modernized, transistorized versions

CHARLES KITCHIN



IT IS NOT MUCH FUN TO BUILD A MODern superheterodyne radio receiver these days because so much of the receiving circuitry is within a few ICs. Even if you do build one, you probably won't learn much about how they work—there is little opportunity to experiment and explore. Moreover, you can expect that the cost of parts will exceed the price of a radio at your local drug store. Nevertheless, educators agree that the best way to "get in touch" with the history of radio and enjoy electronics is to start by building a radio receiver from scratch.

This article will return you to those "thrilling days of yesteryear" when almost anyone with an interest in radio could make his own receiver. It will retrace one of the important "roots" of modern electronics—regeneration or positive feedback. The schematics presented here are based on key circuits that were invented by geniuses whose names are only vaguely familiar to most people today.

The four regenerative detector receiver circuits discussed here were designed to give anyone from a novice to an expert "hands on" experience in building circuits that hold an important place in the history of radio communications. Transistors and ICs have replaced the vacuum tubes of the original circuits so you won't have to deal with 120-volt power. These "redesigns" have also minimized the number of "antique" components required.

This article differs from a typical **Electronics Now** "build-it" article—it does not contain parts placement diagrams nor does it contain complete parts lists. This means that if you want to build some or all of these circuits you'll have to be a bit more resourceful. However, the names of several companies offering the "hard-to-get" parts are included in the article.

You should also know that, although the performance of these modernized versions of classic circuits is quite good, skill and patience are needed to get the most out of them. Also some post construction adjustments are called for.

Back in the 1920s and 1930s radio receivers were simple. If you did not want to buy one (they were expensive in those days), all you needed was a handful of parts, wire, solder, and wooden bread board. With a few hours of hand crafting, you could be listening to shortwave or your local AM station.

In those days radio fans were likely to know a lot more about the contributions of the great radio pioneers like Hertz, Fleming, Marconi, and Armstrong. These days their names are rarely mentioned in classrooms because the study of their accomplishments has been crowded out by such modern subjects as digital electronics, signal processing, and computer programming.

Radio-receiver history

Prior to the development of the vacuum tube, the most common radio circuit was the *crystal set* whose schematic is shown in Fig. 1-*a*. It was found that some natural minerals such as silicon and galena (lead-sulfide) had the ability to rectify current. Electromagnetic waves that intercepted the antenna caused a voltage to be developed across coil L1 between the antenna and ground. That voltage caused a current to flow through crystal D1 and the headphones on the positive half cycle.

When current flowed through the circuit, capacitor C2 was charged. When the polarity reversed, however, there was no current flow through the crystal because of its rectification property. During this half of the cycle, the capacitor discharged through the headphones. Figure 1-*b* shows an audio-frequency wave, Fig. 1-*c* illustrates an audio-modulated radio frequency wave, and Fig. 1-*d* represents a demodulated (detected) wave. The headphone diaphragms followed the audio-frequency wave to produce an audible signal.

Homemade versions of this circuit typically included a lump of galena fastened to a board along with a spring-wire contact called the "cat's whisker." One end of the brass wire was sharpened to point and pressed into the galena crystal. Together these parts formed the diode detector. (The modern Schottky diode also has a metal-to-semiconductor contact.)

A crystal set was easy to make, and the parts were inexpensive. However, the catch was that finding the right contact spot on the crystal with a pointed cat's whisker was likely to be a frustrating experience. Some probing around was necessary to find a location where rectification (detection) would be performed. Moreover, if you wanted the set to work, there had to be a radio station nearby that transmitted a signal strong enough to forward-bias the crystal "diode."

In those early days some hobbyists used Quaker oatmeal boxes as coil forms, and even rolled their own capacitors from the foil-covered paper found in cigarette packs. The antenna was usually about a 100-foot length of bare copper wire strung out the window, suspended from glass insulators. A length of copper pipe was hammered into the earth below the window as a ground connection.

The diode vacuum tube, a simple two-element rectifier, offered little advantage over any of the crystal detectors—it still could not amplify the incoming signal (see Fig. 2). Thus a tube diode circuit still needed a strong signal to detect, and it also it needed power to heat its filament (the early cathode).

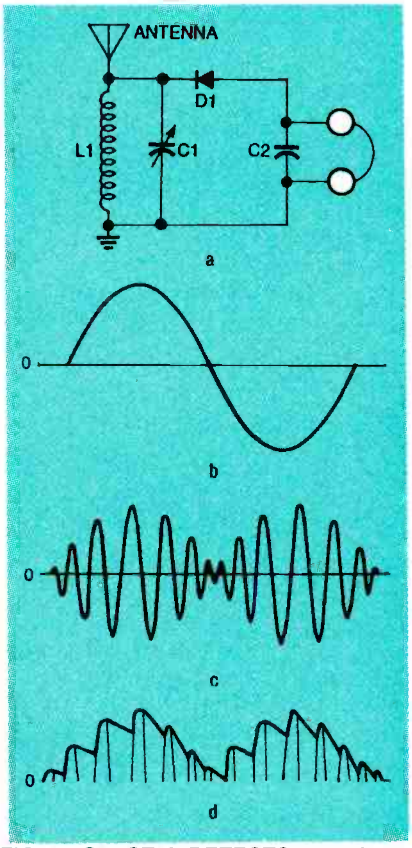


FIG. 1—CRYSTAL DETECTOR receiver with headphones (*a*), audio-frequency signal (*b*), modulated signal (*c*), and demodulated wave (*d*).

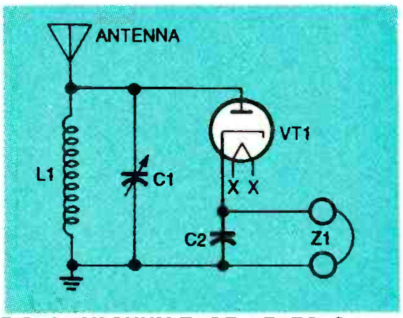


FIG. 2—VACUUM-TUBE DETECTOR receiver.

The great leap forward in receivers occurred with the introduction of the triode vacuum tube. A small voltage variation on the triode's grid caused a large variation in the plate current, providing signal amplification. To receive undistorted signals, the triode amplifier-detector had to be operated on the linear portion of its characteristic curve; thus it needed a bias to put it at the tube's *operating point*. The input signal then caused the total grid voltage to vary above and below the bias value.

The *grid-leak detector* circuit shown in Fig. 3. was one of the early schemes for obtaining the necessary bias. In this circuit, the grid and cathode act as a diode. When an input voltage was applied to the grid, current flowed from the cathode to the grid through grid-leak resistor R1.

A voltage was then developed across the grid leak which provided a bias. The greater the input signal, the more the bias. This caused the voltage between the grid and cathode to vary with the input signal level. As a result, current flowing in the plate circuit was demodulated, and that signal could be heard with a headset.

The simple grid-leak-detector circuit required two power sources—a "B" battery for plate voltage and an "A" battery for the cathode heater combination. This was only one of several possible ways to develop a bias.

The operation of the triode electron tube has similarities to the operation of the N-type bipolar junction transistor (BJT). The cathode is analogous to the emitter, the grid to the base, and the plate to the collector. However, the triode more closely resembles the junction field-effect transistor (JFET). Here the cathode is analogous to the source, the grid to the gate, and the plate to the drain.

The substitution of JFETs or BJTs for the tubes in the original circuits permits the use of 9-volt transistor batteries as power sources, and generally results in performance that is better than that of tube circuits.

The tuned inductive-capacitive (LC) "tank" circuit in the receivers shown so far permitted discrimination between desired and undesired signals. Figure 4 is a simplified schematic for a tuned radio frequency (TRF) circuit with grid-leak detection. The voltage induced in the antenna caused a current to flow through the primary coil L1 of the radio frequency transformer. A voltage was induced in the secondary coil L2, which was tuned by variable capacitor C1 to resonance at the desired station frequency.

When the resonant frequency was reached, the voltage across L2 increased while the voltages from all other frequencies were reduced. Thus the detector operated most efficiently at the *tuned* frequency.

However, a principal drawback of the resonant tank circuit in the earlier crystal or diode detector receivers is that their detectors robbed energy from their input circuits. This occurred because their operation depended on rectifying the voltage induced in the secondary circuit. The unbuffed "loading" caused by crystal or diode detectors decreased the selectivity or sharpness (Q) of receiver tuning.

While the triode's gain improved the circuit's sensitivity and its buffering relieved the tuned circuit from headphone loading, the overall performance was still poor. Adding more than one stage of RF amplification ahead of the detector did little to improve that performance.

Regenerative detector

In 1914, a gifted radio engineer, Edwin H. Armstrong, discovered that by feeding a portion of the amplified signal in the plate circuit of a triode detector back into the grid circuit, there would be a significant increase in amplification.

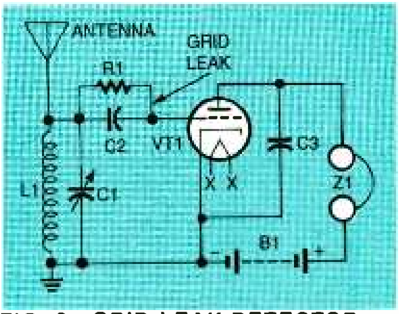


FIG. 3—GRID-LEAK-DETECTOR receiver.

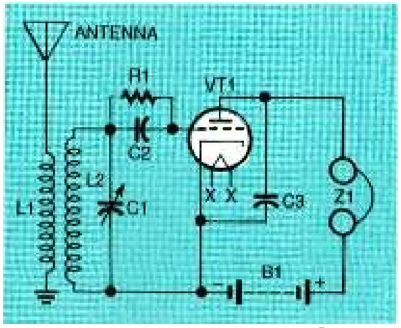


FIG. 4—TUNED-CIRCUIT RECEIVER with grid-leak detection.

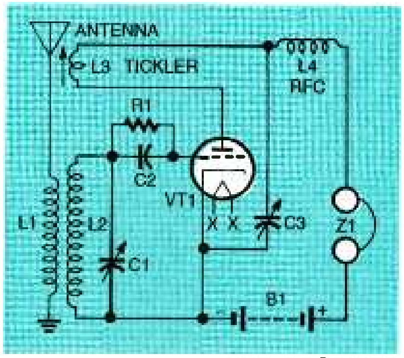


FIG. 5—REGENERATIVE RECEIVER with grid-leak detection.

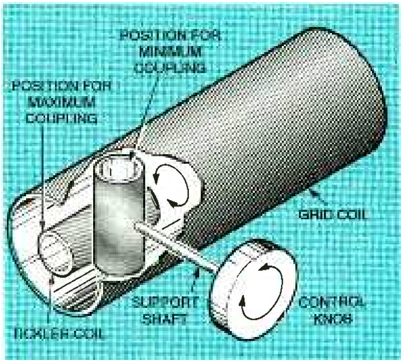


FIG. 6—VARIABLE TICKLER COIL used in early regenerative receivers.

The circuit shown in Fig. 5 is a modern version of Armstrong's original schematic for his regenerative receiver. There was no standard schematic symbol for a vacuum tube.

A regenerative detector is basically a grid-leak detector in which a portion of the output signal is fed back to the tuned input circuit *in phase* with the input signal. The in-phase feedback lowers the resistance of the tuned input circuit, therefore raising its Q. This feedback also substantially increases the strength of input signals at or near the resonant frequency of the tuned circuit. As a result, both the amplification and selectivity of the stage are raised, especially for weak input signals.

The amplified signal in the plate circuit flows through tickler coil L3, which induces an increased current flow through the secondary coil L2. This increases the signal at the grid, causing an even greater signal at the plate. The input signal is therefore repetitively re-amplified providing very high single-stage amplification.

If enough of this energy were fed back into the grid circuit, the circuit would oscillate. This is not surprising: Remove the symbols for the antenna, coil L1, and the headphones, and you have a schematic for an *Armstrong oscillator.*

To prevent the receiver from becoming an unwanted oscillator, Armstrong invented a way to control the amount of positive feedback or regeneration. He did this by rotating the tickler coil L3 within the grid coil L2, as shown in Fig. 6. Coil L3 was mounted on a shaft at right angles to the axis of coil L2. (The shaft projects through the front panel of the radio, and a control knob is attached.)

When the knob is turned so that the two coils are in the same plane, maximum feedback is obtained. When the tickler coil is at right angles to the grid coil, feedback is minimum. By carefully rotating the tickler knob, the right amount of regeneration can be found.

This scheme fell into disfavor when receivers with interchangeable coils for several frequency ranges were introduced. The rotating tickler was also bulky and difficult to manufacture, and the signal was detuned as regeneration was increased. However, it was soon discovered that regeneration could be also be controlled by substituting a variable capacitor for plate-bypass capacitor C3 shown in Fig. 5.

With this so-called "throttle condenser" in the circuit, the listener could simply remove two coils and plug in two alternatives to obtain a different range of broadcast frequencies. The fixed tickler with the right number of turns replaced variable tickler L3 within L2, permitting both L1 and L2 to be exchanged for another set.

The throttle condenser was able to transition the receiver more smoothly into oscillation than the rotating tickler, and regeneration had only a slight effect on tuning. Unfortunately, a second variable capacitor took up more space in the receiver and added to its cost.

However, it was found that varying the plate voltage was a simpler way to control regeneration. Figure 7 is a simplified schematic for a resistive-controlled regenerative detector. It was cheaper than earlier methods and resulted in only slight detuning. Tickler coil L3 was mounted permanently in a fixed position on the same coil form as grid coil L2, and a fixed capacitor bypasses the plate. In this way, plate voltage (and regeneration) is controlled by varying the resistance with panel-mounted control potentiometer R2. Capacitor C4, across the battery, smoothes any sudden changes in plate voltage.

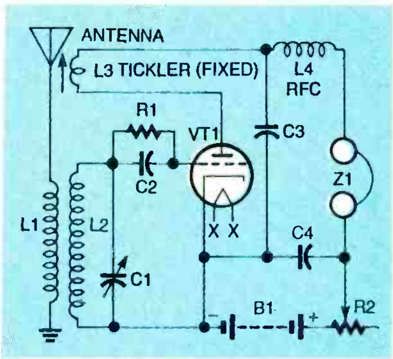


FIG. 7—VARIABLE-RESISTOR-controlled regenerative receiver.

Regeneration principles

While the power gain of a tube or transistor is fixed, the voltage gain of a regenerative detector will approach infinity as it nears self-oscillation. Regeneration introduces a negative resistance into a circuit. Because the circuit's selectivity or "Q" is equal to its net reactance divided by its net resistance, the circuit's selectivity is increased with gain when regeneration is introduced.

When regeneration is below self-oscillation, the circuit's negative resistance (produced by regeneration) is less than its fixed positive resistance. In this condition, regeneration has the effect of providing a stable increase in both gain and selectivity.

With more regeneration, a very dynamic region is reached, just at the threshold of self-oscillation. Here, the circuit's negative and positive resistances near equality. In this nonlinear operating region, minute changes in input level or circuit voltage produce very large (nonlinear) changes in output level.

The exact "balance" point between stable and unstable regeneration (when the circuits net resistance is zero) can never be achieved: even the smallest amount of random noise will eventually build up enough to drive the circuit into sustained self-oscillation.

As regeneration is increased further, a strange "click" will be heard in the headphones. This indicates that the circuit has reached the negative-resistance transition point beyond which free oscillations will occur. If regeneration is increased beyond the oscillation starting point,

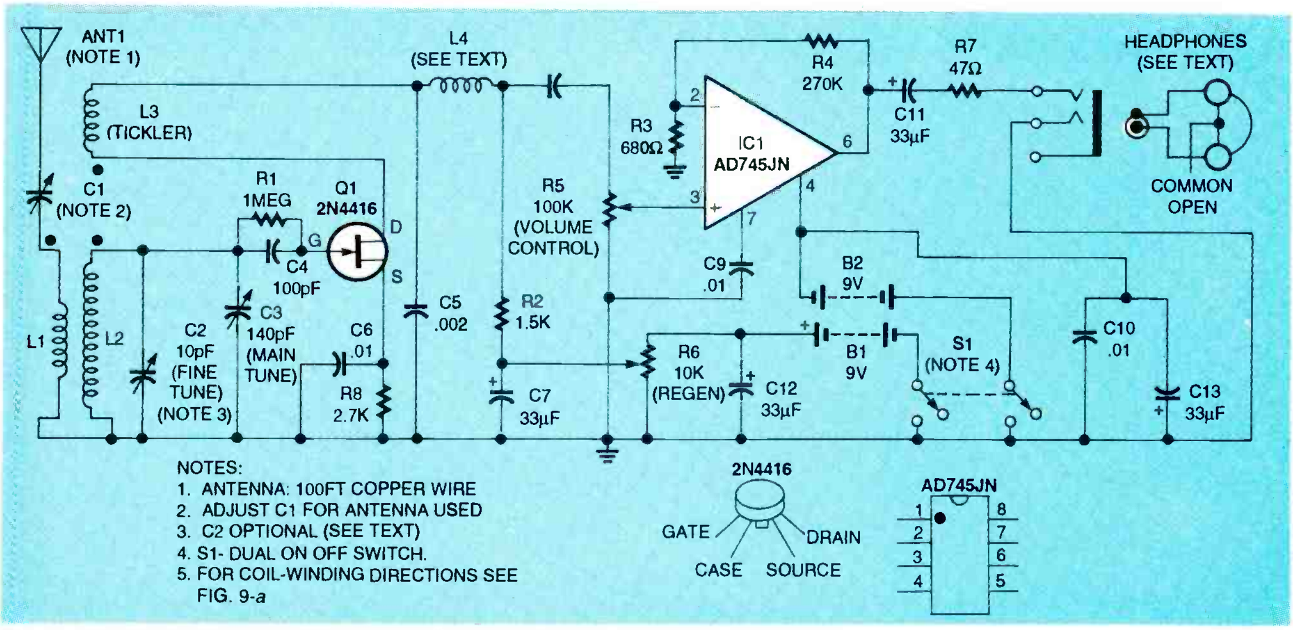


FIG. 8—REGENERATIVE SHORTWAVE receiver with JFET tuning and op-amp amplification. Frequency range is 6 to 17 MHz.

secondary oscillations at a lower frequency are generated. These oscillations tend to suppress or "quench" the main oscillation under certain conditions of input signal level and regeneration. This effect is called *super regeneration*.

Another property of a regenerative detector receiver is its ability to detect single sideband and frequency-modulated (FM) as well as amplitude-modulated (AM) signals. The single sideband signals are transmitted without a carrier; the carrier is restored in the regenerative detector by setting the regeneration threshold just above the level for free oscillation.

The listener's ability to adjust the effective "Q" of the circuit allows a regenerative circuit to detect the amplitude versus frequency slope of an FM signal. Therefore, a regenerative detector circuit can be a single-stage universal detector in a receiver.

Shortwave receivers

Figure 8 is the schematic for a modern regenerative receiver with a frequency range of 6 to 17 MHz. A 2N4416 junction field-effect transistor (JFET) detector replaces the triode tube, and an AD745JN low-noise BiFET operational amplifier acts as the audio amplifier. A change in drain voltage alters the JFET's transconductance (and therefore gain), permitting the regeneration of the circuit to be controlled easily.

The amplitude-modulated signal from the antenna is coupled to coil L1 through variable capacitor C1 whose value determines the coupling and antenna loading of the detector. Because C1 sets antenna coupling, its optimum value will depend on the length of the antenna selected and the capacitance of the antenna. A 100-foot antenna was used with the prototype.

Coils L1, L2, and L3 are wound on the same form, so the antenna signal developed in L1 is inductively coupled to L2. Capacitors C2 and C3, together with L2, form a resonant tank circuit that determines the receiver's tuned frequency. JFET Q1, a Motorola 2N4416, together with resistor R1 and capacitor C4 detect the amplitude of the incoming signal.

The JFET gate, serving as a diode detector, charges capacitor C4. The amplified drain signal is then coupled back to Q1's gate by tickler winding L3 and is repeatedly re-amplified. Regeneration is controlled by potentiometer R6, which adjusts the supply voltage applied to Q1 and thus its transconductance.

The detected audio output passes through the low-pass filter formed by capacitor C5 and radio-frequency choke (RFC) L4. This filter removes the radio-frequency component and allows only the audio signal to pass. That signal is AC-coupled to volume-control potentiometer R5, and then is amplified by operational amplifier IC1.

An operational amplifier is not a normal audio output stage, but for this receiver it is ideal. The Analog Devices AD745JN (IC1), packaged in an 8-pin DIP, provides an audio gain of 400. (It has a low-current noise of 6.9 femtoamperes per hertz and 20-MHz gain-bandwidth product.) It replaces two or three stages of audio amplification and an output transformer.

The low harmonic distortion and 30-milliampere output current of the AD745JN permits it to drive 32-ohm Sony "Walkman" headphones commonly used with personal stereos, at high-volume levels with low dis-

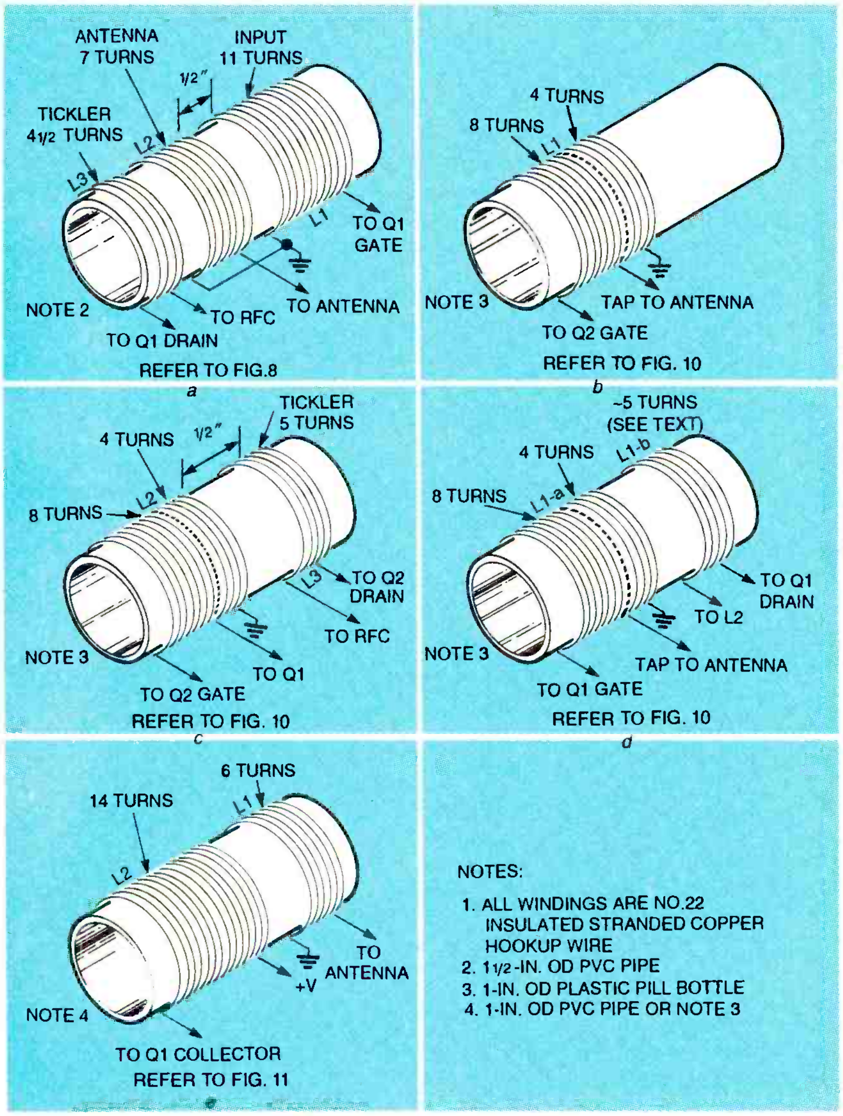


FIG. 9—COIL-WINDING DIAGRAMS for the four regenerative receivers.

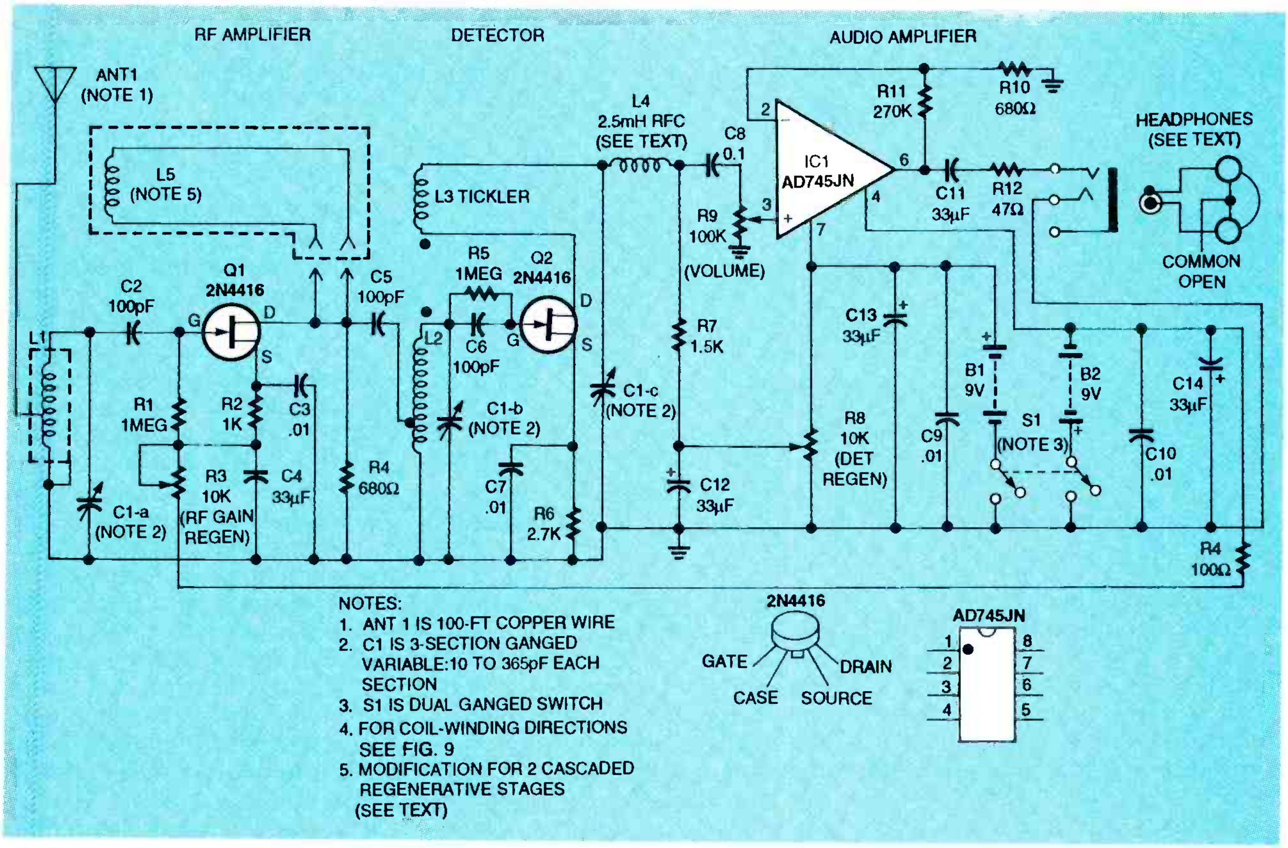


FIG. 10—REGENERATIVE SHORTWAVE RECEIVER with "throttling" capacitor," two JFETs, and an op-amp. An additional coil that adds a second regenerative stage is shown in the dotted box.

tortion. In this circuit, the headphones are series-connected, and their common terminal is floating. This wiring scheme doubles the headphone's impedance to about 64 ohms, making them much easier for the receiver to drive.

The excellent sound quality of this receiver will quickly become evident if you tune to such shortwave stations as BBC London which broadcasts music as well as voice. If a high-fidelity output is not desired, a 0.01 microfarad capacitor can be placed across volume control R5 to attenuate high frequencies.

The optimum number of turns on the tickler winding for a smooth transition into oscillation was found by trial and error. Coil-winding information is given in Fig. 9-*a*. (Figure 9 conains all the coil winding data needed to build the circuits described in this article). Too many turns will cause the circuit to break into free oscillation, making receiver tuning difficult; too few will restrict positive feedback, and receiver sensitivity will suffer.

The main tuning coil for this receiver is wound on a 3-inch length of 1.5-inch outside diameter PVC pipe. Refer to the "Coil winding" section near the end of this article for useful suggestions in coil winding.

PARTS SUPPLIERS

Air-variable tuning capacitors, transformers and miscellaneous components can be purchased from:

- **Antique Electronics Supply, 6221 S. Maple Ave. Temple AZ 85283.**
- **Fair Radio Sales Co. P.O. Box 1105, 1016 E. Eureka St. Lima, OH 45802**
- **Ocean State Electronics, P.O. Box 1458, 6 Industrial Drive, Westerly, RI 02891**

Vernier dials are available from Ocean State Electronics.

The Analog Devices AD745JN operational amplifier and the Motorola 2N4416 JFET can be purchased from any stocking branch of Newark Electronics and many other distributors.

This shortwave receiver was designed to be easy to build. With the exception of the air-dielectric variable capacitors, all of the components are readily available from electronics mail-order houses or retail stores. The two variable capacitors can be purchased from the suppliers whose names and addresses are given in the Source List. The estimated price for all the components is about $20. Stereo headphones add another $7 to $10.

There is nothing critical about the radio-frequency choke (RFC) for this receiver. You can buy a 2.5 microhenry RFC or make your own by winding several layers of turns of No. 30 AWG magnet wire around the entire length of a 470-kilohm, 1-watt, molded carbon composition (or carbon thick-film) resistor. Solder the wire ends to the resistor's leads.

Two 9-volt batteries power this receiver. It draws about 10 milliamperes from the positive battery and 8 milliamperes from the negative battery. The measured sensitivity of this receiver (50-ohm termination, 30% modulated carrier) is approxi-

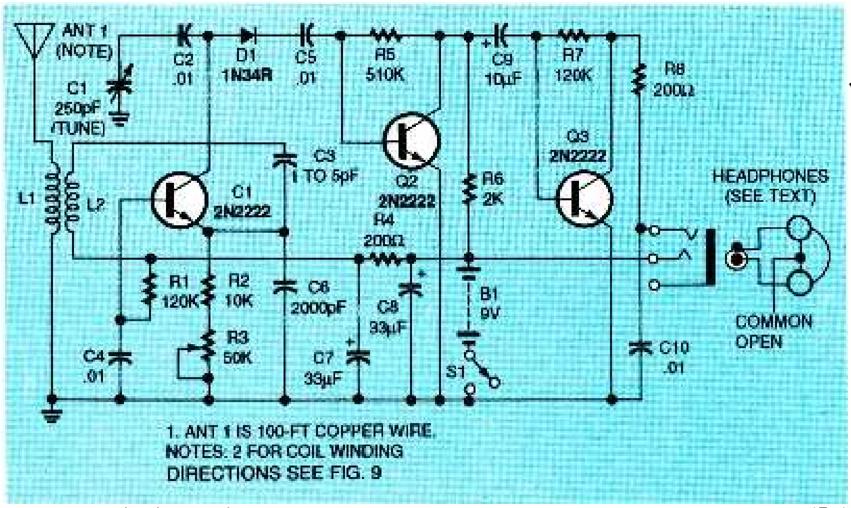


FIG. 11—ECONOMY MODEL REGENERATIVE shortwave receiver based on three NPN transistors.

mately 40 microvolts.

The optional fine-tuning capacitor shown in Fig. 8 can be omitted if you choose to use a vernier dial for operating variable capacitor C3. The author's prototype for this shortwave receiver was built on an aluminum chassis with two side panels. The circuitry was point-to-point wired on a section of prepunched circuit board measuring about 2½ ×2½ inches, with a ground plane on one side. It was mounted on standoffs to the base of the chassis. The potentiometers, tuning dial, jacks, and terminals were mounted on the side walls. The two-9-volt batteries were snapped into clips attached to the side walls.

To operate the receiver, connect the antenna and ground to the set, back the regeneration control knob to the position for minimum regeneration, and turn on the power. With the volume control set in mid position, advance the regeneration control until a click is heard in the headphones.

Tune the receiver until a station is found, and again adjust the regeneration control knob, this time to a point just below oscillation. (There will be an audible howl if the receiver is oscillating when tuned to a station.) If the detector does not oscillate, check the wiring carefully. If the wiring agrees with the schematic, reverse the leads to the tickler winding.

The highest sensitivity and selectivity will be achieved if the receiver is operated at a point just below the threshold of oscillation. The regeneration control must be readjusted each time the receiver frequency is changed. Use one hand for tuning and the other for adjusting regeneration. Here are some tuning hints:

- If a station is being received with adequate volume, a decrease in regeneration will improve the sound quality.
- If more than one station is being received, and they cannot be separated by tuning, an increase in regeneration will provide more selectivity.
- The adjustment of capacitor C1 is important for receiver operation because it adjusts the loading the antenna presents to the detector. For best selectivity, coupling should be just enough to allow the detector to self-oscillate at the low end of its tuning range.
- Increasing the capacitance of C1 loads the detector. This will prevent free oscillation and detune the receiver slightly rather than let it oscillate. (With less capacitance, the detector will oscillate intermittently as the signal level varies.)
- To avoid annoying oscillations, adjust C1 for its highest capacitance. This effectively provides automatic gain control (AGC). While it simplifies tuning, it also reduces receiver selectivity.

In general, for a 100-foot antenna, C1 should be set so that it provides about a third of its total capacitance (30 picofarads). If the antenna length is shorter, capacitance should be 50 to 100 picofarads.

Regenerative negatives

The regenerative receiver of Fig. 8 has its drawbacks. When receiving weak signals, the detector can self-oscillate if the regeneration level is too low to amplify the received signal satisfactorily. As a result, strong signals are amplified significantly with pronounced selectivity, while weak signals receive much less amplification.

When two received signals are close in frequency, it might be difficult to separate the weaker signal from the stronger one, and an audio "whine" occurs. In addition, "dead spots" are encountered as the receiver is tuned across the band because the antenna goes in and out of resonance as receiver frequency is varied. When the antenna is at resonance, it absorbs energy from the detector and loads it down, thus preventing regeneration.

Probably the most annoying characteristic of the simple regenerative receiver is that if its detector free-oscillates, it radiates a signal from the receiving antenna at its tuned frequency. Because the antenna is also tuned to this frequency, it becomes a very efficient radiator.

Therefore, despite the fact that the JFET detector produces only a 10 milliwatt output, the generation of radio

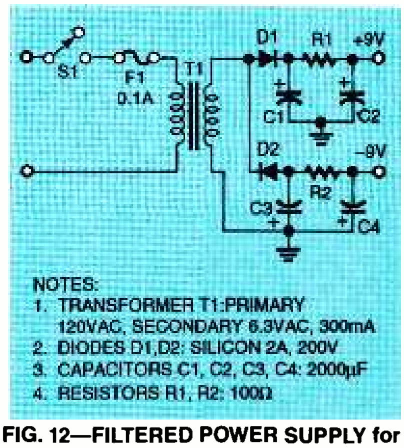


FIG. 12—FILTERED POWER SUPPLY for the transistorized regenerative receiver circuits.

interference must be avoided. With the circuit of Fig. 8, the best way to prevent the detector from oscillating is to adjust the input coupling with variable capacitor C1 so that the detector never quite breaks into oscillation.

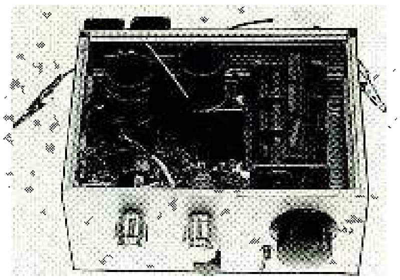
Throttle condenser

The JFET regenerative shortwave receiver circuit in Fig. 10 overcomes many of the drawbacks inherent in the Fig. 8 circuit. It includes a stage of RF amplification that provides about 30 dB of isolation between the detector and the antenna. It substantially improves the sensitivity to better than 0.5 microvolt over most of its operating range, makes some improvement in selectivity, and eliminates antenna "dead spots" caused by antenna resonance effects.

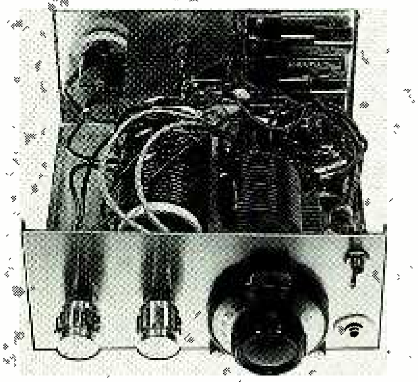
Resistors R1 and R2 set the bias level for RF amplifier Q1. The output of Q1 is coupled to the input of detector Q2 with a 100 picofarad capacitor and a tap on coil L2. This avoids excessive detector loading. Transistor Q1 is powered from the negative battery, while Q2 is powered from the positive battery. This balances the current drain from each battery so that both batteries will be discharged at the same rate.

Potentiometer R3 varies the negative supply voltage that, in turn, varies the RF gain and the signal level applied to Q2. To keep the signal-to-noise ratio high, set detector regeneration control potentiometer R8 near midscale. This allows high RF gain to be adjusted before self-oscillation begins. Resistor R4 and capacitor C4 decouple the power supply between the RF and output stages.

Refer to Fig. 10 and notice that the coils for this receiver (Figs. 9-*b* and 9-*c*) are wound on 1-inch diameter plastic pill containers. The author's prototype was point-to-point wired on perforated universal circuit board with a ground plane on one side measuring 6 × 4½ inches that fit in a 6½-inch × 5 × 3-inch high metal case. Again, as in the Fig. 8 receiver, the manual



REGENERATIVE SHORTWAVE receiver. Note the shield between the RF and detectors.



THIS SENSITIVE AND SELECTIVE receiver was built with a vernier dial for improved tuning accuracy.

controls with knobs, batteries, and headphone jack were mounted on the walls of the metal case.

Unfortunately, the additional gain of the RF stage makes it more difficult to maintain circuit stability. One way to overcome this is to be sure to connect the frame of the multigang tuning capacitor directly to ground with screws rather than relying on a length of wire sandwiched between it and the chassis ground.

Connect the antenna directly to the tap on L1. Connect the gate of Q1, which is AC-coupled by C2, to the top of L1. To maintain its stability, solder a shield made from a small piece of copper-clad circuit board vertically between the RF and detector coils. This prevents strong detector signals from being fed back to the RF stage.

An innovative feature of this circuit is its *tracking throttler* capacitor. In a typical regenerative receiver, feedback or regeneration control must be constantly readjusted as the frequency is varied. However, one section of a three-gang tuning capacitor in this circuit forms a throttling condenser that helps to compensate for higher regeneration levels as the received frequency is increased.

The tracking of regeneration versus the received signal is not precise because the inductance of the tickler coil is less than that of the main tuning coils, while the capacitor values of both are equal. Here a compromise was introduced: additional turns were added to the tickler for better tracking, but the presence of a tickler with the same number of turns as the tuning coils would provide too much feedback. This excessive feedback would, in-turn, require the gain of Q2 to be reduced almost to cutoff, making regeneration difficult to control.

Cascaded regeneration

Two or more cascaded regenerative circuits will significantly increase overall receiver selectivity. The regenerative receiver in Fig. 10 can be modified to make both the RF and detector stages regenerative by adding a second tickler coil, L5, as shown in the inset of Fig. 10. Open the connection between the drain of Q1 and the junction between R4 and C5, and connect the coil shown as Fig. 9-*d* in the coil widing guide. One-inch diameter pill bottles were also used as the forms for this coil. Coils L2 and L3 remain the same.

For the highest selectivity and sensitivity, it is important that both regenerative stages oscillate at the same time. "Regenerative tracking" can be accomplished with just the right number of turns on coil L5-a. (The ≈ symbol indicates that from four to six turns might be required.) Nevertheless, to set both stages for continuous simultaneous oscillation over a useful frequency range, two separate regeneration controls are required: one for the detector and one for the RF stage.

Continued on page 80

POWER LINE MODEM

continued from page 65

#HUFT, where # is the start character, H is HOUSE code, U is UNIT code, F is the FUNCTION code, and T is the number of times the requested function is to be repeated. (See Table 3.) To send DIM I-7 to 50% key #8647, then hit RETURN.

This message is translated as: # (start character), 8 (house code 1), 6 (unit code), 4 (DIM), and 7 (repeat DIM 7 times). The DIM values range from 1 to F.

To send this command, the string is #8647, then hit RETURN.

The same format is used to BRIGHTEN: #865D, then hit RETURN.

For greater flexibility, three more commands are available. The @, $ and &. These allow direct access to the TW-523 with no special handling. The $ is will send *house* and *unit* codes to the TW-523. The @ sends *house* and *unit* codes only. Those commands provide complete control of unique software. To send a valid X-10 command, send the data in this sequence: $HU, then hit RETURN, @HF, then hit RETURN again.

To turn on four lights (B-5, B-6, B10 and B-12), you must *arm* the desired modules. Then send a function code that instructs the modules what to do. The sequence of commands looks like this:

$14—Arm the module at B-5
$15—Arm the module at B-6
$19—Arm the module at B-10
$1B—Arm the module at B-12
&12—Send ON command

The & key sends *house* and *function* codes repeatedly. This command is useful for sending a function code to many different units. The format of this message is &HFT, where H is *house* code, F is *function* code, and T is number of times to repeat (1-F). For example, if you want to dim five lights simultaneously (e.g., A-1, A-2, A-8, A-9, A-16). The sequence would be:

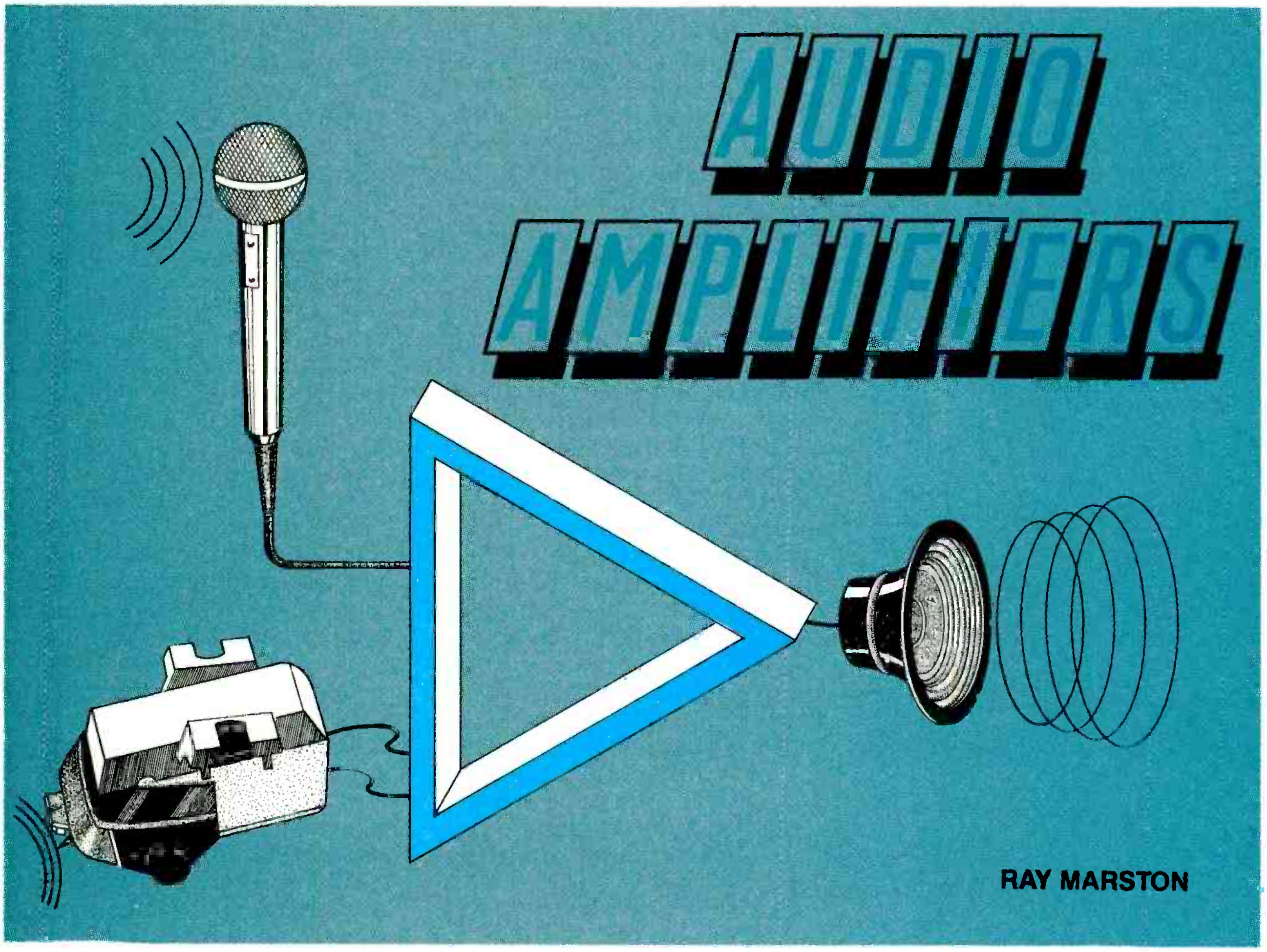
$00—Arm the module at A-1
$01—Arm the module at A-2
$07—Arm the module at A-8
$08—Arm the module at A-9
$0F—Arm the module at A-16
&043—Send DIM command

This instructs the interface to send a dim command to all "armed" modules on house code A, and do it three times. *Note: These last three commands work only on one house code at a time.* The ? key retrieves the ROM data and revisions.

Troubleshooting

If the PLM-1 does not function, examine all of the cables to verify that the plugs were installed correctly. Check the communications program as set by switch S1. Measure the input at pin 1 of IC4 to verify the presence of 9 volts DC, and measure the output at pin 3 to verify the presence of 5 volts DC.

Verify that crystal XTAL1 is oscillating with an oscilloscope probe at either pin 18 or 19 of IC1. Measure the output at unused pin 30 of IC1 to verify that it is one-sixth of the oscillator frequency. Ω



AUDIO AMPLIFIERS

RAY MARSTON

Learn about the audio amplifiers in stereos, tuners, and tape and CD players, and apply your knowledge to experiments or designs.

TRANSISTORS ARE THE KEY COMPONENTS in many different kinds of audio preamplifiers, amplifiers, and tone-control circuits. Recent articles in this series have discussed the operating principles and applications for discrete bipolar junction transistors (BJT). Earlier articles have covered such subjects as low-power amplifier circuits, multivibrators, and oscillators.

Audio amplifier basics

A modern stereo amplifier system has two closely matched high-fidelity audio amplifier channels. Typically each of those channels offers switch-selectable inputs for such signal sources as a tuner, tape player, and CD player. Each also provides a single output signal to a high-power loudspeaker. To analyze one of those systems, it is useful to divide the system into three functional circuit blocks, as shown in Fig. 1.

The first of these blocks is the selector/preamplifier. It permits the system listener to select the desired input signal source, and it automatically applies an appropriate amplification level and frequency correction to the signal to condition it for the second circuit block, tone/volume control.

The tone/volume-control block permits the listener to adjust the frequency characteristics and the amplitude of the audible output to suit his individual taste. This block

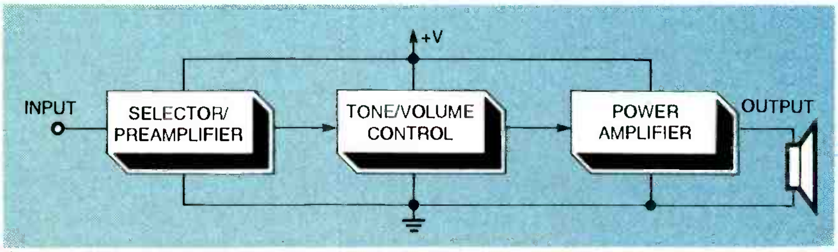


FIG. 1—ONE CHANNEL OF AN AUDIO AMPLIFIER SYSTEM.

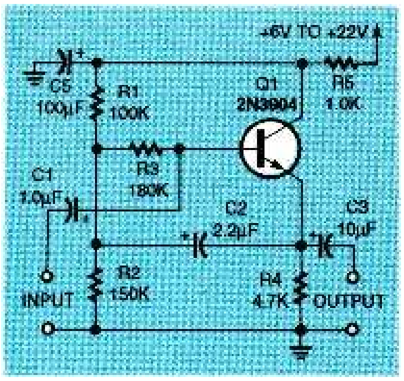


FIG. 2—HIGH-IMPEDANCE preamplifier for use with a ceramic or crystal microphone.

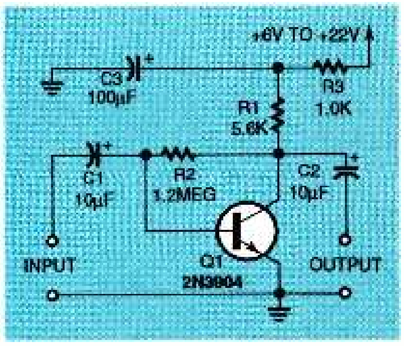


FIG. 3—MAGNETIC MICROPHONE preamplifier that provides a 46 dB gain.

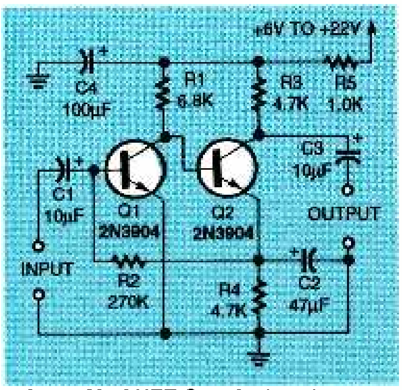


FIG. 4—MAGNETIC MICROPHONE preamplifier that provides a 76 dB gain.

might also contain additional filter circuits including one specifically designed to screen out scratch and rumble.

The last section of the amplifier system is the power amplifier. It might be able to produce power levels from a few hundred milliwatts to hundreds of watts. Audio power amplifiers are designed to cover the audio frequency range with minimal signal distortion. Most quality products today include automatic overload and thermal-runaway protection.

The three sections of the audio amplifier system are all powered from a single built-in power supply. All three sections include individual power supply decoupling networks to prevent unwanted signal interference. The first two amplifier blocks will be discussed here.

Simple preamplifiers

The audio preamplifier circuit modifies the input signal characteristics so that it will have a steady frequency response and the nominal 100-millivolt output amplitude necessary for driving the tone/volume control section.

If the input signal is derived from a radio tuner or a tape player, the signal characteristics are usually in a form that can be fed directly to the tone/control section, bypassing the preamplifier. However, if the input is obtained from a microphone or other audio input device, it will probably need preamplifier conditioning.

Two basic kinds of transducers are found in microphones and audio pickups: magnetic or piezoelectric ceramic/crystal. Magnetic transducers typically offer low output impedance and a low signal sensitivity of about 2 millivolts. Their outputs must be fed to high-gain preamplifier stages.

By contrast, ceramic/crystal transducers usually have a high output impedance and a high nominal sensitivity of about 100 millivolts. Their outputs must be fed to a high-impedance preamplifier stage with near-unity voltage gain.

Most microphones have a nearly flat frequency response, so they can be matched to simple, flat-response preamplifier stages. Figure 2 shows a unity-gain preamplifier circuit that will work with most high-impedance ceramic or crystal microphones. It is an emitter-follower (common collector) amplifier with an input network bootstrapped by C2 and R3. It has a typical input impedance of about 2 megohms. The combination of C5 and R5 decouples the amplifier from the DC power supply.

Figures 3 and 4 show alternative preamplifier circuits that will match magnetic microphones. The single-stage circuit of Fig. 3 gives 46 dB (×200) of voltage gain, and it will work with most magnetic microphones. The two-stage circuit of Fig. 4, however, gives 76 dB of voltage gain, and it is intended for preamplification of the output of very-low-sensitivity magnetic microphones.

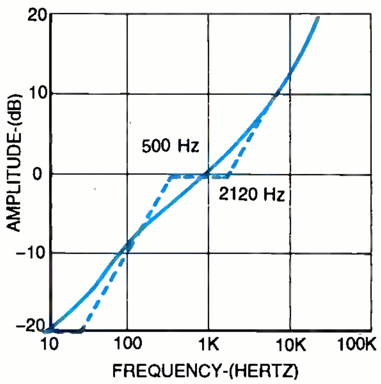


FIG. 5—TYPICAL PHONOGRAPH DISK frequency-response playback curve.

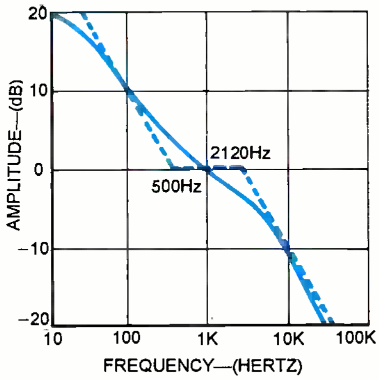


FIG. 6—RIAA PLAYBACK equalization curve.

RIAA preamplifier circuits

The replay of a constant-amplitude 20 Hz to 20 kHz variable-frequency signal that has been recorded on a phonograph disc with conventional stereo recording equipment will generate the nonlinear frequency response curve shown in Fig. 5. Here, the dotted line shows the idealized shape of this curve, and the solid line shows an actual shape.

Examination of the idealized (dotted) version of the curve in Fig. 5 will show that the response is flat between 500 and

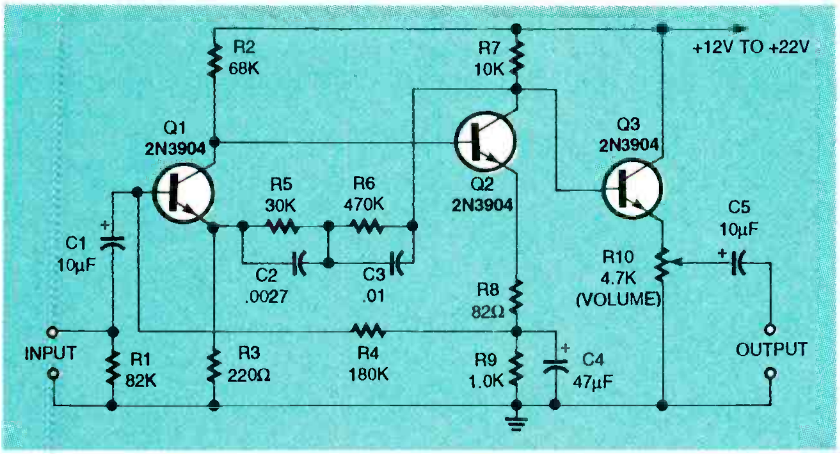


FIG. 7—RIAA EQUALIZATION PREAMPLIFIER for a magnetic phono cartridge.

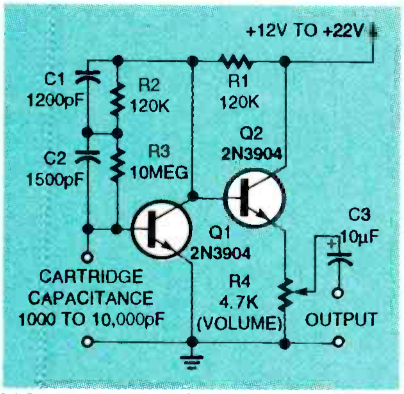


FIG. 8—RIAA EQUALIZATION preamplifier for a ceramic phono cartridge.

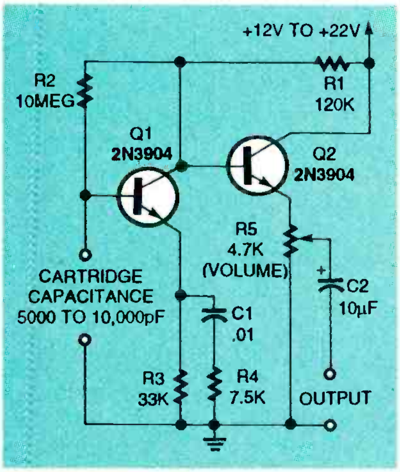


FIG. 9—ALTERNATIVE RIAA equalization preamplifier for a ceramic phono cartridge.

2120 Hz. However, it rises at a rate of 6 dB/octave (20 dB/decade above 2120 Hz), and falls at a 6 dB/octave rate between 500 Hz and 50 Hz. The response then flattens at frequencies below 50 Hz.

There are good–but difficult to explain–reasons why the precise Fig. 5 recording curves are used. However, all you really need to know is that they make it possible to produce disc recordings with excellent signal-to-noise ratios and wide dynamic ranges. The curves were applied during record pressing.

The important point to be made here is that when a disc is replayed, the output of the pickup device must be passed to the power amplifier through a preamplifier whose frequency equalization curve is the mirror image (exact inverse) of the one used to make the original recording. As a result, a linear overall record-to-replay response is obtained.

Figure 6 shows the RIAA equalization curve. RIAA is an abbreviation for the Recording Industry Association of America, the organization that standardized the precise specification of the curve for the equalization of phonograph records. When long-playing phonograph records were the primary source of recorded music and audio entertainment, circuit designers had to include filter networks that corrected the input from the record to conform to the RIAA equalization curve.

The relatively recent worldwide conversion to compact discs (CDs) as the primary source of recorded music and entertainment has diminished the importance of the RIAA curve. Equalization is not required for linear signal sources such as CDs.

Nevertheless, a preamplifier with an RIAA equalization network is still needed if you want to play any of the pressed long-playing and 45 rpm records. This equalization can be obtained by wiring frequency-dependent, resistive capacitive

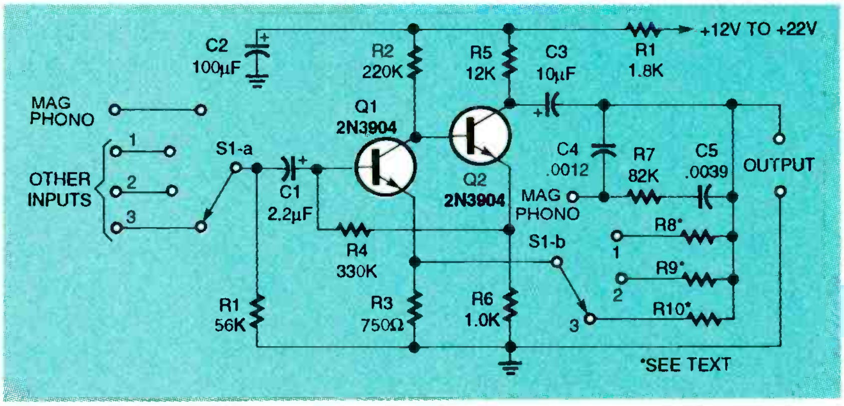


FIG. 10—UNIVERAL PREAMPLIFIER CIRCUIT.

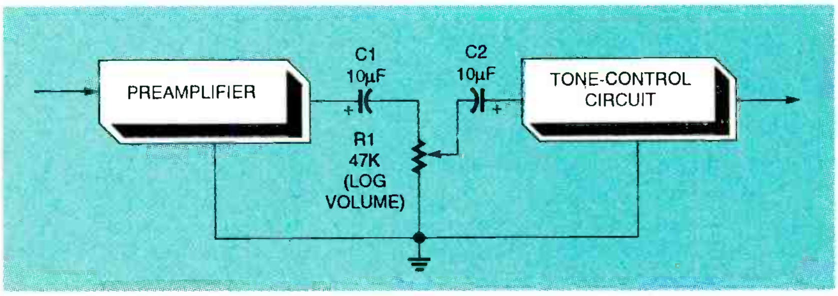


FIG. 11—OPTIMUM LOCATION AND LAYOUT for an audio-amplifier volume control.

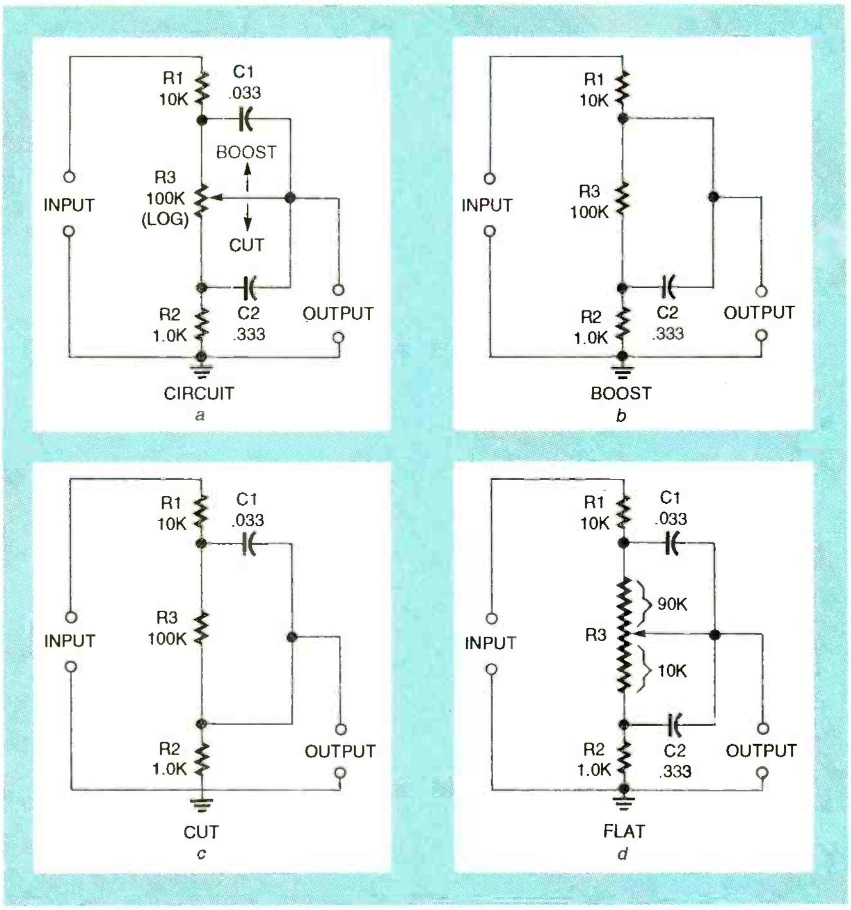


FIG. 12—BASIC CIRCUIT AND EQUIVALENTS OF A BASS tone-control network.

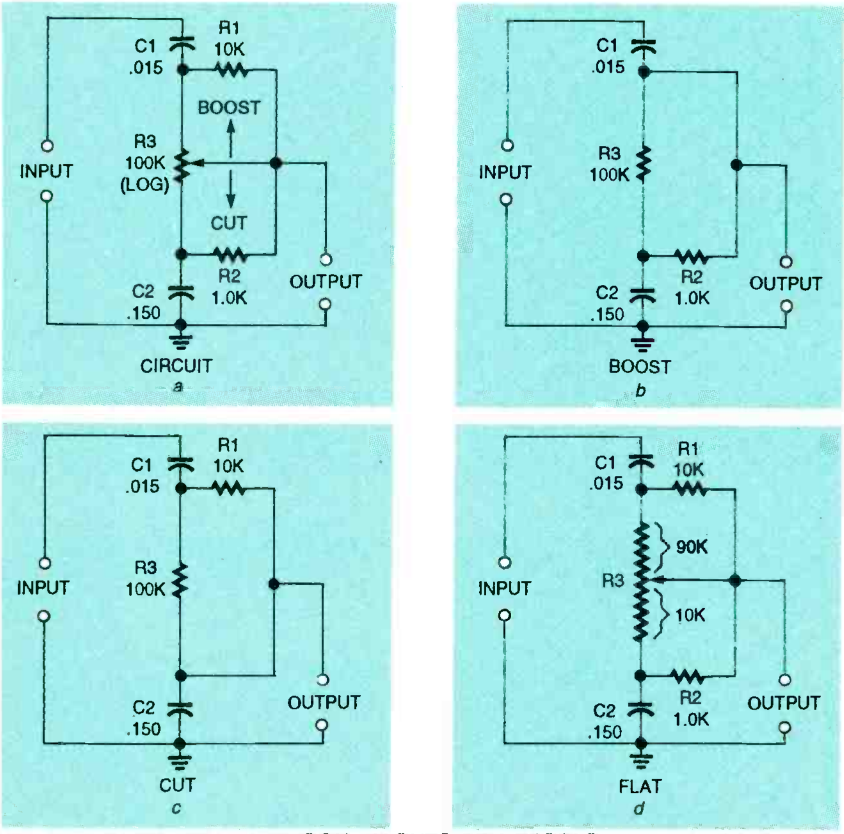


FIG. 13—BASIC CIRCUIT AND EQUIVALENTS OF A TREBLE tone-control network.

feedback networks into a preamplifier. This circuitry causes the gain to fall as the frequency rises. One network will control the 50 to 500 Hz response, and the other will control the 2120 Hz to 20 kHz response.

Figure 7 is the schematic for an amplifier with those networks that will work with any magnetic phono cartridge. It gives a 1-volt output from a 6-millivolt input at 1 kHz, and provides equalization that is within 1 dB of the RIAA standard between 40 Hz and 12 kHz.

The preamplifier circuit is designed around transistors Q1 and Q2, with C2 and R5, and C3 and R6 forming the feedback resistor capacitor equalization network. The output of the emitter-follower buffer stage, transistor Q3, can be controlled by VOLUME control potentiometer R10.

The quality of reproduction of ceramic or crystal phono cartridges is generally lower than that of magnetic cartridges, but they produce far higher amplitude output signals. Ceramic and crystal phono cartridges will work with simple equalization preamplifiers—one reason why those cartridges were installed in so many low-cost record players.

Figures 8 and 9 show alternative phono cartridge preamplifier/ equalization circuits that can function with either ceramic or crystal phono cartridges. Both circuits are designed around transistorized emitter-follower output stages Q1 and Q2. The output of the circuit in Fig. 8 can be controlled by VOLUME control potentiometer R4, and that of Fig. 9 is controlled by R5.

The preamplifier/equalizer in Fig. 8 will work with any phono cartridge whose capacitance is between 1000 and 10,000 pF. Two-stage equalization is provided by the resistance-capacitance network made up of C1, C2, R2, and R3. Preamplification/ equalization for this circuit is typically within 1.6 dB of the RIAA standard between 40 Hz and 12 kHz.

The alternative preamplifier/ equalizer shown in Fig. 9 will work only with phono cartridges whose capacitance values are between 5000 and 10,000 pF because this capacitance is part of the circuit's frequency response network. The other part of the network is formed by C1 and R3. At 50 Hz, this circuit has a high input impedance of about 600 kilohms, which causes only slight cartridge loading.

However, as frequency increases, input impedance decreases sharply, increasing cartridge loading and effectively reducing circuit gain. The equalization curve approximates the RIAA standard, and circuit performance is adequate for most practical applications.

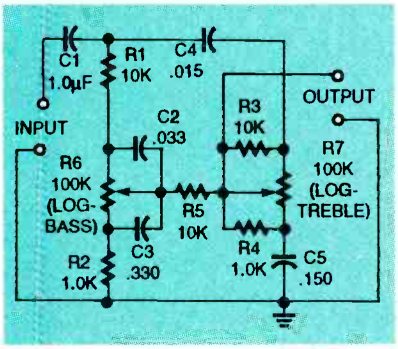


FIG. 14—PASSIVE BASS AND TREBLE tone-control network.

A universal preamplifier

Most audio amplifier systems must have preamplifiers with many different characteristics. These include high-gain linear response for magnetic microphones, low-gain linear response for tuners, and high-gain RIAA equalization for magnetic phono cartridges.

To meet this broad requirement, most amplifier designers include a single universal preamplifier circuit such as the one shown in Fig. 10. Basically a high-gain linear amplifier, its characteristics can be altered by switching alternative resistor-filter networks into its feedback system.

For example, when the selector switch is set to the MAG PHONO position, switch S1-a connects the input to the magnetic phono cartridge, and S1-b connects the RIAA equalization network of C4, C5, and R7 into the feedback loop.

In the remaining switch positions, alternative input sources can be selected by S1-a, and appropriate linear-response gain-control feedback resistors R8, R9, and R10 are selected by S1-b. Those feedback resistor values are selected between 10 kilohms and 10 megohms to suit individual listener tastes. Circuit gain will be proportional to the feedback resistor value.

Volume control

The VOLUME control circuitry of an audio amplifier system is normally located between the output of the preamplifier stage and the input of the tone-control circuit. It is usually only a potentiometer within the circuit, as shown in Figs. 7, 8, and 9. However, the catch here is that rapid rotation of the potentiometer knob can apply DC voltage to the next circuit for brief intervals. That voltage could upset circuit bias and cause severe signal distortion.

The block diagram Fig. 11 shows the ideal topology and location for a VOLUME control. It is fully DC-isolated from the output of the preamplifier by capacitor C1, and from the input of the tone-control circuit by C2. As a result, variation of the wiper of control potentiometer R1 has no effect on the DC bias levels of either circuit. Potentiometer R1 should have a logarithmic taper, that is, its output should be a logarithmic function rather than linear.

Passive tone control

A tone-control network permits the listener to change the system amplifier's frequency response to suit his own mood or taste. He can, for example, boost or reduce the low-frequency (bass) or high- frequency (treble) sections of a musical selection to emphasize the sounds of specific sections of the orchestra.

Tone-control networks typically consist of simple resistive-capacitive filters through which the signals are passed. Because these networks are passive, they cause some signal attenuation. Tone control networks can, if desired, be wired into the feedback loops of simple transistor amplifiers to give the system an overall signal gain. Those are known as *active* tone-control circuits.

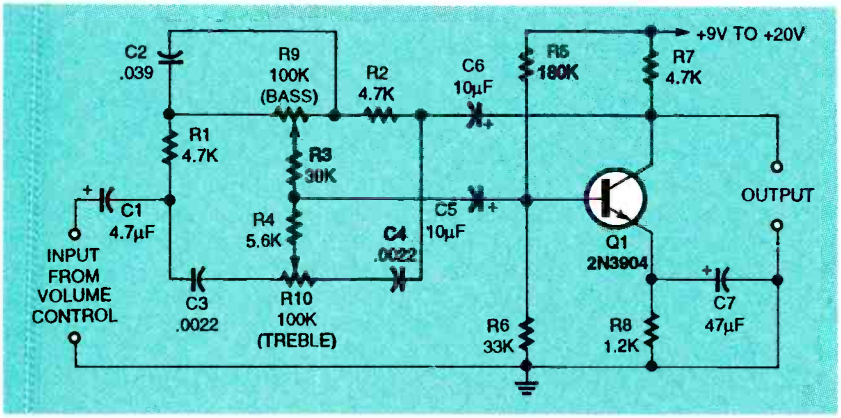


FIG. 15—ACTIVE BASS AND TREBLE TONE-CONTROL NETWORK.

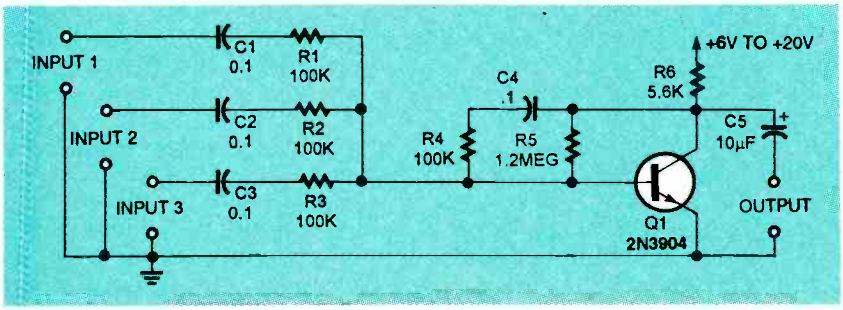


FIG. 16—THREE CHANNEL AUDIO MIXER.

Figure 12-*a* shows a typical passive *bass* tone-control network, and Figs. 12-*b* through 12-*d* show the equivalent of this circuit when control potentiometer R3 is set to its maximum *boost*, maximum *cut*, and *flat* positions, respectively. Capacitors C1 and C2 are effectively open circuited when the frequency is at its lowest bass value. It can be seen from Fig. 12-*b* that the *boost* circuit is equivalent to a voltage divider formed by dividing 10 kilohms by 101 kilohms. This arrangement results in a low resistive value of about 100 ohms that only slightly attenuates bass signals.

The Fig. 12-*c* *cut* circuit, by contrast, has a voltage divider equal to 110 kilohms divided by a 1 kilohm which gives a signal attenuation of about 40 dB. Finally, in Fig. 12-*d* when potentiometer R3 is set to the FLAT position, it will have 90 kilohms of resistance above the wiper and 10 kilohms below it.

This circuit resistance value is equal to 100 kilohms divided by 11 kilohms. It gives a signal attenuation of about 20 dB at all frequencies. As a result, the circuit gives a maximum bass boost of about 20 dB or *cut* relative to the *flat* signals.

Figure 13 shows a typical passive *treble* tone-control network together with its equivalent circuits under maximum *boost*, maximum *cut*, and *flat* operating conditions. This circuit also provides about 20 dB of signal attenuation when potentiometer R3 is in the *flat* position, and it gives maximum treble *boost* or *cut* values of about 20 dB relative to its *flat* performance.

Finally, Fig. 14 shows how the Fig. 12-*a* and 13-*a* schematics can be combined to make a complete bass and treble tone control network. The 10-kilohm resistor R5 has been added to minimize unwanted interaction between the two connected circuit sections. The input to this network can be taken from the circuit's volume control, and its output can be fed to the input of the power amplifier.

Active tone controls

A tone-control network can be included in the feedback path of a transistor amplifier so that the system will have an overall signal gain (rather than attenuation) when its controls are in the *flat* position. These networks can be simplified versions of the basic circuit shown in Fig. 14. Figure 15 is the schematic for an active tone-control circuit.

A comparision of Figs. 15 and 12 will reveal that the BASS control section of Fig. 15 is a simplified version of Fig. 12-*a*. It can be seen that the two capacitors C1 and C2 of Fig. 12-*a* have been replaced by the single 0.039μF capacitor C2 of Fig. 15. Similarly, the *treble* section is a simplified version of Fig. 13-*a*, with resistors R1 and R2 eliminated. Resistors R3 and R4 balance the performance of the two sections of the Fig. 15 control circuit.

An audio mixer

A multichannel audio mixer is an attractive modification that can be added to the volume/tone-control section of an audio amplifier. This mixer permits several different audio signals to be mixed together to form a single composite output signal. This modification will be of value if, for example, you want to hear the front-door buzzer or the sounds of a baby crying in a child's room while you listening to music.

Figure 16 is the schematic for a three-channel audio mixer that will provide an overall gain of one between the output and each input channel. Each input channel includes a single 0.1μF capacitor and a 100-kilohm resistor, to provide an input impedance of 100 kilohms. The number of input channels to this audio mixer can be increased by adding more capacitors and resistors with the same values as C1 and R1.

The mixer should be located between the output of the tone-control circuitry and the input to the power amplifier. One input should be taken from the output of the tone-control circuit, and the other inputs should either be grounded or taken from the desired source. Ω

REGENERATION

continued from page 73

This modification of Fig. 10 will result in a significant improvement in selectivity and some increase in sensitivity, but it involves a tradeoff. It will perform as well, if not better, than most modern superheterodyne receivers. However, there is a catch. If the RF stage is permitted to self-oscillate, it will radiate its signal from the antenna causing unwanted and illegal transmission, and you lose its principal benefit.

The detector could be set so that it oscillates first, but that will reduce the receiver's overall selectivity. Also, the tracking throttler capacitor is less effective now, and the receiver will need more frequent regeneration adjustment during tuning.

Low-cost receiver

Low cost and availability of components were important considerations in the "modern" regenerative receivers presented here. Nevertheless, the shortwave receiver in Fig. 11 is a "true" economy model. It offers a frequency range of 5.5 to 12 MHz. The prototype receiver was built with about $8 worth of parts (less headphones). While its sensitivity is good, its selectivity and stability are not up to the standards of the receivers in Figs. 8 and 10.

The first thing that you'll notice in examining Fig. 11 is that bipolar NPN transistors have replaced the more expensive JFETs and op-amps. Transistor Q1 is part of a regenerative RF amplifier that provides high gain. The output of germanium detector diode D1 directly drives a two- transistor audio amplifier. (A germanium diode was selected because its forward bias voltage—about half that of a silicon diode—gives the receiver increased sensitivity.)

The author's prototype was point-to-point wired on a 3½-inch square of copper-clad circuit board. This was mounted

Continued on page 88

HARDWARE HACKER

Jukebox resources, electric vehicle information, RBDS FM data decoders, and sonoluminescence effects.

DON LANCASTER

Here's the latest thinking on fluxgate magnetometers: Use the *Magnetics* 80511-0.5D-0015-01 core. Wind 200 turns of No. 34 wire on a toroid for the excitation. Wrap 150 turns of No. 34 wire in the *x* sense direction and 150 turns in the *y* sense direction. To minimize feedthrough noise, drive both sense coils at the second harmonic of the drive waveform.

Power consumption can be dramatically reduced if you can sense when the core goes into saturation and then satisfactorally alter the drive waveform. Be sure to maintain drive symmetry to block out any second harmonics. The normal drive frequencies are around 20 kHz.

Several helpline callers took strong exception to my negative comments on magnetoresistors. Nevertheless, (A) I call them as I see them, and (B), after a careful review, I am now even more convinced than ever that today's crop of magnetoresistors are just plain awful—at least for precision low-level field measurements. I feel these components are clearly inappropriate for use in any *Brunton*-class digital compass.

The key problems of the magnetoresistors are their linearity, temperature dependence, noise, and sensitivity, as well as their need for external magnetic biasing. And I haven't mentioned their nasty habit of flipping out.

On the other hand, IBM researchers discovered a *gross magnetoresistance* effect that promises to improve their sensitivity five fold, at least for disk drives. Moreover, there are many new techniques in the wind for ultra-low magnetic field sensing, including tiny micromachined fluxgates.

The big-bucks, top-secret plum that everyone is quietly working toward is direct, real-time imaging of the human heart's magnetic field. Sensitivities on the order of 0.06 gamma are being discussed. Watch for some stunning new magnetoresistance sensor breakthroughs soon. Meanwhile, fluxgates seem to be the way to go.

Solid-state compasses for automobiles have their own unique problems. The magnetic field of the car itself is as much as *ten times stronger* than Earth's magnetic field. Compensating for this condition to obtain accurate results can be tricky. One way to do it is to use a microcontroller to sense when the car has gone completely around a block, closing a circle. Correction vectors can then be stored in memory for later use.

One source of information on low-resolution car compasses is *Dinsmore*. Lower cost hacker magnetometer cores and systems are now available through *OrthoLogic*, and premium-quality magnetometers are offered by EMDS.

Much more on these topics appear in the *Hardware Hacker* reprints and on my *GEnie* PSRT.

Sonoluminescence

How do you spot an emerging new technology *before* it emerges? My usual approach is to review *Science*, *Science News*, and the technology section in the *Wall Street Journal* for hints about new stuff being introduced. There are also hundreds of trade journals to read. Once you have collected a few magic keywords or important author names, you can go to *Dialog* or UMI for the key papers.

Sonoluminescence (or "light from sound") is a typical example. This is an emerging research topic that promises some potentially stunning new applications. Besides the usual academic papers and science-fair projects, this one also seems to be cheaply hackable.

The usual sonoluminescence setup is shown in Fig. 1. You take a small flask of water and couple 25-kHz ultrasonic energy into it. Under carefully controlled conditions, trapped air or other gas bubbles in the water will emit a clear blue light!

Wait, it even gets better. Apparently what's happening is that the sonic energy is being spherically focused up to *twelve orders of magnitude* or higher. That's a million million! The blue light is actually ultraviolet centered on 310 nanometers. The water heavily attenuates the ultraviolet wavelengths, so you see only the blue light.

The light is produced by heating the air at the center of the bubble to beyond 10,000 degrees—and possibly *much* higher.

Even more intriguing is the fact that the light is emitted in very brief pulses a mere 50 picoseconds long. These bubbles are usually tiny. They'll oscillate in size from two mils down to a fraction of a mil. Sometimes less.

Just what good is all this? Nobody knows for sure—yet. It is all too new for commercial applications. Well, *anything* blue should be very handy. Basic laws of physics make generating blue light a real bear. Sonoluminescence could turn out to be a low-cost source for the brief light pulses that are needed in

NEED HELP?

Phone or write your **Hardware Hacker** questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ 85552
(602) 428-4073

For fast **PSRT** access, modem (800) 638-8369, then an HHH. Then XTX99005,SCRIPT.

laser research and for spectroscopy experiments.

Sonoluminescence can concentrate energy to astonishingly high levels. Possibly this same concept could be adapted to solar energy. It should also be possible to scale up the effect to create a plasma torch that might be used to safely dispose of various hazardous materials by vaporization.

The internal sound levels needed are "real loud," comparable to the 110 decibels generated by a nearby jet engine. But those levels are still within hacker range. Surprisingly, they are actually much *lower* than the levels required for sonic refrigeration. Either a piezoelectric transducer or a common tweeter should be useful here.

There have been several hundred papers published on sonoluminescence. I picked five recent samples and put them in Fig. 2. Those should be enough to get you started. As usual, you can get abstracts on all of these papers through *Dialog* and the papers themselves either through UMI or an interlibrary loan.

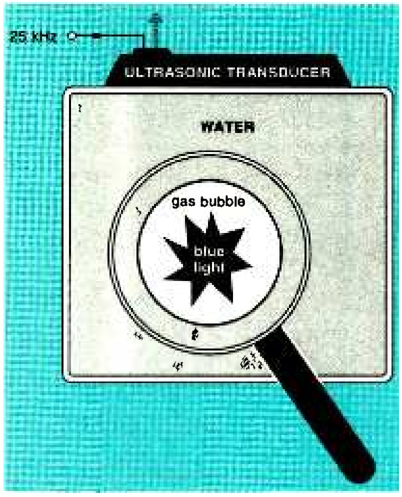


FIG. 1—SONOLUMINESCENCE results when ultrasonic waves become spherically focused to extremely high intensity. The center of a tiny air or gas bubble may get so hot that it emits ultra-short pulses of blue or ultraviolet light!

Let me know what you come up with here.

FM radio data service

Frequency modulation broadcasters are scrambling all over each other to offer a brand new feature called the *Radio Broadcast Data Service*, or RBDS for short. RBDS sends out short digital messages along with the usual audio program material.

The most obvious RBDS application is to display the name of a song being aired and who is singing it. But RBDS can also identify the call letters and format of the station. It can also be used for time, weather, traffic, and emergency information. RBDS is also apparently is also being used for certain cable "CD jukebox" features.

This is all currently in the chicken-and-egg stage, because few receivers are capable of displaying digital data. However, a related RDS service has been in full operation in Europe for a decade.

Three hot new uses for RBDS are emerging. One is for custom paging services; the second is for *coupon radio* that permits special discounts to be offered by advertisers *only* to those listening at the time. Smart cards are involved.

The third big new application is to provide *differential GPS correction data*. This service could dramatically upgrade the accuracy of all Global Positioning Satellite receivers within a station's broadcast area. A plain old GPS receiver can be upgraded to a precision unit simply by adding some software and the correction data.

The RBDS services are now being coordinated by the *National Radio Systems Committee*, which is a cooperative venture between the *National Association of Broadcasters* and the old *Electronic Industries Association*. Copies of the RBDS standard can be ordered from the EIA for $20 each.

FM station transmissions are normally at least 200 kilohertz apart, so there is lots of room in an FM channel for many different services. Figure 3 shows how a typical station might combine mono, stereo, RBDS and SCA simultaneously.

All of these services could simultaneously appear at the broadband output of your receiver's FM detector. The frequencies below 19 kHz will be conventional mono sound, which is also stereo *left + right* audio, and it is the only sound you can hear without further processing. The other services are provided on *subcarriers*.

When stereo is present, there is a pilot reference at 19 kilohertz. The *left − right* stereo information is just below 38 kHz. To produce full stereo, the pilot is doubled in frequency to 38 kHz and then mixed (or multiplied) against the L − R information. The difference term produces baseband audio on a second output. To convert to stereo, a *matrix* technique *adds* the two signals to pick up the left channel (L + R + L − R) and subtracts the two to get the right channel (L + R − L + R).

SCA subcarrier services can be provided at higher frequencies. These are usually fee-based and thay offer music, news, or stock quotes. The oldest of these is the *Muzak* that makes elevators so unpleasant for many people.

SCA services can be demodulated with a bandpass filter and phase-locked loop. Popular carrier frequencies are 67 and 92 kHz. But notice that doing that is a theft of services similar to ripping off satellite signals.

Special identifier codes are usually buried carefully in these signals;

A theoretical study of sonoluminescence.

Kamath, V.; Prosperetti, A.; Egolfopoulos, F.N.
Journal of the Acoustical Society of America
vol.94, no.1 p.248-60 July 1993 (49 Refs)

Shock-wave propagation in a sonoluminescing gas bubble.

Wu, C.C.; Roberts, P.H.
Physical Review Letters
vol.70, no.22 p.3424-7 31 May 1993 (13 Refs)

On sonoluminescence of an oscillating gas bubble.

Greenspan, H.P.; Nadim, A.
Physics of Fluids A (Fluid Dynamics)
vol.5, no.4 p.1065-7 April 1993 (18 Refs)

Sonoluminescence spectra of water.

Didenko, Yu.T.; Pugach, S.P.; Kvochka, V.I.; Nastich, D.N.
Journal of Applied Spectroscopy
vol.56, no.4 p.381-5 April 1992 (21 Refs)

The color of sound: shedding light on sonoluminescence.

Scientific American
December 1993, p24-26

FIG. 2—SOME RECENT SONOLUMINESCENCE REFERENCES.

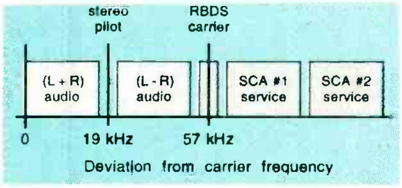


FIG. 3—FM STATIONS can offer mono, stereo, SCA, and RDBS services all at once. Here is how the received broadband audio spectrum is arranged.

quency is centered on 57 kHz, the third harmonic of the stereo pilot. The data is 1200-baud serial using a simple frequency shift keying (FSK). A digital "1" is often 1.2 kHz below, and a digital "0" is 1.2 kHz above the center frequency. Typical amplitude at the detector is in the 20- to 200-millivolt range.

Four important gotchas for RBDS

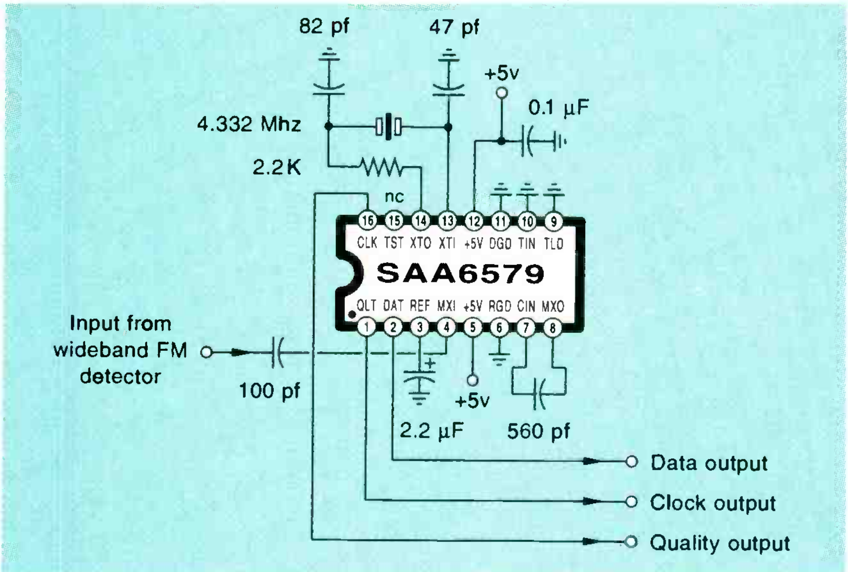
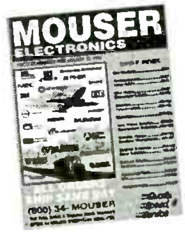


FIG. 4—THE RBDS DATA STREAM is surprisingly cheap and easy to decode. The Signetics/Philips SAA6579T chip combines a bandpass filter, a phase-locked loop data extractor, and a signal-quality detector.

that makes criminal convictions easy!

At any rate, the RBDS carrier frequency is centered on 57 kHz, ...

reception: (A) The FM receiver *must* include wide-bandwidth intermediate frequency (IF) circuitry—most



NAMES AND NUMBERS

Analog Devices
PO Box 9106
Norwood, MA 02062
(617) 329-4700
CIRCLE 316 ON FREE INFORMATION CARD

Coupon Radio
10 Rockefeller Plaza
New York, NY 10020
(212) 595-1313
CIRCLE 317 ON FREE INFORMATION CARD

Dallas Personal Robotics Group
PO Box 1626
Hurst, TX 76053
CIRCLE 318 ON FREE INFORMATION CARD

Dialog
3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700
CIRCLE 319 ON FREE INFORMATION CARD

Dinsmore
1814 Remell Street
Flint, MI 48503
(313) 744-1330
CIRCLE 320 ON FREE INFORMATION CARD

Electronic Industries Assn
2001 Pennsylvania Avenue NW
Washington, DC 20006
(202) 457-4900
CIRCLE 321 ON FREE INFORMATION CARD

EMDS
16618 Oakmont Avenue
Gaithersburg, MD 20877
(301) 840-5710
CIRCLE 322 ON FREE INFORMATION CARD

EPRI Journal
PO Box 10412
Palo Alto, CA 94303
(415) 855-2000
CIRCLE 323 ON FREE INFORMATION CARD

GEnie
401 N Washington Street
Rockville, MD 20850
(800) 638-9636
CIRCLE 324 ON FREE INFORMATION CARD

Home Power
PO Box 520
Ashland, OR 97520
(916) 475-3179
CIRCLE 325 ON FREE INFORMATION CARD

Lawrence Livermore Labs
PO Box 808
Livermore, CA 94551
(510) 422-6416
CIRCLE 326 ON FREE INFORMATION CARD

Magnetics
Box 391
Butler, PA 16003
(412) 282-8282
CIRCLE 327 ON FREE INFORMATION CARD

National Assn of Broadcasters
1771 N Street NW
Washington, DC 20036
(202) 429-5300
CIRCLE 328 ON FREE INFORMATION CARD

OrthoLogic Corp
2850 S 36th Street, Ste 16
Phoenix, AZ 85034
(602) 437-5520
CIRCLE 329 ON FREE INFORMATION CARD

PAIA Electronics
3200 Teakwood Lane
Edmond, OK 73013
(405) 340-6300
CIRCLE 330 ON FREE INFORMATION CARD

Radio World
5827 Columbia Pike #310
Falls Church, VA 22041
(703) 998-7600
CIRCLE 331 ON FREE INFORMATION CARD

RE America
31029 Center Ridge Road
Westlake, OH 44145
(216) 871-7617
CIRCLE 332 ON FREE INFORMATION CARD

SAE Library
400 Commonwealth Drive
Warrendale, PA 15096
(412) 776-4841
CIRCLE 333 ON FREE INFORMATION CARD

SGS Thompson
1000 E Bell Road
Phoenix, AZ 85022
(602) 867-6259
CIRCLE 334 ON FREE INFORMATION CARD

Sharp
Sharp Plaza
Mahwah, NJ 07430
(201) 529-8757
CIRCLE 335 ON FREE INFORMATION CARD

SIAM
3600 University City Sci Cntr
Philadelphia, PA 19104
(215) 382-9800
CIRCLE 336 ON FREE INFORMATION CARD

Surplus Traders
PO Box 276
Alburg, VT 05440
(514) 739-9328
CIRCLE 337 ON FREE INFORMATION CARD

Synergetics
PO Box 809
Thatcher, AZ 85552
(602) 428-4073
CIRCLE 338 ON FREE INFORMATION CARD

UMI
300 N Zeeb Road
Ann Arbor, MI 48106
(800) 521-3044
CIRCLE 339 ON FREE INFORMATION CARD

modern receivers have this. (B) The signals *must* be extracted directly at the detector or discriminator, *before* any stereo demodulation or audio filtering takes place, (C) you *must* have a complete schematic and the proper service information on the receiver being modified. And, finally, if you are doing a computer interface, (D) noise and hum isolation on the data lines is a good idea.

Fortunately, there is a new, cheap, and elegant single-chip solution to RBDS decoding. *Signetics/Philips* is offering a $5 device called the SAA6579T. A typical circuit appears in Fig. 4. The chip is basically a high-quality bandpass filter, which is followed by a phase-locking digital-data detector. It only needs six milliamperes from a 5-volt regulated supply.

To use the chip, you put a magic 4.332-MHz crystal on the device's oscillator terminals. You then bypass the supply input and the reference output. Then capacitor-couple the multiplex signal input, and also capacitor-couple the filter output to the demodulator input.

There are three output lines. The data appears on your data line. A clock output is synchronous with the data and might be useful for simple display circuits. Data is valid on the *leading edge* of the clock signal.

Presumably you can route the data directly into any 1200-baud UART or computer serial port without the clock line. The final output is a signal-quality detector. This pin goes high when valid data is being received. It stays low if the signal is weak or if RBDS is absent.

The chip is in a miniature SOT162 package. This means that you must carefully solder it directly onto your circuit board. You might as well use surface-mount parts for the rest of the circuit while you're at it. There's no reason why the whole circuit has to occupy any more than one square inch. You will want to make the input lead from the detector very short. Chances are that you can get away with two inches of shielded input lead.

The output data leads should be shielded or tightly twisted to prevent them from radiating noise back into the RF circuitry. In its simplest application, the data goes directly into the serial port on your computer. If needed, *Maxim* makes lots of inexpensive RS-232 converters. But your system should already be directly RS423-compatible over short distances.

RBDS encoders for use by the FM radio stations are available from a number of sources. The leader here appears to be the model 532 from *RE America*. The price of an encoder is around a kilobuck—pocket change for a typical FM station budget.

One proponent of coupon services is David Alwadish of *Coupon Radio*. This outfit also intends to offer ready-to-use receivers and cards some time soon.

Several industry insiders believe that RBDS might only form an interim solution, with the higher speed digital transmission systems waiting in the wings. But I can see all kinds of uses where 1200 baud is more than satisfactory. It certainly is cheap and simple to provide, and it sure is one worthwhile project to hack.

More news on RBDS as it unfolds is likely to appear in *Radio World*, a trade magazine for commercial radio stations. In particular, you might want to look at their November 10, 1993 issue.

Jukebox resources

Several of you have asked where to go for more information on jukebox collecting and parts. For our resource sidebar this month, I have gathered together a large handful of the more important jukebox resources.

The best magazine here is *Always Jukin'* with *Jukebox Collector* a close second. Both jukeboxes and their collectors are far more common than you might first guess. It's no big deal to get parts for the more popular boxes—or the "mouldy oldie" records to go with them.

I have posted more information on other electronic collectibles in NUTS23.PS on *GEnie* PSRT. This is also found in my *Resource Bin* reprints.

JUKEBOX RESOURCES

Always Jukin'
221 Yesler Way
Seattle, WA 98104
(206) 233-9460
CIRCLE 340 ON FREE INFORMATION CARD

AMR Publishing Co
PO Box 2007
Arlington, WA 98223
(206) 659-6434
CIRCLE 341 ON FREE INFORMATION CARD

Antique Apparatus
2335 208th Street
Torrance, CA 90501
(310) 328-1306
CIRCLE 342 ON FREE INFORMATION CARD

Electrons Past
851 Enchanted Drive
Midvale, UT 84047
(801) 262-3903
CIRCLE 343 ON FREE INFORMATION CARD

Funtiques
PO Box 825
Tucker, GA 30085
(404) 564-1775
CIRCLE 344 ON FREE INFORMATION CARD

Home Arcade
1108 Front Street
Lisle, IL 60532
(708) 964-2555
CIRCLE 345 ON FREE INFORMATION CARD

Jukebox Central
5540 River Road
Madison, OH 44057
(216) 428-3523 pm
CIRCLE 346 ON FREE INFORMATION CARD

Jukebox Collector
2545 SE 60th Court
Des Moines, IA 50317
(515) 265-8324
CIRCLE 347 ON FREE INFORMATION CARD

Jukebox Junkyard
PO Box 181
Lizella, GA 31052
(912) 935-2721
CIRCLE 348 ON FREE INFORMATION CARD

Jukebox Media
8795-A Corvus Street
San Diego, CA 92126
(619) 271-8294
CIRCLE 349 ON FREE INFORMATION CARD

Jukeboxes Etcetera
223A N Glendora Avenue
Glendora, CA 91740
(818) 914-9434
CIRCLE 350 ON FREE INFORMATION CARD

New England Jukebox
77 Tolland Turnpike
Manchester, CT 06040
(203) 646-1533
CIRCLE 351 ON FREE INFORMATION CARD

Tim Rand
12027 Saint Vrain Road
Longmont, CO 80501
(303) 772-5158
CIRCLE 352 ON FREE INFORMATION CARD

Vern Tinsdale
8402 N 18th Avenue
Phoenix, AZ 85021
(602) 944-8444
CIRCLE 353 ON FREE INFORMATION CARD

Victory Glass Company
3260 Ute Avenue
Waukee, IA 50263
(515) 987-5765
CIRCLE 354 ON FREE INFORMATION CARD

Wurco
908 Niagara Falls Blvd
N Tonawanda, NY 14120
(716) 694-6247
CIRCLE 355 ON FREE INFORMATION CARD

Electric autos

I have had several helpline callers ask me for my views on electric cars, so here goes...

All the largest trucks and the most powerful locomotives in the world today are powered by electricity—and thay have been for decades. So, the key problem is making electric vehicles *more* wimpy, rather than less.

It is completely obvious to me that the minimum number of motors is *four*—one for each wheel. Putting the motors *inside* the wheels eliminates all of the drive-train parts (clutches, transmissions, CV joints, and differentials). Gone also is any need to transmit mechanical power between the sprung and unsprung portions of the vehicle. This makes for greatly simplified braking. It also allows the vehicle's underside to be far more aerodynamic on the road and much less vulnerable when off road. One motor per wheel gives the ultimate in continuous "positraction," driver safety, and anti-lock braking. It's true electronic four-wheel drive—all-terrain, all the time.

What kind of motor? You'd want to turn things inside out, with the axle-based stator on the *inside* and the wheel-mounted rotor on the *outside*. Because brushes or commutators would be a handicap, the best motor is probably a *switched reluctance* unit with high-energy permanent magnets on the rotor.

Come to think of it, four motors are probably too few. It might make more sense to install modular snap-on units that would let one, two, or even four motors to be added per wheel. This could trade off performance for greater economy and range.

The required battery or fuel cell technology will arrive long before it is really needed. Not to worry. For now, the best choice seems to be a hybrid system having a continuous-speed gas engine driving a high-efficiency alternator, plus a limited amount of battery storage for acceleration. *Robert Bosch* is a source for this kind of system.

Regeneration? Well, yeah, maybe, because it simplifies the brakes. But in general, the regeneration will not extend the range very much in the real world. Beware of hype and wishful thinking here.

For our contest this month, send me your views on electric vehicles. There will be the usual *Incredible Secret Money Machine II* books for the dozen best entries, with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the best of all.

As usual, send your *written* entries to me here at *Synergetics* and not to **Electronics Now** editorial.

Lots more stuff on homebrew and low-end electric autos shows up in *Home Power* magazine. Other places to look for ongoing developments are the *EPRI Journal*, the *SAE Library*, and, of course, *Dialog*.

New tech lit

Signetics/Philips is offering three quite impressive new data manuals. Its *Audio Radio Data Handbook* includes information on the RBDS chip that I discussed. There's also a new *RF/Wireless Comm* data handbook and a revised *Desktop Video Data Handbook*.

SGS Thompson offers its latest edition of the *Designer's Guide to Power Products*. *Analog Devices* offers a brochure on *Audio Signal Processing* circuits plus its new *Op-amp slide guide*. These folks also publish a free *Analog Dialog* journal.

I have received a few requests for simple methods to convert off-the-air or cable TV signals down to baseband video. The folks at *Sharp* have a new data book on *RF Components* that includes complete information on the RFSP and RFST front-end modules. Similar units occaisionally show up at *Surplus Traders*. But because these all require stable external circuits for accurate voltage tuning, you are probably better off adapting a junk VCR instead.

More information on aerogels is now available from *Lawrence Livermore Labs*. It offers a new *SEAgel* product made from seaweed agar that offers densities similar to those of balsa wood down to solid-foam structures that are actually *lighter* than air. This material is edible, water-soluble, an excellent insulator, and a good sound absorber.

There's a robotics BBS at (214) 258-1832. This announcement is from the *Dallas Personal Robotics Group* that has a fine labor-of-love newsletter.

A new Yves Meyer book *Wavelets: Algorithms and Applications* is offered by *SIAM* at $19.50. A review appears in the December 3, 1993 *Science*.

Lots more information on wavelets appears on my *GEnie* PSRT. Simply search the library under *wavelets* to get a complete list. And ISODRAW.PS is a new set of simple isometric drawing utilities that I've also just added.

For the insider secrets of starting your own technical venture, check into my *Incredible Secret Money Machine II* book, or the ongoing technical resources in my *Blatant Opportunist*.

As usual, most of the stuff mentioned here appears in either our *Names and Numbers* or our *Jukebox Resources* sidebars. Ω

"When you said you needed my manual to stabilize your scope, I thought you meant. . . "

REGENERATION

continued from page 80

on a 4-inch square by ¾-inch square wood board. Sheet aluminum panels were attached to the wood base for mounting the control potentiometers, switches, jacks, and other components. The components were soldered onto two terminal strips attached to the end and center of the board. The coil form with coils L1 and L2 was mounted between the terminal strips and variable capacitor C1 was mounted on the other side.

The coil winding diagram that applies to this receiver is Fig. 9-*e*. The headphones are connected in series with the collector of Q3, eliminating the need for an output transformer.

Alternative power

Because a regenerative receiver includes an oscillating detector, it will amplify hum as well as radio signals. This makes it essential that it be powered with batteries or a very low-ripple power supply. Figure 12 is the schematic of a suitable supply.

Coil winding

Refer to Fig. 9, the coil winding guide, and study it carefully before winding any coils. Number 22 insulated, stranded-copper hookup wire was used for winding the coils.

Before winding the insulated hookup wire on a pipe section or pill bottle, it is recommended that you drill two small holes about ½-inch apart at one end where the turns are to begin. Feed one end of the insulated wire through both holes and tie a knot in it to secure the starting position, being sure to leave enough extra wire outside the knot for the external connections that are to be made.

Then complete that winding and drill two more holes in the coil where the winding ends and tie a knot there as well. Again, be sure to leave enough excess wire outside the knot for external connections.

Building tips

All of the circuits described in this article include RF stages that require special attention, regardless of construction method. The cardinal rule in building any high-frequency RF circuit, is that all ground leads should be kept as short as possible. The audio (output) wiring should be physically separated from the RF (input) wiring. The volume controls should be connected to other circuit components with shielded wire.

Be sure that all polarized components are installed correctly. This double-checking procedure is especially important for students and novice first-time circuit builders.

The power supply bypass capacitors for all ICs should be located in close proximity to the device with short ground leads. If the antenna is too short for the high-gain circuits (Fig. 10 and its modification) the RF stage could be unstable. A capacitor with a value of about 100 picofarads connected between the antenna input and ground should restore stability to the radio-frequency stage.

The tuning of these receivers can be improved by adding a small 5 or 10 picofarad capacitors in parallel with the main tuning capacitor. In the multi-stage versions in Fig. 10, dual capacitors are needed to maintain tracking over frequency. Other possible refinements for making tuning easier include tuning capacitors with rotary motion reduction gears, main tuning knobs with large diameters (2½-inch or more), and vernier dials intended for precision potentiometers.

A ten-turn precision potentiometer will make it easier to adjust regeneration. The volume control should be connected with shielded wire. A separate wire from the ground side of this control to chassis ground helps to prevent ground loops. If you select an enclosure with a non-metalic front panel, the metal bodies of the controls should also be grounded to avoid hum and detuning caused by internal parasitic effects. Ω

RF SIGNAL GENERATOR

continued from page 42

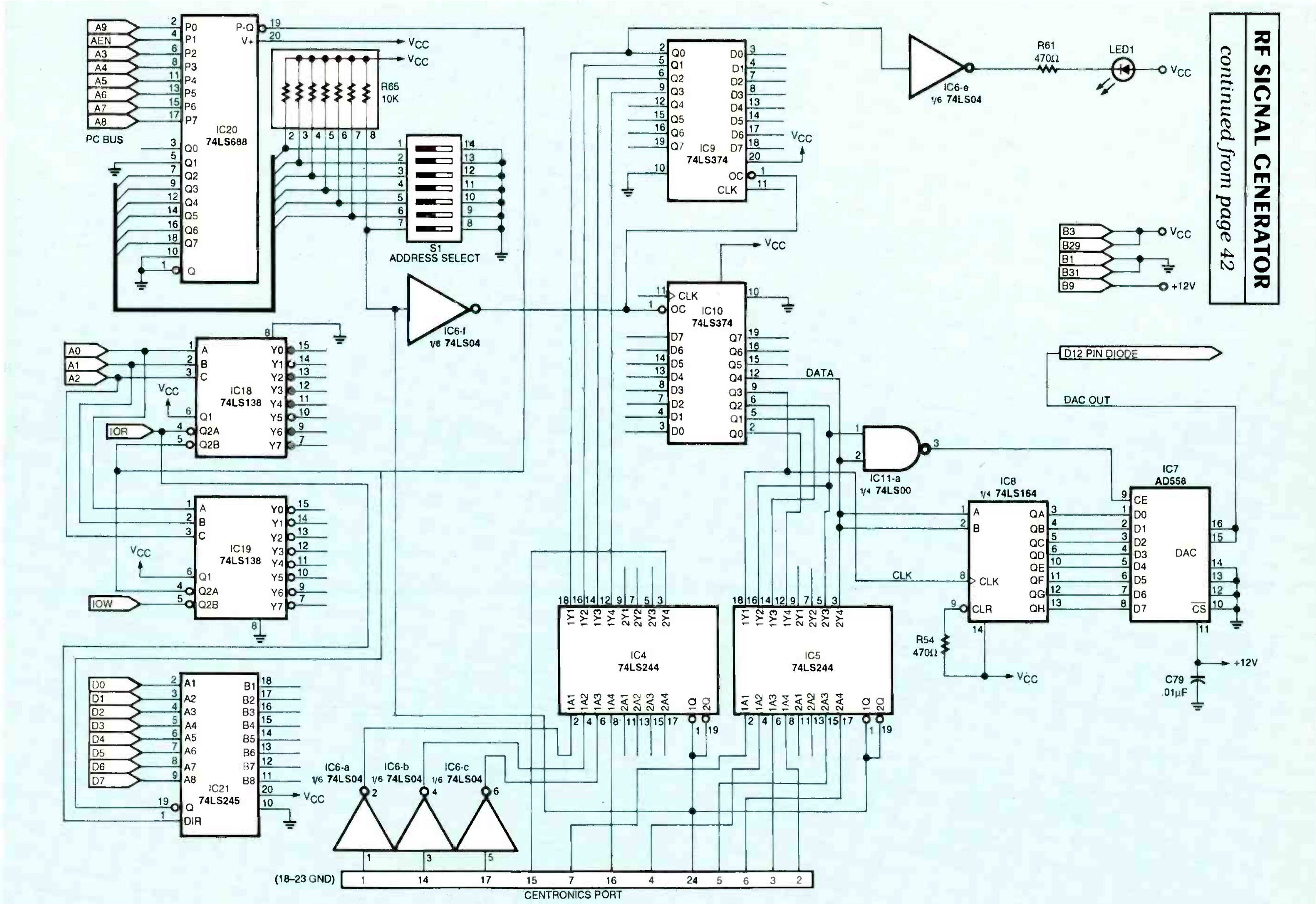


FIG. 13—THE PC-BUS INTERFACE comprises an address/strobe decoder made up of a 74688 (IC20) and two 74138s (IC18 and IC19). The PC data bus is bidirectionally buffered by the 74245 (IC21).

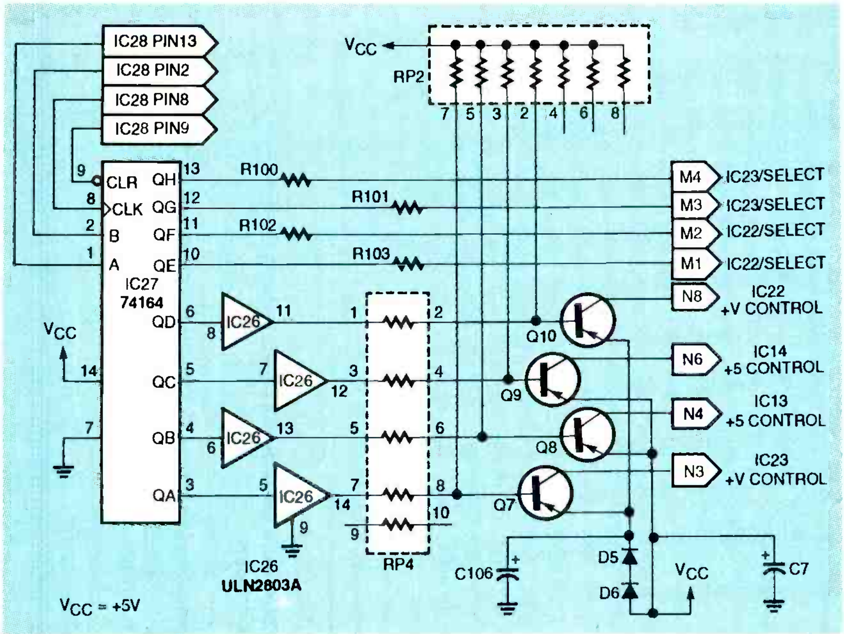


FIG. 14—TWO 74164s (IC27 AND IC28) convert a serial data stream to 16-bit parallel words for the control register.

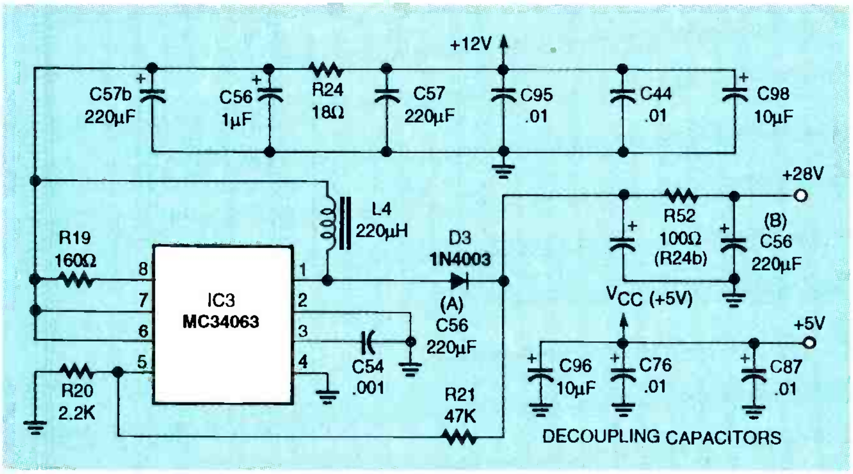


FIG. 15—THE MC34063A +12- TO 28-VOLT CONVERTER provides the higher voltage needed to drive the VCO across its full range.

available on the *Electronics Now BBS*, as part of a ZIP file called TG2000.ZIP.

The TG2000.EXE program contains a menu that allows the user to configure and control the generator. A complete user manual is also contained in the TG2000.ZIP file, so only the highlights will be covered here.

Before using the TG2000 software, you must choose the interface, and possibly the address where the generator will reside on the PC bus. Select the SETUP item from the main menu to configure the software for the chosen address/interface. The setup information is stored in a configuration.

Once the setup operation is complete, you can select either linear or log sweeps and the modulation function. The linear sweep has a constant step size for the entire band of the instrument. The log sweep increases its step size by a factor of two every time it crosses a band boundary. Both sweep functions sweep from a user-defined starting frequency to a user-defined stopping frequency. Sweep rate can be controlled by the DELAY entry.

The other modulation function is a frequency toggle. Two user-defined frequencies are toggled back and forth at a user-defined rate controlled by DELAY. This function can simulate FSK modulation, commonly used for digital data transmission.

Three diagnostic functions are available: Blink, Bitroll, and DAC Ramp. Blink will verify interface operation by toggling all output lines at a 1-Hz rate. Bitroll will debug the 16-bit control register. An alternating pattern of ones and zeros is sent to the 74164s. This results in a square wave at each control bit. DAC Ramp commands the DAC to produce a ramp voltage that will permit any missing codes to be spotted with a scope.

Next month's article will cover the building and and test of the TG2000. Ω

ORDERING INFORMATION

Note: The following items are available from DKD Instruments, 1406 Parkhurst St., Simi Valley, CA 93065. (805) 581-5771:

- **TG2000 kit—$775.00**
- **TG2000 assembled and tested—$1100.00**

CAR STEREO

continued from page 56

cutouts for the existing speakers. Obviously, this will save you the job of deciding on new locations and making new cutouts. Your task is limited to tailoring the existing cutout for the new speakers. Even this work can be minimized if you purchase new speakers that closely match the size of the existing units.

Speakers are available in a wide range of shapes and sizes, suitable for just about any automotive application. For example, there are low-profile speakers for door-panel mounting, flush-mount speakers, and oddly shaped speakers that will fit in narrow rear decks.

Front speakers can be mounted under the dash panel grille, as shown in Fig. 8, or in the doors. In a sedan, rear speakers can be installed from the trunk by mounting them against the rear deck or from above as shown in Fig. 9. In a hatchback car, the rear speakers can be positioned behind the back-seat side panels, as shown in Fig. 10, or on the panels in the hatch area of the car, as shown in Fig. 11.

When considering a speaker location such as the door panels or on the front kick panels, remove the panel first and check to be sure that there is enough clearance behind the panel to accommodate the speaker, as shown in Fig. 12. Then carefully mark and cut out the required opening. Avoid locating a speaker in a door in a way that will interfere with normal window opening and closing.

To install speakers on the top of the rear deck, examine the sheet metal panel underneath the rear deck from inside the trunk for round or oval cutouts. You might have to cut away some thin metal strips that span the cutouts to install a new speaker.

You should be able to cut through the rear-deck cover easily from inside the trunk with a utility knife or keyhole saw because the cover is usually made of cardboard or pressed wood.

If you have trouble deciding where to place the speakers—or if you want to avoid doing any cutting, you can install flush-mount or stand-alone speakers. Flush-mount speakers, which can be mounted on any flat surface, are held in place with screws. Stand-alone speakers, which look like miniature home-stereo units, can be mounted with a simple bracket.

There is another alternative: Some manufacturers offer complete speaker systems in custom cases intended for certain models and years for installation in designated locations, such as in the hatch area. The cases might contain several speakers that offer excellent audio quality, but expect them to be expensive.

Speakers mounted in the dash panel are the easiest to wire. Just run the speaker wires directly from the stereo to the speakers. When wiring speakers in the back of the car, bury the wires under the carpet where necessary and pass them under rocker-panel covers and around the seats on their way to the speakers.

If you want to mount speakers in the doors, run the wires from inside the doors to the stereo at locations where they will not be damaged by or interfere with door opening and closing. The electrical wiring in the doors of cars with power windows is usually bundled and covered with a protective sleeve.

If you are unable to pass the speaker wires through the protective sleeve, wrap them with vinyl electical tape and bind them to the outside of the sleeve.

To make future maintenance easier, try to make all connections to the stereo with one multi-connector plug. That way, the stereo can be removed easily. Permanent connections between wires can be made with approved electrical wire nuts or crimp-type sleeve connectors. Alternatively, they can be twisted together to form a mechanical bond and then soldered. All soldered connections should be isolated. Ω

Suites for the sweet?

JEFF HOLTZMAN

Low cost, high functionality: Those are the watchwords of one of today's fastest growing software categories—the "suite." What's a suite? A more-or-less integrated collection of top-ranked Windows applications programs from one or more vendors. They offer financial and technical incentives over purchasing a grab-bag of individual products. The typical suite sells on the street for around $300. It typically contains the latest versions of a word processor, a spreadsheet, a presentation graphics program, a database manager, and sometimes E-mail client, or a personal-information manager. No, these are not close-out buys on two-revision-old packages, but full-blown, up-to-date versions of leading products. Despite extremely attractive pricing, however, the "suite" trend is worrisome.

TABLE 1—SOFTWARE SUITES

Company/ Product	Microsoft/ Office	Microsoft/ Office Pro.	Lotus/Smart Suite	Borland-WordPerfect
Spreadsheet	Excel	Excel	1-2-3	Quattro Pro
Word Processor	Word for Windows	Word for Windows	Ami Pro	WordPerfect
Email	Mail	Mail	cc:Mail	
Presentation Graphics	PowerPoint	PowerPoint	FreeLance	
Database		Access	Approach Windows	Paradox for
Personal Information Manager			Organizer	

Example suites

The defining product in this category is offered by Microsoft. Called Office, it is widely advertised in computer magazines and trade journals for $259 to $299. Bought separately, each of the products lists for $495 or more; consequently, the suite price is about 10% of the total of the original list prices. Lotus also sells a suite, which is now available for both Windows and OS/2, and Borland and WordPerfect have countered with combined packages of their own. Table 1 summarizes the differences between these packages. (Microsoft's base package does not include a database; the Professional version does.)

Comparing the suites against one another, the Borland/WordPerfect offering covers the least breadth, but the name-recognition attributable to WordPerfect is phenomenal. Looking at the individual products comprising each suite, it is difficult to denigrate any of them. Most users probably will not care about the fine points differentiating Word for Windows, WordPerfect for Windows, and Ami Pro. The same can be said of the spreadsheets. As for the graphics programs, FreeLance is generally regarded as a more powerful package than PowerPoint. And on the subject of databases, Approach is the easiest to use, Paradox for Windows the most powerful, and Access covers the broadest range; its usability is near that of Approach, its power near that of Paradox.

Obviously, there is much that can be said about the products under discussion. But the objective of the suite approach is to ignore those differences and focus on overall benefits. And suites have benefits besides just low cost.

Suites are typically offered on CD-ROM with a single installation program for all packages. They have complete, fully indexed, on-line versions of the documentation. Some have an integrating shell for running all packages contained in the suite, and perhaps others as well. Some save disk space over installing separate graphics modules, spelling checker dictionaries, and other common components. In addition, there's the promise of increased functionality because of consistency of user interface. Microsoft, for example, has been trumpeting its use of menu bars that are similar to those in Word, Excel, and PowerPoint. Lotus has a very nice icon-based toolbar that originated with Ami and has now spread to 1-2-3 and cc:Mail.

So what's the problem?

On the surface, paying a few hundred dollars for several top applications programs seems to be an incredible deal. But when you look deeper, you begin to wonder.

For one, falling software prices (across the board, not just in suites) have forced Microsoft, Borland, and many other vendors to reduce the availability of "free" support drastically and to start charging for support of any kind. Even WordPerfect Corp., which has a legendary telephone-support system, has been criticized recently.

As for fee-based support, vendors typically charge in one of three ways: on a per-event basis, by the minute (via a 900 number), or on a yearly basis. That scheme might appear reasonable. However, support costs are not cheap; they typically average $30 per event. That figure includes only what the vendor charges; it does not include the customer's lost productivity.

Small businesses and individual

users will be less able to afford these prices than large corporations, and, ironically enough, it is the small organizations that most need vendor support. Large corporations usually have their own product-support departments, as well as lots of informal resources ("Hey Joe, what's the formula for net present value in Excel?") that small organizations simply lack.

The second problem with suites is vendor control—rather, lack of user control. If I choose Word for Windows, Paradox for Windows, and FreeLance as best for my purposes, I will end up spending much more than if I had bought a prepackaged suite. In addition, I run an increasingly high risk of encountering the problem of integrating applications from multiple vendors. On both counts, it's going to be harder, both technically and financially, to build custom "best-of-breed" application ensembles with products from multiple vendors.

The third problem is loss of competition. Not long ago there were dozens of companies selling word processors and dozens selling spreadsheets. Now most of the smaller vendors are either dead or might as well be dead. Will the software industry coalesce into a big three like the auto industry? And if so, what will happen to innovation? When Detroit stopped innovating, it was devastated by foreign competition. Even now, after two decades of struggle, the auto industry still suffers. Are our software producers headed down the same path?

For now, Microsoft, Lotus, and Borland (and to a lesser extent, WordPerfect), are innovating like crazy, so loss of competition is not an immediate worry. And so far, difficulties in inter-vendor application integration (e.g., Word to 1-2-3) have not really been much worse than those of intra-vendor application integration (e.g., Word to Excel). Version 2.0 of Microsoft's object linking and embedding (OLE) is supposed to simplify inter-application integration, be it inter- or intra-vendor. However, other than Shapeware's Visio (an excellent product, by the way), Microsoft's own applications are the first and only to use OLE 2.0 facilities, and because of the complexity of the application programming interface (API), it's going to take other vendors a while to catch up.

Nevertheless, as the software price wars continue to drive prices down, something has to give. At small companies, which don't sell in high volume, that something is the company itself. At large companies, that something is support. Gone are the days of unlimited toll-free technical support. Fee-based systems are one answer, but they're not suitable for everyone. Another option is to embed support into the product itself. And that puts a whole new slant on the concept of *support*.

The EPSS

Changes in support structure put the onus on vendors to provide better documentation—and I don't mean printed manuals or even electronic hypertexts. I mean a proactive, agent-based approach that relies on expert systems, case-based reasoning, natural-language processing, fuzzy logic, and other AI (artificial intelligence) techniques to help users solve their problems themselves. Combining these technologies with traditional context-sensitive hypertext help systems creates the Electronic Performance Support System (EPSS). This is not some pie-in-the-sky concept. Compaq is already shipping a disk-based EPSS with some new printer models.

The distribution mechanism that makes sense for an EPSS is CD-ROM. You don't want to clutter up your hard disk with lots of seldom-if-ever-used information and tools for accessing it. Whenever you have a problem, just pop in the distribution CD and run the EPSS to get expert, yet focused assistance.

Another possible means of spreading the word is by some interactive on-line system.

Of course, traditional support

cannot be counted out yet. In fact, decreases in both quality and quantity of vendor-supplied support is creating a market for third-party support products and services. Several options are possible.

One is to provide telephone support at more competitive rates. If a company can figure out a way to provide quality support for $10 to $15 per call, it might have a winner.

The second option is to provide third-party EPSSs. This option would consist of a very friendly database and query tool (with AI-based agents), and it would have to be sold at a very reasonable price. Several databases corresponding to several applications could be stored on a single CD; users could then call an 800 number, credit card in hand, to access the data for a particular application.

The third option is to make the EPSS of Option 2 available on-line. Users would dial in through a custom telecommunications front end (much like CompuServe, America Online, and Prodigy provide). The database would be maintained live, so users would never have to worry about getting current information. Again, the key is a user-friendly front end and quality information.

So go ahead, snap up those $300 suites. Just be prepared to pay for what you formerly thought was your due.

News bits

HDTV is becoming real. The FCC approved testing a system comprised of the best elements of prior proposals from AT&T, The David Sarnoff Research Center, General Instrument, MIT, Philips, Thomson, and Zenith. This "best-of-the-best" system includes both digital audio and video. The audio will include a special form of Dolby noise reduction. The video will be based on a compression standard called MPEG (from the organization that created it, the Motion Picture Experts Group), and will support both interlaced (TV) and non-interlaced (computer) operation. Tests are set to begin early in 1994, but commercial systems are still several years away.

Apple Computer has gone through some wrenching changes during the past year. Of greatest technical interest are continued rumors that the company will port the Mac operating system to run on Intel-based hardware. In its first move, Apple has introduced a dual-CPU Macintosh, in which the second CPU is not a 680x0, but a 486/25. Yes, you can now run DOS/Windows and Macintosh software on the same machine simultaneously. Changing operating system is as simple as pressing two keys. Both OS's run off the same hard disk, but from different partitions. On the other hand, the 680x0 architecture has seen its final days. Beginning in early 1994, all new Macs will be based on IBM's Power PC architecture. And speaking of the devil . . .

IBM is getting lots of good press for the PowerPC RISC microprocessor and systems built based on it. In addition, the company is getting lots of support from Lotus, which just announced availability of its SmartSuite package for OS/2. WordPerfect, on the other hand, has halted development of a 32-bit OS/2 version of its product.

Traveling Software has released an intriguing $229 device called LapLink Wireless that transmits data at rates as fast as 115K bps by RF. The primary purpose of the device is to synchronize files between laptop and desktop computers, but it might have more general applications. On a related note, the Infrared Data Association (IrDA) expects to unveil its standard formally in March of 1994. Traveling Software belongs to IrDA, as do IBM, AST, Compaq, Intel, HP, and other computer makers. IrDA promises greatly simplified (as compared with today's network and other cabled solutions) low-volume data transmission between computers.

Laptop users take note: Advanced Energy Resources (404-433-2127) has announced a new rechargeable battery that the company claims will last for 15 to 20 hours of use, about 2 to 4 times that of today's Ni-Cd packs.

And for you memory mongers, Mitsubishi will release, by the end of 1993, 64-megabit DRAMs. (NEC has already demonstrated similar devices.) Ω

BUYER'S MART

FOR SALE

TUBES: "oldest", "latest". Parts and schematics. SASE for lists. **STEINMETZ,** 7519 Maplewood Ave. RE, Hammond, IN 46324.

TUBES, new, up to 90% off, SASE, **KIRBY,** 298 West Carmel Drive, Carmel, IN 46032.

CABLE test chips. Jerrold, Tocom, S.A., Zenith. Puts cable boxes into full service mode! $29.95 to $59.95. 1 (800) 452-7090, (310) 902-0841.

SECRET cable descramblers! Build your own descrambler for **less** than $12.00 in **seven easy steps! Radio Shack** parts list and **free** descrambling methods that **cost nothing** to try, included. Send $10.00 to: **INFORMATION FACTORY,** Dept. 4, PO Box 669, Seabrook, TX 77586. For COD's (713) 922-3512 any time!

I.C.'s Huge selection. Low, low prices. Send for free listing. Foreign orders welcome! **MAC N2EWH,** PO Box 114, Westfield, NJ 07090. Fax (908) 654-4317.

CABLE TV descramblers. All major brands. Have make and model of the type used in your area when calling. 1 (800) 327-3407. **K.D. VIDEO,** PO Box 29538, Mlps., MN 55429.

THE Case Against the Patents. Thoroughly tested and proven alternatives that work in the real world. $24.50. **SYNERGETICS PRESS,** Box 809-C, Thatcher, AZ 85552. (602) 428-4073. Visa/MC.

CABLE descrambling New secret manual. Build your own descramblers for cable and subscription TV. Instructions, schematics for SSAVI, gated sync, sinewave, (HBO, Cinemax, Showtime, UHF, Adult) $12.95, $2.00 postage. **CABLETRONICS,** Box 30502R, Bethesda, MD 20824.

TV notch filters, professional cylinder type. Channels 2 thru 11 and 14 thru 24. Order by single channel. Better quality non-tunable type. Best quantity discounts. Call the rest then call the best. All channels in stock for fast service. We will beat any competitor's advertised prices. 1 (800) 331-2156, ext#800.

CABLE TV descramblers most models, best prices, all guaranteed! Monthly special, Zenith Ztac $199.00. COD orders & catalog only **1 (800) 337-CABLE.** (206) 944-9134 info. **CABLE CREATIONS.**

CB RADIO OWNERS!

We specialize in a wide variety of technical information, parts and services for CB radios. 10-Meter and FM conversion kits, repair books, plans, high-performance accessories. Thousands of satisfied customers since 1976! Catalog $2.

CBC INTERNATIONAL
P.O. BOX 31500RE, PHOENIX, AZ 85046

CABLE TV converters: Jerrold, Oak, Scientific Atlanta, Zenith & many others. "New MTS" stereo add-on: mute & volume. Ideal for 400 and 450 owners! 1 (800) 826-7623, Amex, Visa, M/C accepted. **B & B INC.,** 3584 Kennebec, Eagan, MN 55122.

300 Experimenters Circuits — Complete in 6 practical books using diodes, relays, FET's, LED's, IC 555's, and IC CA3130's for building blocks. Only $33.00 plus $5.50 for shipping. USA and Canada only. US funds. **ETT, INC.,** PO Box 240, Massapequa Park, NY 11762-0240.

CABLE Converters, accessories below wholesale! Immediate delivery from giant stock! COD orders only. 1 (800) 995-1749.

RESTRICTED information: surveillance & schematics, locks, cable, hacking, more. Details: **MENTOR,** Box 1549-Z, Asbury, NJ 07712.

CABLE TV converters. Jerrold, Zenith, Pioneer, Oak, Scientific Atlanta, and many more. 12 years experience gives us the **advantage.** Visa/MC Amex COD **ADVANTAGE ELECTRONICS, INC., 1 (800) 952-3916** 1125 Riverwood Dr., Burnsville, MN 55337.

FREE CATALOG

FAMOUS "FIRESTIK" BRAND CB ANTENNAS AND ACCESSORIES. QUALITY PRODUCTS FOR THE SERIOUS CB'er. SINCE 1962

FIRESTIK ANTENNA COMPANY
2614 EAST ADAMS
PHOENIX, ARIZONA 85034

TEST equipment pre-owned now at affordable prices. Signal generators from $50.00, oscilloscopes from $50.00. Other equipment including manuals available. Send $2.00 U.S. for catalog refunded on first order. **J.B. ELECTRONICS,** 3446 Dempster, Skokie, IL 60076. (708) 982-1973.

CABLE test-chips as low as $9.95, for testing cable boxes in **full service** mode. Jerrold; Starcom VI & VII; Pioneer, clears E2 thru E5; Pioneer cubes: BA-5000 thru BA-6700; Tocom 5503/5507; Scientific Atlanta: 8500 thru 8600; Zenith: all but PZ1; remotes $10.00. **N.E. ENGINEERING,** 1 (800) 926-4030, fax (617) 770-2305.

CONVERTER — descramblers: Examples, Zenith Ztac $199.00, ST1600 $240.00, Scientific Atlanta 85XX $190.00, 8600 $325.00, Oak RTC56 $99.00, M35B $45.00. **All Pioneer test generator** $160.00. Most makes in stock, COD ok. **MOUNT HOOD ELECTRONICS,** (206) 260-0107.

PAY TV AND SATELLITE DESCRAMBLING
Our Best Yet — 1994 EDITION — Our Best Yet

Includes the latest cable box and satellite (PLUS, B-MAC) fixes. Lots of schematics and chip files (all new), bullets, ECM's, etc. ONLY $15.95. Our best yet. Other Pay TV editions, volumes 1-5 (all different) $15.95 each The Complete Wizzard VCII PLUS hacking. $15.95. Satellite Systems Under $600. $12.95 Wireless Cable Hacking $12.95. Hacker Video $19.95. Any 3/$34.95 or 5/$52.95. Scrambling News monthly $29.95. Scrambling News Year One (176 pages) $39.95. Everything listed here and more $129.95. Includes all our information. Catalogs $1

Scrambling News, 1552 Hertel Ave., #123
Buffalo, NY, 14216. Voice/Fax (716) 874-2088
COD'S ARE OK. ADD $6

CABLE doctor. Stop the bullet and ID signals in cable lines. Send $20.00 to: **R.R. ENTERPRISES,** PO Box 3532, Easton, PA 18043.

TV notch filters, cylinder type. Eliminates beeping on your system. Professionally manufactured. Discounts. 1 (800) 331-2156 ext #2156.

CABLE descramblers, test turn-on kits, bullet stoppers. We have the lowest prices in the industry. Call everyone else, then call us for the best price. We will buy or repair your cable equipment. No Florida sales. (305) 425-0751.

PLANS AND KITS

60 SOLDERLESS Breadboard Projects in two easy-to-read pocket books. Complete with circuit descriptions, schematics, parts layouts, component listings, etc. Both books (BP107 & BP113) only $11.90 plus $3.50 for shipping. USA and Canada only. US funds. **ETT, INC.,** PO Box 240, Massapequa Park, NY 11762-0240.

FASCINATING electronic devices! Voice Disguiser! Vocal truth indicator! Lasers! Transmitters! Detectors! Free energy! High voltage! More! Kits/Assembled! Catalog $4.00 (refundable). **QUANTUM RESEARCH,** 17919-77th Ave., Edmonton, Alberta, Canada. T5T 2S1.

PRINTED circuit boards, etched & drilled. Free delivery. **K&F ELECTRONICS INC.,** 33041 Groesbeck, Fraser, MI 48026. (313) 294-8720, fax (313) 294-5999.

CABLE TV turn-ons. Kits and chips for cable converters are easy to install and use. They will turn on your cable box to their full ability for as long as your test may last. Call **TAZ ELECTRONICS,** for the best pricing and guaranteed #1 quality. 1 (800) 800-8532, 1 (800) 800-9521.

SATELLITE TV

FREE catalog — Lowest prices worldwide. **SKYVISION,** 1012 Frontier, Fergus Falls, MN 56537. 1 (800) 334-6455. See full page ad the Shopper section.

VIDEOCYPHER II descrambling manual. Schematics, video and audio. Explains DES, Eprom, CloneMaster, Pay-per-view (HBO, Cinemax, Showtime, Adult, etc.) $16.95, $2.00 postage. Schematics for Videocypher II Plus, $20.00. Schematics for Videocypher II 032, $15.00. Software to copy and alter Eprom codes, $25.00. VCII Plus Eprom, binary and source code, $30.00. **CABLETRONICS,** Box 30502R, Bethesda, MD 20824.

INVENTORS

INVENTORS! Can you patent and profit from your idea? Call **AMERICAN INVENTORS CORP.** for free information. Serving inventors since 1975. 1 (800) 338-5656.

CABLE/SATELLITE

UNDETECTABLE cable/satellite descrambler will work on all systems **guaranteed!** Send SASE/info, $94.95/kit, $14.95/plans. **MYSTICAL ELECTRONICS,** PO Box 481, Cooper Station, New York, NY 10276.

WANTED

INVENTORS: We submit ideas to industry. Find out what we can do for you. 1 (800) 288-IDEA.

BUSINESS OPPORTUNITIES

MAKE $75,000.00 to $250,000.00 yearly. Learn **IBM monitors** repairs. (solutions most brands). New home based business program. Software available. Information: **USA-Canada** $3.00 cash (no checks), dealers wanted worldwide ($35.00) **US funds. RANDALL DISPLAY,** PO Box 2168 R, Van Nuys, CA 91404 USA.

LET the government finance your small business. Grants/loans to $500,000.00. Free recorded message: **(707) 449-8600.** (KS1).

EASY work! Excellent pay! Assemble products at home. Call toll free **1 (800) 467-5566** Ext. 5192.

START your own technical venture! Don Lancaster's newly updated **Incredible Secret Money Machine II** tells how. We now have autographed copies of the Guru's underground classic for $18.50. **SYNERGETICS PRESS,** Box 809-C, Thatcher, AZ 85552. (602) 428-4073. Visa/MC.

CAPACITORS, resistors, diodes, transistors, no minimum order requirements. Send for price list and specification. PO Box 1262, Fort Washington, PA 19034. Fax (215) 643-4121. Phone (215) 643-4128.

PATENTING

INVENTORS: THE CONCEPT NETWORK represents people who want to patent and market their new product ideas. Schematics or prototype preferred but not required. **Free** information kit. Call 1 (800) 835-2246 ext 67.

INVENTIONS

FREE Invention package: DAVISON AND ASSOCIATES offers customized development, patenting, and licensing for new products and ideas. Proven results: 1 (800) 677-6382.

CABLE TV TURN-ON CHIPS

SUPER Cable TV "Test Chips". Provides full service activation. Excellent instructions & illustrations. **Jerrold:** Starcom-6 ..Starcom-7. **Scientific Atlanta:** 8500 thru 8600. **Tocom:** 5503-VIP..5507. **Zenith:** ST-1000 thru ST-5000. **Call now!! MASTER COMPONENTS. 1 (800) 233-0570.**

BEST BY MAIL

Rates: Write National, Box 5, Sarasota, FL 34230

OF INTEREST TO ALL

"NOW STOP SMOKING Guaranteed" Without Gadgets or Hypnosis. Only $2.65 to: AMS, Box 17388-(RE), Tucson, AZ 85731.

SPORTS FANS: CALL 1-800-PLAY-ISC to see what you are missing!

HIGH SCHOOL DIPLOMA Fast New Program Credit For Experience 1-800-494-9065.

FINANCIAL

STOP BILL COLLECTORS COLD!! Extensive Report $29.00 FREE Information: 800-393-1114 Ext. 11.

RECIPES

20 ITALIAN RECIPES. $4.00 (SASE) To: Sylvester, Box 528, Scranton, PA 18501.

VACATIONS

$5.00 A DAY VACATION HOTELS!! Save Big $ With Great Vacation Hotel Specials. 6 Days 5 Nights Walkiki, Hawaii; 5 Days 4 Nights Las Vegas; Freeport, Bahamas; Cancun, Mexico, As Low As $25.00. Plus Discount Airfares, Cruises And Much Much More! **Call Now 1-800-864-8720.**

EDUCATION & INSTRUCTION

F.C.C. Commercial General Radiotelephone license. Electronics home study. Fast, inexpensive! "Free" details. **COMMAND,** D-176, Box 2824, San Francisco, CA 94126.

ELECTRONIC engineering. 8 volumes complete. $109.95. No prior knowledge required. Free brochure. **BANNER TECHNICAL BOOKS,** 1203 Grant Avenue, Rockford, IL 61103.

ELECTRICITY/Electronics training series used by U.S. military. 23 volumes, other courses available. Free info: **FEDERAL TECHNICAL PUBLISHERS,** Box 1061 N, Glen Lake, MN 55345.

F.C.C. General Radiotelephone Operators license in only 2 or 4 weeks. 16 hr prep course covers all materials needed to pass exam. Guaranteed pass. **THE CENTER FOR F.C.C. EXAM PREPARATION,** Brooklyn, NY (718) 940-3273.

Invest a stamp...
...Save a bundle

For the price of a stamp, you can get the federal government's free **Consumer Information Catalog.** It lists more than 200 free or low-cost publications. Send your name and address to: **Consumer Information Center, Department SB, Pueblo, Colorado 81009**

ADVERTISING INDEX

Electronics Now does not assume any responsibility for errors that may appear in the index below.

ADVERTISING SALES OFFICE

Gernsback Publications, Inc.
500-B Bi-County Blvd.
Farmingdale, NY 11735
1-(516) 293-3000
Larry Steckler, EHF/CET
President

Christina Estrada
assistant to the President

For Advertising ONLY
516-293-3000
Fax 1-516-293-3115

Larry Steckler
publisher

Arline Fishman
advertising director

Denise Mullen
advertising assistant

Kelly Twist
credit manager

Subscriber Customer Service
1-800-288-0652

Order Entry for New Subscribers
1-800-999-7139
7:00 AM - 6:00 PM M-F MST

ADVERTISING SALES OFFICES

EAST/SOUTHEAST
Stanley Levitan
Eastern Advertising
1 Overlook Ave.
Great Neck, NY 11021
1-516-487-9357
Fax 1-516-487-8402

MIDWEST/Texas/Arkansas/Okla.
Ralph Bergen
Midwest Advertising
One Northfield Plaza, Suite 300
Northfield, IL 60093-1214
1-708-446-1444
Fax 1-708-559-0562

PACIFIC COAST
Blake Murphy
Pacific Advertising
Pattis/3M
1800 North Highland Avenue
Suite 717
Hollywood, CA 90028
1-213-462-2700
FAX 1-213-463-0544

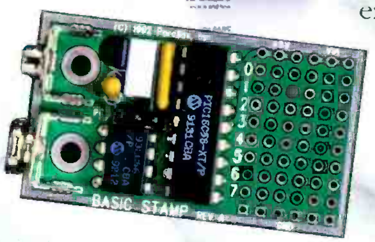
Electronic Shopper
Joe Shere
National Representative
P.O. Box 169
Idyllwild, CA 92549
1-909-659-9743
Fax 1-909-659-2469

THE BASIC STAMP™

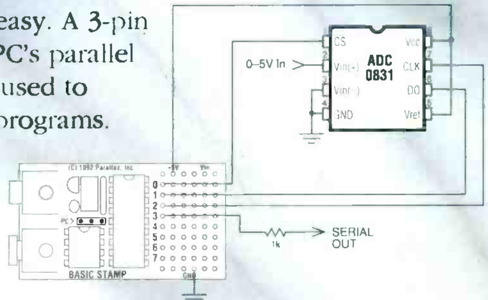
$39 Stamp-Sized Computer Runs BASIC

The BASIC Stamp is a 1x2-inch computer that runs BASIC programs written on your PC. It has 8 I/O lines, which can easily be programmed for serial communications, potentiometer input, pulse measurement, button debounce, tone generation, PWM, etc. And all by just adding a resistor and/or capacitor, if anything. It's so simple, you'll be ecstatic! *

Writing programs for the Stamp is easy. A 3-pin cable connects the Stamp to your PC's parallel port. And one piece of software is used to enter, debug, and download your programs.



For adding circuitry, the Stamp has a small prototyping area. Included are 8 I/O lines, 5-volt supply, unregulated supply, and ground.



17 BASIC instructions are all it takes to run the A/D and send the results out serially.

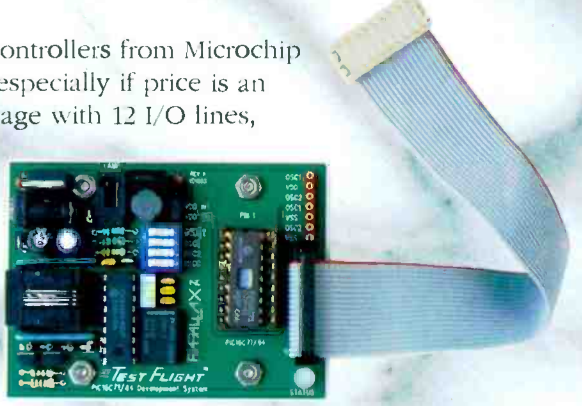
For programming, we offer the Stamp Programming Package. The package includes software, cable, manual, application notes, and free technical support. For those who'd like to make their own, we offer the software and cable info on our BBS.

BASIC Stamps $39 • Programming Package $99 • BASIC Interpreter Chips also Available

PIC®16Cxx MICROCONTROLLERS and TOOLS

NEW! TrueFlight™ for PIC16C71 & PIC16C84

You may already know about the PIC16Cxx series of 8-bit microcontrollers from Microchip Technology. They're the answer to many small controller needs, especially if price is an issue. A typical PIC is the PIC16C54-RC/P; it's an 18-pin DIP package with 12 I/O lines, 512 words of PROM, and 32 bytes of RAM, all for around $4.00.



With our programmer ($179), downloader ($299), and new TrueFlight ($349), you can develop applications for all PIC16Cxx devices (16C5x, 16C71, 16C84, and 16C64). And if you've ever written 8051 assembly language, you'll feel right at home. That's because our assembler accepts our friendly 8051-like instructions (of course, it also accepts Microchip's).

The programmer is used to program and read all PIC's (ZIF, SOIC, & SSOP adapters available). The downloader plugs in place of a PIC16C5x in your target system and allows you to run code in-circuit at 8 MHz. And the new TrueFlight programmer/downloader accomplishes both functions for the popular 16C71 and 16C84. Using a production part and an on-board flash UV eraser,** TrueFlight can quickly program and erase 16C71's, allowing it to work as a 20 MHz downloader. For the EEPROM-based 16C84, the same is done with no UV time.

PARALLAX™

3805 Atherton Road, #102 • Rocklin, CA 95765 • USA
(916) 624-8333 • Fax: 624-8003 • BBS: 624-7101

BASIC Stamp, TrueFlight, and the Parallax logo are trademarks of Parallax, Inc. • PIC is a registered trademark of Microchip Technology, Inc. • Features and prices subject to change without notice.
* Excitement is common, but not guaranteed. ** Patent pending (on-chip eraser not shown above).

CIRCLE 183 ON FREE INFORMATION CARD

DC-2000 MHz

AMPLIFIERS

In plastic and ceramic packages, for low-cost solutions to dozens of application requirements, select Mini-Circuits' flatpack or surface-mount wideband monolithic amplifiers. For example, cascade three MAR-2 monolithic amplifiers and end up with a 25dB gain, 0.3 to 2000MHz amplifier for less than $4.50. Design values and circuit board layout available on request.

It's just as easy to create an amplifier that meets other specific needs, whether it be low noise, high gain, or medium power. Select from Mini-Circuits' wide assortment of models (see Chart), sketch a simple interconnect layout, and the design is done. Each model is characterized with S parameter data included in our 740-page RF/IF Designers' Handbook.

All Mini-Circuits' amplifiers feature tight unit-to-unit repeatability, high reliability, a one-year guarantee, tape and reel packaging, off-the-shelf availability, with prices starting at 99 cents.

Mini-Circuits' monolithic amplifiers...for innovative do-it-yourself problem solvers.

Models above shown actual size

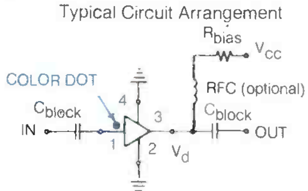
from **99¢** Unit price $ (25 qty)

PLASTIC SURFACE-MOUNT			++VAM-3 1.45		+VAM-6 1.29	++VAM-7 1.75		
add suffix SM to model no. (ex. MAR-ISM)	MAR-1 1.04	MAR-2 1.40	MAR-3 1.50	MAR-4 1.60	MAR-6 1.34	MAR-7 1.80	MAR-8 1.75	
	MAV-1 1.15	+MAV-2 1.45	+MAV-3 1.55	MAV-4 1.65				MAV-11 2.15
CERAMIC SURFACE-MOUNT	RAM-1 4.95	RAM-2 4.95	RAM-3 4.95	RAM-4 4.95	RAM-6 4.95	RAM-7 4.95	RAM-8 4.95	
PLASTIC FLAT-PACK	MAV-1 1.10	+MAV-2 1.40	+MAV-3 1.50	+MAV-4 1.60				MAV-11 2.10
	MAR-1 0.99	MAR-2 1.35	MAR-3 1.45	MAR-4 1.55	MAR-6 1.29	MAR-7 1.75	MAR-8 1.70	
Freq.MHz,DC to	1000	2000	2000	1000	2000	2000	1000	1000
Gain, dB at 100MHz	18.5	12.5	12.5	8.3	20	13.5	32.5	12.7
Output Pwr. +dBm	1.5	4.5	10.0	12.5	2.0	5.5	12.5	17.5
NF, dB	5.5	6.5	6.0	6.5	3.0	5.0	3.3	3.6

Notes: + Frequency range DC-1500MHz ++ Gain 1/2 dB less than shown

designer's kit, KH-1 available only $59.95 includes:
40 AMPLIFIERS* 10 MAR-1, 10 MAR-3, 10 MAR-4, 10 MAR-8
150 CAPACITORS* 50 100 pf, 50 1,000 pf, 50 10,000 pf
740 page RF/IF DESIGNER'S HANDBOOK
• MIXERS • POWER SPLITTER/COMBINERS • AMPLIFIERS • ELECTRONIC ATTENUATORS
• I&Q/QPSK MODULATORS • ATTENUATORS/TERMINATIONS • DIRECTIONAL COUPLERS
• RF TRANSFORMERS • DIGITAL ATTENUATORS • PHASE DETECTORS • SWITCHES/DRIVERS
• FILTERS • LIMITERS • FREQUENCY DOUBLERS
*values or models may be substituted without notice, depending on supplies.

Typical Circuit Arrangement



finding new ways...
setting higher standards

Mini-Circuits™

WE ACCEPT AMERICAN EXPRESS AND VISA

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Distribution Centers / NORTH AMERICA 800-654-7949 • 417-335-5935 Fax 417-335-5945 EUROPE 44-252-835094 Fax 44-252-837010

CIRCLE 179 ON FREE INFORMATION CARD

F155 REV. A