HOW TO USE DC-DC CONVERTERS IN YOUR PROJECTS

Electronics NOW®

DECEMBER 1995

JACOB'S LADDER

Build this fascinating attention-getter!

ELECTROCHEMISTRY

Build a power supply designed for small scale electrolysis and electroplating

VIDEO RECEIVER

Easy-to-build experimenter's project

CIRCUIT COOKBOOK

Waveform generating circuits

HOBBY POWER SUPPLY

No benchtop is complete without it!

$3.50 U.S.
$3.95 CAN.

A GERNSBACK PUBLICATION

Electronics NOW®

Vol. 66 No. 12

CONTENTS

DECEMBER 1995

ON THE COVER

TECHNOLOGY

ELECTRONICS NOW, (ISSN 1067-9294) December 1995. Published monthly by Gernsback Publications, Inc., 500 Bi-County Boulevard, Farmingdale, NY 11735-3931. 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. © 1995 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.

DECEMBER 1995

BUILD THIS

DEPARTMENTS

AND MORE

Typography by Mates Graphics
Cover design by David Loewy

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 94.
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

WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

Serpentine robot snoops in tight places

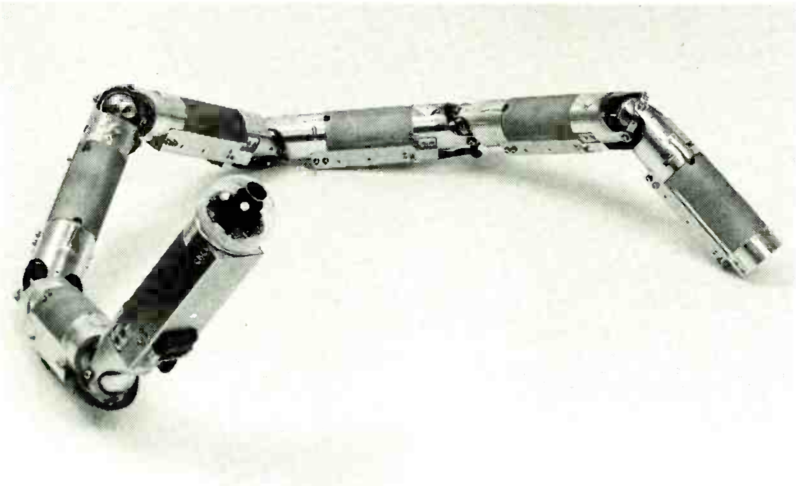
A long, cylindrical, manually-operated robotic arm, developed by NEC Corporation, can move in three dimensions, giving it the appearance of a living serpent. Its dexterity and form factor suit it for exploring and working in restricted spaces. Consequently, a television camera mounted in the robot's head can give its operator a clear view around corners and over and under obstructions.

NEC sees the possibility of putting the mechanism to work examining inaccessible conduits or plenums to determine the condition of piping or cables. NEC also sees it as a rescue tool that will help to find people trapped under the rubble of buildings collapsed by earthquakes, tornadoes, or explosions.

The "active universal joint" mechanism has six joints, each with two degrees of freedom. This allows the mechanism to move up and down and left and right. Each of the mechanism's joints contains a microcontroller to control the two drive motors at each joint. This means that with six joints, each with two-degrees of freedom, the complete mechanism has a total of 12 degrees of freedom. Each of the mechanisms joints can be controlled separately or linked with other joints.

The mechanism is 55 inches long and has a diameter of 1.7 inches. It weighs only 10 pounds. Strictly speaking, the device is not a robot because it is controlled manually, not by a stored software program.

Most floor-standing, computer-controlled industrial robots have at least three primary degrees of freedom for positioning their arms. However, the wrist, attached to the end of the arm, can have two or three additional degrees of freedom so that a tool or gripper can be positioned at an optimum angle of attack for the performance of a variety of tasks.



THIS SERPENTINE ROBOT has six active joints, giving it 12 degrees of freedom. A TV camera in the NEC machine permits its operator to see around corners.

Digital videodisc standard unified

The converging interests of consumer electronics manufacturers, the entertainment industry, and computer manufacturers could be seen clearly in the recent agreement on a unified standard for high-density videodiscs. The standard is a merger of two competing proposals, one put forward by a group of companies lead by Toshiba Corporation and Time Warner Inc, the other by Sony Corporation and Philips Electronics.

The agreement, reached primarily because of the influence of IBM, opens the door for the storage of two-hour movies on a disc the size of today's CD—about seven times more information than can be stored on a CD-ROM.

However, the agreement on a standard was largely at the expense of the Philips-Sony proposal. But Philips and Sony accepted the decision to include only their modulation technique as a kind of consolation prize, more for economic reasons than technical merit.

Computer manufacturers want to include the new videodisc system in future computers because the discs can store far more information than either hard magnetic disks or CD-ROMs. IBM threw its weight behind the combination of the Toshiba format and the Sony-Philips modulation technique because it believes, based on its own laboratory research, that the Sony-Philips modulation technique is more reliable than the one proposed by Toshiba and that it will permit the discs to be manufactured

Continued on page 81

VIDEO NEWS

WHATS NEW IN THE FAST-CHANGING VIDEO INDUSTRY

BY DAVID LACHENBRUCH

DVD Peace Breaks Out

Finally—there is but a single format for the digital videodisc (DVD), after months of conflicting claims and bravado on both sides. The advocates of the Super Density (SD) system espoused by Time Warner and Toshiba and the Multimedia CD (MMCD) approach backed by Sony and Phillips finally have gotten together to avoid a format war. There was face-saving on both sides in reaching a compromise, but the finally approved system appears to be closer to SD than to MMCD. The SD camp had achieved more entertainment and consumer electronics industry endorsements than had MMCD advocates, and the final choice reflects that condition.

The Sony/Philips group was the side which finally sued for peace, and the side which gained the least from the negotiations. One of the principal bones of contention was the issue of two-sided vs. single-sided discs. The SD camp pushed for dual-side discs with the two sides laminated together, while the MMCD group pushed for a single-sided disc but with the future possibility of dual-layer recording on a single side. The final compromise specifies the bonded two-sided disc but also permits dual-layer technology. The conferees in the compatibility discussions chose the Sony-Philips EMMPlus modulation system, which reduces data capacity to 4.7 gigabytes from the 5-gigabyte capacity of the SD specs but is claimed to be more robust.

Although the system is touted as a new videodisc designed eventually to replace the videocassette for prerecorded material, there is strong evidence that the compromise was instigated by computer manufacturers anxious for a single format for high density storage. The computer industry demanded that the two sides get together, and IBM reportedly was instrumental in urging Sony and Philips to make the peace overtures. At our press time, the final details hadn't been worked out—the system didn't even have a name—and there was a slight chance that the truce will fall apart. Nevertheless, the parties involved estimated that the switch to the new compromise system would delay the introduction of a consumer digital videodisc by three months—from next summer to around Labor Day.

'Micromirrors' are Hot

You'll be hearing a lot in the next few months about the Digital Micromirror Device (DMD) and digital light processing technology. The two catch phrases are part of a system which could revolutionize projection television—and could appear on the market before the end of 1996. The system was developed by Texas Instruments, and is based on a 5/8-inch square chip with half a million tiny pivoting mirrors. In a projection TV, the mirrors tilt to reflect an external light source into a lens or away from it, producing and excellent picture and one which is—to use a magic word—digital. Texas Instruments did its homework carefully and didn't expose its system to the light of publicity until it was perfected. The company worked for three years with Sony to develop an optimum projection system, Sony supplying some optics and electronics to work with TI's tiny mirrors.

The system is finally ready. Several commercial and industrial projection TV manufacturers will soon offer their versions. But more important, three consumer TV manufacturers so far have announced plans for home systems using the technology. The first was Nokia, the Finnish manufacturer which is the fourth largest color-TV producer in Europe. At the recent Berlin consumer electronics fair, Nokia showed a prototype of a set it plans to offer early in 1997. Although it's a projection set, it's less than 16 inches deep and has a bright flat 51-inch screen. Two manufacturers which specialize in home theater systems have promised DMD projectors for late 1996 or early 1997. Runco is planning to market two different versions of the DMD system this year—front and rear projection systems—initially at a target price of "under $10,000" and eventually to migrate down to the mainstream consumer electronics market. "At some point down the road we're going to see this technology everywhere," said President Sam Runco.

Italy's Vidikron plans to introduce DMD projectors in 52 countries, including the U.S. in 1997, also at less than $10,000. While the only mass marketer to adopt the DMD approach so far is Nokia, which doesn't sell in the U.S., it's still a good guess that we'll be hearing more DMD announcements from major manufacturers about plans to offer sets here. Who's next? Best guess is Sony, which helped perfect the DMD projection system.

Continued on page 87

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Remote-control repeater

Q *How can I extend the use of my IR remote control to operate my VCR from another room? I have experimented with a RadioShack IR emitter and detector, but it burned out.—F. J. H., Jensen Beach, FL*

A The trick here has to do with how your VCR distinguishes remote-control signals from other sources of infrared (IR) light. Each pulse of IR from the remote control is modulated by switching it on and off at a rate of 40 kHz. RadioShack sells a module that detects and recognizes these pulses, but if you want to send the same signals out again, you have to regenerate the 40-kHz modulation.

Figure 1 shows a circuit that you can experiment with. The Radio Shack IR detector module gates a TLC555 oscillator on and off. The oscillator, in turn, lights an infrared LED with the requisite 40-kHz on-off pattern. Thus, each pulse coming in is faithfully retransmitted at the output.

Instead of a TLC555, you can use an LMC555 or 7555. Don't use the original NE555 (non-CMOS) timer; it doesn't work well at a frequency this high.

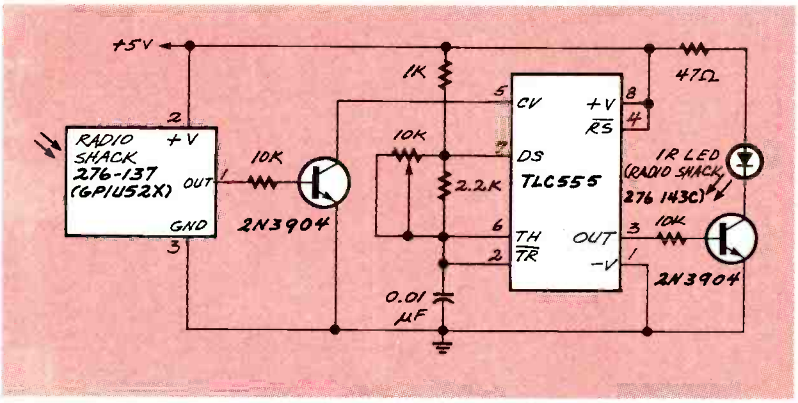


FIG. 1—THIS CIRCUIT RECEIVES TV REMOTE CONTROL SIGNALS and retransmits them out again. The 555 oscillator provides 40-kHz modulation. The IR LED can be placed in another room.

To adjust the frequency, connect a frequency counter across the LED. Then temporarily ground the base of the first transistor and adjust the potentiometer until the frequency counter reads 40 kHz. If you don't have a frequency counter, the alignment procedure is slower but simpler—just set up the circuit and adjust the potentiometer until it works! The IR receiver module must be shielded from extraneous light. The IR LED, which can be mounted separately from the rest of the circuit, might need to be fairly close to the VCR (within a few feet) and aimed straight toward it.

Note that some remote controls are switched at 32 kHz instead of 40 kHz. You can get a 32-kHz receiver module from Jameco (1355 Shoreway Road, Belmont, CA 94002, 405-592-8097). To make the repeater transmit at 32 kHz, simply adjust the potentiometer in the repeater circuit.

Radio hacker's delight

Q *I am trying to design a standard broadcast AM receiver using a ZN414 IC. The problem is, I can't find a coil needed for tuning it, called a loopstick antenna. Where can I find this component and some books or data on the ZN414?—N. B. G., Amherst, NY*

A The Plessey (formerly Ferranti) ZN414 is a fascinating IC that contains a complete AM receiver except for the audio section, and requires only a few external components (see Fig. 2). It will work from 150 kHz to 3 MHz depending on the tuned circuit, and it includes automatic gain control (AGC) so that almost all stations come in at the same loudness regardless of signal strength. Because the input impedance is very

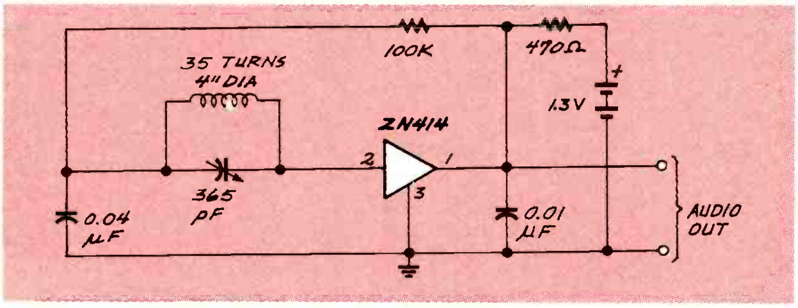


FIG. 2—THE ZN414 IC contains a complete AM radio, with AGC, except for an audio section. Like an MMIC, it is powered through its output terminal.

high, the coil and tuning capacitor provide good selectivity without additional tuned circuits. The audio output is about 0.1 volt peak-to-peak, just right for feeding to an LM386 or similar audio amplifier; or you can use the ZN416 chip, which consists of a ZN414 plus a headphone amplifier.

The only peculiar requirement of the ZN414 is the 1.3-volt supply. You can use a 1.5-volt battery, but you might get overloading on strong signals when the battery is fresh. A single Ni-Cd cell, at 1.25 volts, is perfect. Or you can use two diodes as shown in Fig. 3 to derive 1.3 volt from a higher DC voltage. The ZN414 draws less than 1 milliampere.

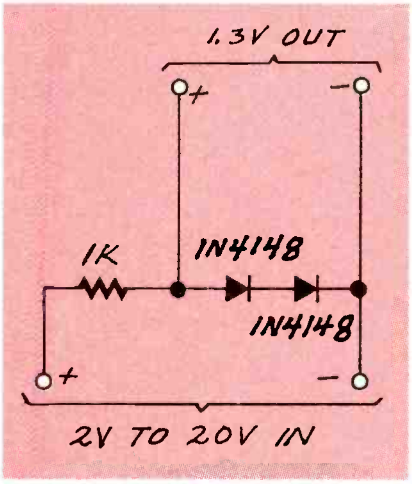


FIG. 3—SIMPLE 1.3-VOLT REGULATOR to power the ZN414 IC.

The antenna is normally a ferrite loopstick, but as you've noticed, these are hard to find nowadays. You can salvage one from a discarded transistor radio, or you can make your own coil. Any coil that has the right inductance to tune the broadcast band and is big enough to be effective as an antenna will work.

Rather than give exact specifications, I'll tell you how to "cut and try." Wind 40 turns of thin wire (such as No. 28 magnet wire) around a nonmetallic object about 4 inches in diameter; you can use a large paper cup, a plastic jar, a small rectangular box, or the traditional Quaker Oats cylinder. Hook up the radio and see how well it works. If it tunes only the lower end of the broadcast band, take some turns off the coil; if it tunes only the upper end, add turns. Along the way, you might pick up some interesting shortwave stations or longwave beacons.

Ferrite loopsticks, tuning capacitors, and other AM radio parts are available from Antique Electronic Supply, 6221 S. Maple Ave., Tempe, AZ 85283 (phone 602-820-5411). The ZN414, ZN416, and many other interesting chips, along with data sheets, are available from DC Electronics, PO Box 3203, Scottsdale, AZ 85271 (phone 800-467-7736).

Transistor switching circuits

Q *I'm hoping you can assist me with a small problem that I am currently facing with transistor switching circuits. What are the proper ways to set the base bias current using current limiting resistors? Should I use Ohm's law, or is there another way to come up with the answer?—L. S., Frackville, PA*

A Yes, you're on the right track—Ohm's law figures prominently in the design of switching transistor circuits.

The essence of a transistor is that a small current through the base controls a large current through the collector (see Fig. 4). Both currents go through the emitter, and both of them must be limited so that the transistor won't burn out. In a switching circuit, the transistor is always either *cut off* (not conducting at all) or *saturated* (conducting as much as it can).

In Fig. 4, the collector current is limited by the resistance of the light bulb. It would be OK to connect the bulb directly to the 12-volt supply, leaving the transistor out of the circuit.

The base current is limited by the 2K resistor. The value of the 2K resistor is not at all critical, but a rule of thumb is that to ensure saturation, the base current should be about $^1/_{10}$ of the collector current. (Anything from about $^1/_{30}$ to $^1/_4$ will generally work fine.)

We know that the collector current is 125 milliamperes, so we want to inject about 12 milliamperes into the base, and the current is coming from a 6-volt source. Ohm's law (R = E/I) tells us that a 500-ohm resistor will do the job (6V/0.012A = 500 ohms).

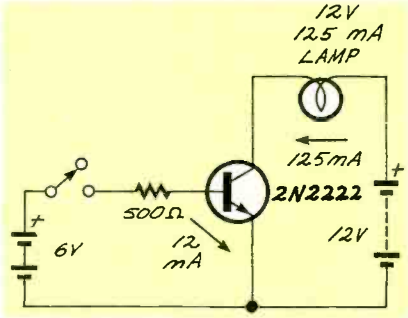


FIG. 4—SMALL CURRENT THROUGH THE BASE controls large current through the collector. Close the switch, and the bulb light up.

If you're a real purist, you'll subtract 0.6 volt, which is the fixed voltage drop of the base-emitter junction; then the formula will tell you need a 466-ohm resistor. This is similar to subtracting 1.8 volts when you calculate the resistor in series with an LED. But the base resistor in a switching circuit is so non-critical that you can ignore the 0.6-volt drop with impunity.

You do need to check transistor maximum ratings. In a switching circuit, the dissipation rating (in watts) doesn't matter because the transistor is always fully on or fully off. But the maximum current ratings (collector and base, IC and IB respectively) are important. The 2N2222 can take up to 800 milliamperes through the collector and over 50 milliamperes through the base. The popular 2N3904 (the world's cheapest name-brand transistor, 6 cents each in wholesale quantities) is rated for 100

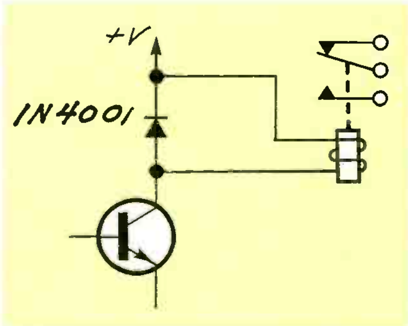


FIG. 5—DIODE PROTECTS SWITCHING TRANSISTOR from voltage spike caused by the relay coil.

Continued on page 40

More lessons! **More Services!**

A Shocking Offer!

Now you don't have to be enrolled at CIE to receive our introductory Electronic and Electricity Lesson Modules. This program is available for a limited time to non-students for the shockingly low price of only $99.50.

With CIE's patented AUTO-PROGRAMMED method of learning you will quickly learn and then master the basics of electronics and electricity and then move on to... DC/AC circuit theories, fundamentals of bi-polar junction transistors (BJT), field effect transistors (FET), wiring, diagram and schematic readings, component identification, soldering techniques... and much, much, more. This introductory offer includes the first 39 lessons in CIE's Associate in Applied Science in Electronic Engineering Technology Degree.

Your commitment to CIE ends with your payment, but CIE's commitment to your success just begins when you receive your lessons, exams, binder and equipment. This special introductory price includes all the benefits and assistance CIE normally extends to its full time students. You'll be entitled to unlimited access to CIE's faculty and staff to assist you in your studies via a toll free 800 number six days a week, 24-hour turn-around on grading your submitted exams, CIE bookstore privileges, a patented learning method, reference library, access to CIE's electronic bulletin board and a free issue of CIE's school newspaper The Electron.

And best of all, when you decide to continue your electronics education in any of CIE's programs you'll receive full academic credit for successful lessons submitted and a $100.00 Tuition Credit Certificate.

All this knowledge and support will put you on the road to understanding digital electronics, automotive and industrial electronics, microprocessing principals, computer systems, telecommunications and much, much, more.

All This For Only!

$99^{50}

- **$100.00 Tuition Credit**
- **Academic Credit**
- **Free issue of The Electron**
- **Build your personal burglar alarm**
- **Toll Free Instructor Assistance**
- **24-hour grading**
- **CIE bookstore privileges**
- **39 theory and hands-on training lessons and exams.**
- **Patented learning method**
- **CIE electronic bulletin board privileges**

☐ **Yes! Send me CIE's Introductory Electronic and Electricity Lessons and Equipment.** A7330

Name: ____________________

Street: ____________________ Apt#: ______

City: ____________________

State: ____________ Zip: ____________

Age: ______ Phone: (____) ____________

CIE

BOOKSTORE
1776 East 17th Street
Cleveland, Ohio 44114

Total Merchandise: ____________ $99.50

Ohio Residents add 7% Sales Tax: ____________

California Residents add 6 1/2% Sales Tax: ____________

Total This Order: ____________

Shipping and Handling Charge: ____________ $5.00

Method of Payment/Amount Enclosed: ____________ $

Personal Check or Money Order

Master Card Visa Discover

Card Expiration Date: ____________

Signature: ____________

DISCOVER VISA MasterCard

CHARGE BY PHONE!
9 AM to 4:30 PM Eastern Time;
1-800-321-2155 ext. 7330

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

SEEING THE UNSEEN CORRECTIONS

The article, "Seeing the Unseen," by Philip Condax (*Electronics Now*, October 1995) was an impressive review of the contributions of Harold Edgerton. As a professional photographer, I have long admired the work of Mr. Edgerton, and his effects on photography are with me daily.

I must point out two possible errors in the article. The photograph on page 91, showing a .22 caliber bullet "passing through a candle flame," would have been more accurately captioned: "passing through the heat waves above a flame."

The article made this reference to bomb tests: "Edgerton-designed cameras photographed hydrogen bomb tests that were conducted both in Nevada and on Pacific islands." I was under the impression that all *hydrogen* bomb tests were in the Pacific and none in Nevada.

GEORGE DUNBAR
Scarborough, Ontario, Canada

BUILDING BARGAIN BRIDGES

I'm writing to add some information to Ray Marston's excellent articles on bridges in the September and October issues of *Electronics Now*.

I've built several bridges over the past 40 years, so I have a few suggestions. If you are building a bridge, look around for General Radio type 1432 or 1433 decade resistors. They were manufactured from the 1930s until the '70s, I think, and are often available at low cost from used electronic test equipment dealers. Those decades are ruggedly built with solid coin silver contacts and ±0.05% resistors (except for the lowest resistance decade).

I bought precision fixed resistors (±0.01%) from Electro Scientific Industries, but the new owner (Tegam, Inc.) has apparently discontinued that line. You might try Wilbrecht Electronics, Inc. (612-659-0919) for those now.

The Hewlett-Packard model 415 A, B, or C makes an excellent AC balance detector. Although it is called a "standing wave indicator," it's just a very sensitive 1000-Hz voltmeter with a 70-dB measurement range. Those instruments are frequently offered at "give-away" prices. I paid $10 last year for one in very good condition.

RON TIPTON
Las Cruces, NM

TO DOT OR NOT TO DOT

I hope I don't hit a particularly sensitive spot with the editors of *Popular Electronics*—articles of faith that are difficult to prove tend to be held all the more strongly because of that.

I reacted strongly to TJ Byers' article, "Low-Cost Software for Electronics," which appeared in the October issue. I disagree about placing a dot at junctions. It is much better to omit the dot altogether, and also to forbid four-way joints. Use jogs instead! If two wires cross, they *cross*. They don't join.

That way you avoid the problem illustrated on page 71 in the same October issue, where a dot missing at the drains of Q16/Q23 makes one wonder what exactly is driving the output of the circuit. Don't draw it as a four-way joint and you have no problem.

DEREK W. MOORE, P.ENG.
Rexdale, Ontario, Canada

Write To:
Letters,
Electronics Now Magazine,
500 Bi-County Blvd.,
Farmingdale, NY 11735

Due to the volume of mail we receive, not all letters can be answered personally. All letters are subject to editing for clarity and length.

THE DMM DIALOG CONTINUES

I just read Charles Hansen's letter (*Electronics Now*, October 1995) about my letter, which appeared in the June issue. He is correct. In my letter, I was giving only a short description of the unit that I build. Nevertheless, I should have mentioned that 2000 volts is the maximum reading, but the meter should not be used for voltages that high unless adequate insulation is used. I marked my meter "maximum 1000 volts," similar to what is on most digital multimeters, and probably should change that to 750 volts.

Also, I later replaced the 8.2-megohm and one-megohm resistors mentioned in my letter with two 4.3-megohm resistors, and probably should replace them with four 2.2-megohm resistors, according to Mr. Hansen's data. (I used $^1/_2$-watt carbon film resistors because one-percent resistors are not available in values over 2.2 megohms.)

Another consideration is the flashover voltage between terminals of the range switch. The spacing is rather close on most rotary switches.

I have decided that building a DC voltmeter such as mine is not really cost effective. Even using the DPMs advertised in recent issues of *Electronics Now* and *Popular Electronics* at about $10, a lower-priced digital multimeter is a better buy. A better use for DPMs is for something not on the market, or something that has a high price. For example, I build an automobile voltage monitor,with a range of 20 volts, that works better and costs less than any commercial unit I have found.

BILL STILES, CET
Hillsboro, MO

QUIET, PLEASE!

In reference to Mark Rumreich's article, "A Subwoofer for your Car Stereo" (*Electronics Now, October 1995*)—oh boy! Just what we need, more cars cruising the neighborhood with subwoofers pounding. I am ready to kill now.

If you can invent some kind of device to send their loud music back into their vehicles and blow out their stereos, please let me know.

BOB RINEHULS
Tallahassee, FL

THERMAL CUTOUTS

Dave Ching's question about thermal cutouts in the June 1995attracted my attention. I recently replaced a thermal cutout in the motor winding of a portable air compressor with a Microtemp No. 4158A (72°C) whose characteristics matched those of ECG and NTE part numbers 8070 (72°C). The important issue is that my ECG catalog specifies that if the trip temperature of the original thermal curtout is less than 120°, the replacement unit should have a trip temperature within 4°C of that specified for the OEM part.

If the OEM part's trip temperature is greater than 120°C, the replacement should have a rating within 8°C. Thus, "Q&A" might have given Ching the wrong answer if the trip temperature of his battery pack's OEM thermal cutout was rated very much below the 128°C trip temperature specified for Radio Shack's No. 270-1322 thermal cutout.

M.J. McCLYMONT
San Diego, CA

THE DEMISE OF SWEEP ALIGNMENT

I'd like to offer a more precise answer to the question, 'Sweep AlignmentA Lost Art?" in the June 1995 "Q&A."

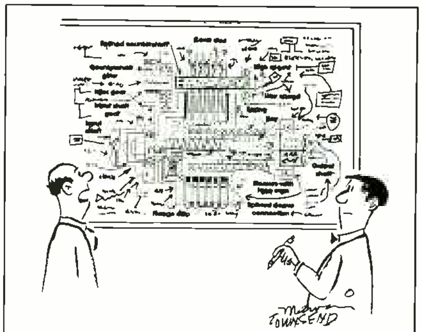
Sweep alignment died because of the introduction and rapid acceptance of the *sur .face acoustic wave* (SA@ filter more than 20 years ago. Developed for the communications, SAW filters gained wide acceptance in television receivers because they offer precise bandwidth and can't be adjusted. If the device is out-of-limits, you simply replaced it.

The SAW filter is based on piezo-electric principles. If a signal is applied to an input section on a piezo-electric crystal substrate (made from such materials as lithium niobate or quartz), a surface wave will propagate across the substrate and be picked up by an output section at the other end.

A SAW substrate is t)Tically about 0.15-inch square. By carefully controlling the length and spacing (weighting) of the input and output sections, a filter with the desired bandwidth is produced. These devices revolutionized traditional line-up procedures.

DOUGLAS L. MOORE
Oklahoma City, OK

EN



"Can you be a bit more specific?"

Two ways to fit a 100 MHz benchtop scope in your hand.

Bigger hands.

TekScope™

Got huge hands? Then you can probably lug a benchtop scope around the field. For the rest of us, there's TekScope,™ the first hand-held with true 100 MHz bandwidth and 500MS/s sample rate on both channels. It's got the familiar Tek interface, a bright, backlit display and is priced at just $2195 MSRP. Call 1-800-479-4490, action code 709, or visit our Web site at http://www.tek.com.

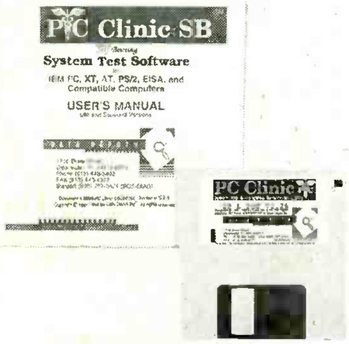
TEK TOOLS

Tektronix

EQUIPMENT REPORTS

DATA DEPOT PC CLINIC SYSTEM TEST SOFTWARE

Get to the bottom of a personal computer's hardware with PC Clinic System Test Software.



CIRCLE 15 ON FREE INFORMATION CARD

Troubleshooting electronic circuits is a skill that's acquired over time, and it is similar to detective work in that one must follow a series of clues to reach the problem. It's pretty much obvious that when you turn on a stereo receiver and everything works except the FM section, then that's where you start looking for problems. Likewise, if the only problem is that you aren't getting any sound from the left channel, then you should immediately suspect the left-channel amplifier. If an entire unit is completely dead, then the power supply is the first place to look.

Computers are different, though. If a computer is up and running and something starts to act up, someone familiar with operating a PC might know what to do. If you are lucky the problem will turn out to be an annoying setup problem. Having slightly less luck, your computer will turn on, but something such as the floppy disk drive will not work and need to be replaced. Other times a hard disk drive failure is what's giving a computer fits.

If a computer will not boot at all, you might have run out of luck. If your computer is dead and you suspect the power supply, you can swap it with a known good supply if you know how. If it turns out that you were right and your system is up and running again, then three cheers for you because you still had a bit of luck left.

If it turns out that there is a problem with your computer's motherboard or memory, then it's the end of the line for most people. While many people are technically capable enough to swap out a motherboard or a memory module, the cost of doing so might be very expensive and not be worth the cost. Other times a replacement motherboard will simply not be available for one reason or another. In these situations, the only alternative is to diagnose and repair the problem yourself or by someone who knows how to do it.

Now here's the biggest problem: even someone who knows how to repair computers needs something to help pinpoint the problem. A computer with an intermittent problem is a tricky thing to troubleshoot because there are so many components in a computer and almost anything can bring down the entire unit.

Software itself can also get in the way of properly diagnosing a computer problem. Many times a computer will crash for no apparent reason. Sometimes faulty hardware will be suspected when it's actually a troublesome bit of software that's causing all the trouble. In these instances it is necessary to eliminate the possibility of software problems before a computer's hardware can be given a clean bill of health. The question is, how do you give a computer's hardware a thorough workout without accessing or eliminating any of the software loaded on it?

PC Clinic

A company called Data Depot, Inc. (1710 Drew Street, Suite 5, Clearwater FL, 34615-6213, 800-767-3424) manufactures a system test software package called PC Clinic SB. The "SB" stands for "self booting," and that's the beauty of this software. It requires no operating system to work, and thoroughly checks hardware integrity without accessing any of a computer's own software. It can be used to troubleshoot old computers or to perform quality control on new computers without loading software on them.

The PC Clinic package consists of one PC-compatible diskette and a user's manual for $199. The package normally includes a 3½-inch diskette that must be placed in the A: drive. A program on the disk, CLINCOPY.EXE, will allow the user to make up to two self-booting copies of the diskette on either 3½- or 5¼-inch disks. If your computer's A: drive is 5¼-inch, then you must first use CLINCOPY.EXE to make

Continued on page 55

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

CLAMP-ON CURRENT PROBES

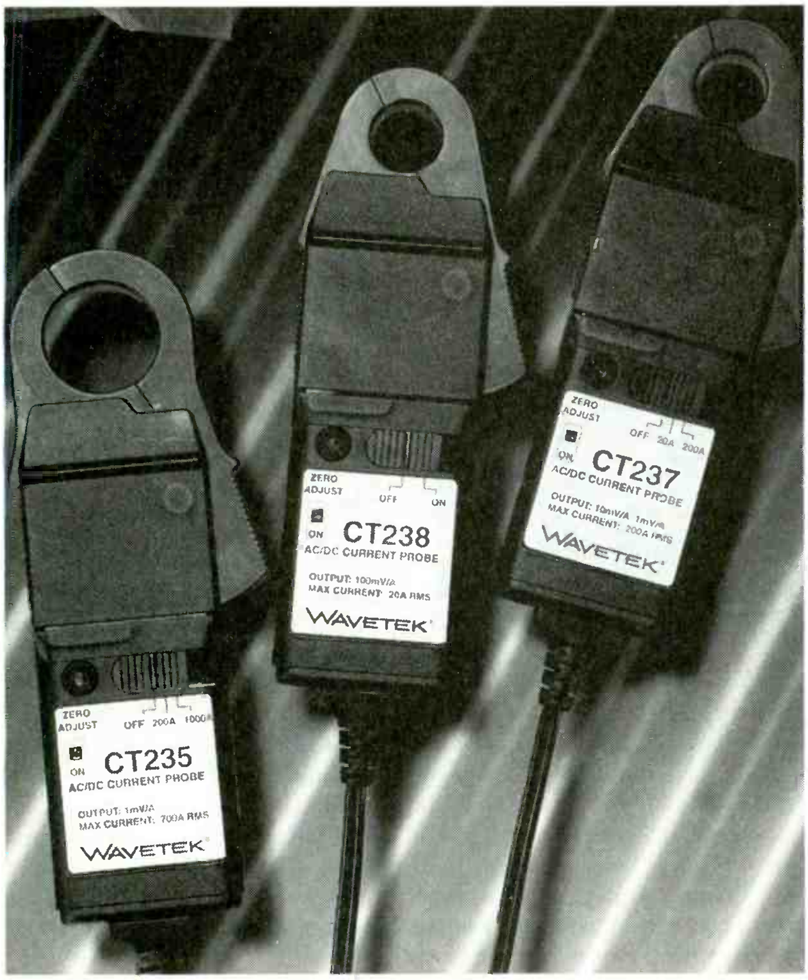
WAVETEK HAS INTRODUCed its CT235, CT237, and CT238 AC/DC clamp-on current probes that will measure AC or DC current noninvasively from 5 milliamperes to 1000 amperes peak with 1% accuracy. The broad AC bandwidth and 1% accuracy of the probes permit the precise measurement of complex waveforms distorted by harmonics or power-line anomalies.

The current probes can be used with different test instruments including analog or digital multimeters, dataloggers, chart recorders, and power analyzers. Current measurements are obtained with Hall-effect sensing, and the zero-adjust feature cancels residual magnetic fields, so DC measurement accuracy is unaffected.

Applications for the probes include the analysis of current waveforms for harmonics, the testing of banks of batteries, the analysis of inverter power output, the recording of UPS charge and discharge rates, and the diagnosis of automotive electrical systems. The probes have IEC1010-1, Category III, 300-volt, pollution degree 2 safety approval.

The pricing on the probes is: CT235 (1000-ampere)—$179.00; CT237 (200-ampere)—$249.00, and the CT238 (20-ampere)—$299.00

WAVETEK CORPORATION
9045 Balboa Avenue
San Diego, CA 92123
Phone: 619-279-2200
Fax: 619-565-9558



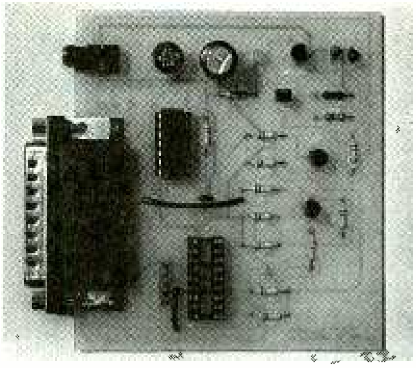
CIRCLE 20 ON FREE INFORMATION CARD

LOW-COST PIC PROGRAMMER

ITU TECHNOLOGIES MOdel PIC-1 PIC programmer will program the Microchip family of PIC16C6, 16C7 and 16C8 microcontrollers in conjunction with an IBM or compatible personal computer host. An 18-pin socket is provided on board for programming 18-pin PIC devices; and 28/40-pin adapters are available from the manufacturer. An expansion header is provided for adapters and in-system programming of PICs with on-chip EEPROM.

The Model PIC-1 includes all accessories needed to do microcontroller programming. It is recommend for students, hobbyists, and novice programmers. It is supplied with a cable for interfacing to the personal computer's parallel port, a power supply, programming software for the computer, and a user's manual.

The PIC-1 is available as a kit or fully assembled and tested. The kit,



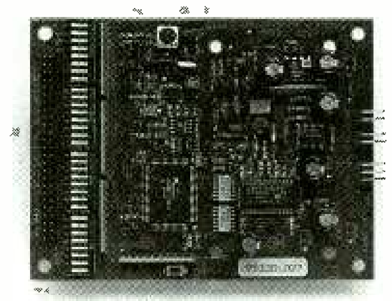
CIRCLE 21 ON FREE INFORMATION CARD

including a PC board and construction manual, is priced at $29.00 The assembled programmer is priced at $49.00.

ITU TECHNOLOGIES
3477 Westport Court
Cincinnati, OH 45248-3026

DIRECT DIGITAL SYNTHESIZER MODULE

THE MODEL DDS4M DIRECT digital synthesizer (DDS) module from Novatech Instruments generates a precise sinewave and an accurate TTL clock signal. It is packaged on a 3.5×4.5-inch circuit board. The output frequency is programmable from 1 Hz up to a maximum of 34 MHz in steps as small as 0.02 Hz.



CIRCLE 22 ON FREE INFORMATION CARD

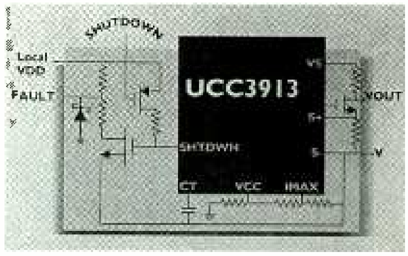
The typical phase noise for the module is −i90 dBc at 1-kHz offset from carrier. The desired frequency can be selected by setting a 31-bit binary number, either manually with DIP switches or remotely with HCMOS-compatible parallel input lines. The DDS4m contains a quartz crystal oscillator that provides stability of 10-ppm/year.

The DDS4m direct digital synthesizer module is priced at $395.00

NOVATECH INSTRUMENTS, INC.
1530 Eastlake Avenue East, No. 303
Seattle, WA 98102
Phone: 206-322-1562
Fax: 206-328-6904

NEGATIVE-VOLTAGE CIRCUIT BREAKERS

THE UCC3913 FAMILY OF BiCMOS electronic circuit breakers from Unitrode is intended for negative power supplies. The circuit breakers are intended for mainframe computer systems, telecommunications equipment, fault-tolerant and point-of-sale computers, banking ATMs, mass data storage equipment, and industrial-control systems.



CIRCLE 23 ON FREE INFORMATION CARD

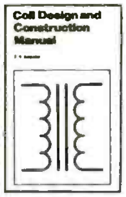
According to Unitrode, the electronic circuit breakers react faster and have more accurate thresholds than the large bus fuses it is designed to replace. Their protection levels exceed those of fuses. Under fault conditions, the UCC3913 devices quickly limit overcurrent, preventing damage to host circuitry. They open the circuit automatically and reset with a 2% duty cycle to limit power dissipation during extended-duration faults.

An automatic reset feature reduces field maintenance. The auto-reset feature also prevents overheating that could lead to circuit failure. The UCC3913 devices manage power by permitting full logic control of each module's power. Their programmable start delays are especially important in "hot-swap" situations such as when power supply modules are being replaced in fault-tolerant computer systems.

The electronic circuit breakers keep the power off, then "soft-start"

Hobbyist's Paperback Budget Books

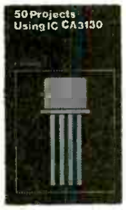
☐ **BP80/98—Popular Electronic Circuits-Books 1 and 2...$11.90.** Contains a wide range of circuits which are accompanied by text giving a brief Introduction, circuit description and special notes on construction and setting-up that may be necessary.



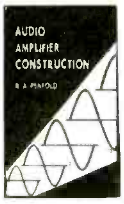
☐ **#160—Coil Design and Construction Manual...$5.95.** A complete book for the home builder on how to make RF, IF, audio and power chokes and transformers. Practically every possible type is discussed and calculations are explained in detail.

☐ **BP271—How to Expand, Modernize and Repair PC's and Compatibles...$7.75.** All the practical information you are likely to need to upgrade your PC and compatible. Also contains useful information and illustrations to help you with repairs.

☐ **BP276—Shortwave Superhet Receiver Construction...$6.95.** Provides construction details, including coil winding, of a number of advanced-design receivers which should have performance levels at least equal to commercial sets of similar complexity.



☐ **#223—50 Projects Using IC CA3130...$5.00.** One of the more practical and useful operational amplifiers (opamp), the CA3130 integrated circuit chip is the heart of several easy-to-assemble projects covered in the book. The projects are divided into five categories: audio projects, RF projects, test equipment, household projects and a catch-all miscellaneous group. Ideal for all skill levels.

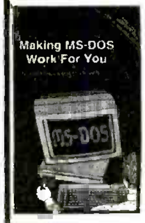


☐ **BP122—Audio Amplifier Construction...$5.75.** Practical designs are featured and include circuit diagram and description, Veroboard or printed-circuit board layout and construction notes. The text is divided into two parts. The first deals with many types of preamplifiers. The second covers power amplifiers from a simple low-power battery type to a 100-watt DC-coupled amplifier using four MOSFETs in the output stage.

☐ **BP107—30 Solderless Breadboard Projects-Book 1**...$5.95. Each project is designed to be built on a "Verobloc" breadboard and is presented with a brief circuit description, circuit diagram, component layout diagram and components list. Notes on construction and applications are provided. Wherever possible, the components are common to several projects to keep project costs down.

☐ **BP266—Electronic Modules and Systems for Beginners...$7.25.** Shows the reader how to build a number of simple analog and digital circuit modules, all suitable for battery operation, and all based on only 1 or 2 transistors or ICs.

☐ **BP329—Electronic Music Learning Projects...$6.25.** A beginner's book that will assist you in assembling such projects as the Elexylophone, Gildaphone, Melody Ranger, Cordmaker, Appealing Handbells, Electronic Sol-Fa, Tune-up Box and more.



☐ **BP319—Making MS-DOS Work for You—$6.50.** What you need to know first, comes first, however the text is written in a circular style so that the reader can start anywhere in the text. This book Is relevant to all versions of both MS-DOS and PC-DOS.

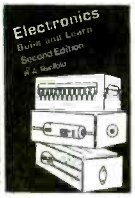
☐ **BP303—Understanding PC Software...$6.95.** Covers main types of PC software, giving details of typlcal uses, the basics of how they are used and their limitations. Each chapter covers popular software and programs of a similar type.

☐ **BP105 Aerial (Antenna) Projects...$5.50.** In this book the author has considered practical antenna designs, including active, loop and ferrite antennas which perform well and are relatively simple and inexpensive to build. The complex theory and mathematics of antenna design have been avoided. Also included are construction details of a number of antenna accessories including a pre-selector, attenuator and filters.

☐ **BP33—Electronic Calculator Users Handbook...$5.75.** The book eliminates the mysteries of the calculator and offers unique ideas for the simplest to most complex calculators. Covers the basic functions plus trigonometric, hyperbolic, logarithms, square roots and powers. Included are formulas and data for VAT, discounts, and mark up, currency conversion, interest, binary and octal numbers, and much more!

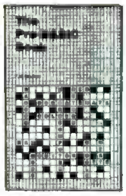
☐ **BP125—25 Simple Amateur Band Antennas...$5.50.** Plans to build antennas that are simple and inexpensive to construct and perform well. From the simple dipole to beam, triangle and even mini-rhombic types made from four TV masts and about 400 feet of wire. After the antenna discussion you will find a complete set of dimension tables that will help you "tune" an antenna on a particular frequency.

☐ **BP263—A Concise Introduction to dBASE...$6.95.** The most popular data-base program, dBASE, is difficult to master without help. This book helps you spend your time using dBase, not setting it up. A user's guide that covers all the basics up to dBase IV.



☐ **PCP104—Electronics—Build and Learn...** $9.95. Construction details are given to build a circuit demonstrator that is used throughout the book to introduce common electronic components and how these components are built up to useful circuits.

☐ **BP302—A Concise Users Guide to Lotus 1-2-3 Release 3.1...$6.25.** Written to help existing spreadsheet users upgrade to 1-2-3 Release 3.1, which has the ability to work 3-dimensionally with both multiple worksheets and files.



☐ **BP146—The Pre-BASIC Book...$6.95.** Another book on BASIC but with a difference. It concentrates on introducing technique by looking In depth at the most frequently used and more easily understood computer instructions.

Just What the Project Builder Is Looking For!

- ☐ **#160—Coil Design and Construction Manual $5.95**
- ☐ **#219—Solid State Novelty Projects $4.95**
- ☐ **#222—Solids State Shortwave Receivers for Beginners $5.50**
- ☐ **#223—50 Projects Using IC CA3130 .... $5.00**
- ☐ **#225—Practical Introduction to Digital ICs $5.25**
- ☐ **PCP111—Electronic Test Equipment Handbook $13.95**
- ☐ **1596T—24 Silicon-Controlled Rectifier Projects $9.95**
- ☐ **BP58—50 Circuits Using 7400 Series ICs $5.50**
- ☐ **BP69—Electronic Games $5.50**
- ☐ **BP71—Electronic House Projects $5.00**
- ☐ **BP84—Digital IC Projects $5.50**
- ☐ **BP93—Electronic Timer Projects $5.50**

ELECTRONIC TECHNOLOGY TODAY INC.
P.O. BOX 240, Massapequa, NY 11762-0240

Name ____________________

Address ____________________

City __________ State ________ Zip ________

PE5 Allow 6-8 weeks for delivery

SHIPPING CHARGES IN USA AND CANADA

$0.01 to $5.00	$2.00
$5.01 to $10.00	$3.00
$10.01 to 20.00	$4.00
$20.01 to 30.00	$5.00
$30.01 to 40.00	$6.00
$40.01 to 50.00	$7.00
$50.01 and above	$8.50

SORRY No orders accepted outside of USA & Canada

Number of books ordered ☐

Total price of merchandise .... $________
Shipping (see chart) .... $________
Subtotal .... $________
Sales Tax (NYS only) .... $________
Total Enclosed .... $________

All payments must be in U.S. funds!

the module in hot-swap applications. That controlled start prevents the module from excessively loading the bus as it powers up, preventing power and data glitches. The UCC3913 family is offered in eight-pin SOIC and DIP packages in three temperature ranges.

The UCC3913 is priced at $1.40 in 1000-piece quantities.EP

UNITRODE CORPORATION
7 Continental Blvd.
Merrimack, NH 03056-0399
Phone: 603-424-2410
Fax: 603-424-3460

INSULATED-GATE BIPOLAR TRANSISTORS

A NEW SERIES OF 600- AND 1200-volt insulated-gate bipolar transistors (IGBTs) for high-voltage applications has been announced by Motorola. The high-voltage IGBTs are optimized to operate efficiently from full-wave rectified 230- or 460-volt AC with minimum conduction and turn-off losses. The IGBTs will withstand a short circuit for a minimum duration of 10 microseconds.

The IGBTs are suitable as inverters for motor drives. They perform the power-switching function that converts rectified DC line voltage to pulses that permit the control of various kinds of motors. IGBTs can also function in uninterruptible power supplies and conventional switching power supplies operating directly off line at moderate frequencies.

CIRCLE 24 ON FREE INFORMATION CARD

For applications where the stored energy of an inductive load is returned back to the power source through a diode, IGBTs and fast-recovery diodes have been co-packaged. The fast-recovery diode is connected anti-parallel to the IGBT to allow reverse conduction. That permits the return of energy stored in an inductive load to the power source in bridge circuits.

The reverse characteristics of the anti-parallel diodes have been designed to achieve "soft recovery" to minimize transients and EMI. The co-packaged diode minimizes transient voltages that are generated by stray circuit inductance. For applications where the anti-parallel diode is not needed, IGBTs without the diode are available at a slightly lower price.

The high-voltage IGBTs are priced in the range of $4.50 to $6.00 each in 100 to 999 quantity.

MOTOROLA, INC.
MD Z-301
5005 East McDowell Road
Phoenix, AZ 85018
Phone: 602-244-4911
Fax: 602-944-4015

PORTABLE PROTOCOL ANALYZER

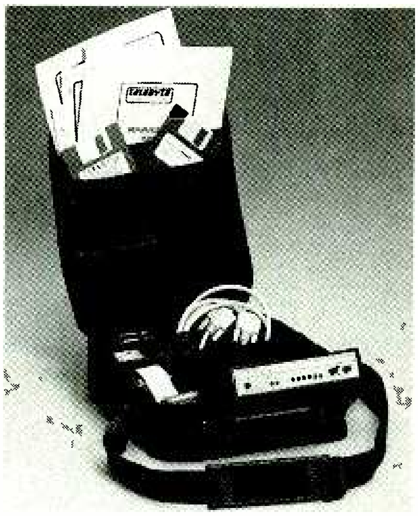
THE MODEL 904 PC COMscope from Telebyte Technology is a portable protocol analyzer that interfaces with a host computer to access its resources. It can function as a high-performance communications data line monitor, emulator, and bit error rate tester (BERT).

The Model 904 can be connected to any personal computer through any available serial port. The analyzer uses the serial port in a way that provides a high-speed data channel along with a serial control channel. The analyzer's embedded coprocessor permits the monitoring and emulation of data lines rated to 64 kilobytes per second on a full-duplex basis.

The Model 904 supports most WAN protocols, including asynchronous and synchronous protocols such as BiSync and IPARS, and bit-oriented protocols such as HDLC, SNA, and X.25. The protocol analyzer captures all parameters of the communications link: data, control leads, time stamps, and error conditions.

That information permits extensive post-capture analysis of data, even at a different location. Any combination of data line events can be searched or trapped. This allows the review of live data or search through captured data. Captured data can be saved as a DOS file on disk for later viewing, analysis, or printing. The included protocol emulator program interface allows the use of Telebyte off-the-shelf test analysis programs or the user can write his own custom programs.

In addition to monitoring, the Model 904 has emulation capabilities. A menu-driven program on the PC allows the selection of many combinations of communications options to emulate X.25, HDLC, Async, and BiSync. A built-in BERT tester offers a choice of test patterns and modes of operation. The analyzer is supplied with standard RS-232C monitoring software and two additional programs for X.25 and HDLC.



CIRCLE 26 ON FREE INFORMATION CARD

For portable field operation the Model 904 will run for 2 hours on a standard 9-volt battery. Since problems don't always happen in the same place, being able to hook up to the nearest PC without having to open the PC's case is convenient. For the lab, the Model 904 includes an AC adaptor for continuous operation.

The Model 904, supplied in a carrying case with cables, software, and manuals, is priced at $499.00

TELEBYTE TECHNOLOGY, INC.
270 Pulaski Road
Greenlawn, NY 11740
Phone: 1-800-835-3298
Fax: 516-385-8184 or 516-385-7060 for complete data sheet
E-mail: Sales@telebyteUSA.com EN

Enter A World Of Excitement with a Subscription to

Popular Electronics®

Get the latest electronic technology and information monthly!

Now you can subscribe to the magazine that plugs you into the exciting world of electronics. With every issue of **Popular Electronics** you'll find a wide variety of electronics projects to build and enjoy, and feature articles that inform and entertain.

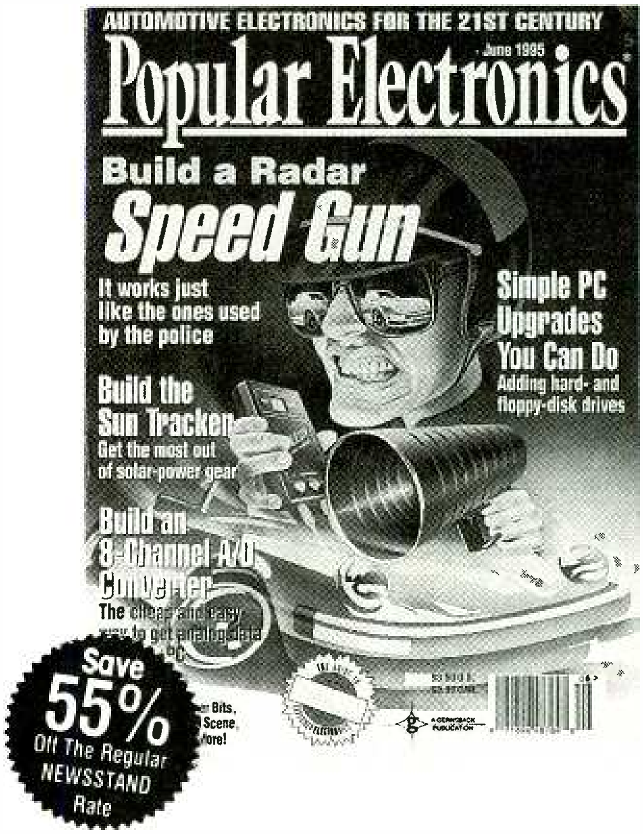
Popular Electronics brings you feature articles on technology, computers, test gear, and more—all designed to keep you tuned into the latest developments in electronics. So if you love to build fascinating projects, just fill out the subscription form below to subscribe to Popular Electronics... It's a power-house of fun for the electronics enthusiast.

EXCITING MONTHLY FEATURES LIKE:

- ❑ **CONSTRUCTION**—Exciting projects that range from simple radios to working robots
- ❑ **FEATURES**—Learn about new technology, see how to troubleshoot all types of electronics gear, refresh your knowledge of basic electronics theory, see how components work and how to use them in your own designs, and much more
- ❑ **PRODUCT REVIEWS**—Get in depth, hands-on reviews of all types of hobby gear, and learn about the latest and the greatest in consumer electronics in our no-holds-barred Gizmo section
- ❑ **SPECIAL COLUMNS**—Think Tank, Circuit Circus, Computer Bits, DX Listening, Antique Radio, Scanner Scene, Amateur Radio, Multimedia Watch, and more

PLUS: ALL OUR GREAT DEPARTMENTS!

You'll get 12 exciting and informative issues of Popular Electronics for only $18.95. That's a savings of $23.05 off the regular single copy price. Subscribe to Popular Electronics today! Just fill out the subscription order form below.



FOR FASTER SERVICE CALL TODAY

1-800-827-0383

(7:30AM–8:30PM) EASTERN STANDARD TIME

AENM5

Popular Electronics SUBSCRIPTION ORDER FORM

P.O. Box 338, Mt. Morris IL. 61054

YES! I want to subscribe to Popular Electronics for 1 Full year (12 Issues) for only $18.95. That's a savings of $23.05 off the newstand price.
(Basic Subscription Rate—1 yr/$21.95)

❑ Payment Enclosed ❑ Bill me later

Please charge my: ❑ Visa ❑ Mastercard

Acct. # | | | | | | | | | | | | | | |

Signature Exp. Date

PLEASE PRINT BELOW:

NAME

ADDRESS

CITY STATE ZIP

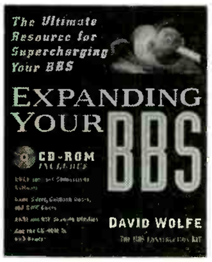
Allow 6 to 8 weeks for delivery of first issue. U.S. Funds only.
In Canada add $6.68 Postage (Includes G.S.T.).
All Other Foreign add $7.50 Postage.

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Expanding Your BBS

by David Wolfe.
John Wiley & Sons, Inc.
605 Third Avenue, New York, NY 10158-0012
Phone: 1-800-CALL-WILEY
$34.95, including CD-ROM



CIRCLE 337 ON FREE INFORMATION CARD

This book and an included CD-ROM gives bulletin board system (BBS) administrators all the information they need to maintain an active, attractive bulletin board. There are an estimated 10-million BBS users around the world whose interests are as diverse as scuba diving to gourmet cooking.

Wolfe's book offers the software and expert advice needed to add the most wanted features to your BBS. For example, Wolfe explains how to add UUCP Internet connectivity, fax capability, and QWK networking and mail. Wolfe also explains how to add improved graphics and speed, and multimedia applications. The topics covered include the integration of high-speed modems, digiboards, intelligent I/O boards, and telephone caller ID.

The companion BBS-ready CD-ROM contains game doors such as "Tradewars 2002, Baron Realms Elite, Land of Devastation, Battle Grid, Murder Motel," and "Yankee Trader." Call back doors increase BBS security and automate the registration process, while Waffle and Waffle utilities are for Internet UUCP connectivity.

The CD-ROM also includes upload checkers that scan for viruses, purge old files, insert BBS ads, and check file integrity. Batch file power is increased with four DOS utilities. ANSI and RIP screen-drawing utilities include "The Draw, Dead Paint," and "Tombstone Artist." Other BBS utilities included are Fossil drivers, external protocols, QWK mail doors, hard-to-find compression utilities, and port and modem diagnostics.

Zworykin, Pioneer of Television

by Albert Abramson.
University of Illinois Press
1325 South Oak Street
Champaign, IL 61820
$36.95

CIRCLE 338 ON FREE INFORMATION CARD

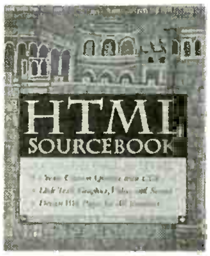
Vladimir Kosma Zworykin, the Russian-born American scientist, made a significant contribution to the electronically-scanned television system that we know today with his invention of the iconoscope, the first practical television camera tube. To write this book, Abramson researched Zworykin's original patents and both his published and unpublished notebooks and papers, and he interviewed many television pioneers, including Zworykin himself.

This biography reviews the life of this television pioneer and scientist, including its often dramatic periods. It covers Zworykon's early years in Russia as well as his career at the RCA laboratories. He was invited there by RCA founder David Sarnoff. More than 50 photographs in the book highlight Zworykin's work.

While Abramson acknowledges the important contributions made by other TV experimenters and scientists including Korn, Baird, and Zworykin's chief rival, Philo T. Farnsworth, he argues that Zworykin's inventions really made modern electronically scanned television possible. He sees Farnsworth's invention of the image orthicon as essentially an improvement on Zworykin's iconoscope.

HTML Sourcebook

by Ian S. Graham.
John Wiley & Sons, Inc.
605 Third Avenue, New York, NY 10158-0012;
Phone: 1-800-CALL-WILEY
$29.95



CIRCLE 339 ON FREE INFORMATION CARD

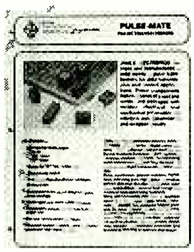
This book is a complete guide to composing and distributing documents on the World Wide Web. It provides both the code and the real-world examples of well-designed hypertext documents that will teach you how to form a Web page. If you want to write documents for publication in the World Wide Web, you will want to use the Hyper Text Markup Language, or HTML.

This language allows the reader to click on a word from a body of text and jump, or "hyperlink," to other databases, text files, and Web resources. With the introduction of WWW to the Internet, the need for HTML has expanded dramatically. Mosaic or other browsing software might provide an easy way to "surf the net," but the author believes that you must master the right tools to prepare well-designed, functional Web pages.

From a brief tutorial on the basics of HTML to actual programming code, Graham explains all of the HTML commands, CGI tools, and Uniform Resource Locator syntax. He also explains how to translate documents from word-processing programs into hypertext and format the HTML document from Mosaic, Netscape, Lynx, and other WWW browsers. The author explains how to create multimedia documents by including graphics, video, and sound; and how to choose hypertext servers for computers with Unix, Macintosh, and DOS or Windows operating systems

Pulse Transformer Literature

James Electronics Inc.
4050 North Rockwell Street
Chicago, IL 60618
Phone: 312-463-6500
Fax: 312-463-1504
free.



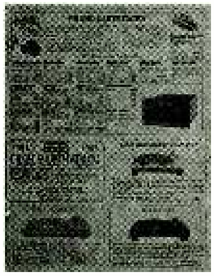
CIRCLE 340 ON FREE INFORMATION CARD

This mini catalog from James Electronics covers the manufacturer's Pulse-Mate pulse transformers for data transmission and control applications. It includes data sheets for the Pulse-Mate transformers, a line that includes leaded and surface-mount single and multiple transformers. Each data sheet gives complete electrical and mechanical specifications for the many models available.

The Pulse-Mate line of transformers is expected to find applications in the T' series of digital carrier systems, systems based on the DS data standard developed by the Danish Standards Institution, CEPT a European standard; and the ISDN standard. The catalog defines typical waveform characteristics, and explains how the matching pulse transformer must interact for optimum system performance in the system under design.

1995 Great Sound Catalog

K-A-B Electro-Acoustics
P. O. Box 2922
Plainfield, NJ 07062-0922
Phone: 908-754-1479
free



CIRCLE 341 ON FREE INFORMATION CARD

This brochure covers the high-fidelity equipment available from K-A-B Electro-Acoustics, emphasizing vinyl records and related playback equipment. The company offers are a wide selection of phonograph cartridges, books on earlier generation audio equipment, loudspeakers, phonographs, record cleaners, and high fidelity accessories.

Among the products offered are the K-A-B SpeedStrobe, for easy setting and verification of turntable speed, the K-A-B Souvenir VSP Vintage Signal Processor, which restores the sound of vintage 78-rpm shellac and 33$^{1}/_{3}$-rpm vinyl monophonic-LP records, and the Stanton 500 cartridge and custom styli.

Consumer Electronics Replacement Parts Source Book 1995

The EIA/Consumer Electronics Group
2500 Wilson Blvd.
Arlington, VA 22201
$12.00

CIRCLE 342 ON FREE INFORMATION CARD

This is the 1995 edition of an annually updated replacement parts catalog for service technicians seeking replacement parts for consumer-electronics products. Prepared by the Consumer Electronics Group of the Electronic Industries Association, the book lists parts information for of its member companies.

The source book is arranged alphabetically with entries from more than 60 manufacturers, from Adcom to Zenith. In addition information from five distributors is included. The addresses and phone numbers are given for each manufacturer and distributor along with information about all of the items available from them, in replacement parts technical support, customer service, and service manuals.

Active Filter Cookbook

by Don Lancaster.
Synergetics Press
3860 West First Street
Box 809, Thatcher, AZ 85552
$28.50

CIRCLE 343 ON FREE INFORMATION CARD

This 17th edition of the *Active Filter Cookbook* written by Don Lancaster, the "Hardware Hacker" columnist for *Electronics Now*. This new updated book provides information on how to build active low-pass, bandpass, and high-pass filters. It also includes design charts with explanations of the mathematics on which those designs are based. The book emphasizes practical knowledge rather than theory, making it particularly easy to apply to your needs.

Lancaster begins with a discussion of inductorless active-filters and operational amplifiers. He then explains the characteristics of the five basic types of first- and second-order filters, and goes on to explain their response curves.

Three chapters include practical filter circuits, covering four different styles of low-pass, bandpass, and high-pass circuits. Switching, tuning, and voltage control are discussed, and current applications on active filters are included.

RETAILERS THAT SELL OUR MAGAZINE MONTHLY

Alaska

Frigid North Co.
1207 W. 36th Avenue
Anchorage, AK 99503

Alabama

Radio Distribuiting Supply
121 East Broad Street
Gadsden, AL 35903

Arizona

Dalis Electronics
2829 E. McDowell Road
Phoenix, AZ 85008

California

California Electronics
221 N. Johnson Ave.
El Cajon, CA 90202

Signal Electronics
22307 Ocean Avenue
Torrance, CA 90505

Ford Electronics
8431 Commonwealth Avenue
Buena Park, CA 90621

All Electronics
14928 Oxnard Street
Van Nuys, CA 91411

Gateway Electronics of CA
9222 Chesapeake Drive
San Diego, CA 92123

Mac's Electronics
191 South "E" Street
San Bernardino, CA 92401

Electronics Warehouse
2691 Main Street
Riverside, CA 92501

Orvac Electronics
1645 E Orangethorpe Ave.
Fullerton, CA 92631

Sav-On Electronics
13225 Harbor Blvd.
Garden Grove, CA 92643

Marvac Dow Electronics
980 S. A Street
Oxnard, CA 93030

Kandarian Electronics
1101 19th Street
Bakersfield, CA 93301

Whitcomm Electronics
105 W. Dakota #106
Clovia, CA 93612

Marvac Dow Electronics
265-B Reservation Road
Marina, CA 93933

Minuteman Electronics
37111 Post St., Suite 1
Fremont, CA 94536

HCS Electronics
6819 S. Redwood Drive
Cotati, CA 94931

Halted Specialties Co.
3500 Ryder Street
Santa Clara, CA 95051

JDR Micro Devices
2233 Branham Lane
San Jose, CA 95124

Metro Electronics
1831 J Street
Sacramento, CA 95814

The Radio Place, Inc.
5675-A Power Inn Road
Sacramento, CA 95824

HSC Electronics
4837 Amber Lane
Sacramento, CA 95841

Colorado

Gateway Electronics of CO
2525 Federal Blvd.
Denver, CO 80211

Centennial Electronics
2324 E. Bijou
Colorado Sps., CO 80909

Connecticut

Signal Electronics Supply
589 New Park Avenue
W. Hartford, CT 06110

Cables & Connectors
2198 Berlin Turnpike
Newington, CT 06111

Electronic Service Prod.
437 Washington Avenue
North Haven, CT 06473

Georgia

Norman's Electronics, Inc.
3653 Clairmont Road
Chamblee, GA 30341

Idaho

The Current Source
5159 Glenwood
Boise, ID 83714

Illinois

Tri State Elex
200 W. Northwest Hwy.
Mt. Prospect, IL 60056

Maryland

Mark Elec. Supply Inc.
5015 Herzel Place
Beltsville, MD 20705

Massachusetts

U-Do-It Electronics
40 Franklin Street
Needham, MA 02194

Michigan

Purchase Radio Supply
327 East Hoover Avenue
Ann Arbor, MI 48104

Norwest Electronics
43087 Plymouth Road
Livonia, MI 48150

The Elec. Connection
37387 Ford Road
Westland, MI 48185

Elec. Parts Specialists
711 Kelso Street
Flint, MI 48506

Professional Data Corp.
1332 US Highway 41 West
Ishpeming, MI 49849

Minnesota

Acme Electronics
224 Washington Avenue N.
Minneapolis, MN 55401

Missouri

Gateway Electronics Of MO
8123-25 Page Blvd.
St. Louis, MO 63130

New Jersey

Lashen Electronics Inc.
21 Broadway
Denville, NJ 07834

New York

Sylvan Wellington Co.
269 Canal Street
New York, NY 10013

Unicorn Electronics
Valley Plaza
Johnson City, NY 13790

Ohio

Philcap Electronic Suppliers
275 E. Market Street
Akron, OH 44308

Oregon

Norvac Electronics
7940 SW Nimbus Avenue
Beaverton, OR 97005

Portland Radio Supply
234 S.E. Grand Avenue
Portland, OR 97214

Texas

Tanner Electronics
1301 W. Beltine
Carrollton, TX 75006

Mouser Electronics
2401 Hwy. 287 N
Mansfield, TX 76063

Electronic Parts Outlet
17318 Highway 3
Webster, TX 77598

Virginia

Elec. Equipment Bank
323 Mill Street, N.E.
Vienna, VA 22180

Washington

Amateur Radio Supply Co.
5963 Corson Ave., Ste 140
Seattle, WA 98108

Wyoming

Chris Supply
2007 S. Douglas Hwy., Ste. C
Gillette, WY 82716

If you'd like to sell our magazine in your store, please circle 210 on Free Information Card.

JACOB'S LADDER

Build this exciting Jacobs's Ladder and watch electric arcs ascend the ladder and evaporate in space. It works from a clever 12,000-volt power supply.

ROBERT IANNINI

PEOPLE HAVE LONG BEEN FASCINATED BY ELECTRIC arcs—and perhaps put off by them. They show up as lightning, Tesla coil discharges, and long sparks that sting as you reach for the doorknob on a cold, dry, winter day. This Jacob's Ladder project turns electric arcs into a dramatic but harmless conversation piece.

If you build this project, you'll learn how a simple power supply operating from the 120-volt AC line can produce 12,000 volts. In addition to powering the Jacob's Ladder, the supply can power plasma displays, and it has even powered a light-duty, bench-type spot welder.

Perhaps you would like to know the origin of the term Jacob's Ladder. The Bible tells the story of Jacob's dream about a ladder that extended from earth to heaven. Jacob, the son of Isaac, was the father of the founders of the twelve tribes of Israel. Among sailors, however, a Jacob's Ladder is a long rope ladder that is hung over the side of a ship so the harbor pilot can climb aboard.

Climbing arcs

The power supply for this project forms electric arcs across two diverging stainless steel strips mounted in a protective case. The 16-inch long strips are mounted on insulating Teflon blocks to eliminate possible leakage. The stainless steel strips are angled with respect to each other so that the arcs form at the edges of the strips that are separated by about 3⁄16 inch at their bases, but the strips diverge to a distance of about 2 inches at their upper ends.

The strips form a gap in the secondary winding of the output transformer. After power is turned on, the air dielectric breaks down due to the "almost" short-circuit state across the lower end of the gap, and an electric arc is formed.

As the arc heats up, thermal convection causes the arc to rise up the vee-shaped "ladder." As the plasma arc ascends the ladder, its length increases, thereby increasing the arc's dynamic resistance and thus increasing power consumption and heat. This causes the arc to stretch as it rises and extinguish when it reaches the top of the ladder. When the arc extinguishes, the transformer output momentarily exists in an open circuit state until the breakdown of the air di-electric produces another arc at the base of the ladder and the sequence repeats.

The power supply for the Jacob's Ladder contains circuitry to protect persons and property from electrical shock or fire hazard if the ladder strips should be shorted accidentally when the ladder is operating.

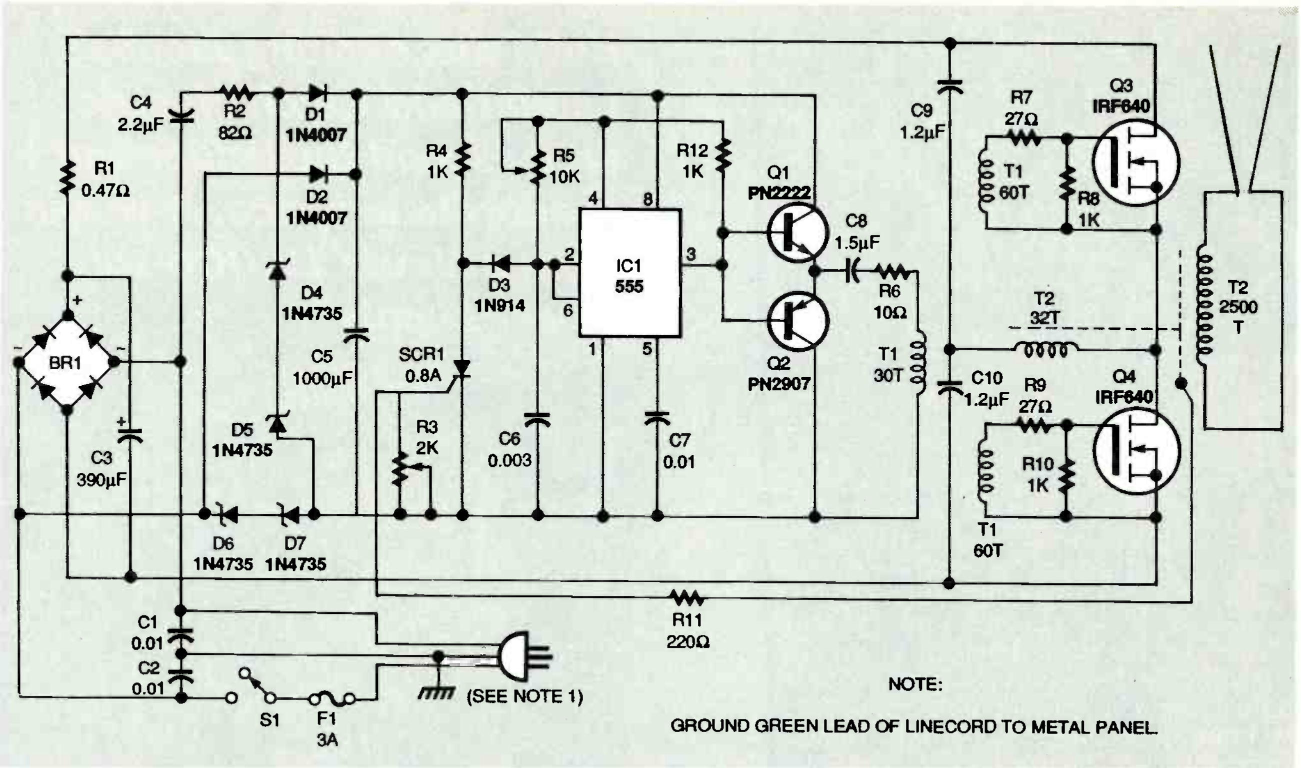


FIG. 1—SCHEMATIC FOR HIGH-VOLAGE power supply. All components except transformers are standard.

12,000 volt supply

The operation of the Jacobs's Ladder depends on the current-limited power supply that delivers 12,000 volts at 40 milliamperes from the 120-volt AC line. Refer to the schematic Fig. 1. The full-wave bridge BR1 rectifies the 120-volt AC line input, and resistor R1 limits the DC charging current of capacitor C3 to a safe value. The Jacob's Ladder project is powered by 150 to 160 volts DC derived from the 120-volt AC line.

The drive circuit power is obtained by dropping the 120-volt AC line through capacitor C4 and current limiting resistor R2. Diodes D1 and D2 alternately conduct only in the positive direction, and their DC output pulses are integrated by filter capacitor C5. Zener diodes D4 and D5 regulate these DC pulses to peak values of 15 volts DC.

Capacitor C4 and resistor R2 present a complex impedance so that most of the AC line voltage is dropped across the reactance. This configuration eliminates the waste of real power and heat losses that would have occurred by dropping the line voltage with only a resistor.

The 555 timer IC1 is configured as a square-wave oscillator. The output frequency of its square waves is determined by the setting of trimmer potentiometer R5 and capacitor C6. The frequency is about 25 kHz for the values of R5 and C6 shown in Fig. 1. Resistor R12 limits the high-frequency setting to an acceptable value. Potentiometer R5 can be used to adjust the circuit's power output. Increasing the frequency reduces the circuit's output by increasing the inductive reactance of the transformer leakage inductance.

The output of IC1 on OUTPUT pin 3 appears at the bases of the current "source," NPN transistor Q1 and "sink" PNP transistor Q2. The emitters of this transistor pair are AC-coupled through capacitor C8 and resistor R6 to drive the primary of driver-isolation transformer T1. This drive prevents DC from flowing through the primary. Resistor R6 dampens any overshoot that results from transformer T1's leakage inductance.

This scheme provides a satisfactory source for driving the high gate-to-source capacitance of the two NPN switching power MOSFETs, Q3 and Q4. Transformer T1 is wound on a high-permeability core with as few turns as possible to eliminate leakage inductance.

The gate circuits of MOSFETs Q3 and Q4 contain 27-ohm resistors (R7 and R9) to slow their switching times. This eliminates possible parasitic oscillations that could occur if the MOSFETs were switched at their speed limit.

Output transformer T2 has a half-bridge configuration so that MOSFETs Q3 and Q4 are only subjected to half of the rectified DC line voltage, or about 80 volts. Assuming that the voltage midway between capacitors C9 and C10 is about half of 160 volts (or about 80 volts), when Q3 turns on, the charge on C9 causes current to flow through T2 in one direction.

When Q3 turns off, Q4 turns on, dumping the charge on C10 through T2 in the opposite direction.. This drives the magnetic flux of T2 evenly and symmetrically, making full use of T2's core capability. The primary of output transformer T2 contains 32 turns, but its sec-

Continued on page 56

Regulated Power *for* Electrochemistry

Build this regulated electrochemistry power supply and learn about electrolysis and electroplating. Then plate small objects to protect them and improve their appearance.

EDWARD BARROW

THE REGULATED POWER SUPPLY CIRcuit described in this article will permit you to experiment with electrolysis and electroplating. It is intended for the experimenter or hobbyist who wants to perform experiments in electrochemistry and electroplate small objects—tools, rings, spoons, or miscellaneous hardware items.

This power supply will also be especially valuable for science and chemistry teachers or laboratory assistants in high schools, technical schools ,and colleges. It is a versatile power supply that can be controlled to adapt it to various demonstrations or experiments in chemistry, physics, biology, or general science.

This power supply permits better control of its output voltage than a typical linear power supply, and it can function either as a constant-voltage or constant-current source. Both functions can be set by a potentiometer with a voltage range of 0 to 10 volts and a current range of 0 to 1.0 amperes. Figure 1-a is a block diagram of the basic regulator circuit.

A constant-current mode can be set to control the current for electroplating. This control is critical for achieving uniform deposition of metal. This mode also permits the user to compensate for electrolyte loss that occurs during electroplating. Figure 1-b is the block diagram for the measurement circuit for the power supply. It monitors the output allowing either the voltage or current value to be read on a two-digit LED digital display.

This display is especially useful in electroplating because the voltage must be monitored continuously. Applied voltage determines the reactions that will take place. If the voltage is too high, the quality of the plating will suffer.

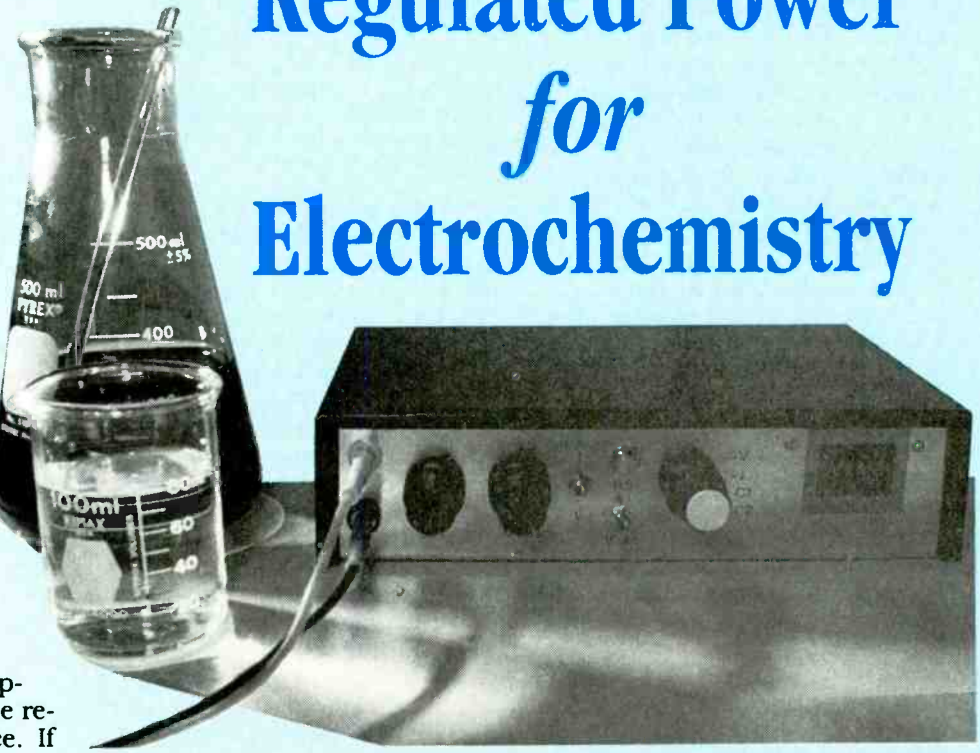
The digital display can also record the total amount of charge passed from the output. In electrochemistry, this quantity is directly related to the extent of ionization that has occurred within the electrolyte. In electroplating, the thickness of the plating deposited is directly proportional to the charge in coulombs passed per second.

Electrochemical theory

Before building this power supply, you might want to review the fundamentals of electrochemistry. This subject is covered in most introductory high school chemistry text and college level inorganic or general chemistry texts. There are also self-teaching texts in general chemistry keyed to do-it-yourself experimentation available.

Even if you have never taken a formal course of instruction in general chemistry, you can learn the fundamentals of electrolysis and electroplating by studying one or more of the available texts. Some of the important terms in electrochemistry that you should know are defined in the box. *Common Electrochemical Terms Defined*.

In electrochemistry, reactions involve only electrons (hole motion is not discussed). Elements bond either by sharing (*covalent bonding*) or transferring electrons from one another (*ionic bonding*). Electrochemistry is concerned only with ionic bonding. It is possible to reverse



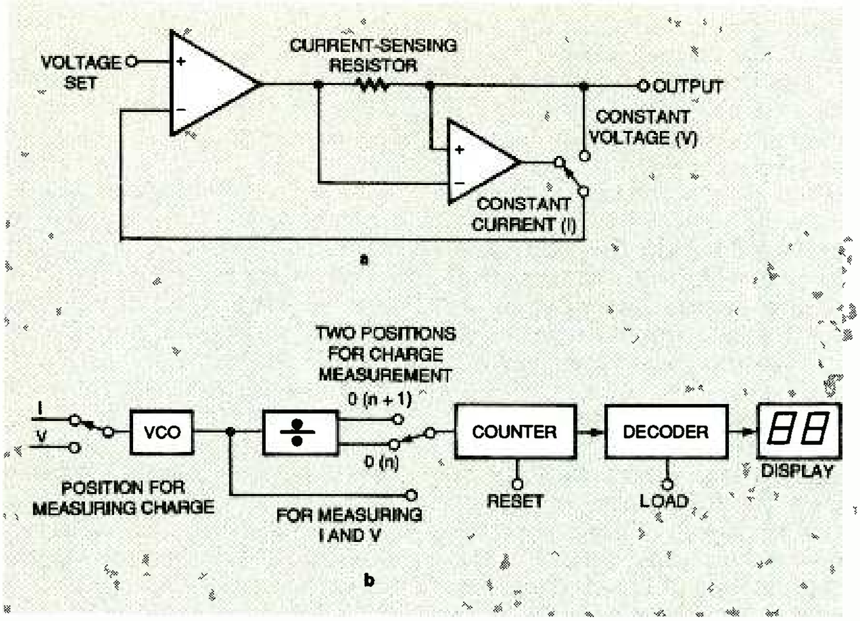


FIG. 1—BLOCK DIAGRAM OF REGULATED POWER SUPPLY CIRCUIT: Basic regulator circuit (a), and measurement circuit (b). Current and voltage or charge can be measured. Values can be read on the LED digital display.

the electron transfer process with current.

Electrolysis explained

Nearly 200 years ago it was found that water breaks down into hydrogen and oxygen when an electric current is passed through it. This was discovered after the Italian scientist, Alessandro Volta, made the first electric battery capable of producing continuous current. When wires were connected to both terminals of a battery and their ends were dipped into a tank of water to act as electrodes, it was found that gas bubbles formed in the water at each electrode.

When the gas was collected, it was found that hydrogen gas (H_2) was given off at the negative electrode and oxygen gas (O_2) was given off at the positive electrode. The volume of hydrogen collected was twice the volume of oxygen in the same time the apparatus was operating. It was then discovered that some of water had been decomposed into its elements. This process was called *electrolysis*.

The formula for electrolysis of water is:

$2H_2O \rightarrow H_2 + O_2$

Figure 2 shows a glass Hoffman laboratory apparatus organized for the electrolysis of

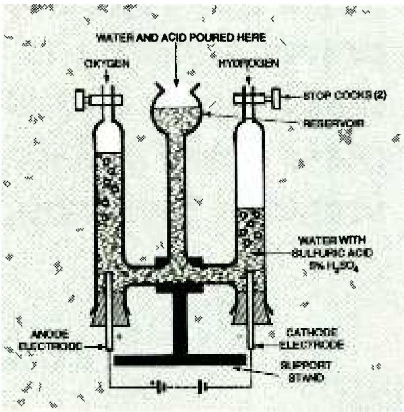


FIG. 2—ELECTROLYSIS OF WATER yields hydrogen and oxygen gas as byproducts. Acid additive increases the conductivity of water.

water. It is necessary to add 1 part in 20 of sulfuric acid (H_2SO_4) to increase the conductivity of the water. While this experiment can be done with separate small bottles or test tubes, the stop cocks at the top of each column of the Hoffman apparatus permit the gases to be bled off conveniently and ignited by a burning splint to identify them.

Electroplating.

Electroplating is the process of causing electric current to deposit a layer of metal such as copper on an object to be plated. Figure 4 shows the apparatus for electroplating. The plating solution is a salt of the metal. In Fig. 4, the electrolyte is a solution of copper sulfate.

A bar or strip of the metal is connected as the anode (positive electrode) to provide positive ions for electroplating. The object to be plated is connected as the cathode (negative electrode) and receives the positive ions that it reduces to a metallic layer of electroplate.

Regulated power supply

Figure 5 is the schematic for the regulated power supply. Its output current is provided by a voltage regulator consisting of operational amplifier IC5-a and transistors Q1 and Q2. The cir-

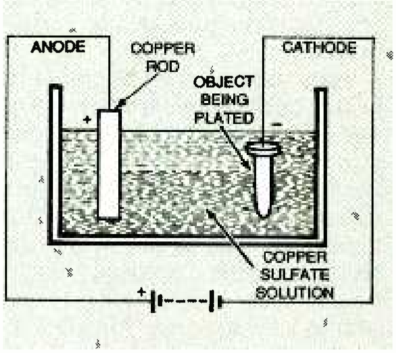


FIG. 3—APPARATUS FOR ELECTROPLATING: The copper strip is the anode and the object to be plated with copper is the cathode.

cuit has two modes of operation: constant-current and constant-voltage. In the constant-voltage mode, a variable reference voltage is generated across potentiometer R34. The voltage is fed to operational amplifier IC5-a, which functions as a buffer. This operational amplifier also serves as a feedback device to monitor the output voltage.

Operational amplifier IC5-a has an inverting input, and its output voltage is altered to match this input with the reference voltage. IC5-a's output is sent to transistor Q1 configured as an emitter follower. This circuit buffers the output, producing a lower impedance version of it.

The output of Q1 is fed to power transistor Q2 which

Continued on page 64

Tektronix Helps You Build a Better Benchtop One Great Instrument at a Time

Look for the entry form in a future issue.

A MODEL OF EXCELLENCE

NUMBER THREE IN A SERIES

Collect all four punch-out models, then enter Tek's drawing to win a real Model of Excellence.

Tektronix offers a full line of bench instruments:

- oscilloscopes
- power supplies
- function generators
- digital multimeters
- universal counters
- complete line of accessories

Contact your Tektronix Authorized Distributor for details, or call **1-800-479-4490, Action Code 302** and we'll connect you.

Tektronix

Center Your Bench on Legendary Performance

with Affordable, Excellent Scopes from Tektronix

Power, reliability, ease of use — the hallmarks of Tektronix laboratory scopes — are alive and well in our portable, benchtop oscilloscopes.

The TAS 220 and TAS 250 analog oscilloscopes are affordable cursor-readout scopes for the customer who values low cost and ease of use, and who demands the quality and safety of a Tektronix instrument.

Both the TAS 220 and the TAS 250 are complete, 2-channel, 1 mV/div, single time base, analog oscilloscopes whose feature set will surprise you. Channel 1 output is provided for ancillary instruments such as frequency counters, chop/alt mode is automatically set, and on-screen cursors display ΔT, $1/\Delta t$, and ΔV. Triggering is simplified by inclusion of both a set to 50% auto trigger, and a TV trigger that automatically selects TV-line/TV-field. The TAS 220 has 20 MHz bandwidth, and the TAS 250 has 50 MHz bandwidth.

Benchtop Scope Solutions

TAS 200 Series	TAS 400 Series	TDS 300 Series	TDS 400A Series
■ Analog	■ Analog	■ Digital Real-Time	■ Advanced digital signal processing
■ 20–50 MHz	■ 100–200 MHz	■ 50–200 MHz	■ 200–400 MHz
■ 2 Channels	■ 2–4 Channels	■ 2 Channels	■ 2–4 Channels
■ Single Time Base	■ Dual Time Base	■ Dual Time Base	■ Triggered delayed sweep
■ Fast updating analog CRT display	■ Fast updating analog CRT display	■ Single-event waveform up to fastest sweep speed	■ Record length up to 120K
■ CRT readout and cursors	■ CRT readout and cursors	■ 21 automatic measurements	■ 25 automatic measurements
	■ Auto Setup/Recall	■ Auto Setup/Recall	■ 12-bit Hi-Res mode
		■ Selectable pre-trigger	■ Selectable pre-trigger

The TAS 200 Series is safety certified, as are all Tektronix oscilloscopes. And, like the popular TAS 400 Series, the TAS 200 Series uses a modified "TDS-look-and-feel" user interface.

Discover Tek's affordable, excellent scopes and the chance to win a real Model of Excellence

Collect all four punch-out models. Line 'em up on your bench and imagine their problem-solving impact. Then enter to win our Models of Excellence drawing, and you could turn one of those models into the real thing!

Contact your Tektronix Authorized Distributor.
Your Tektronix Authorized Distributor can tell you more about Tek's low cost, high performance benchtop oscilloscopes, including the TAS 200 Series of analog scopes.

Not sure who to call?
Dial 1-800-479-4490, Action Code 302 and we'll make the connection.

Drawing good in U.S. only. Void where prohibited. Drawing to be held March 1, 1996.

Tektronix

VERSATILE POWER SUPPLY

Build this bench power supply that offers five different output voltages.

CARL J. BERGQUIST

THE VERSATILE POWER SUPPLY IS one of the most basic but overlooked items of test bench equipment. Good commercial bench-type power supplies are expensive, and they might not have some feature you want. The best solution is to build your own supply that can provide the voltages, currents, and features you want.

Circuits such as operational amplifiers and analog to digital converters (A/D) converters require both a positive and negative voltage, so a supply with a dual-polarity output is essential. A +12-volt DC source is necessary for testing car audio equipment and CB radios. A display section that will indicate the active voltages and the exact output voltage is also essential for your convenience.

The prototype power supply described in this article fills those needs. It includes both positive and negative variable power sources that produce between 1.2 and 28 volts at about 1 ampere. A separate ±5 volt source powers the A/D voltage meter, and also provides a second dual-output voltage. A third section provides 12 volts at 1.5 amperes, maximum.

LEDs indicate the status of the five available outputs, and a digital display provides a digital readout of either voltage or current. The prototype has banana jacks as output connections, but binding posts or multi connectors can be substituted. The switches can be either pushbutton, toggle, or slide; it's really just a matter of your personal preference.

Circuit operation

Figure 1 is the main schematic. All five power supply sections conform to standard design practice. The AC voltage from transformer T1 is rectified by bridges BR1, BR2, and BR3, and filtered by capacitors C1, C2, C5, C6, and C9. Voltage regulators IC1 to IC5 reduce the voltage to the desired fixed or variable levels.

The LM317 regulator, IC1, provides a positive variable output from 1.2 to 28 volts DC, while an LM337, IC2, provides a negative variable output with the same range. The LM7805 regulator, IC3, supplies a fixed +5 volts, and the LM7905, IC4, supplies a fixed −5 volts. The LM7812 regulator, IC5, supplies a fixed +12 volts.

Capacitors C3, C4, C7, C8, and C10 improve transient response and prevent oscillation. Resistor networks R1-R3 and R2-R4 for IC1 and IC2, respectively, provide the necessary feedback to obtain the variable output voltages. An LED and current-limiting resistor is wired across each output to indicate when each output voltage is present. The main power in-

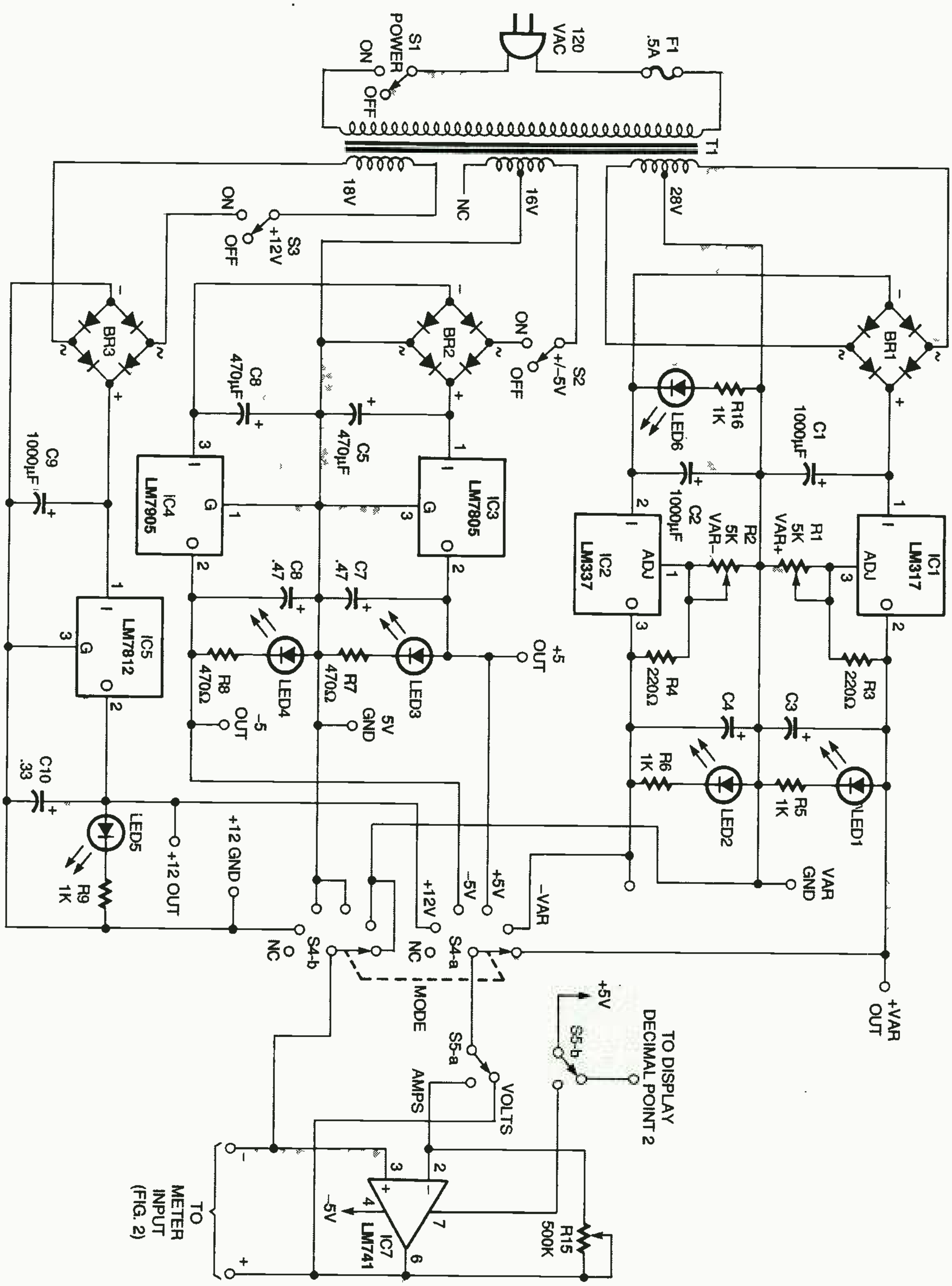


FIG. 1—MAIN POWER-SUPPLY SCHEMATIC. The supply provides both positive and negative variable outputs, a positive 5-volt output, a negative 5-volt output, and a positive 12-volt output.

dicator for the entire unit consists of LED5 and R18.

Switch S1 controls AC power to the transformer primary, and switches S2 and S3 connect the secondary voltages to the 5- and 12-volt regulator circuits. The ±5-volt supply powers the volt-

Continued on page 73

EXPERIMENTER'S VIDEO RECEIVER

Build this versatile video receiver so you can perform video descrambling experiments and learn about TV basics.

STEVE BOTTS

THE MINIMALIST VIDEO RECEIVER described in this article could be considered as a kind of "crystal set" of television receivers. This TV receiver offers no frills such as color, automatic gain control, or sound, but it is amazing to see television images appear with only a handful of parts in a simple circuit.

Back in the late 1940s, a TV pitchman/manufacturer named "Madman" Muntz asked the engineer who designed the TVs for him what all the parts inside a TV set did. As the engineer explained the circuits, Muntz began snipping out components until the set stopped working. He told his engineer to put that part back and build the sets that way!

This might be an apocryphal story, but it illustrates the concept of eliminating all nonessential electronics components. Television receivers contain many circuits that are inherently incompatible with each other. High-voltage circuits, oscillators, high-gain amplifiers, and sensitive tuners all must interact compatibly with each other. Moreover, a lot of circuitry is included in the television receiver for user convenience and to assure long-term dependability.

But, as Madman realized, all of those "extra" components add to the complexity and cost of the TV receiver. Nevertheless, Madman's thinking was an example of the minimalist approach taken by the author in this project.

Possible applications

In addition to experimenting with video signals, there are other applications for the video receiver. The author built one of the receivers into a spectrum analyzer to help identify television signals. The video receiver can also function as a platform for video descrambling experiments. It can also provide amateur television (ATV) and TV long-range reception because of its manual gain control. When it is connected to an old computer monitor, the receiver will let you catch up on your favorite daytime TV programs.

Finding parts

Be warned! You might have to be resourceful in obtaining some of the parts for this project, especially the tuner. Figure 1 shows a typical TV tuner. Late model discarded TV receivers (1980s or later) are a valuable source for the right tuners. Surplus tuners can also be purchased for as little as $5 (see the Parts List for sources). Even if the tuner has extra components or a small circuit board attached to the connecting pins, leave them in place. These are usually filters that improve the tuner's performance. There might be several holes in the tuner's case for accessing various tuning controls—do not touch these controls because they are usually factory-set.

The output of the tuner must be 45 MHz or the receiver will not work without making modifications to the tuning circuits. The receiver has been tested with the SW-5800 and the KV-1217 from a Sony TV with good results. The SW-5800 is a good tuner but it is expensive. In addition to the solid-state tuner module, you'll also need a DC power supply, antenna, and video monitor.

All other components are low-cost items that can be purchased from electronics retail stores and mail-order distributors. The tuning circuits require temperature-stable capacitors. The author's prototype

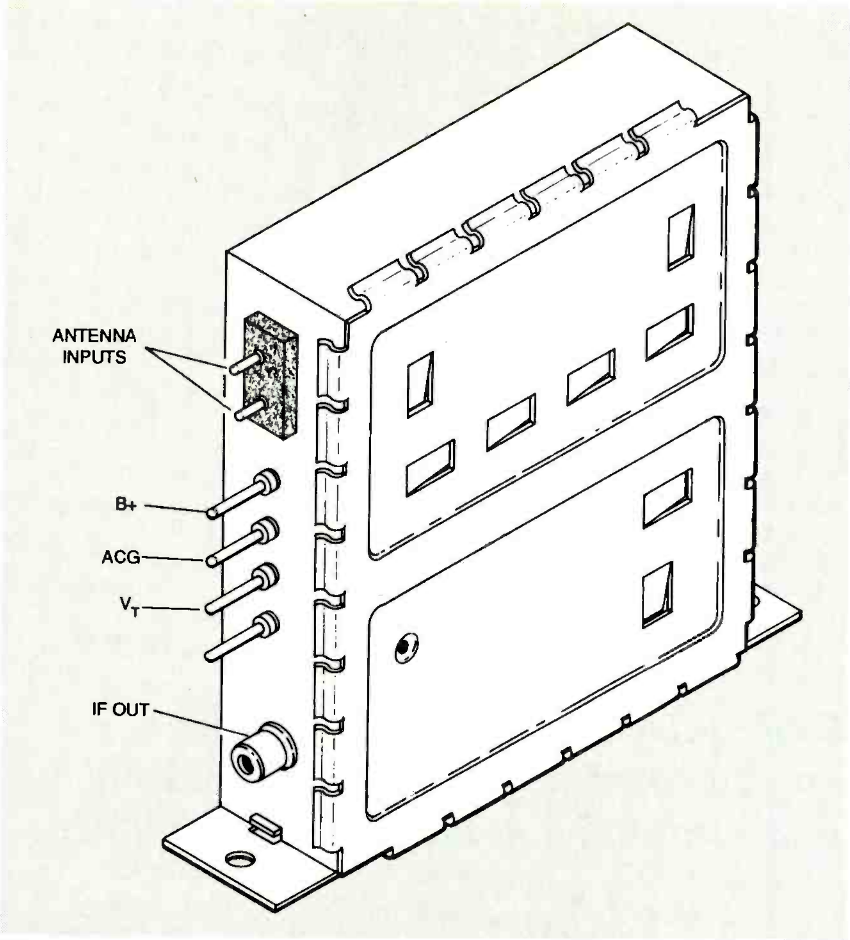


FIG. 1—THIS IS WHAT A TYPICAL TV TUNER looks like. Surplus tuners can be purchased for as little as $5.

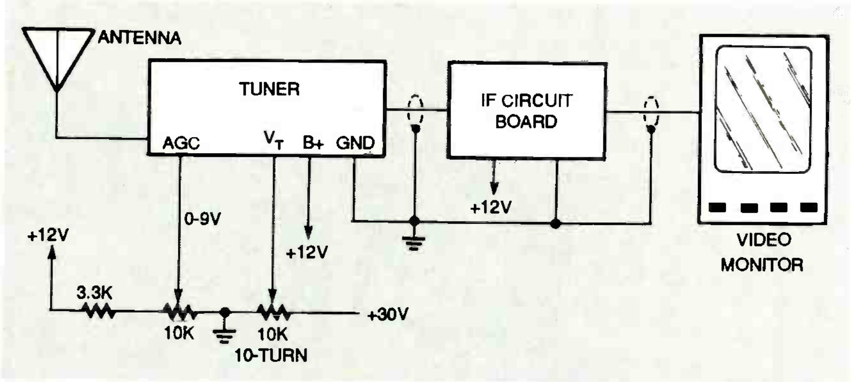


FIG. 2—VIDEO RECEIVER BLOCK DIAGRAM. The tuner requires a B+ voltage of about +12- to +24-volts DC and a variable tuning voltage from 0- to 30-volts DC.

included commonly available coils, but this article also includes instructions for making your own. The total cost for the prototype was less than $20. Although an oscilloscope is helpful and will save time, the circuit alignment—the adjusting of a couple of coils—can be done visually with the help of a standard video monitor.

How does it work?

Figure 2 is a block diagram of a typical video receiver. An antenna feeds the tuner module directly. Typically, the tuner requires a B+ voltage of about +12- to +24-volts DC and a variable tuning voltage from 0- to 30-volts DC. Some tuners (typically UHF) also require from 5- to 10-volts DC for the automatic gain control (AGC). Most tuners have the pin labels stamped on their case covers. The output is typically an RCA- or F-type jack that is connected to the video receiver board with a short length of small diameter coaxial cable. The output from the receiver is a standard NTSC video signal that is then fed into a video monitor.

The prototype worked well with a Sanyo VM4509 monitor, and was also tried with an old Gorilla composite CGA computer monitor—which is fine if you don't mind green TV images! An oscilloscope can be used as a monitor by making use of its Z-axis. The antenna for the prototype was a "rabbit ears" unit.

Continued on page 77

PARTS LIST

All fixed resistors are ¼-watt, 5%.
R1—100 ohms
R2—47 ohms
R3—3300 ohms
R4, R6, R7—4700 ohms
R5—10,000 ohms, PC-mount trimmer potentiometer
R8—56 ohms

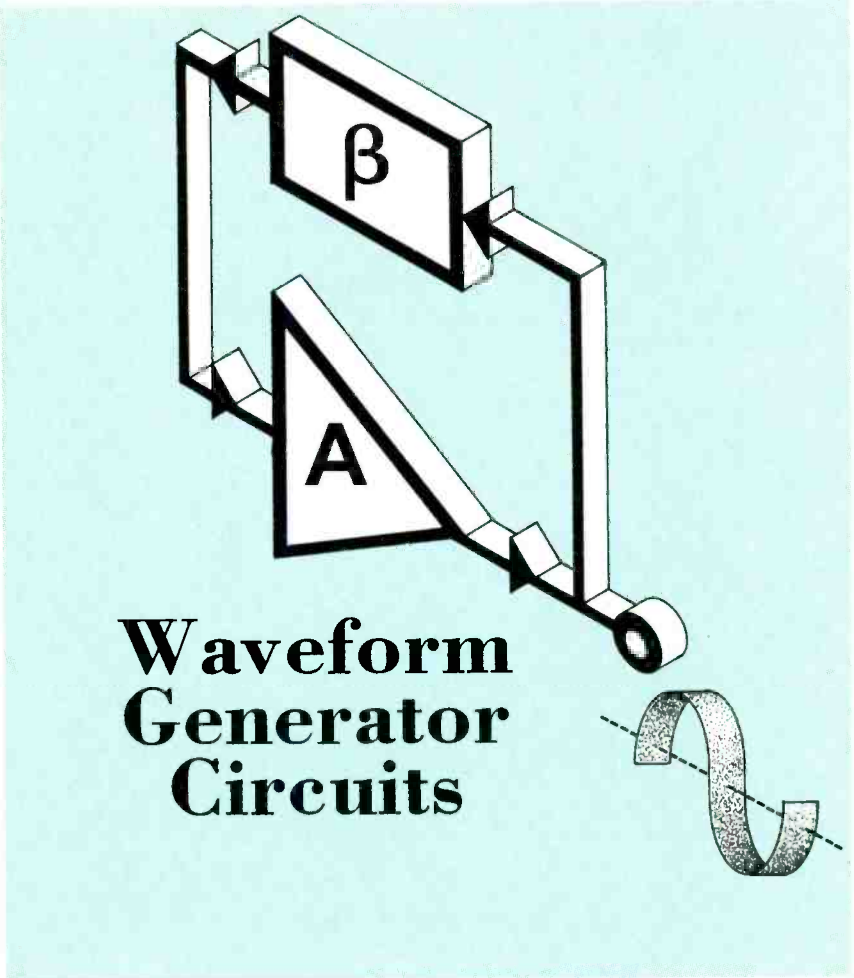
Capacitors
C1, C9—56 pF, 5%, silver mica or ceramic NPO
C2–C6, C10—470 pF, 20% ceramic disc
C7—0.001 µF, 20%, ceramic disc
C8—47 pF, 5%, NPO (optional, see text)

Semiconductors
IC1—MC1350 monolithic IF amplifier (Motorola)
IC2—MC1330A2P low-level video detector (Motorola)
Q1—2N3904 NPN transistor

Inductors
L1, L2—0.25 µH coil, Toko No. TK2812, Digi-Key type MC122 or equivalent
L3—1.17 µH coil, Toko No. TK2916, Digi-Key type MC130 or equivalent (optional, see text)

Miscellaneous: solid-state tuner (see text), multiturn potentiometer (10K minimum, see text), RF gain-control potentiometer (10K minimum, see text), PC board, two short lengths of small diameter coaxial cable, two RCA-type connectors (for connecting to tuner and monitor), multi-voltage power supply, video monitor, solder, hookup wire.

CIRCUITS THAT ARE CAPABLE OF generating a variety of waveforms are important for test and analysis in electronics. The sinewave, the most useful waveform, can be generated by various resistive-capacitive (RC) or inductive capacitive (LC) oscillators. They can also be synthesised by integrated circuit waveform generators. This article focuses on two popular, low-frequency sinewave and square wave generators, the Wien-bridge and twin-T oscillators.



Waveform Generator Circuits

Learn about Wien-bridge and Twin-T oscillator circuits and put them to work in your circuit designs.

RAY MARSTON

Oscillator fundamentals

An oscillator, as illustrated in block diagram Fig. 1, is basically an amplifier with positive feedback. The gain equation for an amplifier with positive feedback is:

$A_F = A/(1 + A\beta)$

Where:

A_F = gain with feedback
A = open-loop gain
β = feedback factor, V_i/Vsbo

Feedback is provided by the feedback or phase-shift network, as shown in Fig. 1. The output signal is fed back to the amplifier's input terminal through a phase-shift network, where it undergoes a 180° phase shift. The amplifier also causes a 180° phase shift. The two conditions for sustained oscillation are known as the *Barkhausen criteria*.

1. The phase shift in the circuit is zero.
2. The closed-loop gain, the product of Aβ, must be equal to or greater than one.

An input signal is not necessary to start oscillation—a transient is sufficient. The closed-loop gain should be greater than unity to ensure strong oscillations. However, if the gain is too high , the circuit will operate in a saturation condition, and the sinewave will be distorted.

An oscillator's frequency-selective, phase-shift network consists of a combination of resistive and capacitive components (RC) or inductive and capacitive components (LC). A combination of inductive and capacitive components is called a *tuned circuit* or a *tank circuit*.

RC oscillators are preferred to LC oscillators at low frequencies because the size and weight of inductors at low frequencies makes the circuit too large and heavy. RC sinewave oscillators work best at frequencies from 10 Hz to about 150 kHz. This band includes the audio-frequency range of 20 Hz to 20 kHz. By contrast, LC networks work best at frequencies above 50 kHz. There is some overlap between these frequency ranges. The most common output impedances of audio oscillators are 75 ohms and 600 ohms.

Two popular low-frequency oscillators with RC phase-shift networks commonly used today are the Wien-bridge and twin-T oscillators.

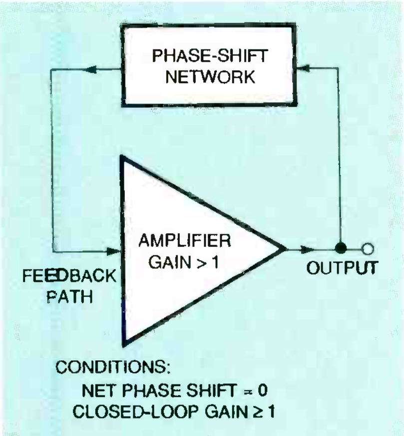


FIG. 1—CONDITIONS for oscillation based on an amplifier.

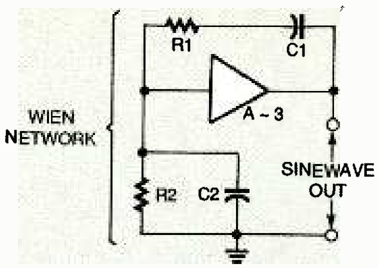


FIG. 2—BASIC WIEN-BRIDGE oscillator for producing sinewaves.

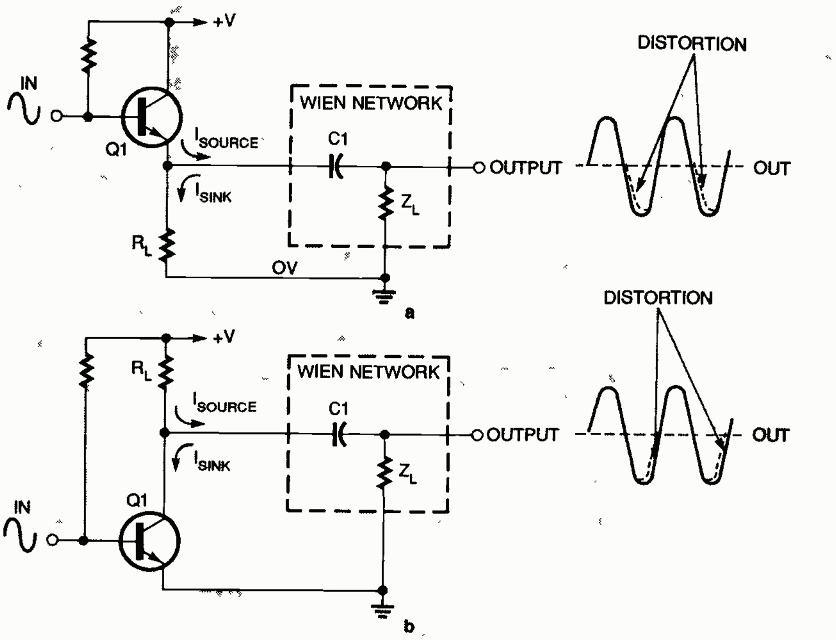


FIG. 3—WAVEFORM DISTORTION from an emitter-follower amplifier (a), and common-emitter amplifier (b), if the value of the load resistor exceeds the load impedance.

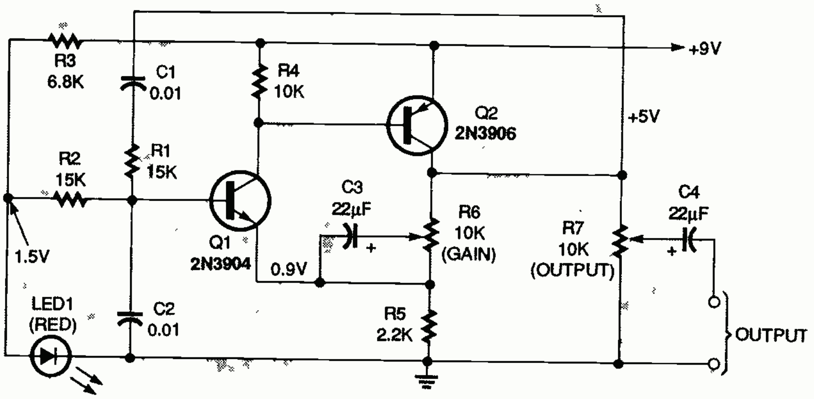


FIG. 4— THIS WIEN-BRIDGE OSCILLATOR generates variable-amplitude, 1-kHz sinewaves.

Wien-bridge oscillator

The Wien-bridge oscillator is essentially a feedback amplifier that includes a Wien bridge as its phase-shift network. The Wien bridge is an AC bridge whose balance is achieved at a single frequency. The oscillator produces a relatively pure sinewave at a very stable frequency.

Figure 2 is a simplified diagram of a Wien-bridge oscillator showing an amplifier with a Wien-bridge, RC frequency-selective network. The Wien network consists of resistor and capacitor pairs R1 and C1 in series and R2 and C2 in parallel. Here C1 = C2 = C, and R1 = R2 = R. The main characteristic of the Wien network is that the phase relation between its output and input signals can vary from −90° to +90°, and it is precisely zero at the center frequency $f_0 = 1/(2\pi \times RC)$.

At this frequency, the network has a voltage gain of 0.33. The Wien network in Fig. 2 is connected between the output and input of a noninverting amplifier with a voltage gain of 3. Consequently, the circuit has a zero overall phase shift and a unity loop gain at the center frequency. These satisfy the Barkhausen criteria for oscillation.

A practical Wien network is unlikely to be precisely symmetrical because of the tolerances of its components, so its gain might deviate widely from the ideal 0.33 value. To compensate for this variation and permit the oscillator's loop gain to be set at unity, the amplifier's gain must be variable between about 3 and 5

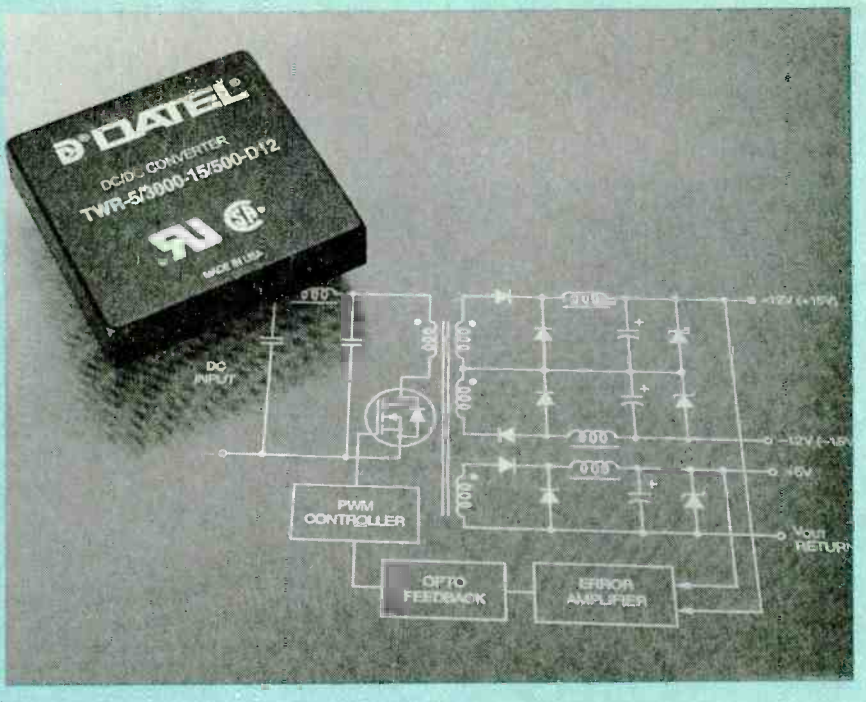
Moreover, the loop gain must initially be slightly greater than one to initiate oscillation. Then it must be reduced, either manually or automatically, to a value of one necessary to produce low-distortion sinewaves.

If the amplifier's output stage is a simple emitter follower, it might not be a low-distortion drive for the Wien-bridge network. This can be seen in Fig. 3-a, a schematic for a sinewave-driven NPN transistor emitter-follower Q1 driving the input of a Wien-bridge network. The network is represented by capacitor C1 and complex load Z_L.

On positive-going half-cycles, the forward currents of C1 and Z_L are sourced (supplied) by transistor Q1, but on negative-going half-cycles, their reverse currents are sunk (absorbed) by R_L. If R_L is large relative to Z_L, the reverse currents of C1 and Z_L might be too low to permit the Z_L voltage to follow the negative-going half cycles. If this occurs, the waveforms will be distorted, as shown in Fig. 3-a.

Similar distortion can occur if the amplifier's output stage is an NPN common-emitter amplifier, as shown in Fig. 3-b. Here, the distortion that occurs if R_L is large relative to Z_L appears on the rising edge of the output waveform because the C1-Z_L source currents flow through

Continued on page 82



MODULAR DC-TO-DC CONVERTERS

The DC-to-DC converter module might be a better alternative to the custom design of a power supply.

DENNIS EICHENBERG

ELECTRONIC CIRCUITS TYPICALLY require several different operating voltages, which can be provided by many different sources. In AC power systems, transformers usually provide the various voltage levels. Transformers are simple, inexpensive, and efficient. In DC power systems, however, the supply of power can be a lot more complex.

Linear DC regulation, such as is obtainable from the ubiquitous three-terminal integrated circuit regulators, is perfectly acceptable for low power levels. For higher power levels, however, linear regulators are inefficient. This inefficiency shows up as excessive heat dissipation and high power consumption. Switching regulated power supplies have become economical alternatives because of advances and price reductions in magnetic components and switching power transistors. Switching regulators can have efficiencies of 80%, but their application can be complex and difficult because of EMI problems. The modular DC-to-DC converter has greatly simplified switching regulation for many applications.

There are several advantages for the use of modular DC-to-DC converters. These converters are readily available from many manufacturers in an extremely wide range of input and output voltages and power ratings. Because DC converters are efficient, they run cooler, are more reliable, cost less to operate, and are smaller and lighter than other common power supplies.

DC-to-DC converters provide fixed output voltages over a very wide input voltage range, so they're suited for many battery-powered applications. The converters can be easily configured and permit great circuit flexibility. In addition, the converters provide substantial isolation between input and output, thus providing a safety advantage as well as improved performance in many system applications.

Some modular DC-to-DC converters have built-in output-current limiting, output overvoltage protection, and overtemperature shutdown. These features improve the reliability of the DC-to-DC converters.

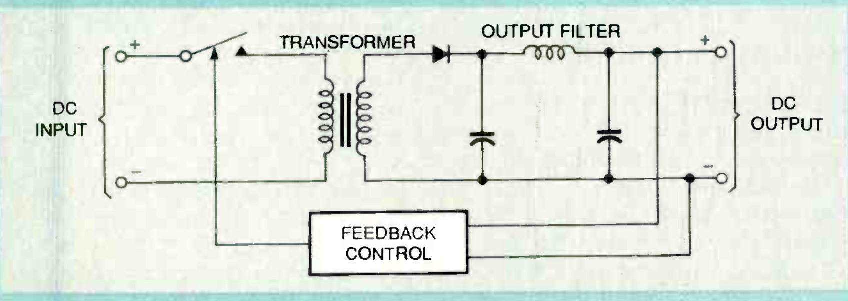


FIG. 1—BASIC DC-TO-DC CONVERTER CIRCUIT. The input voltage is "chopped" and converted to the desired voltage value by a transformer.

Basic converter circuit

A simplified schematic for a basic modular DC-to-DC converter circuit is shown in Fig. 1. The DC input voltage is "chopped" at a rapid rate, usually 20 kHz or more. A transformer converts the chopped DC to the desired voltage level. The transformer output voltage is rectified to DC and filtered to remove ripple. Output voltage regulation is achieved with feedback control.

DC-to-DC converters that operate at frequencies of 1 MHz are usually more efficient. High-frequency operation permits smaller transformer and filter components. The trend in DC-to-DC converters has been to higher operating frequencies, with 1 MHz typical today, and some units operating at 2 MHz or higher.

Modular DC-to-DC converters eliminate the need for the circuit designer to get involved in the design particulars of the power-supply circuit. Thus a system can be up and running in a much shorter time.

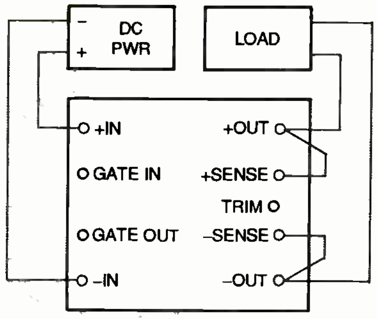


FIG. 2—BASIC DC-TO-DC CONVERTER APPLICATION. The output voltage remains constant, independent of the input voltage and the load, within the operating range of the unit.

Applications

DC-to-DC converters can be configured for many different applications. Here are some of them:

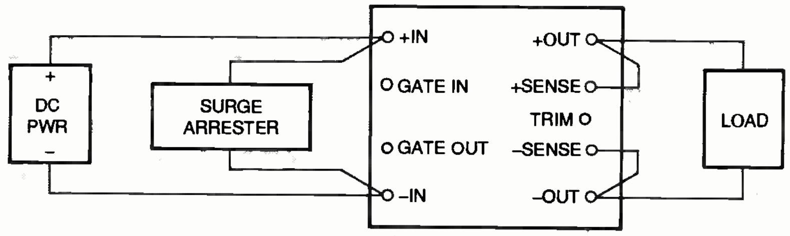


FIG. 3—A SURGE ARRESTOR should be connected across the converter inputs if input power stability is questionable.

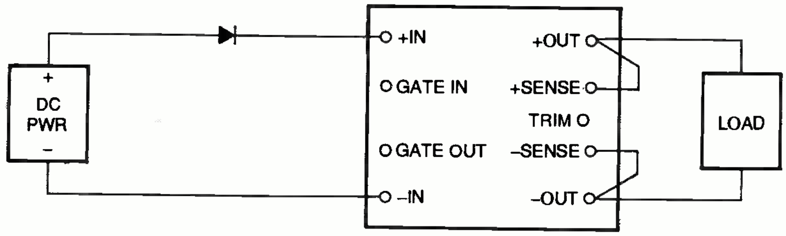


FIG. 4—THE INPUT CAN BE PROTECTED from reverse polarity by a series diode. The diode should be rated for twice the maximum expected input voltage and current for the best reliability.

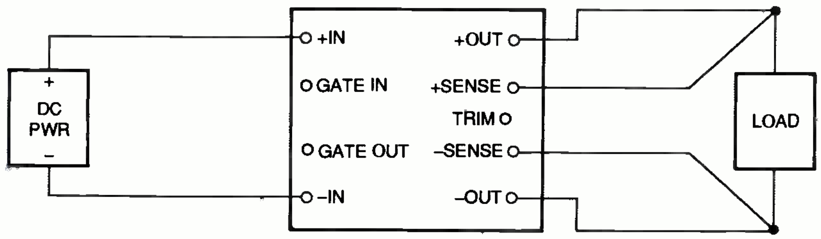


FIG. 5—REMOTE SENSING should be used if the load voltage is critical.

Basic configuration. A basic modular DC-to-DC converter application is shown in Fig. 2. The output voltage remains constant, independent of the input voltage and the load, within the operating range of the converter. Select a converter that is compatible with the input voltage provided and the load that it must feed. Most DC-to-DC converters have sense terminals that must be connected to the output terminals, as indicated in Fig. 2, for proper operation; they should never be left disconnected. The gate terminals are intended for synchronizing multiple converter arrays.

Connect a surge arrestor across the converter inputs, as shown in Fig. 3, if the input power stability is questionable. The input polarity is critical, and should be connected cautiously. The input can be protected from reverse polarity by a series diode, as shown in Fig. 4. The diode should be rated for twice the maximum expected input voltage and current for the highest reliability.

A Schottky diode is recommended for this function because of its low forward voltage drop of 0.4 volt. A silicon diode with a 0.7-volt forward drop can be used if lower efficiency is acceptable. For maximum efficiency, install wire of adequate gauge for the input and output connections.

Remote sensing. Remote sensing should be used if the load voltage is critical. Compensation for the voltage drop between the DC-to-DC converter and the load can be obtained by configuring the circuit as shown in Fig. 5. A converter will compensate only for a voltage drop within its operating range. The remote sensing wires can have a much smaller gauge than the load wires because very low currents will be carried by these conductors. Connect the remote sense leads as close to the load as possible to obtain the best performance.

Adjustable output voltage. Many modular DC-to-DC converters have an output voltage that can be adjusted from its nominal value by setting a voltage at the trim terminal, as shown in Fig. 6. The trim voltage is usually between 0 and 5 volts. Read the manufacturer's literature to determine the actual value for the converter you have.

Continued on page 88

Q & A

Continued from page 10

milliamperes through the collector, and the base current is not specified. You can get power transistors that handle as much as 60 amps.

One last caution: If you're switching the current to an inductive load (anything with a coil in it, such as a relay or motor), use a protective diode as shown in Fig. 5. Under normal circumstances the diode doesn't conduct, but when the power to the load is suddenly switched off, the collapsing magnetic field induces a sudden pulse of high voltage in the coil. The diode gives this pulse a place to go so it won't damage the transistor.

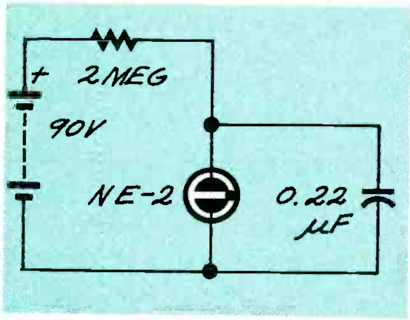


FIG. 6—NEON LAMP HAS NEGATIVE DYNAMIC RESISTANCE—the voltage across it falls while conduction is increasing. As a result, it flashes on and off.

We published an article on transistor switching circuits in February 1986 (pp. 83-87) and a general article on transistor theory in September 1993 (pp. 57-62). You can get these from our Reprint Bookstore.

HOW TO GET INFORMATION ABOUT ELECTRONICS

Books: Several good introductory electronics books, including *Building Power Supplies*, are available at Radio Shack.

Our favorite general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is The *ARRL Handbook* for Radio Amateurs, comprising 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham radio equipment dealers.

Copies of past articles in Electronics Now, Radio-Electronics, Popular Electronics, and Hands-On Electronics are available from our Reprint Bookstore, PO Box 4099, Farmingdale, NY 11735 (516-293-3751).

Electronics Now and many other magazines are indexed in the *Reader's Guide to Periodical Literature*, available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, Sams may have a schematic on file that can be copied for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502.

Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including Radio Shack on special order). The ECG, NTE, and SK lines contain just a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations can be located by writing to the American Radio Relay League (Newington, CT 06111). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts both amateur and professional.

Writing to Q&A: We welcome your questions. The most interesting ones are answered in print, usually within 6 to 9 months. Please be sure to include plenty of background information (we'll shorten your letter for publication). We regret that we cannot give personal replies.

State machines

Q *I am developing a control system that is becoming complex. A colleague suggested using an EPROM as a state machine. Where can I learn more about how to do this?—D. A., Willoughby, OH*

A A state machine is any machine that has a particular number of distinct states, is always in one of them, and has rules for changing from one state to another. The classic example is a vending machine: its states are "idle" (ready for customer), "25 cents deposited," "50 cents deposited," "drink selected," and so on, and the transitions occur when the customer inserts money or presses a button. This same kind of logic applies to lots of other kinds of control systems.

A good introduction to state machines—and a lot of other useful things—is found in *The Art of Electronics*, by Paul Horowitz and Winfield Hill, published by Cambridge University Press (visit your local bookstore or call 800-872-7423 to order). This is one of the best all-around electronics books we know of, and we recommend it to everyone. EN

Send Questions to:
Electronics Now Magazine,
500 Bi-County Blvd.,
Farmingdale, NY 11735
Due to the volume of mail we receive, not all Questions can be answered. All Questions are subject to editing for clarity and length.

BY DON LANCASTER

Pseudoscience Strikes Again

Plus important EE Internet sites, a MIDI music book, the BASIC Stamp II microcomputer, and more.

IT'S NOW OUR MONSOON SEASON OUT HERE IN ARIZONA. FOR SOME WEIRD REASON, THIS SEEMS TO BRING THE PERPETUAL-MOTION FOLKS AND PSEUDOSCIENCE ENTHUSIASTS OUT OF THE woodwork. I've recently been seeing one a day. One was a "motors and magnets" drop in. Uh, sure, a magnet offers a repulsive force. But only a few permanent-magnet developers seem to pick up on the fact that you have to think *cyclically*. The energy you will need to get your magnets into a position where they can do the repulsion *always* exceeds any possible output.

The second was an individual who genuinely believes he has a workable *zero point energy* solution. For some strange reason, he is sorely lacking development funds. He does appear a lot more credible than most. To be fair, I'll have to put this one in my "wait and see" mode. But I won't be holding my breath.

Meanwhile, all of the cold-fusion diehards appear to have gone into a "circle the wagons" state. They also seem to be running critically low on ammunition. They are now centered on an *Infinite Energy* magazine and an *CFNET* online resource. The fact that they have now allied themselves with pyramid power (now renamed as *tetrahedral superscalars*) does not bode well.

Genuine new energy developments certainly will emerge. And research certainly should continue. So should independent thinking. For instance, the August 18th issue of *Science* tells us about a dramatic improvement in lower cost polymer solar cells on pages 920-921. These are still woefully inefficient and totally unstable, but they just got a whole lot better.

Any legitimate new energy development should meet these guidelines: It must (A) economically generate *one net watt* of useful power in (B) a simple experiment.

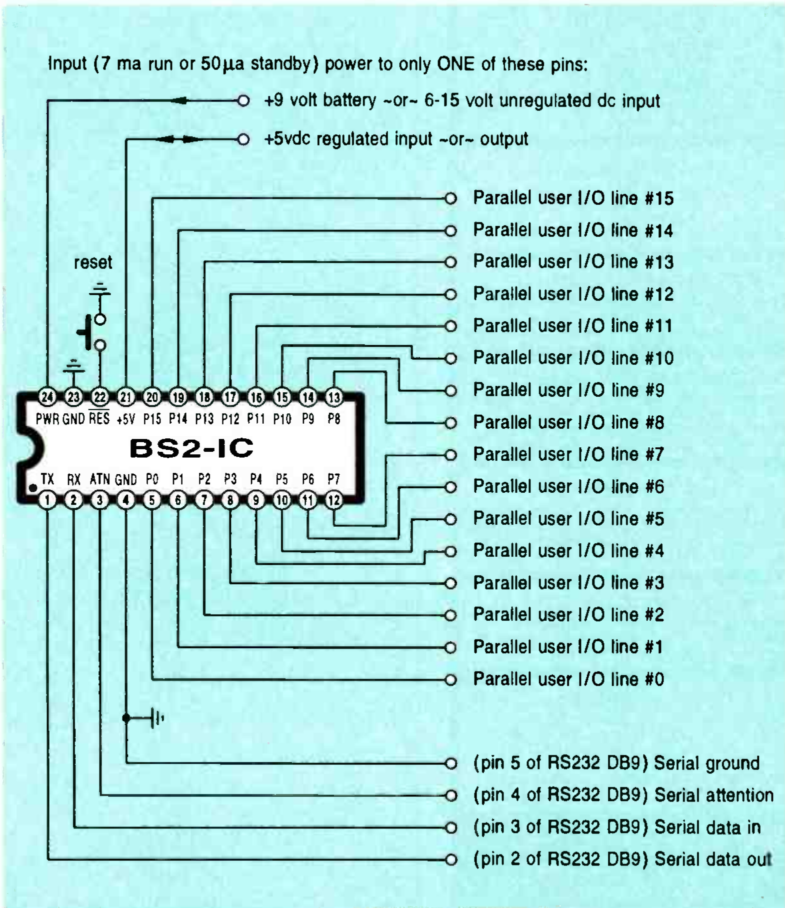


FIG. 1—THE BASIC STAMP II has greatly improved capabilities over its earlier release. This is an entire $49 computer the size and shape of a 24 pin DIP.

MORE OUTPUTS–

There are now sixteen user defined parallel I/O lines. Each can source or sink 20 mils over the full supply range.

MORE MEMORY–

There is now a 2K nonvolatile program memory, good for several hundred BASIC statements, plus lots of data storage.

IMPROVED MEMORY ACCESS–

Data may now be prewritten into memory before downloading your Basic program. You can also read or write nonvolatile memory data.

FULL TIME SERIAL–

The serial port is now usable at runtime, following simple software commands. The baud rate can go as high as 38,400.

TOUCH TONE OUTPUT–

Simultaneously generates a touch tone audio tone pair. Can also be used to generate one or two sinewaves of any frequency to 32 kHz.

BSR OUTPUT–

Directly generates the BSR home remote control tones. For use with a TW513 or TW523 power line interface module.

PWM OUTPUT–

Simple commands output any number of variable duty cycle pulses. Making for ultra-simple D/A conversion.

POTENTIOMETER INPUT–

Directly measure an analog potentiometer. Can also be used to measure RC charging or discharge times.

BIT SHIFTING–

Shift bits in from parallel to serial. Or shift bits out serial to parallel. Valuable for talking with other microcontrollers.

CYCLE COUNTER–

Count the cycles on any pin for a given time period. Input frequency can be as high as 150 kHz.

POWER MATH–

New single command math features now include square root, sine, cosine, and absolute value. One degree accuracy on trig.

POWER LOGIC–

Unusual new bit and digit manipulation features include a priority encoder, decimal digit selector, order reversal, and lots more.

FIG. 2—NEW OR IMPROVED FEATURES of the Basic Stamp II.

It must (C) be easily verified by disinterested outsiders. It must be created by a credible individual who is (D) both trade-journal and on-line research literate. They must also be (E) totally devoid of paranoid, patent, political, or puritanical hangups, and backed up by (F) some reasonable and likely theoretical framework based on physics.

The latest perpetual-motion flap on the Internet involved the usual screwup: You can not measure AC power with a voltmeter and an ammeter! You never could and you never will. As usual, their "over unity energy gain" was in fact nothing but awful labwork. More on this in my HACK49.PDF or in my Hardware Hacker reprints.

MICROCOMPUTER STARTUP RESOURCES

Scott Edwards Electronics
964 Cactus Wren Lane
Sierra Vista AZ 85635
(520) 459-4802

Electronics Now
500-B Bi-County Blvd
Farmingdale NY 11735
(516) 293-3000

Microchip Technology
2355 W Chandler Blvd
Chandler AZ 85224
(602) 963-7373

Circuit Cellar Ink
4 Park St #20
Vernon CT 06066
(203) 875-2751

Midnight Engineering
1700 Washington Ave
Rocky Ford CO 81067
(719) 254-4558

Motorola
PO Box 1466
Austin TX 78767
(800) 521-6274

Nuts & Volts
430 Princeland Ct
Corona CA 91719
(909) 371-8497

Parallax
3805 Atherton Rd, #102
Rocklin CA 95765
(916) 624-8333

Popular Electronics
500-B Bi-County Blvd
Farmingdale NY 11735
(516) 293-3000

Western Design Center
2166 E Brown Rd
Mesa AZ 85203
(602) 962-4545

HELP LINE

Phone or write all your Hardware Hacker questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(520) 428-4073

For fast PSRT access,Modem (800) 638-8369. On prompt, Type JOINGENIE. When asked for the offer code, enter DMD524.

US Internet email access link:
SYNERGETICS@GENIE.GEIS.COM.

The *Skeptical Enquirer* is a good source for pseudoscience debunking. All of the latest new pseudoscience developments show up in the *KeelyNet BBS*.

The sad thing about wasting your time on any pseudoscience is that the odds of success are zero. There are so many new and exciting things you could be trying instead, such as my new magic sinewaves, that mystery band, those PIC chips, X-Y flutterwumpers, isopods, DNA computing, spread-spectrum communication, book-on-demand publishing, desktop finishing, fluxgates, car alternator steppers, Santa Claus machines, short haul telemetry, sonoluminescence, or Navicubes. More on these in the *Incredible Secret Money Machine II*. Also see EMERGOP4.PDF.

The BASIC Stamp II

Lance Wally of Parallax just sent me a few samples of his new BASIC Stamp II, a PIC-based microcontroller the size and shape of a 24-pin DIP integrated circuit. The pinouts are shown in Fig. 1, and new features in Fig. 2.

You program the Basic Stamp by connecting it to a PC's serial port and then executing host software. That places tokenized BASIC commands in the Stamp's internal non-volatile memory. Once programmed, the stamp may be taken anywhere or be used any way you care to.

Because of the nonvolatile serial EEPROM flash memory, you can reprogram the Basic Stamp as often as you like, making for simple debugging and reuse. You can power your stamp from a nine-volt battery or an unregulated 6- to 15-volt source applied to its built-in voltage regulator. Or, you can instead directly input a five-volt regulated DC system supply voltage. The operating current is typically seven milliamperes. Some standby options can reduce this down into the 50-microampere range.

There is an optional breadboard area about three inches square. Included are battery clips, the reset button, and a DB-9 connector for

RS-232 serial access. Improved features include more memory, better and faster serial communication, BSR and touchtone outputs, and more output lines. Programs can now contain up to 600 BASIC instructions. There is also a modest performance improvement.

This is by far the easiest micrcontroller to use, ever. I particularly like its A/D conversion that makes use of RC discharges and the D/A conversions based on pulse-width modulation (PWM). I've uploaded the new Basic Stamp II manual to my GEnie PSRT along with the earlier Stamp I introduction, instruction sets, and application notes.

Some alternatives

The BASIC stamp is the best starting point when you decide to become microcomputer literate. And its PIC chip is by far the best low-cost microcontroller available today. First because of its 3ˇ speed and 3ˇ program length advantages. Second, because it is cheap, simple, and fun to use. And third, because the PIC encourages creative new algorithms.

As we've seen in the past, the PIC makes it totally unthinkable to ever again use the 555 timer or any other "bits and pieces" solution. But there are some useful BASIC Stamp alternatives. I've listed several of them in our resource sidebar.

Any interpreted language will chew up resources and slow you down. So, once you're past your bare beginnings of understanding a microcontroller, your stamp may end up a little slow and a tad cramped.

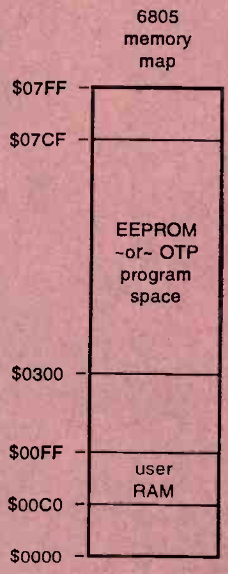
As always, the solution is to drop into machine language in which you select only the exact code you need. This trades off speed for storage and lets you create your own custom integrated circuit in the process. You can begin with the *PIC Data Handbook* and that *Microcontroller Applications Handbook* offered by *Microchip Technology*. I've posted a PIC introduction as HACK88.PDF.

Scott Edwards offers lots of useful PIC products. His *PIC Software Tools* has machine language equivalents to most of the Stamp commands. You select only the ones you really need.

The 6805 has 1232 bytes of user EPROM or OTP programming space that can **not** be run time modified.

It also has 64 bytes of user RAM, that normally get used as variable storage (at bottom) and as a stack (at top).

You are also allowed to insert short programs, subroutines, or indirectly written access links into your user RAM area. This is the key to adding your new address modes.



To add an indexed indirect load addressing mode, first reserve four contiguous user RAM bytes. Then write the following bytes to user RAM during chip setup time...

```
NULOAD   EQU #D0         ; Stash code at $00D0

OPCODE   EQU #$D6        ; Want LDA (opr),X opcode
BASEHI   EQU #$06        ; Default base high address
BASELO   EQU #$00        ; Default base low address
RETURN   EQU #$81        ; RTS opcode

         LDA OPCODE      ; poke LDA (opr),X opcode
         STA NULOAD      ;
         LDA BASEHI      ; poke default high address
         STA NULOAD+1    ;
         LDA BASELO      ; poke default low address
         STA NULOAD+2    ;
         LDA RETURN      ; poke RTS opcode
         STA NULOAD+3    ;
```

To use your new indirect indexed addressing mode, you stuff your two calculated values of `BASEHI` into `NEWLOAD+1` followed by `BASELO` into `NEWLOAD+2`. Then simply do a...

```
         JSR NULOAD      ; get indirect indexed value
```

Your new instruction will get a data value from the sum of an indirectly calculated 16-bit address and an 8-bit offset in your X register. Indirect or indirect indexed loads, jumps, logic, and even subroutine calls can be handled similarly. There is often a 12 clock cycle speed penalty.

FIG. 3—ADDING NEW ADDRESSING MODES to the 6805 microcontroller.

These run a lot faster and take up far less memory. Scott also offers stamp extenders and interfaces for servos, LCD displays, thermometers, touchtone decoders, and A/D converters. Meanwhile, Steve Ciarcia over at *Micro Mint* has an *Intel* approach to low-end micros in his new low-cost *Domino* series. These are well done "sort of Stampish" solutions. If you like Intel chips (I definitely do not), these might be a good route to explore.

Whenever the Basic Stamp is not "enough," you might instead want to consider the 65C265-based *Mensch* computer offered by *Western Design Center*. We looked at this gem last month and in MUSE93.PDF. This one includes PCMCIA card access, a

NAMES AND NUMBERS

Amsco Publications
257 Park Avenue South
New York NY 10010
(212) 886-6500

Atmel
2125 O'Nel Drive
San Jose CA 95131
(408) 441-0311

Biophotonics International
PO Box 4949
Pittsfield MA 01202
(413) 499-0514

Gem Star Development
135 N Los Robles #870
Pasadena CA 91101
(818) 792-5700

GEnie PSRT
401 N Washington Street
Rockville MD 20850
(800) 638-9636

Infinite Energy
PO Box 2816
Concord NH 03302
(603) 228-4516

International Rectifier
233 Kansas Street
El Segundo CA 90245
(310) 322-3331

KeelyNet BBS
Box 1031
Mesquite TX 75149
(214) 324-3501 BBS

Maxim
120 San Gabriel Drive
Sunnyvale CA 94086
(800) 998-8800

Microchip Technology
2355 W Chandler Blvd
Chandler AZ 85224
(602) 963-7373

MicroMint
4 Park Street Ste 20
Vernon CT 06066
(203) 875-2751

Motorola
5005 E McDowell Road
Phoenix AZ 85008
(800) 521-6274

PAVO
PO Box 47
Buchanan MI 49107
(800) 546-5461

Radar Sales
5485 Pineview Lane
Plymouth MN 55442
(612) 557-6654

Skeptical Inquirer
PO Box 703
Buffalo NY 14226
(716) 636-1425

Synergetics
Box 809
Thatcher AZ 85552
(520) 428-4073

Sysop News & Cyberworld
8125 SW 21st Street
Topeka KS 66615
(913) 478-3157

Texas Instruments
PO Box 809066
Dallas TX 75380
(800) 336-5236

graphics and text video display, an printer add-on, 12-megabyte addressibility, and full expandability.

Meanwhile, *Motorola* is offering a bargain $95 development kit for its 6805 microprocessor. The part number is 68HC705J1A. The one-piece hardware includes a programmer, tester, verifier, and even an in-circuit (but not real time) emulator, along with development software that runs on a PC. I found both their assembler and debugger to be fast, fun, and easy to use. Some additional startup resources appear in the sidebar.

A 6805 programming trick

Being a 6502 person, I never go anywhere in microland without an *indexed indirect* addressing mode. This ultra power addressing scheme lets you reach anywhere you want that is so much as near an on-the-fly calculated 16-bit address. At first glance, the Motorola 6805 seems to lack any addressing scheme even remotely as powerful. But, as Fig. 3 shows, there is one ultra-sneaky trick that you can pull to fake indirect indexed power.

Unlike many micros, the 6805's working registers are *inside* of its address space map. Normally, your program goes into the 1280 bytes of write-once memory and your data and variables go in a 64-byte stash of read-write RAM shared with the system stack. Now for the sneaky part: There's nothing keeping you from executing short blocks of program code inside of the register and variable stash! For instance, set aside four user RAM "variables" that happen to sit beside each other, say \$D0-D3. Now force feed this subroutine...

http://aip.org	American Institute of Physics
http://www.info.apple.com	Apple Computer technical library
http://www.bellcore.com	Bell Telephone Laboratories
http://www.civent.carlton.ca/ecl	Carlton University case studies
http://www.cmu.edu	Carnegie-Mellon university
http://www.englib.cornell.edu	Cornell University engineering library
http://www.monster.com	East coast technical employment
http://www.e2w3.com	Electrical engineer's hotlist
http://www.techweb.cmp.com	E.E. Times magazine
http://www.epri.com	Electric Power Research Institute
sci.electronics	Electronic circuits database
http://www.eff.org	Electronic Frontier Foundation
http://www.commerce.net	Electronic marketplace catalog
Gopher to: enews.com	Electronic newsstand online magazines
sci.electronics repair	Electronic servicing and repair
http://www.careermosiac.com	Employment database links
comp.software.eng	Engineering software listings
http://galaxy.einet/einet/einet.html	Enterprise integration network
FTP to: ftp.prep.ai.mit.edu	Free Software Foundation
http://www.ge.com	General Electric online database
http://www.nearnet.gnn.com	Global network navigator
http://www.harris.com	Harris Semiconductor technical data
http://www.ieee.org	Institute of Electrical & Electronic engineers
http://www.intel.com	Intel technical product data
http://www.ibm.com	IBM online database
http://www.www.spie.org	International Society for Optical Engineering
http://www.internic.net	InterNIC net locator
http://www-atp.linl.gov	Lawrence Livermore National Laboratory
FTP to: ra.nrl.navy.mil	Macintosh Engineering Users Association
http://www.marshall.com	Marshall Industries semiconductor reference
http://www-mtl.mit.edu	Massachussets Institute of Technology
http://www.mathworks.com	Mathworks help and technical support
http://www.mrc.uidaho.edu	Microelectronics Research Center
http://www.motserv.indirect.com	Motorola online data library
http://www.hypatia.gsfc.nasa.gov	National Aeronautics and Space Admin
http://www.nist.gov	National Institute Science & Technology
http://www.nsc.com	National Semiconductor product information
http://www.nec.com	NEC semiconductor components
http://www.ageninfo.tamu.edu/jobs.html	Online employment agency links
sci.optics	Optoelectronic resources
sci.physics.research	Physics and physical sciences
http://www.dynemo.ecn.purdue.edu	Purdue University ee labs
http://www.sandia.gov	Sandia National Laborarory
http://www.sri.com	Sarnoff Research Institute
http://www.stanford.edu	Stanford University design research center
sci.math	State of the art mathematics
http://www.sun.com	Sun Microsystems access links
http://sunsite.unc.edu/unchome.html	Sun Microsystems technology exchange
http://www.ti.com/sc/docs/schome.htm	Texas Instruments technical data
http://www.berkeley.edu	University of California Berkeley research
http://www.bunny.cs.uiuc.edu/jobs	University of Illinois career center
http://www.ee.umr.edu	University of Missouri Rolla
http://town.hall.org	US patent database
http://www.uspto.gov	US patent and trademark office
sci.electrical wiring	Wiring standards
http://www.yahoo.com	Yahoo Internet directory

For more details on these sites: **http://techweb.cmp.com/eet/docs/eetff.html**

FIG. 4—IMPORTANT INTERNET SITES for electronic engineering.

```
$00D0 FAKEIT LDA (XX YY),X
$00D3 RTS
```

where HH is the high eight bytes of your calculated address and LL is the low eight bytes from your calculated address. To use your new address mode, you stuff the address values you want on into HH and LL and then call your new mode as an ordinary subroutine...

```
$03?? GETVAL JSR FAKEIT
```

Whenever control is passed back from the subroutine, the accumulator holds a copy of the value stashed at the sum of the calculated 16-bit address and the offset in the X register. You also have the option of using a JMP into RAM plus a JMP back into the normal program space, or even an indexed jump.

Among many other possibilities, you might now load, store, or jump indirect indexed. You can even do a JSR to an indirect indexed subroutine—a feature that is sorely lacking on many microcontrollers. The only penalties for this sneaky ploy are the extra machine cycles involved and the "loss" of four bytes of user RAM. Note that a subroutine call on a 6805 takes *twelve* or *thirteen* clock cycles to execute. Any PIC can do the same thing in *two* clock cycles!

This month's contest

If you are not familiar with the 6805, what you have just read might seem like so much gibberish. But every microprocessor family has its *insider snippets*—short and sneaky code sequences that do amazing things in ways previously unthought of ways. As another insider snippet, we looked at a PIC generating a high quality sinewave in an astonishing *six bytes* of code back in HACK85.PDF. So, for this month's contest, just tell me your favorite insider snippet for any low-end micro.

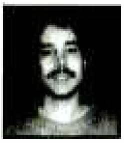
As usual, there will be a dozen or more copies of my *Incredible Secret Money Machine II* book going to the better entries, plus an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two for the best of all—or a tramway hunt if you prefer. The choicest (and hardest) pieces of the trace still remain. Bring your own catclaw, just in case we don't find enough on the route. Naturally, your 4WD vehicle gets an absolutely free Arizona pinstriping job. More information in GRAMTRAM.PDF. Be sure to send all your written entries to me here at *Synergetics* and *not* to the *Electronics-Now* editorial offices. To be fair to everyone, E-mail entries are not acceptable.

Important EE Internet sites

A detailed listing of the top one hundred EE Internet sites appeared

Continued on page 54

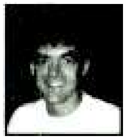
Just like these Fully Trained Electronics Professionals



"Thanks to CIE I have tripled my previous salary, and I am now in a challenging and rewarding new field where only the sky is the limit."
Daniel Wade Reynolds
Industrial Electrician
Ore-Ida Foods

"CIE was recommended to me by my boss. It was appealing since I could study at my own pace at home and during business travel."
Dan Parks
Marketing Manager/Consumer Products
Analog Devices, Inc.

"I loved the flexibility CIE offered. It was the only way I could continue both school and my demanding job."
Britt A. Hanks
Director of Engineering
Petroleum Helicopters, Inc.



"I liked the way the school was set up with laboratory assignments to enforce conceptual learning. The thing which impressed me the most about CIE's curriculum is the way they show application for all the theory that is presented."
Daniel N. Parkman
Missile Electro-Mechanical Technician
U.S. Air Force

"Completing the course gave me the ability to efficiently troubleshoot modern microprocessor based audio and video systems and enjoy a sense of job security."
Tony Reynolds
Service Manager/Technician
Threshold Audio & Video

Graduate with an Associate Degree from CIE!

CIE INSTITUTE OF ELECTRONICS · 1934 ·

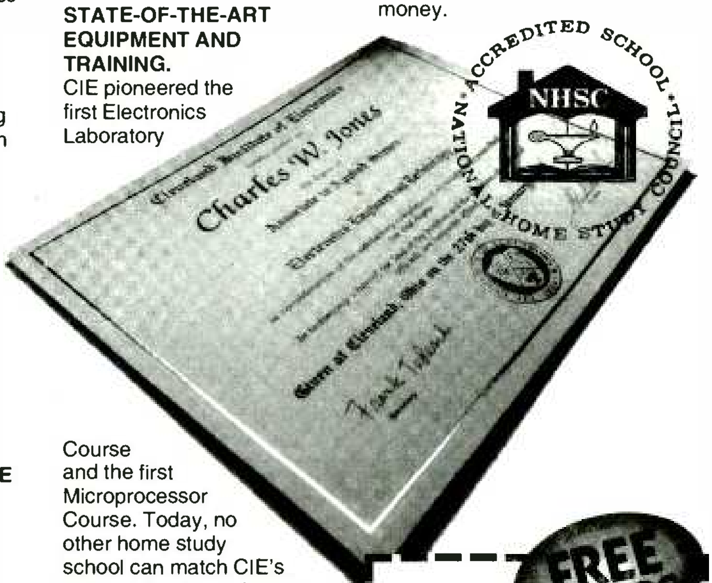
CIE is the best educational value you can receive if you want to learn about electronics, and earn a good income with that knowledge. CIE's reputation as the world leader in home study electronics is based solely on the success of our graduates. And we've earned our reputation with an unconditional commitment to provide our students with the very best electronics training.

Just ask any of the 150,000-plus graduates of the Cleveland Institute of Electronics who are working in high-paying positions with aerospace, computer, medical, automotive and communications firms throughout the world. They'll tell you success didn't come easy...but it did come...thanks to their CIE training. And today, a career in electronics offers more rewards than ever before.

CIE'S COMMITTED TO BEING THE BEST...IN ONE AREA...ELECTRONICS.
CIE isn't another be-everything-to-everyone school. CIE teaches only one subject and we believe we're the best at what we do. Also, CIE is accredited by the National Home Study Council. And with more than 1,000 graduates each year, we're the largest home study school specializing exclusively in electronics. CIE has been training career-minded students for nearly sixty years and we're the best at our subject... ELECTRONICS... IT'S THE ONLY SUBJECT WE TEACH!

CIE PROVIDES A LEARNING METHOD SO GOOD IT'S PATENTED.
CIE's AUTO-PRO-GRAMMED® lessons are a proven learning method for building valuable electronics career skills. Each lesson is designed to take you step-by-step and principle-by-principle. And while all of CIE's lessons are designed for independent study, CIE's instructors are personally available to assist you with just a toll free call. The result is practical training... the kind of experience you can put to work in today's marketplace.

LEARN BY DOING...WITH STATE-OF-THE-ART EQUIPMENT AND TRAINING.
CIE pioneered the first Electronics Laboratory Course and the first Microprocessor Course. Today, no other home study school can match CIE's state-of-the-art equipment and training. And all your laboratory equipment, books and lessons are included in your tuition. It's all yours to use while you study and for on-the-job after you graduate.



PERSONALIZED TRAINING....TO MATCH YOUR BACKGROUND.
While some of our students have a working knowledge of electronics others are just starting out. That's why CIE has developed twelve career courses and an A.A.S. Degree program to choose from. So, even if you're not sure which electronics career is best for you, CIE can get you started with core lessons applicable to all areas in electronics. And every CIE Course earns credit towards the completion of your Associate in Applied Science Degree. So you can work toward your degree in stages or as fast as you wish. In fact, CIE is the only school that actually rewards you for fast study, which can save you money.

Send for CIE's FREE Course Catalog and See How We Can Help Your Career Too!

FREE CATALOG

YES! I want to get started. Send me my CIE course catalog including details about the Associate Degree Program. (For your convenience, CIE will have a representative contact you - there is no obligation.)

Please Print Clearly

Name ____________

Address ____________

City ____________

State ____ Zip ________ Age ____

Phone No. ____________

Check box for G.I. Bill Benefits.
Veteran
Active Duty AE81

Cleveland Institute of Electronics, Inc.
1776 East 17th Street
Cleveland, OH 44114

A School of Thousands.
A Class of One. Since 1934.

BY LARRY KLIEN

Hum, Dance SPL, and Medical Music

LAST SUMMER MY WIFE SCHLEPPED ME, OUR SON, AND OUR DOG THROUGH AN 1,850 MILE DRIVE/VACATION IN NEW MEXICO. MY WIFE AND THE DOG ENJOYED IT VERY much. One of our tour stops was Taos, an area revered by many for its perceived New-Age spiritual qualities. From my old-age spiritual perspective, Taos and its crystal shops couldn't compete with Kyoto and its Zen temples, but Taos did have one thing that Kyoto lacked—an elusive hum heard by many Taos residents and others in the surrounding areas.

According to a local paper, this somewhat paranormal audio event appears as an incessant low-frequency vibration that has been described as sounding like a distant idling diesel engine by those who hear it. This noise drives certain Taos residents to distraction—despite the fact that most people in the area, including the Kleins, heard nothing special going on.

The situation came to the attention of Dr. Jim Kelly, director of ear research in the Department of Surgery at the University of New Mexico School of Medicine in Albuquerque. As an initial investigative step Kelly mailed out some 8,000 questionnaires to residents of Taos and adjacent areas within a 60-mile radius. There was a high 18 percent return with 11 percent of the respondents reporting having heard the hum. When statistical weighting was applied to the results, it appeared that perhaps one percent of the local population was hearing something out of the ordinary.

Kelly and his associates used standard audiological comparison techniques to pin down the hum's spectral characteristics. The tested "hearers" agreed that a 20 to 80 Hz "carrier" AM modulated at 1 or 2 Hz duplicated what they heard—which accounts for the "idling diesel engine" description.

Meanwhile, other investigators were pursuing other theoretical causal agents. For example, a team armed with various low-frequency detectors and geophones plumbed the depths of Carlsbad Caverns exploring the possibility that some sort of seismic phenomenon was at work. Nothing showed up. (The Kleins when visiting the Caverns didn't hear anything strange either.)

Other source ideas include secret Government VLF transmissions to communicate with submarines—and who knows what else? And of course, we shouldn't leave out the ever-popular space aliens communicating with their mother ship. In any case, theories (mostly untestable) run rife.

Dr. Kelly's hypothesis is that the phenomenon is real and entirely natural—if somewhat difficult to explain. His operating theory, which is yet to be proven, is that atmospheric inversions have produced resonant channels by a tunneling effect arising from differing densities of air in the atmosphere. The resonance signal is very low in amplitude and is normally masked by ambient noise. A sensitive listener—meaning someone with excellent low-frequency hearing—can detect the signal through the noise and, once having done so, for better or worse, is then subjectively attuned to it. Apparently also required are the mountainous areas that produce the temperature inversions and a very low level of ambient environmental noise.

I suspect that those of us living in or near big cities rather than in the wide open and mountainous spaces of New Mexico will remain untroubled by mysterious hums. As far as I know, no one has advanced the theory that something is humming simply because it doesn't know the words. (Sorry, I couldn't resist.)

School dance update

I've written twice before about my efforts to damp the deafening decibels at our local middle-school dances. After my last article I checked out one more dance. Surrounded by prancing pre-adolescent middle-schoolers, I measured between 95 and 105 dB over the course of the evening. This, despite the DJ's promise to keep it down. (By his normal standards, perhaps he did.)

I reported my findings to the school principal. Apparently he, and the other interested parties, had finally been convinced by my white paper (See the June and July 1995 Audio Updates) and were ready to endorse and enforce my recommendation for a maximum DJ level of 85 dB (measured at 8 feet, slow response, A weighting).

Armed with a new sense of power and my sound pressure level (SPL) meter, I dropped in on the new DJ as he was setting up for a dance. He and his group had been alerted to my arrival and appeared willing, even anxious, to cooperate. To start, I positioned myself on a centerline 8 feet in front of the speakers and asked them to play something at their "normal" dance volume. My SPL reading averaged about 110 dB!

I showed them the reading and asked that they slowly turn the volume down until my meter showed the "legal" maximum of 85 dB—and to leave the volume at that level for the rest of the evening. I turned over my Radio Shack SPL meter with instructions for its use to one of the teachers monitoring the dance and left.

When I checked with my son the next day, he said that the music sounded fine and that none of his friends complained that it wasn't loud enough. I don't expect that the same situation would obtain at a high school dance where the students were used to the aural overloads of live rock concerts, but for the next several years at least that's outside of my jurisdiction. (However, the high school principal has been given a copy of my white paper.)

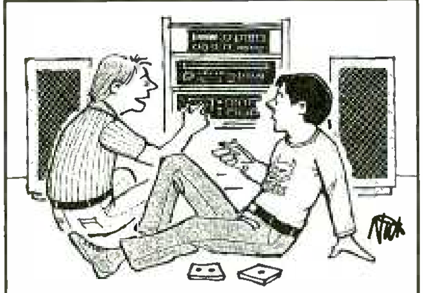
The musical cutting edge

Those of us who are addicted to prime-time hospital shows (ER and Chicago Hope) may have been bemused by the musical accompaniments the TV surgeons seem to demand while slicing and dicing their patients. Apparently, music to extract organs by is not simply a scriptwriter's fantasy but is drawn from real life.

A study recently published in The Journal of the American Medical Association concluded that surgeons were likely to do a better job when operating with a musical accompaniment. Fifty doctors were tested as having lower blood pressures and pulse rates and doing better on non-surgical mental exercises when listening to their preferred musical selections. Lest potential patients become concerned about wild rock-and-roll parties during their surgeries, one interviewed doctor felt it necessary to make the point that the music is always played softly.

Medical musical taste varies widely, including country & western, jazz, Mozart, Beatles, Beethoven, and, of course, silence. The last, in fact, is the choice of some older surgeons. One doctor who brings his personal boom-box to the operating room prefers to vary the musical program in accord with his surgical progress. "Opening and closing (the patient) in neurosurgery is lengthy," he said, "but not particularly difficult. For that I use something upbeat. But when I work under a microscope to remove brain tumors, I play Mozart or Vivaldi." Apparently some hospital operating rooms now come equipped with car stereo components as a reasonable alternative to portable boom boxes.

Mind you, all of this music is meant to aid and comfort the surgeon, not the patient. However, there have been claims that patients under anesthesia can hear and remember doctors' comments made during their surgeries. It would be interesting, but unlikely,to find that patients occasionally wake up with, say, their appendix removed and a love of Mozart installed. EN



"It's digital audio. My dad puts his fingers in his ears when I turn it on."

BY JEFF HOLTZMAN

Solipsism and Cyberspace

THIS COLUMN IS SOMEWHAT DIFFERENT FROM USUAL. USUALLY I TRY TO PRESENT SOME THOUGHTS ON ONE CENTRAL TOPIC IN A LINEAR FASHION. THIS TIME I'M GOING TO DISCUSS SEVeral seemingly unrelated topics more or less independently. Then I'll braid them together to show the complex interrelationships among them. My purpose in this is not to provide a definitive answer to the problems that I raise, but rather to instill in you some sense of wonder about how certain themes of human existence keep surfacing again and again in different ways throughout history. The topics are:

- Philosophy and science
- Solipsism
- Going places
- Storytelling
- Space

Philosophy and science

Philosophy gets a bad rap today, some of it deserved, some not. If they think about it at all, most people think of philosophy as high-falutin' but useless discussions performed by white-bearded university professors. Or else they think of new-age "philosophers," shaman espousing "feel-good-ism" over substance. In truth, a philosopher is simply a lover (philos) of knowledge (sophos). A true philosopher asks hard questions and doesn't settle for easy answers.

Philosophy attempts to gain knowledge about the world by means of reason, thought, and discourse. But ours is a scientific and technological age. We believe in scientific method: observation, experimentation, and verification. We don't merely assume that heavier bodies fall faster than lighter ones because it seems logical; we perform tests to prove—and to disprove—our conjectures.

Philosophy and science were not always so antithetical; scientists used to be called natural philosophers. Science and philosophy were seldom united in one person, but there have been exceptions, such as Descartes. Science and philosophy have done nothing but diverge since the beginning of the Industrial Revolution, but certain pesky philosophical problems have nonetheless continued to raise their ugly little heads in scientific circles. Early in this century, for example, Heisenberg's Uncertainty Principle taught science a lesson in humility concerning the achievable goals of the profession. Perhaps some things are in principle unknowable.

Solipsism

An extreme philosophical point of view is called *solipsism*, which is the theory that the self is the only thing that can be known and verified, or that the self is the only reality.

Thus, if I were a solipsist, I could simply say that you don't exist. Or I could say that you may exist, but I have no way of knowing for sure. Or I could say that you (and everything else) are just figments of my imagination. Even if I grant that you exist, I can never really *know* you or your thoughts. I can never really know whether, when we're looking at something, we're seeing the same thing. I see red, you see orange. I hear Bach, you hear cacophony. I see an elegant design; you see a convoluted mess. I see a promising young athelete; you see a vicious murderer. I see a greed-ridden businessman; you, a generous benefactor. I see a classic automobile; you, an uncomfortable old gas guzzler.

The point is that even in the everyday world, it is hardly uncommon for two people to see two totally different things when looking at what appears to be the same physical object. Then along come cyberspace, virtual reality, and software generally. When you start thinking about what these things are, full-blown solipsism starts looking downright tame.

Going places

Did you ever notice how people talk about software? "Go to the file menu, click open, and . . ." or "Go to the Windows System directory, and . . ." or "Go to this great new

Web site . . ." But what does it mean to "go" to a menu or a directory or a Web site? Obviously we mean something different than when we tell a recalcitrant child "Go to your room!" (Under other circumstances, it is unlikely that we would tell the child "Go to your home page!") More generally, how can we "go" anywhere at all when we're seated mobile before a computer screen?

Back in the real world, things may seem simpler, but they're not. Listen to this conversation:

A: I'm going on vacation next week.

B: Really? Where are you going?

A: Nowhere, really. We're staying at home this year. What about you?

B: We're going canoeing on the Current River.

A: We don't go there are any more. It's not the same as when we were young. Too many people, too much noise, too much pollution.

B: It's hardly the same as when it was settled. . . .

Think about returning to a place after the death of someone closely associated with it. The place seems different, even though it hasn't changed. Think about returning anywhere you spent significant time: your home town, your college, your high school, your grade school, the house you grew up in.

Ancient Greek philosopher Heraclitus was right: *You could not step twice into the same river; for other waters are ever flowing on to you.*

Storytelling

People have a universal tendency to anthropomorphize the external world and things in it. In other words, we assign to inanimate objects and other species human characteristics. We see ourselves reflected in the external world. Our society, in its attempt to digest the changes being wrought by computer technology, is anthropomorphizing the computer.

Two films, *The Lawnmower Man* and *Virtuosity* exemplify this tendency. In this view, cyberspace becomes a magical alternate world, directly analogous to the one we live in, perhaps with the same physical constraints, perhaps with enhancements such as increased mental or physical powers.

This type of displacement seems very imaginative, but it's not. It seems so because of the special effects (provided ironically enough by cyber equipment). In fact, the basic idea is as old as the oldest folk tales. Alice goes through a magic mirror to enter another world. Spaceships enter other galaxies. People enter subterranean caverns and encounter strange creatures. People enter ghost worlds through cemeteries or sacred grounds. There are stories of repetition at scales ranging from the microscopic to the cosmic.

So the stories behind these new cyberflix aren't really so new after all. In fact, they're just the same old adventure stories, but with the cyber stuff serving as the portal to and from the other world.

Space

The computer has brought us a new kind of "space," along with new ways to "go" to and from it, and new ways of existing "in" it. Science fiction and popular culture represent cyberspace as an different-but-equal form of the everyday space we take for granted. But the truth is a whole lot more subtle, more complicated—and more interesting.

What is the truth about cyberspace? Suppose that space in general is an abstract class from which other specialized instances of space descend. For example, there is cyberspace, fishing and hunting space, book space, sports space, music space, war space, drama space, love space. . . What these different kinds of space share is that they provide an arena for human activity, a "place" where production and transformation and synthesis can occur.

In this sense, everyday 3Dspace is a necessary but insufficient condition for any other kind of space. In other words, without 3Dspace, none of the others could exist; on the other hand, the existence of 3Dspace is no guarantee of the existence of any other kind of space.

Further ideas

Here are a few more thoughts:

- Imagine a treasure hunt in which a

hunter takes an initial false step. Then every subsequent step moves the hunter farther and farther from the goal. Now suppose that knowledge was the treasure, and that 2000 years ago an early Greek hunter took a wrong step.

- There is no such thing as virtual reality. All reality is virtual. More precisely, every reality is virtual.
- Space is not the final frontier. Space was the initial frontier. And it is not the most interesting frontier.
- Material space is only known through abstract space.
- The computer is only truly interesting in how it opens up new kinds of space, not in how it reinterprets existing forms.

Final thought: *Metaphors are much more tenacious than facts.*—Paul de Man

E-mail

Lots of people empathized with the "Politically Correct = No PC" column. Some however seemed to want to limit the interpretation of PC to Intel-based machines running MS-based software. In that context, I meant "PC" in the most generic sense: PC, Mac, whatever.

In that vein, I've been hearing from a surprising number of Mac users lately. More than one claims that Windows 95=Macintosh84, but that's ridiculous. The Macintosh in 1984 was a 128K machine that would "never need to be upgraded." No color, small screen, no hard disk, limited keyboard, no multitasking, . . . However, based on the increasingly strident tone of the Mac-related messages I've been receiving, I can't help but wonder whether the Mac is now headed down the same spiral as the Amiga. Methinks the Mac-ies do protest too much. Can Apple avoid the fate of Commodore?

Several people out there were offended by my implication that DOS is dead. OK, sure, you can put it on life support, give it dialysis every day, patch it, upgrade, compress it, expand it, do whatever you want with it, but it's dying. Most major software development companies have dropped all plans for further development of DOS versions, and will soon drop support as well. You can sit around and wait for it to happen, but why not just get with the program?

On the other hand, I keep hearing good things about Linux. The best thing that people seem to have to say is that Linux is not DOS/Windows. Question: Where are the apps? I can certainly see using Linux as an Internet gateway or Web server or something similar. But in that scenario I see it in the computer room of a moderate size company, not on desktops running 1-2-3. If a Linux vendor put together a CD of quality application programs, precompiled, documented, and with filters for popular file formats—then *maybe* there would be some broad-based interest.

John Harrison had some interesting comments about how software development is performed in his company: ". . . if you want to write a program the first thing you do is turn off the computer. The 'hack until it is OK' syndrome seems to me to lead to a 'well I guess it works' mentality where the customer is expected to figure out that it doesn't work and yet understand it well enough to describe what went wrong! Whatever happened to . . . "'I have thought this through and believe it is correct."

Contact me at jkh@acm.org. EN

HARDWARE HACKER

Continued from page 46

in *E.E. Times* for July 10, 1995, pages 75-78. I have extracted some of the more interesting of these for you in Fig. 4.

A new MIDI book

Craig Anderton just sent me a copy of his unique *Digital Projects for Musicians* book. The book is helped along by Bob Moses and Greg Bartlett, and introduced by Herbie Hancock. It contains some 363 oversize pages for $24.95; it's published by *Amsco*. Included are all sorts of hardware and software MIDI goodies. Software and development tools are separately available. One source is PAVO. Most projects use the 6805 microcontroller.

Craig's earlier *Electronic Projects for Musicians* was a classic. Some additional electronic music resources appear in my NUTS43.PDF. One good source for MIDI and other electronic music books in general is the *MIX Bookshelf*.

New tech lit

From *International Rectifier*, there's a free new 1700-page *Hexfet MOSFET Designer's Manual*. And *Texas Instruments* has an equally thick *MOS Memory Data Book*. *Atmel* is offering free samples of its new serial EEPROMS. These are non-volatile memories with densities to 64K and operating voltages down to 1.8 volts. *Maxim* has a new *Power Supplies Design Guide*. It includes dozens of ready-to-go circuits.

Sysop News & Cyberworld Report is a tabloid for online sysops. *Biophotonics International* is a brand-new trade journal centering on UV, visible, IR, and submillimeter light solutions for biotechnology and medicine. A tutorial on new mystery band applications (which are called T-Rays) showed up in the July 95 edition on pages 58-59.

Sports radar systems are sold by *Radar Sales*. Uses include baseball, jet skis, race cars, boating, and RC models. Many of them are recycled police speed radars. Others are new units that have been designed from the ground up for sports uses.

I still get lots of calls concerning VCR Plus+ codes—these are highly proprietary. The leading resource here is *Gem Star Development Corp.*

I've just added a MAGSINET .PDF magic sinewave tutorial to PSRT. The already impressive magic sinewaves in last month's column have also been dramatically improved. This is an outstanding new power-electronics opportunity for you, one that promises to revolutionize power electronics forever. Especially for home energy management.

A new disabled and handicapped resource directory has also been added as NUTS44.PDF. A reminder that my *Active Filter Cookbook* is once again back in print. Autographed texts are now available through my *Synergetics Press*. Reselling partners are welcome. EN

EQUIPMENT REPORTS

Continued from page 16

a 5¼-inch self-booting diskette. Copies of the disk made using DOS's DISKCOPY commands won't work.

PC Clinic is very easy to use, and can be controlled from a keyboard or mouse. You simply insert it in the A: drive and press Ctrl-Alt-Del to reboot the system. If the system is not already you just stick the disk in the A: drive and turn on power. PC Clinic SB is an intensive low-level hardware diagnostic system with its own built-in operating system. A main menu presents five options: The Configuration option displays information concerning the computer's hardware configuration. The Tests option accesses all of the diagnostic tests. The Benchmarks option indicates processor, coprocessor, video, and fixed-disk performance.

Using PC Clinic

The Configuration menu is used to see how a computer is currently configured. Information on the hardware, CMOS setup, IRQ and DMA usage, memory configuration, and drive partition information is displayed. Information stored in the computer's CMOS memory can be edited. The Configuration menu is divided into General, Video, Memory, Disk Drive, and Port sections, and within them every aspect of a computer's hardware configuration can be checked.

The Diagnostic Tests menu performs various tests on the computer hardware. CPU tests include the main CPU and NPU, internal registers, DMA channels 0–3 on the first DMA controller and 4–7 on the second controller, IRQ 0–7 on the first IRQ controller and 8–15 on the second controller (not available on PCs and XTs), timer channels, real-time clock, and CMOS RAM. Memory tests include base memory from 0 to 640K, extended memory (all memory above 1024K), and video RAM.

Disk drive tests are included for floppy and hard drives. Floppy drives are tested for drive-ready status, write-protect, sequential read/verify, random read/verify, and sequential write. Hard disks tests include drive ready, controller diagnostics, sequential read/verify, random read/verify, and accordion read/verify. Serial and parallel port tests can also be performed, and the video card and monitor can be exercised as well.

Benchmark tests are used to measure the performance of the hardware installed in a PC. The processor benchmark determines the speed of the microprocessor and calculates an index relative to a PC/XT running at 4.77 MHz. A similar test is used for the coprocessor. The video benchmark tests the speed of the video card's graphics and text RAM and tests the display speed of the video BIOS. Results are displayed in kilobytes per second. The BIOS display speed is calculated by measuring how many characters can be written to the screen through BIOS in one second. The speed of fixed disks, fixed-disk BIOS, fixed-disk device drivers, and disk-caching software can also be measured and displayed.

Is it worth it?

PC Clinic's clever way of not using any of a computer's loaded software makes it easy to properly determine the status of its hardware. It can help you determine whether the solution to a computer problem involves hardware repair or replacement or just software reformatting. It is also a quick way to give brand new PCs a clean bill of health without loading any software onto them. A print out of every test report display is an invaluable way to record permanently your computer's specifications.

When you obtain PC Clinic or a new computer, run the program and obtain all the printouts. Compare the reports against your computer's printed specifications. You never can tell, you might have been short changed on the computer purchase. People who own only one computer should seriously consider the $199 investment in the software, particularly when you adjudge the cost of your entire computer setup and what downtime will cost you! Nevertheless, anyone who regularly has to deal with (fix!) malfunctioning computers will appreciate what PC Clinic has to offer. EN

JACOB'S LADDER

continued from page 28

ondary contains 2500 turns. The ratio of these turns is approximately 1 to 78. When multiplied by the rectified line voltage of 160 volts DC, an output of about 12,000 peak volts is obtained across the secondary.

This 12,000-volt output is the peak open-circuit voltage of the system, and it produces a short-circuit current of approximately 40 milliamperes. This current is limited by the leakage inductance caused by the loose magnetic coupling between the primary and secondary circuits of transformer T2. This leakage inductance can be controlled to some extent by placing air gaps between the cores, changing the reluctance of the magnetic circuit.

Safety provisions

Because this project is operated from the 120-volt AC line, fault and safety shutdown provisions are included. They are provided by silicon controlled rectifier SCR1 connected as shown in Fig. 1 with its anode in series with diode D3. When the gate current reaches a specified threshold, the SCR is triggered on and latched by the holding current through resistor R4. TRIGGER pin 2 and THRESHOLD pin 6 of IC1 are now clamped to ground, thus preventing oscillation and turning off the circuit.

The signal current for the gate of SCR1 is obtained from the capacitive connection to the actual core of the output transformer T2. This connection is made by winding three to four turns of insulated hookup wire around the core of transformer T2. In effect, it is a capacitive wire pick-up probe. As long as output current is flowing between the output connections of T2, the Jacob's Ladder will continue to operate.

If, for some reason, one of the output leads (vee strips) is grounded, a return current is forced to flow by capacitive action between the core of transformer T2 through the wrapped-wire pick-up probe. This current then turns on SCR1, shutting down the Jacob's Ladder.

Building the circuit

The high-voltage power supply circuitry for the Jacob's Ladder can be built by point-to-point wiring methods on a $5\frac{1}{2} \times 2\frac{1}{4}$-inch piece of standard perforated circuit board (holes spaced 0.10-inch on centers) or on a circuit board available from the source given in the Parts List. Drill mounting holes in the four corners of the circuit board before inserting any electronic components.

All of the electronic components with the exception of transformers T1 and T2 are standard, off-the-shelf components available from electronics stores and mail-order distributors. However, the transformers must be custom wound. Both transformers, completely wound and tested, are available from the source given in the parts list. Alternatively, you can wind your own tranformers if you have some experience in doing this. Some useful information on winding these transformers and material selection is given later in this article under the heading, "Winding the transformers."

Refer to schematic Fig. 1 and parts placement diagram Fig. 2. The parts placement diagram gives the approximate locations of all components except for switch S1 and transformer T2, which are off-board components. There is nothing critical about parts placement, and the suggested layout of Fig. 2 is based on keeping interconnecting wiring as short as practical. Be sure to make the gate connection to MOSFETs Q3 and Q4 as short and direct as possible.

Begin by inserting and soldering all components except MOSFETs Q3 and Q4. Observe the correct polarities for all silicon diodes, (D1 to D3), Zener diodes (D4 and D5) and electrolytic capacitors (C3 and C5). If you wire point-to-point, do not trim the leads of the components until you have made use of as many excess lead lengths as is practical to form interconnections between components.

Then insert the TO-220-packaged MOSFETs Q3 and Q4 close to the outer edges of the circuit board in the locations shown in Fig. 2, with their metal tabs are facing outward. In a later step, the tabs of Q3 and Q4 will be fastened to the sides of a U-shaped channel that functions both as a heatsink and as a support for the circuit board.

Carefully examine all the electronic components on the board to be sure that they are correctly placed and oriented. Examine all solder joints to verify that there are no inadvertent solder bridges or cold solder joints. Make any corrections at this time before proceeding. Then set the completed circuit board aside.

Product enclosure

Figure 3 illustrates the author's enclosure for the Jacob's Ladder project. It was designed to meet two objectives: 1. to meet all reasonable safety re-

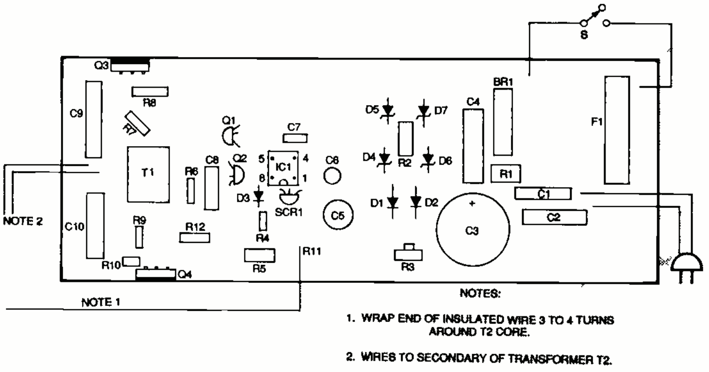


FIG. 2—PARTS PLACEMENT DIAGRAM for high-voltage power supply.EP

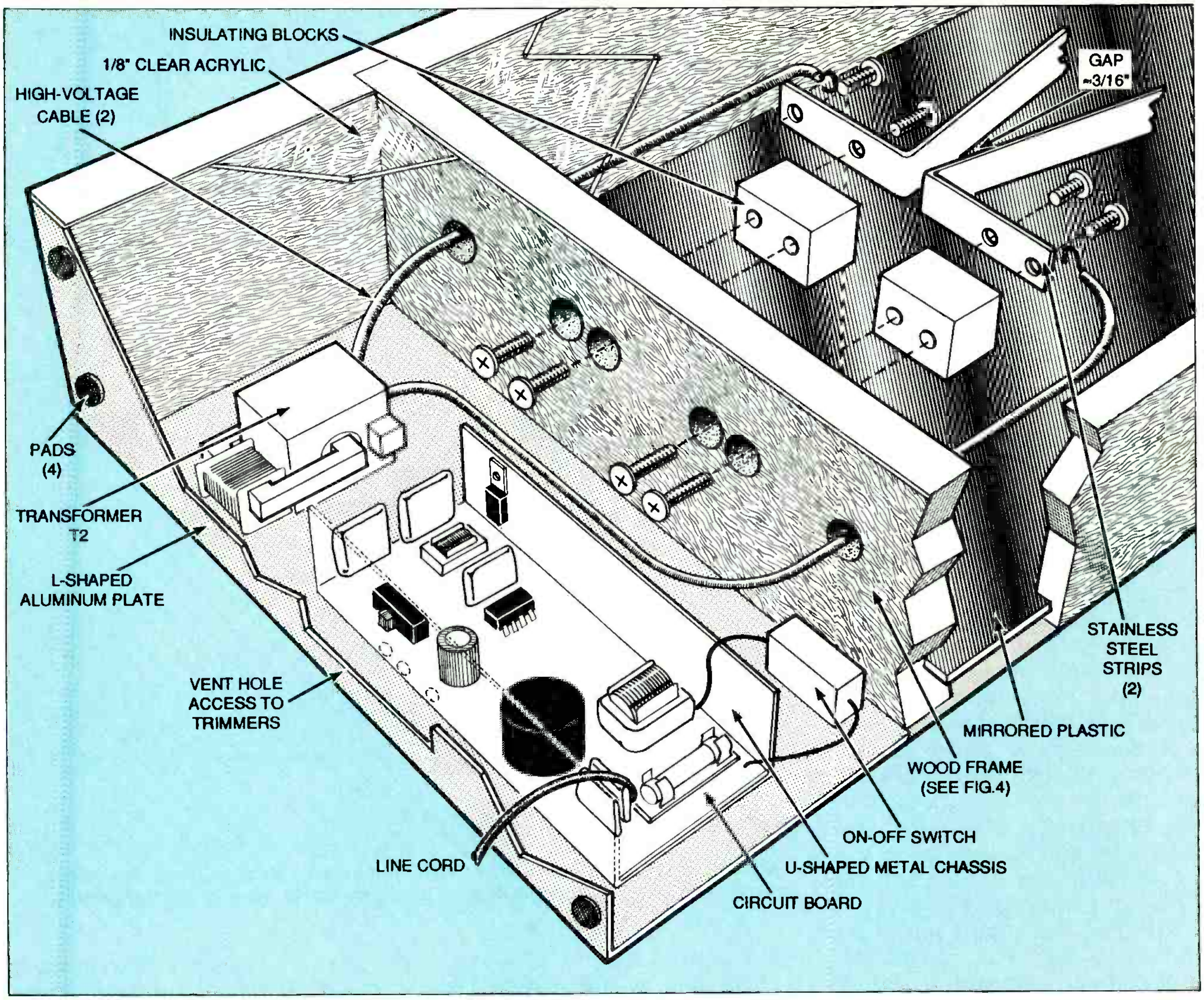


FIG. 3—ASSEMBLY DIAGRAM FOR JACOB'S LADDER. All circuitry is enclosed with insulating wood and protective plastic covers.

quirements by providing adequate insulation between people and flammable materials and the enclosed high-voltage circuitry, while at the same time protecting the circuitry from dust and dirt. 2. to be simple enough to be made by persons with minimal carpentry skills from materials readily available at hardware and home-improvement stores.

Many variations on the author's enclosure design are possible including changes in exterior and interior dimensions and the substitution of more expensive wood for the framing. However, it is imperative that all provisions for ventilating both the circuitry and the vee "ladder" to dissipate any heat buildup be followed, but make sure that those spaces are not large enough to admit fingers or the small hands of curious children.

The overall case dimensions are 24 × 12½ × 4 inches. The closed H-shaped frame was made from ¾-inch thick × 4-inch wide soft wood. Slots that are ⅛- inch wide and ¼ deep were milled ⅛-inch in from each edge of the inside surfaces of the frame members to accommodate protective transparent plastic covers on the front side and a metallized plastic mirror on the back side. (These protective sheets could be fastened directly to the case edges with screws.)

The bottom of the case and the back of the lower circuit/transformer compartment is covered by an L-shaped aluminum plate that serves as the vertical support for the circuit board and output transformer. Holes drilled in the bottom of this plate permit circuit ventilation and access to the on-board trimmer potentiometers R3 and R5. Another hole is formed in the back of the plate for mounting ON-OFF pull switch S1.

Figure 4 provides general information on the sizes and shapes of the principal wood and aluminum parts. Notice the holes drilled in the top member of the frame for cooling the ladder compartment. The author's prototype frame was made by assembling the wooden frame with screws after the clear ⅛-inch plastic front windows and rear mirror were cut to fit the milled slots.

The transparent plastic cover

for the ladder compartment was cut 1-inch shorter than the inside dimensions of the frame to provide a bottom opening for ventilation. This ventilation slot is important and should be there regardless of any dimensional changes you might want to make in the frame. The cover for the circuit compartment protects that compartment completely. It is transparent plastic in the prototype so that the circuitry could be seen, but it could be opaque.

Project metalwork

No hole sizes or location dimensions are given here for the enclosure components. Those are left to the builder's judgment. Cut and form the U-shaped aluminum channel from No. 22 gauge sheet aluminum, as shown in Fig. 4. Drill holes in both ends of the channel along the centerline. Then, using the drilled holes in the circuit board as a guide, centerpunch and drill four holes for mounting the circuit board to the channel. (These can be omitted if you elect to bond the circuit board to the channel with hot plastic glue drops.)

Cut the L-shaped panel as shown in Fig. 4 from No. 22-gauge sheet aluminum. Before bending the front lip or folding the plate, drill 1-inch diameter holes for circuit cooling and access to trimmer potentiometers R3 and R5. Above the fold line, drill another hole for the linecord, large enough to admit a rubber or plastic grommet, and drill a hole to accommodate chain-pull switch S1. Then bend the flat plate 90° along the fold line and bend up the front lip.

Drill two holes evenly spaced within 2 inches of the ends of the stainless steel "ladder" strips, and bend those 2-inch long sections approximately 90° with respect to the rest of the strips. Note: Stainless steel was selected for the ladder strips because the electric arcs will not cause the strips to oxidize or corrode, and tests showed that stainless steel permits easier starting of the arcs than other metals.

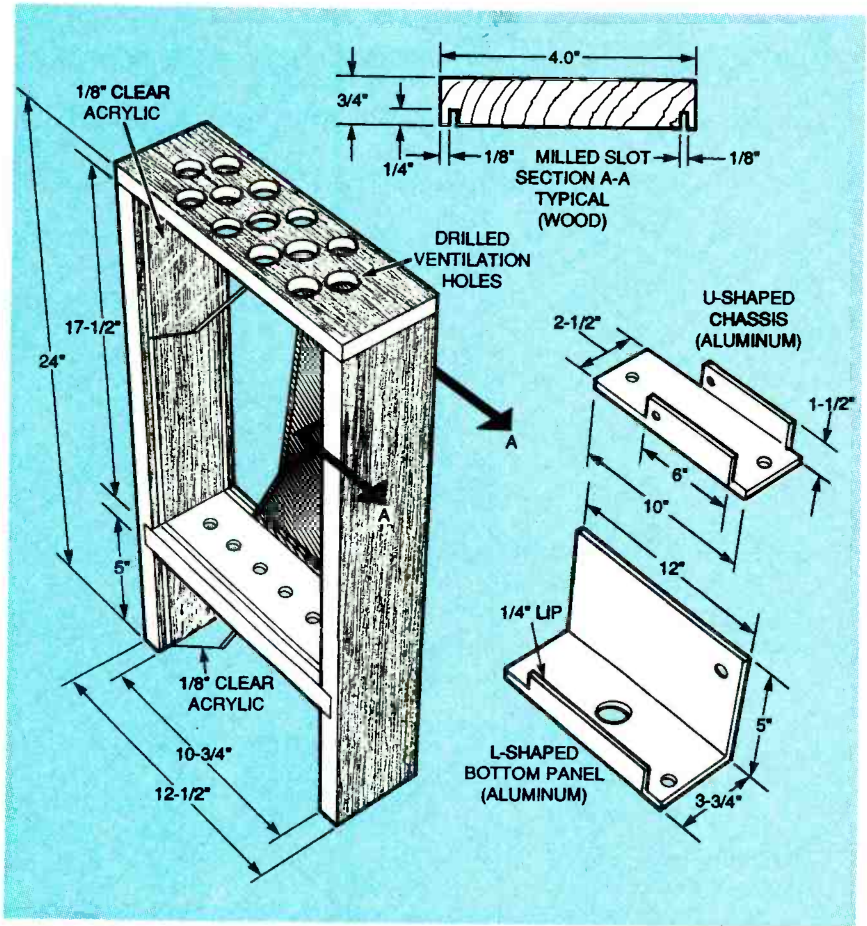


FIG. 4—JACOB'S LADDER ENCLOSURE and circuit mounting hardware details. All materials are readily available at most hardware and home-improvement stores.

Insulator blocks

The two metal strips that form the "ladder" must be mounted on insulators that have high dielectric strength. The insulators in the prototype were made from Teflon blocks that measure $1\frac{1}{4} \times 1 \times \frac{3}{4}$-inch high. This material can be drilled and tapped, and it is strong enough to withstand the heat created by electric arcs. Individual Teflon blocks are available from the source given in the parts list.

Project assembly

With the completed circuit board inserted in the channel, elevated slightly above the bottom of the channel, mark, centerpunch and drill the holes in each side wall for fastening the tabs of MOSFETs Q3 and Q4. Be sure to deburr and perhaps countersink slightly the holes in the channel so that the tabs on the MOSFETs will be clamped securely against the channel walls. Cut and trim the ends of two 3-inch lengths of insulated, stranded linecord to the circuit board, as shown in Fig. 2, to make the connections with the linecord. Insert and solder the ends of the wires on on-off switch S1.

Attach the circuit board to the U-channel with screws and nuts, using several nuts as standoffs to isolate the circuit board from the channel. Align the tabs of MOSFETs Q3 and Q4 with the holes in the sidewalls of the channel, insert insulating mica washers with a film of silicone grease between each tab and the channel walls, and fasten them with screws and nuts.

Cut a 2½-inch square of phenolic laminate or circuit board stock and place it between the base of transformer T2 and the bottom of the channel. Bond the transformer to the insulator and channel base with epoxy or hot glue.

PARTS LIST

All resistors are ¼, 10%, unless otherwise specified.
R1—0.47 ohm, 2 watt
R2—82 ohms, 2 watt
R3—2000 ohms, PCB-mount, trimmer potentiometer
R4, R8, R10, R12—1000 ohms
R5—10,000
R6—10 ohms, 1/4 watt
R7, R9—27 ohms
R11—1229 ohms

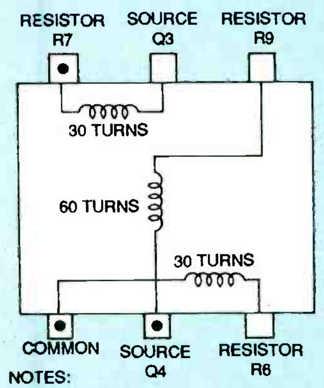
Capacitors
C1, C2—0.01 µF, 1000 volts, ceramic disk
C3—390µF, 200 volts, aluminum electrolytic
C4—2.2µF, 250 volts, metallized polyester
C5—1000µF, 25 volts, aluminum electrolytic
C6—0.003 µF, 50 volts, polyester film
C7—0.01 µF, 50 volts, ceramic disk
C8—1.5 µF, 100 volts. metallized polyester film
C9, C10—1.2 µF, 400 volt, metallized polyester film

Semiconductors
BR1—bridge rectifier, silicon diode, 4 ampere, SIP
D1, D2—1N4007, 1000 volts, 1, ampere, silicon diode
D3—1N914, silicon diode
D4. D5, D6, D7—1N4735 Zener diode, 6.2-volt, 1 watt
SCR1—silicon controlled rectifier 0.8 ampere, 200 volt, sensitive gate, TO-92, Teccor EC103B1 or equiv.
Q1—2N2222, NPN transistor
Q2—2N2907, PNP transistor
Q3, Q4—IRF640 N-channel power MOSFET, 200 volt, 10 ampere, International rectifier or equiv.
IC1—555 timer

Magnetics
T1—driver transformer, 30 turns primary, 60 turns two secondaries (see text)
T2—output transformer, half bridge, 32 turns primary , 2500 turns secondary (see text)

Other components
S1—switch ,SPST, panel-mount, 10 amperes, pull chain
F1—fuse, 3 ampere, slow-blow
Miscellaneous: uit board or perforated board (see text); U-chassis, (see text); mirror, metallized plastic (see text); transparent plastic covers (see text); L-panel, (see text) stainless steel strips, 0.060-inch thick, 18-½ inches (see text) insulating blocks (see text); high-voltage wire, 15 kilvolt rating, 2 feet; 3-wire power cord with line plug; fuse holder; phenolic transformer insulator (see text); hookup wire; miscellaneous nuts, screws; rubber feet,four; linecord grommet; silicone grease; TO-220 mica washers; solder.

Note:The following parts and kits are available from Information Unlimited, Box 716, Amherst, N.H, 03031; Telephone 603-673-4730; Fax 603-672-5405:
- **Kit of electronics components and circuit board, less transformers—$69.50**
- **Assembled and tested electronic circuit board—$89.50**
- **Assembled and tested driver transformer T1—$9.50**
- **Cores and bobbins for driver transformer T1—$4.50**
- **Assembled and tested high-voltage transformer T2—$24.50**
- **Cores, bobbins, and potting cap for high-voltage transformer T2—$14.50**
- **High-voltage wire (15 KV)—$0.50/foot**
- **Teflon insulating blocks (2 required)—$5.00**



NOTES:
DOTS ON PINS INDICATE STARTING POINTS FOR ALL WINDINGS.
FOR SOURCE OF CORES AND BOBBIN, SEE TEXT.

FIG. 5—TRANSFORMER T1 WINDING. This is the "footprint" for driver transformer T1.

Drill two holes through the wooden frame member between the two compartments, and drill mating holes in the two insulating blocks. Drill a single hole in the opposite sides of each block and fasten the ladder strips to the blocks with screws, as shown in Fig. 3.

Then attach the insulation blocks and strips to the frame member with screws. Fasten the bent metal strips so that they are offset by about 30°, as shown in Fig. 3. The base strips are diagonal across the insulator blocks so that the corner edges are separated by about 3/16 inch. The upper ends of the strips should be about 2 inches apart.

Fasten the channel with transformer T2 and the circuit board to the L-shaped panel with screws and nuts, as shown in Fig. 3. Complete the installation of switch S1 and the linecord with a grommet, and complete all soldering. Be sure the L-shaped metal panel is hard-wire connected to the earth ground by means of the green wire within the three-wire power cord. Assemble the enclosure with its plastic covers and aluminum base plate. The Jacob's Ladder is now complete.

Adjusting the ladder

Carefully examine your work to be sure that there are no inadvertent short circuits or cold solder joints. The circuit is now ready for testing. First, adjust potentiometer R5 as follows:

1. Disconnect one end of R1 to Q3.
2. Connect an oscilloscope to the Q4 gate.
3. Plug in power cord and turn on power.
4. Adjust R5 for a period of 40ns so 15-volt squarewaves are symmetrical.
5. Shut off power, reconnect R1, and connect the oscilloscope to the Q4 drain. Turn on power. A near perfect squarewave should appear, and it should remain constant as arcs form and reform.

Adjust the ground-fault potentiometer R3 to shut off the circuit if there is ground-fault current.

1. Turn off power and set wiper of R3 for maximum sensitivity.
2. Disconnect a high-voltage lead from a ladder strip, and connect it to ten 1-watt, 100 kilohm resistors in series. (This simulates a 10 milliampere ground current.)
3. Apply power and verify that the circuit shuts down. Turn off power, adjust R3 slightly clockwise. Reapply power until high voltage stays on. Note: Allow time for C3 to discharge before reapplying power or SCR1 will stay on.

Winding the transformers

Figure 5 is a "footprint" diagram of drive transformer T1 with callouts that can be related

Continued on page 87

ELECTROCHEMISTRY

continued from page 30

lowers the impedance so that it can source currents up to 1 ampere. The feedback loop consists of resistors R2, R4, R3, and R5. Operational amplifier IC5-a is configured in the feedback loop to compensate for voltage drops across the transistors (i.e., 0.7 volts each). Consequently, the output is a low impedance "mirror" of the input.

A method for measuring the output current and converting it to a voltage allows the circuitry to function as a constant-current source. This voltage can replace the feedback voltage. Then the feedback loop will adjust the output voltage so that this feedback voltage (which represents the output current) is the same as the reference voltage taken from the potentiometer R34. The current will also be set by R34, and the output will behave like a constant-current source.

The voltage across R2 is proportional to the current flowing through it. The 1-ohm value of R2 was selected for connection in series with the output to act as a sensor. The voltage across the resistor is referenced to the output voltage, not the ground. Thus, differential amplifier IC5-b corrects this condition. It responds to the difference in voltage across the resistor and amplifies that difference by a factor of K.

By carefully selecting the values of R and gain or K, a scale is obtained whose current I can be measured in volts. Resistor R and gain K are set so a current of 1 ampere produces 10-volts. Consequently the output current is $V_{REF}/10$.

PARTS LIST

All resistors are ¼-watt, 10% unless otherwise stated.
R1—1200 ohms
R2—1.0 ohm, wirewound , 1 watt
R3—820 ohms
R4, R6, R14, R15—10,000 ohms, 1%
R5, R7—100,000 ohms, 1%
R8, R10—1000 ohms
R9—33,000 ohms
R11—68,000 ohms
R12—2,000,000 ohms
R13—47,000 ohms
R16 to R29—3000 ohms
R30—3900 ohms
R31—10, 000,000
R32—86, 000 ohms
R33—panel potentiometer, 10,000 ohms, linear taper, ½ watt, Mouser 31VC401 or equiv.
R34—panel potentiometer, 25,000 ohms, linear taper, ½ watt, Mouser 31VC403 or equiv.
R35—trimmer potentiometer, 10,00 ohms, vertical mount

Capacitors
C1—2.2μF, tantalum electrolytic
C2—0.1μF, polyester film
C3—0.1μF, polyester film
C4—0.3μF, polyester film
C5, C6—22pF, ceramic (see text)
C7, C8—0.010μF, polyester film
C9—10μF, tantalum electrolytic
C10—4700μF, aluminum electrolytic
C11, C12, C13—0.010μF, polyester film

Semiconductors
D1—1N5239B, Zener diode, 9.1 volts, 500 mW
D2—1N5237B, Zener diode, 8.2 volts, 500 mW
BR1—, bridge rectifier, 1.5 ampere, 200 PIV, General Instrument WO2 or equiv.
Q1—2N3705, NPN transistor, TO-92
Q2— MJE3055T NPN power transistor, Motorola or equiv.
IC1—CD4521B CMOS 24-stage frequency divider, Harris or equiv.
IC2—CD4011UB CMOS quad 2-input NAND gate, Harris or equiv.
IC3—CD4046B CMOS phase-locked loop, Harris or equiv.
IC4, IC6, IC7—CD 4518B CMOS dual BCD up-counter, Harris or equiv.
IC5—LM358 dual operational amplifier, National or equiv.
IC8, IC9—CD4543B CMOS BCD to seven segment decoder driver, Harris or equiv.
IC10—MC7812 three-terminal positive voltage regulator, Motorola or equiv.
DISP 1—MAN6740, light-emitting diode display, 0.56-inch dual digit, common cathode, RHDP, red, 7-segment or equiv.

Other components
S1, S3— toggle switch, miniature SPDT panel-mount
S2—rotary switch 3-pole, 12-station
S4—pushbutton switch, nonlatching, push-to-make
XTAL1—crystal, 4.194304 MHz, 2-pin metal case
TR1—transformer 120 volts to 6 volts, panel-mount
J1, J2—banana plug jacks

Miscellaneous: main circuit board; dual-digit LED circuit board; metal project case, two part (see text); heatsink (see text); knobs for two potentiometers and one switch; No. 18 and No. 22 AWG stranded, insulated hookup wire; No. 28 AWG flat ribbon cable; 120-volt AC linecord with plug; linecord grommet; red plastic filter for LED display DISP1 (1-14 × 1½ inches—see text); assorted nuts, lockwashers and screws; four adhesive rubber footpads, solder, silicone grease.

Measurement method

Electrical charge is current integrated with respect to time. Therefore, to measure the charge passed by the output, the voltage, a measure of the current, is integrated. It will be the output of the differential amplifier IC5-b.

Unfortunately, an analog integrator formed from an operational amplifier and a feedback resistor will not work satisfactorily because of the duration of electrolysis or electroplating (over an hour). A very large and expensive capacitor would be needed to meet this requirement, but it would introduce drift and leakage. Moreover, the output would be an analog value that would have to be converted to obtain a digital readout. For this reason, a voltage-controlled oscillator (VCO) was selected as the integrator.

As a result of including the VCO, the following statements can be made:

1. Output frequency = gain $\times V_{IN}$
2. The number of pulses = frequency × time
3. It then follows that if V_{IN} = I
4. Then the number of pulses = K × I × time

If gain K is chosen correctly, the number of output pulses effectively equals current integrated with respect to time.

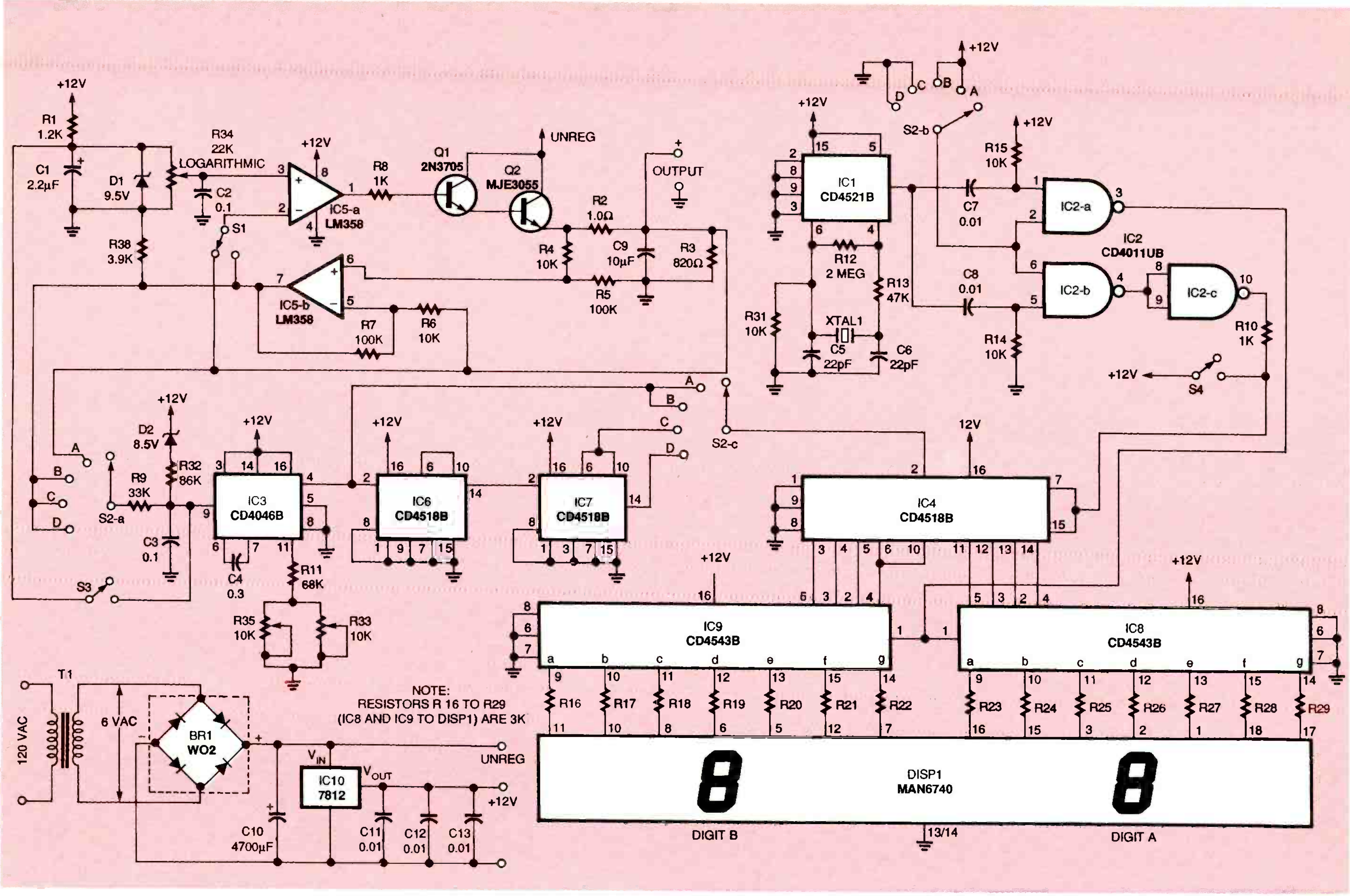


FIG. 4—SCHEMATIC FOR THE REGULATED POWER SUPPLY. Power is obtained from the 120-volt AC line. Provision is made for reading voltage, current and charge on the LED display.

Thus it is a digital representation of the charge passed.

This method offers three advantages: 1. A large capacitor is not needed because the VCO can operate in any frequency range. (The frequency is divided down to obtain the desired range); 2. Range can be changed by altering the divisor to suit your requirements; 3. To display the result it is only necessary to decode the output of the counter to drive a seven-segment display. (This eliminates analog-to-digital conversion.)

The 4518B CMOS binary-coded decimal (BCD) up counter IC4 feeds two 4543B CMOS BCD to 7-segment decoder drivers (IC8 and IC9) to give a maximum count of 100 on DISP1. Two ranges are provided so that each count can represent either 10 or 100 columns.

To increase the versatility of the circuit, options have been provided that permit both the voltage and current to be read on DISP1. Because the VCO in the 4046B CMOS phase-locked loop (IC3) has an output frequency that is proportional to its control voltage, the counter/decoder circuitry can be converted to a frequency counter that will measure voltages.

To make this conversion, a 0.5-Hz reference clock is included in this circuit based on a 4521B CMOS 24-stage frequency divider, crystal XTAL1, and a related resistor-capacitor network. It generates a waveform whose rising edge resets the counters. One second later, the falling edge latches the number of pulses per second or the signal's frequency on the counter. The method for matching the VCO to give an accurate reading and the inaccuracies of scaling is discussed later under the "How it works" section.

How it works

The variable voltage that sets the current and voltage of the output is obtained from 7812 voltage regulator IC10. The stable 9.5 volts reference applied to potentiometer R34 is derived from Zener diode D1. The voltage drop across D1 limits the voltage to 9.5 volts and the current to 950 milliamperes.

The two output transistors, Q1 and Q2, obtain their power directly from the unregulated supply, and the remainder of the circuit derives its power from a 12-volt regulated supply. Capacitor C9 has been included at the output to dampen any sudden load change.

The LM358 operational amplifiers (IC5-a and IC5-b) were selected to avoid a negative power supply requirement. A 1-ohm, 1-watt, wirewound resistor R2 is the sensing resistor, the gain of differential amplifier IC5-b is set at 10 by the ratios of the pairs of resistors R5 and R4, and R7 and R6. The accuracy of this network depends primarily on how well these resistors are matched, so 1% resistors are specified.

Switch S1 selects the feedback to op-amp IC5-a to determine whether IC5-a operates as a constant-voltage or constant-current source. The 820-ohm resistor R3 acts as a load to stabilize the output so that it only sources current.

Circuit instability will occur if other than passive loads are connected to the output. Instability is not likely to happen in normal operation, but it can occur when the output voltage is being monitored by the internal meter, if no passive external load is connected. In that situation, current can flow in the reverse direction through 33-kilohm resistor R9 to the output and disable the feedback loop. Nevertheless, resistor R3 makes this unlikely.

Similarly, errors in the current-sensing network can occur when little or no current is flowing. These errors are caused by the use of a single power source for the operational amplifier because the output impedance of the amplifier rises as its output nears ground. This prevents it from sinking the necessary current from R7 and R9, causing inaccurate readings. To minimize this effect, 3.9-kilohm resistor R30 was added to decrease the effective output impedance of operational amplifier IC5-a when it is near ground level.

COMMON ELECTROCHEMICAL TERMS DEFINED

Anode—The electrode at which oxidation occurs

Atom—The smallest particle into which an element can be divided and still retain the chemical properties of that element. It is made up of electrons, protons and neutrons.

Atomic charge—The electric charge of an ion. It is equal to the number of electrons the atom has gained or lost in its ionization multiplied by the charge on one electron.

Atomic number—The number of protons in the nucleus of the atom which defines the element.

Atomic Weight—A measure of the average mass of the atoms of a chemical element.

Cathode—The electrode at which reduction occurs.

Charge (C)—A quantity of electric energy stored in a capacitor, battery, elementary particle, or insulated object.

Chemical bond—The stabilizing of two atoms by the sharing or transferring of electrons.

Coulomb—The SI unit of electrical charge quantity. With a current of 1 ampere flowing in a conductor, one coulomb of electrons (or other charge carriers) passes a fixed point in 1 second. C = 1A × 1s.

Current (I)—The flow of electrons or holes measured in amperes (A) or in fractions of an ampere (milliamperes (mA), microamperes (μA), nanoamperes (nA) or picoamperes (pA). Current can be induced by the application of an electric field through a conductor or by changing the electric field across a capacitor (displacement current). Current is proportional to the amount of charge passing per unit of time. Thus, the more charge that is passing on a conductor, the more the flow of current.

Current = Charge/Time or I = C/t or rearranging terms

C = I × t.

Electrolyte—Aqueous solutions of acids and salts with the ability to conduct electrical current. (nonconductors are called nonelectrolytes).

Electrolysis—Conduction due to the motion of ions toward the electrode having a charge opposite its own when current is passed through an electrolyte solution. Two streams of particles move through the electrolyte in opposite directions. When the ions reach the pole toward which they are moving, their charge is neutralized by the transfer of electrons from the ions to the pole, if the ions are negatively charged. They move from pole to the ions, if they are positively charged. As a result of this loss of charge, neutral atoms or groups are released.

Electrolytic conduction—Conduction in which the current is carried through the liquid medium by the motion of weighable charged particles of the materials involved.

Under certain operating conditions, power transistor Q2 can act as a heat dissipating element. For example, if a 1-volt output is sourcing a current of 1 ampere, and Q2 is connected to a 16-volt supply, there will be 15-volt drop across Q2 and 1 ampere will flow through it. This means that Q2 is dissipating 15 watts—as much as a small light bulb or soldering iron!

Obviously this condition cannot exist for long before Q2 is destroyed and the circuit is damaged. Consequently, a heatsink capable of dissipating about 5°C/watt was included to keep the transistor's case temperature below 110°C at 25°C (room temperature).

The VCO in the 4046B CMOS phase-locked loop IC3 has no minimum frequency limitations (i.e., at V_{IN} = 0 volts, f_{OUT} = 0 Hz). Consequently, the meter can cover the full range without introducing any offset errors.

The frequency range is set with a resistor and a capacitor. To allow the circuit to be set accurately, both a preset trimmer potentiometer R35 and panel-mounted potentiometer R33 can be adjusted. Panel potentiometer R33 allows the meter to be set accurately so that temperature and aging drifts can be compensated out. To simplify the calibration process, switch S3 ties the control voltage pin 9 to the reference voltage discussed earlier. The meter can be set with this known voltage.

The VCO is subject to drift and nonlinearity. Offset and nonlinearity is serious at lower frequencies. The occurance of offset means that f_{OUT} is zero from V_{IN} = 0 to 1.5 volts. From here frequency increases nonlinearly until V_{IN} equals about 3 volts. Compensation requires nonlinear biasing provided by the combination of the 8.5-volt Zener diode D2 and 86-kilohm resistor R32.

Consider what happens when 0 to 10 volts is applied to 33-kilohm resistor R9. When that voltage is zero, current will flow through Zener diode D2 and resistors R32 and R9. This will cause a voltage at pin 9 of IC3 (set to 1.5 volts). As the voltage on R9 increases, the value of this bias-current level will fall until, at about 3.5 volts, it reaches zero. This happens because the voltage across diode D2 will be less than 8.5 volts, (12 V - 3.5 V = 8.5 V).

This offset circuitry compensates for its shortcomings adequately. Nevertheless, it is worth keeping in mind that electrolysis and other electrochemical reactions require only about ±10% current and voltage output tolerance. As for measuring charge, errors are not accumulated, so a VCO with a ±5% output accuracy will give errors that are only about 5% of the total reading.

Three-pole, four-throw rotary switch S2 selects the four different functions available. The first of its poles selects the input to the VCO, either the output voltage, or, for the other three settings, the voltage that represents the current.

To transform the squarewave output of the VCO to a signal that corresponds to 10 and 100 coulombs of electric charge, the output signal must be divided down. The VCO has been set so that 10 volts gives a frequency of 100 Hz. Consequently, a current of 1 ampere gives a frequency of 100Hz.

To translate this signal to a coulomb scale, it is necessary to divide the signal by 100 so that the output is 1Hz, (i.e., it corresponds to 1 ampere per second). To obtain the two ranges, this signal is further divided by 10 and 100. The respective signals can be selected with S2-c. One output of the VCO is to provide the voltage and current monitoring settings.

The counter/decoder block consists of two 4518B CMOS dual BCD up-counters (IC6 and IC7) connected in series. Their outputs feed another 4518B dual CMOS up-counter (IC4) which, in turn, feeds a pair of 4543B CMOS BCD-to-seven-segment decoder drivers (IC8 and IC9) for the LED display. There are two control lines: one resets the counters, and one latches the display. A pair of CMOS NAND gates in IC2 (IC2-b and IC2-c) of a 4011UB controls the state of these lines.

When counting coulombs, both of these lines from IC2 are disabled by changing the state of one of the control lines on the two gates, thus disabling the control lines. The latch load line remains high, thus making the latch transparent so the state of the counters is always displayed. Switch S4 resets the counters, and counting can begin at a definite value. This forces the reset line high.

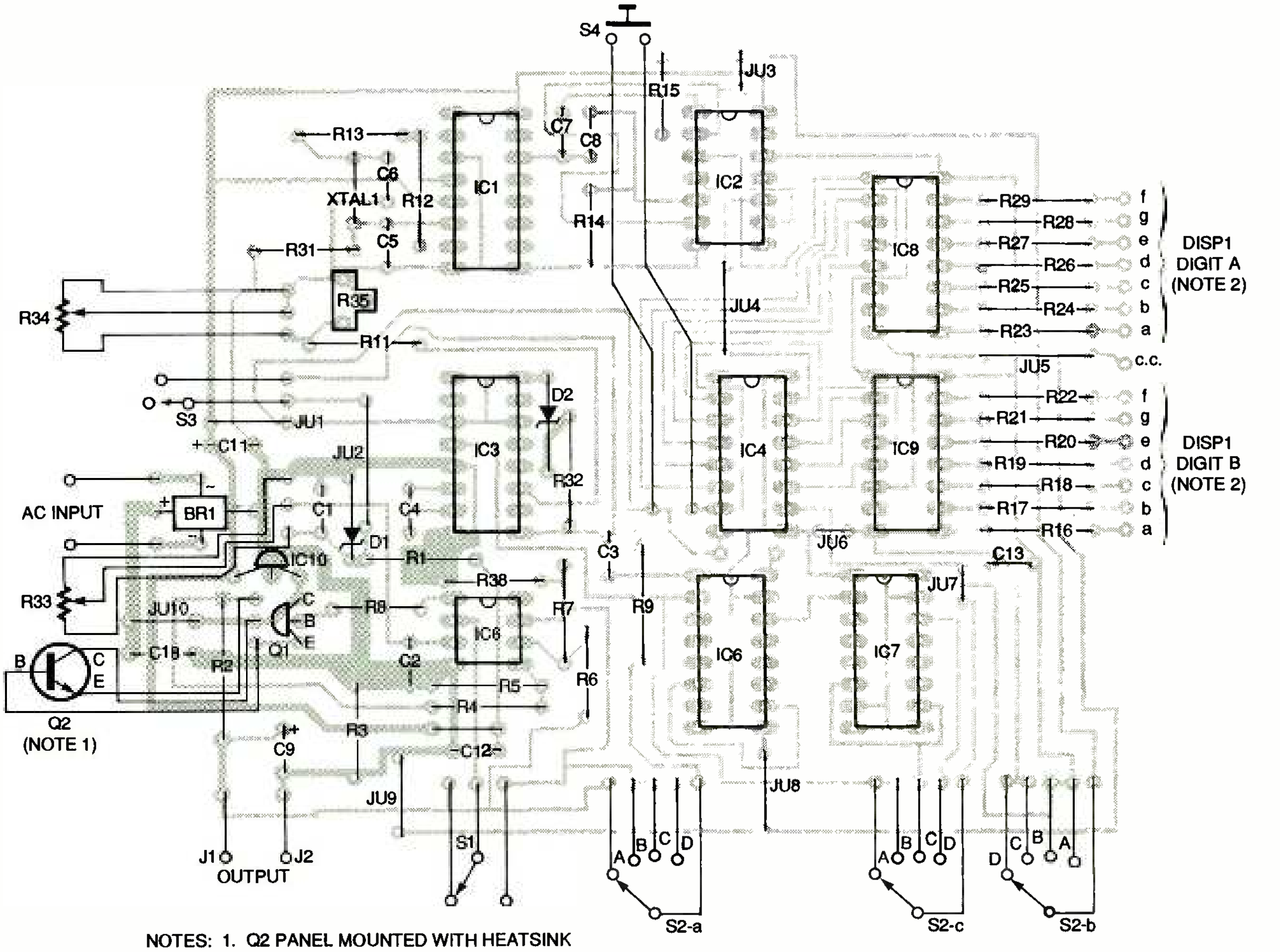
To measure current and voltage, a reference clock signal is generated by a crystal oscillator consisting of a 4521B 24-stage frequency divider IC1, crystal XTAL1, and associated circuitry. A 4.194304-MHz signal is divided by IC1 (division by 8388608) to yield a 0.5-Hz signal. On the positive edge of this clock pulse, the network of capacitor C8 and resistor R14 at pin 5 of IC2-b and c forms a positive-going pulse which is gated through to the reset line.

Because the other input to the NAND gate is high, the counter is reset to zero, and all pulses will be recorded for the next second. The latch load line will normally be low when the gate inputs are both high. This means that changes in the data inputs of the latch will not affect the display.

However, when the negative edge of the clock waveform appears, the capacitor network of C7 and R15 at input pin 1 of IC2-a passes a negative-going pulse that is gated through as a positive-going pulse. This pulse loads the latch with the number held in the counter at that time (i.e., accumulated pulses for 1 second). This value corresponds to the VCO's frequency.

Circuit construction

The power supply circuit can be built on standard perforated board (0.042-inch diameter holes in a 0.1×0.1grid) and point-to-point wiring, but a circuit board is recommended. A foil pattern for the circuit board is included in this article. Make a template for drilling a hole in each corner of the circuit board



NOTES: 1. Q2 PANEL MOUNTED WITH HEATSINK
2. SEE FIG.7 FOR CONNECTIONS TO DISP1

FIG. 5—PARTS PLACEMENT DIAGRAM. The power transformer, power transistor, switches, panel potentiometers and display are mounted off the board.

for mounting it to the base of the case with standoffs. Drill holes in the four corners of the board before mounting any parts.

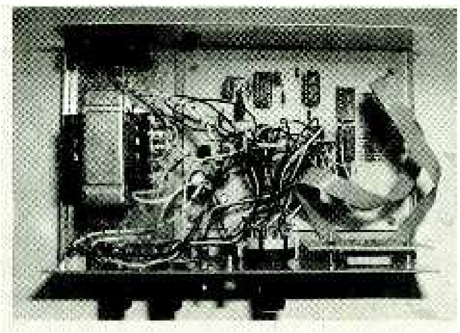
A second, smaller $2\frac{1}{2} \times 1\frac{3}{4}$-inch board is required for the two-digit LED display DISP1. It can be made from the foil pattern provided. Drill two mounting holes on each side of the board, avoiding the circuit traces, for later mounting to the inside of the case.

Refer to the parts placement diagram Fig. 6. It is recommended that all nine dual-in-line-(DIP) packaged integrated circuits in this power supply be mounted in sockets. Of those nine ICs, eight are CMOS devices subject to damage or destruction from electrostatic discharge (ESD). Insert and solder all nine IC sockets, all fixed resistors, trimmer potentiometer, discrete transistors Q1, voltage regulator IC10, and non-polarized capacitors on the board.

Then insert and solder all polarized components, making sure they are correctly oriented: Zener diodes D1 and D2, Capacitors C1, C9, and C10, and bridge BR1. After completing this board, examine it carefully to be sure that there are no inadvertent solder bridges or cold solder joints. Make any corrections necessary, and set the board aside

Insert and solder the LED display DISP1 on the small circuit board. Cut two six-inch lengths of seven-conductor ribbon cable (No. 28 AWG), strip the wire ends, and insert and solder each cable separately to the circuit board.

Next month, case construction and testing instructions will be presented. Ω



AUTHOR'S PROTOTYPE with cover removed.

INFRARED LOGIC PROBE

Here's a device to help you troubleshoot infrared emitters. You can't buy it anywhere—you have to build it yourself!

ALEXANDER D. FIRMANI

IF YOU HAVE EVER TRIED to test an infrared LED with a fluorescent phosphor card, you'll be happy to know that there's a better way. This project, called the infrared logic probe, combines an infrared photodiode sensing circuit and a logic-probe pulse detecting circuit. The device is handy for checking just about any infrared emitting source.

The infrared logic probe consists of two sections: a probe and a PC board containing the electronics. The probe is packaged in a felt-tip pen case. The electronics are packaged in a plastic case and connected to the probe through a thin coaxial cable. The circuit will detect 0.3-milliwatt continuous levels and pulses as narrow as 40 microseconds at a frequency of 7.1 kilohertz. The probe's tip is small enough to fit in a slotted optical switch and other hard-to-reach optical sensing devices. Sensitivity to ambient light is not a problem, but the probe can be sensitive to sunlight or incandescent light that is rich in infrared. The photodiode is packaged in a visible-light rejecting case with a peak spectral response of 925 nanometers and a usable range of 725 to 1150 nanometers.

Circuit description

The schematic for the IR logic probe is shown in Fig. 1. Infrared light detected by photodiode D2 is amplified by IC1-a, half of an LM392N op-amp. Resistors R1 and R2 set the voltage gain of IC1-a. The value of R2 can be changed to decrease the sensitivity of the circuit if your application demands it. Connector J1 provides an output to an oscilloscope for the display of the amplified photodiode signal. This is handy when checking the pulsed emitters found in most remote controls.

Voltage comparator IC1-b squares up signals from IC1-a to digital logic levels for IC2-a. Resistors R4 and R5 set the reference voltage at the non-inverting input to one half of the supply voltage, and R6 provides hysteresis to prevent oscillations. Resistor R8 pulls up the comparator's output for a near rail-to-rail voltage swing for IC2-a. LED1 and current-limiting resistor R7 indicate the presence of steady-state infrared and also function with pulsed emitters, if the duty cycle is appropriate.

Monostable multivibrator IC2-a conditions pulse trains with any period shorter than the time constant of R9 and C1 into a low-frequency waveform with a very high duty cycle. Monostable IC2-b triggers on the waveform from IC2-a. This provides pulses for LED2 that are constant in frequency and duty cycle, regardless of the high input frequency to IC2-a. Any frequency input to IC2-a with a period longer than the time constant of R9 and C1 creates IC2-b output pulses with the same width as before at the input frequency. Resistor R10 and C2 set the output pulse width for IC2-b.

Tricolor LED2 (a dual red/green device) functions as a pilot lamp and indicator for pulsed infrared sources. LED2 will always glow red and pulse amber (red+green) when infrared pulses are detected. Transistor Q1 is an emitter-follower buffer that allows IC2-b to drive the green diode. Resistors R11 and R12 limit current for LED2.

The power source for the circuit is a 9-volt battery. Diode D1 protects the circuit from accidental voltage reversals when you install the battery. Power supply noise is decoupled by C3 and C4. Alkaline batteries will provide many hours of operation, because the circuit has low-power integrated circuits

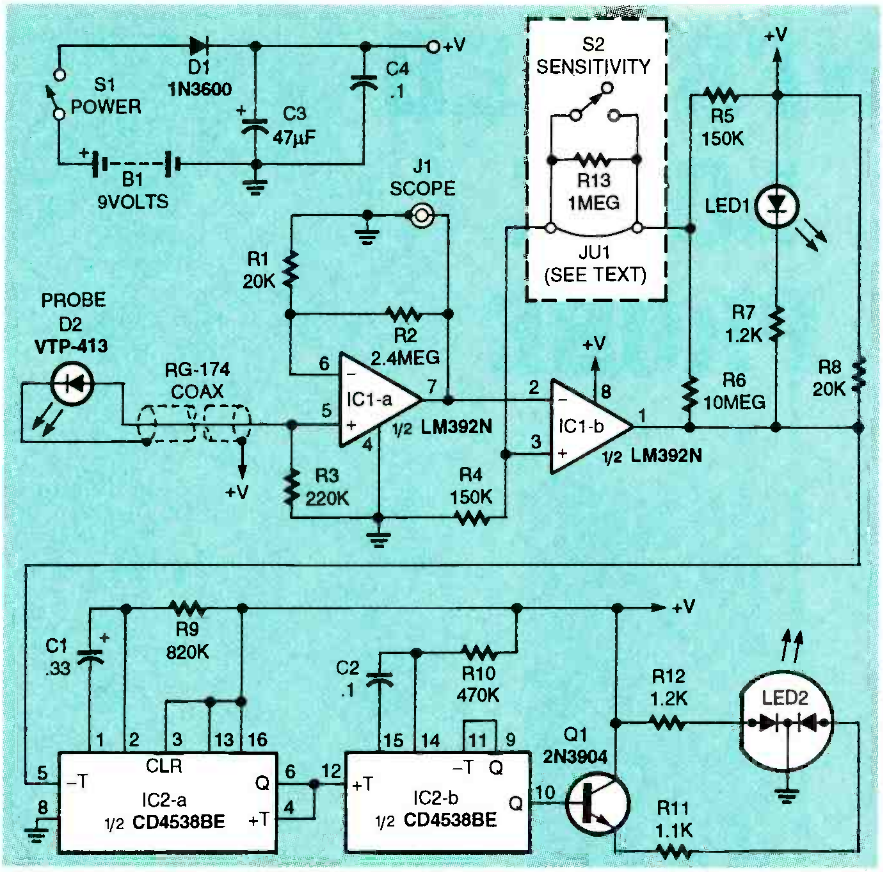


FIG. 1—SCHEMATIC FOR THE IR LOGIC PROBE. Infrared light detected by photodiode D2 is amplified by IC1-a, half of an LM392N op-amp.

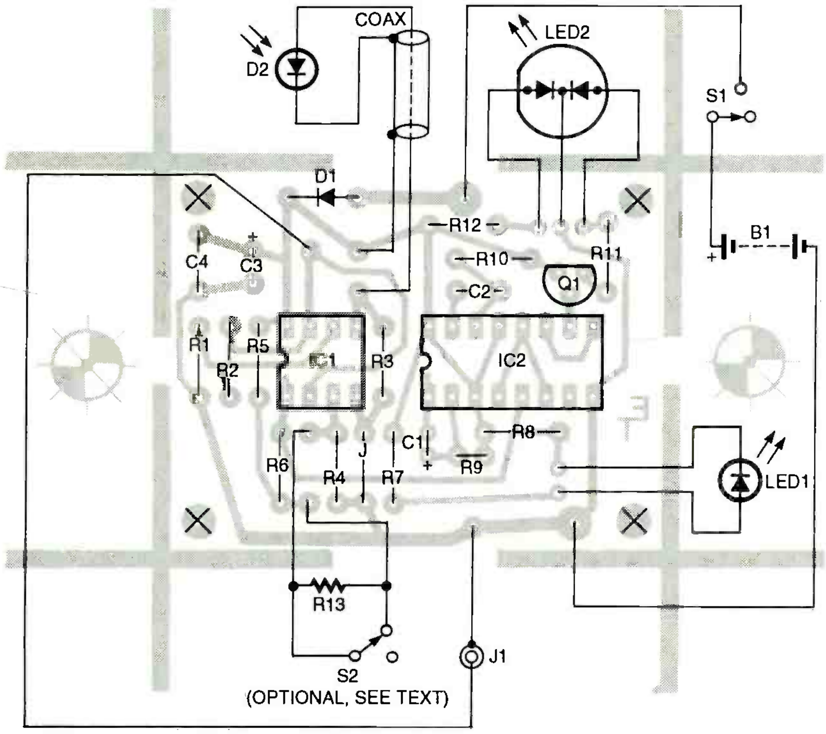


FIG. 2—PARTS-PLACEMENT DIAGRAM. Sockets for mounting the integrated circuits are recommended.

and high-efficiency LEDs.

Switch S2 (and R13) is optional. The probe will operate properly with a wire jumper in place of S2 for most emitters (remote controls) found on consumer electronic equipment. For certain devices such as slotted optical switches, CD laser diodes, and reflective sensors, more sensitivity might be desirable. If you plan to use the probe for LEDS that operate below 0.5 milliwatts, install S2 and R13—if not, you can install a wire jumper on the board instead of the switch.

Construction

The circuit can be built on a PC board or point-to-point wired. You can make your own PC board from the foil pattern provided here, but point-to-point wiring is practical because of the low component count. The photograph and parts placement diagram within this article will help. Sockets for the ICS are recommended. Figure 2 is the parts-placement diagram.

If you are using the same case as the prototype (see the Parts List), place the unpopulated PC board on the bottom half of the enclosure, centered and positioned about 5⁄16-inch from the battery compartment wall. Mark the four mounting holes and then drill them for 2-56 hardware.

Mount the components on the board, taking care not to make any solder bridges or poor connections. Note that R9 must be mounted vertically. Again, if you are using the recommended case, cut the leads on the LEDs to approximately 5⁄8-inch, and solder them to the board straight up. (If you are using a case with a different height, cut the LED leads to a length so that they will just extend through holes drilled in the top of the case after the board is mounted in the case.) Next solder 6-inch lengths of No. 24 wire for the switch/switches (remember that S2 is optional), jack J1, and the negative lead of the battery snap, to the points indicated in Fig. 2. Do not connect the switches and jack now. Mount the board to the bottom of the case with short 2-56 machine screws and nuts.

Drill two holes in the en-

PARTS LIST

All resistors are 1/8 watt, 5%.
R1, R8—20,000 ohms
R2—2.4 megohms
R3—220,000 ohms
R4, R5—150,000 ohms
R6—10 megohms
R7, R12—1200 ohms
R9—820,000 ohms
R10—470,000 ohms
R11—1100 ohms
R13—1 megohm (optional, see text)

Capacitors
C1—0.33 µF, 50 volts, electrolytic
C2—0.1 µF, 50 volts, Mylar
C3—47 µF, 16 volts, electrolytic
C4—0.1 µF, 25 volts, ceramic disk

Semiconductors
IC1—LM392N dual op-amp/comparator National Semiconductor
IC2—CD4538BE dual monostable multivibrator
Q1—2N3904 NPN transistor
D1—1N3600 or NTE-519 silicon diode
D2—Vactec VTP-413 photodiode (Allied Electronics)
LED1—High-efficiency yellow LED
LED2—Tricolor LED (Digi-Key P391 or equivalent)

Other components
S1—SPST slide switch
S2—SPST slide switch (optional, see text)
J1—Chassis mount phono jack
B1—9-volt alkaline or lithium battery

Miscellaneous: One 8-pin low profile IC socket, one 16-pin low-profile IC socket, 4 feet of RG-174 coaxial cable, 9-volt battery connector, Pac Tec HM-9VB or Radio Shack 270-293 plastic project case, 2-56 hardware, clear casting resin and catalyst or clear RTV silicone sealer, 5-minute epoxy, Sanford *Sharpie* fine-point permanent marker pen (use a dried up one if you have one), small piece of 1/10-inch thick clear Plexiglas, denatured alcohol, black paint, foam rubber, No. 24 hook up wire, solder.

closure's removable end plate: one 1/8-inch hole for the probe's cable and one 1/4-inch hole for phono jack J1. Install J1 in the end plate and place the plate into the enclosure. Solder the wires to the jack, observing polarity and taking care not to melt the plastic end plate.

Next use the drill guide in Fig. 3 to mark and drill the holes in the enclosure's top. (The drill guide matches the PC board layout, so it can be used for any case.) Remember, S2 is optional, so don't drill holes for mounting it if you're not using it. The rectangular holes for the switches can be made by drilling a pilot hole in the center and carefully cutting away the plastic with a sharp hobby knife. Mount the switches and solder the wires to them. Figure 4 shows the inside of the completed unit.

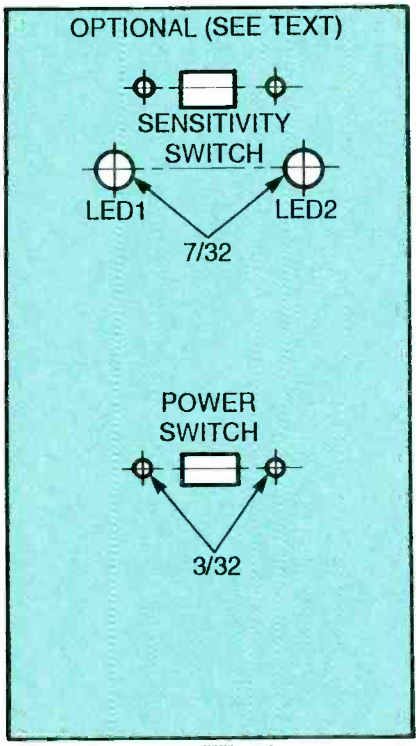


FIG. 3—DRILL GUIDE. S2 is optional, so don't drill holes for mounting it if you're not using it.

The IR probe

The prototype's photodiode probe case was made from a fine-point (not extra-fine point) Sanford *Sharpie* felt-tip marker pen. Figure 5 shows a cutaway view of the probe. To disassemble the pen, first pull out the writing tip with pliers. Grasp the pen's upper portion (the part that is the same color as the ink) and the pen's gray barrel. Then pull the pen apart with a twisting, bending motion. Wear rubber gloves to improve your grip on the pen. Discard the ink cartridge and wash the pen's interior with denatured alcohol to remove any remaining ink. Denatured alcohol will also remove the embossed lettering on the outside of the pen's barrel.

To make the "light pipe" that conducts light into the probe's interior, cut a small piece of 1/10-inch thick clear Plexiglas, 1/8-inch wide and 1¼-inches long.

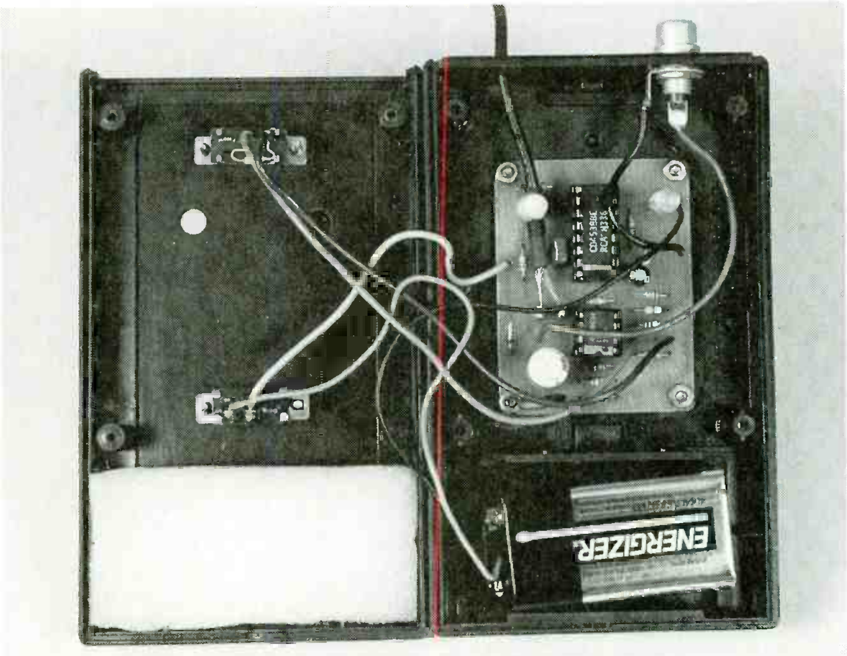


FIG. 4—THE INSIDE OF THE COMPLETED UNIT. You can use the same case (see the Parts List) or any other that will accept the board and a 9-volt battery.

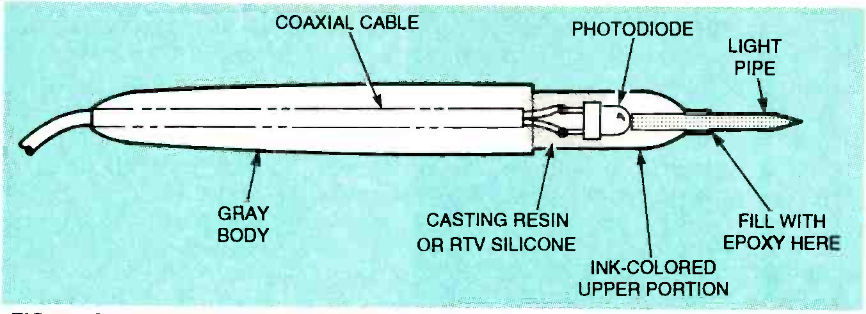


FIG. 5—CUTAWAY VIEW OF THE PROBE. The probe case was made from a fine-point felt-tip marker pen.

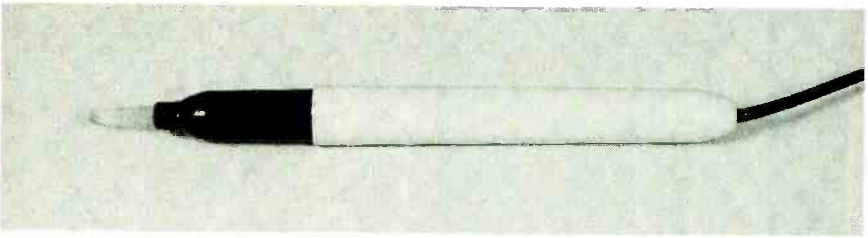
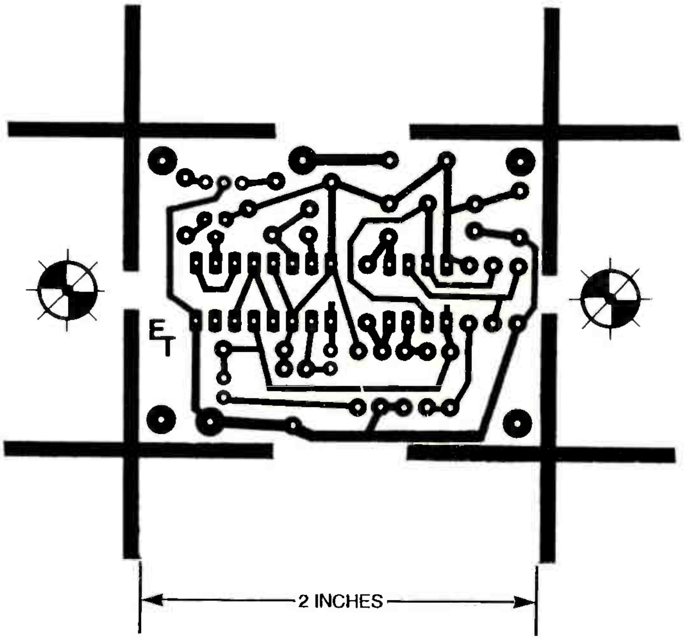


FIG. 6—THE COMPLETED PROBE. Use the pen's original cap to protect the light pipe from breakage.



IR PROBE FOIL PATTERN.

This can be accomplished by deeply scribing the sheet on both sides and clamping the piece to be cut off in a vise. Snap the piece off and cut it to length with diagonal cutters. File one end to a screwdriver-shaped tip, and then dress also clean up the

To make the "light pipe" that conducts light into the probe's interior, cut a small piece of 1/10-inch thick clear Plexiglas, 1/8-inch wide and 1¼-inches long. This can be accomplished by deeply scribing the sheet on both sides and clamping the piece to be cut off in a vise. Snap the piece off and cut it to length with diagonal cutters. File one end to a screwdriver-shaped tip, and then dress up the sides with the file.

Tap the light pipe into the hole in the pen's upper portion where the writing tip was. The screwdriver point should be outside, and the light pipe should extend about ½-inch. Mix some five-minute epoxy and seal the gaps where the rectangular light pipe enters the round hole in the pen's upper portion.

Prepare one end of the probe's coaxial cable by stripping about an inch of the jacket off and separating the braid with an awl. Place a length of heat-shrink tubing over the cut jacket for a neat appearance. Drill a hole in the end of the marker's gray barrel large enough to admit the coaxial cable.

The photodiode's leads must be bent to extend from the center of the device. Mark the photodiode's cathode lead (it's the shorter lead), and then cut both leads down to a ¼-inch length from the back of the device. Solder the leads of the coaxial cable to the leads of the photodiode; use the cable's braid for the cathode and the center conductor for the anode. Make sure the leads cannot short together!

Mix about an ounce of clear casting resin (available at an art supply store) according to the directions on the package. (Alternatively, you can use clear RTV silicone sealant.) Place the probe's upper portion in a vise with the open end facing upwards. Insert the photodiode in the open end, and push it down until its lens touches the light pipe. Pour the resin (or RTV silicone) in the open end and completely fill the void, encapsulating the diode in the marker's upper body. The coaxial cable should be positioned in the center of the upper body while the resin hardens overnight.

When the resin (or RTV silicone) has cured, apply black paint to the resin around the cable. This prevents infrared light from entering through the probe's gray barrel. When the paint dries, slide the barrel over the cable, and push the two sections of the probe together. Sand the light pipe with 400-grit sandpaper to finish the surface. Use the pen's original cap to protect the light pipe from breakage when it is not in use. Figure 6 shows the completed probe.

Final assembly & testing

Pass the free end of the probe's coaxial cable through the hole in the enclosure, and

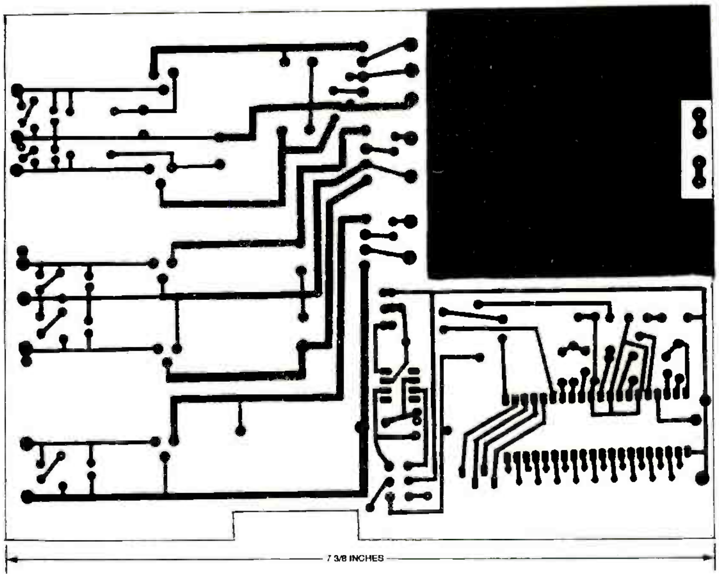
Continued on page 87

POWER SUPPLY

continued from page 32

meter and display circuitry, so this section must be turned on to power the output meter. Fuse F1 protects the supply in the event of an overload, and disables it to prevent electrical shock or fire.

Each voltage output is connected to one of the panel jacks and to one throw position of switch S4. Switch S4 is a two-pole, six-throw (2P6T) rotary unit. Pole A switches the positive input to the voltmeter, and pole B switches the ground input. (There are three separate grounds in the circuit.)



MAIN POWER SUPPLY FOIL PATTERN.

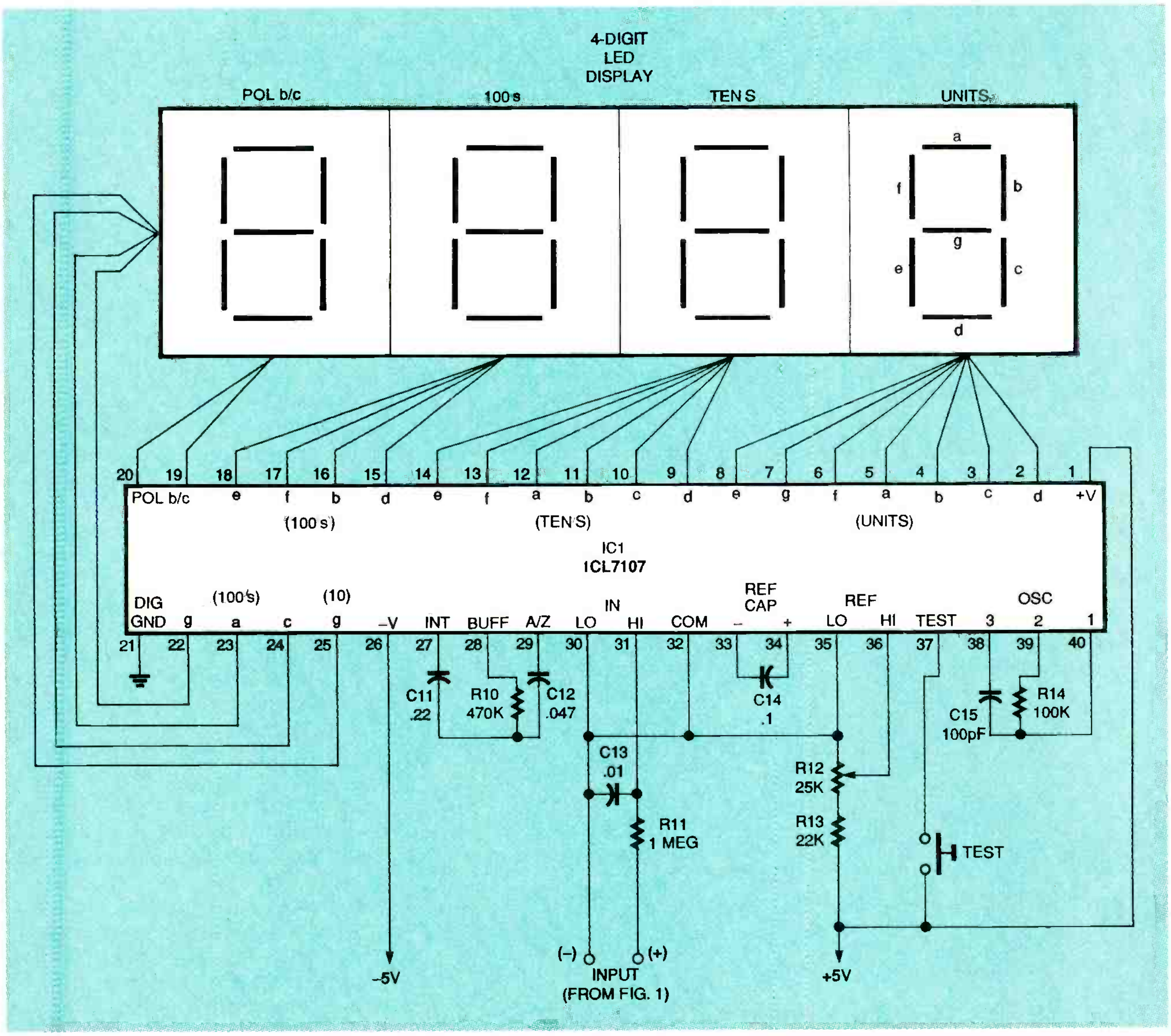


FIG. 2—VOLTMETER CIRCUIT. The Harris ICL7107 A/D converter includes segment decoders and LED display drivers.

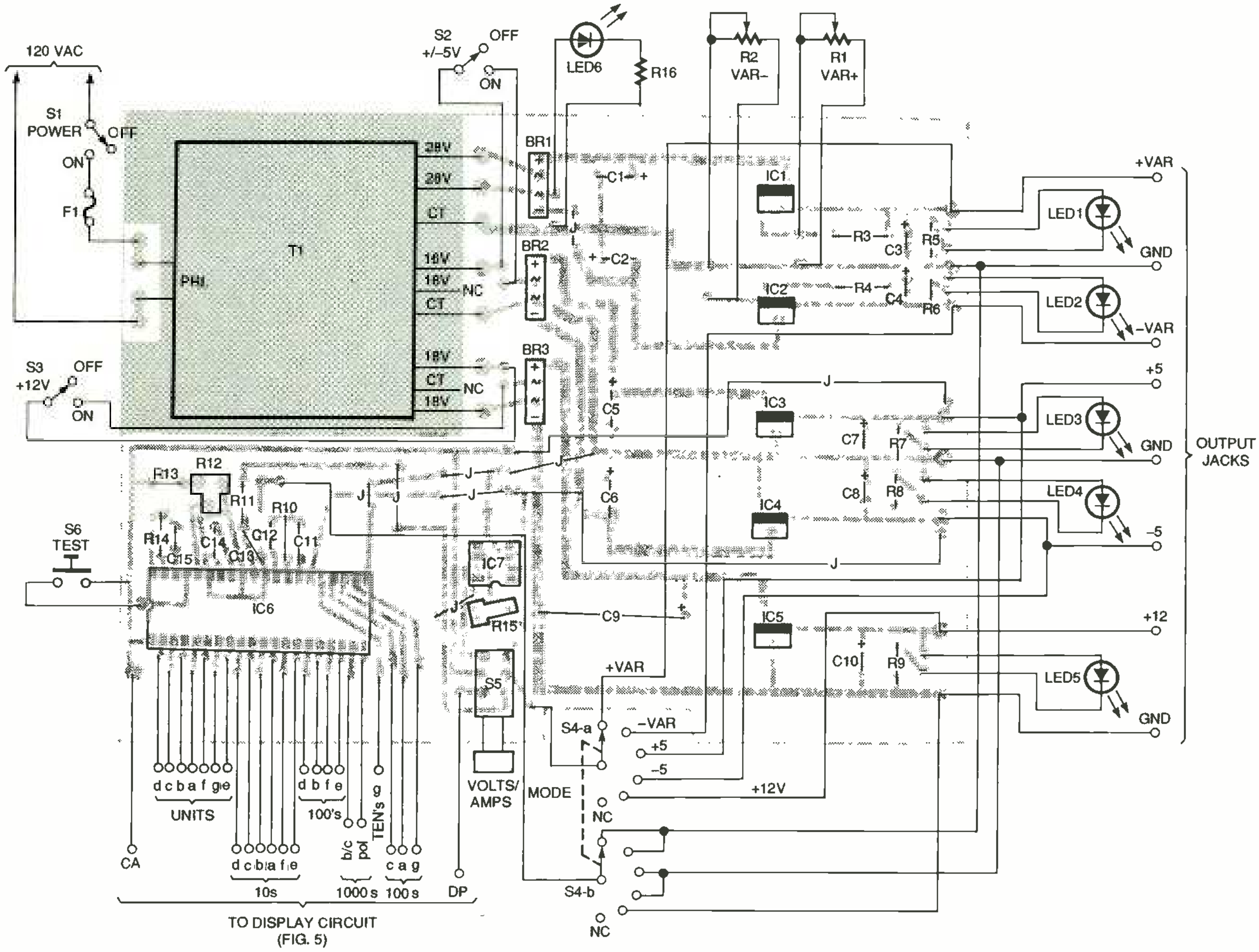


FIG. 3—PARTS-PLACEMENT DIAGRAM. Mount heatsinks on all voltage regulators to prevent them from overheating.

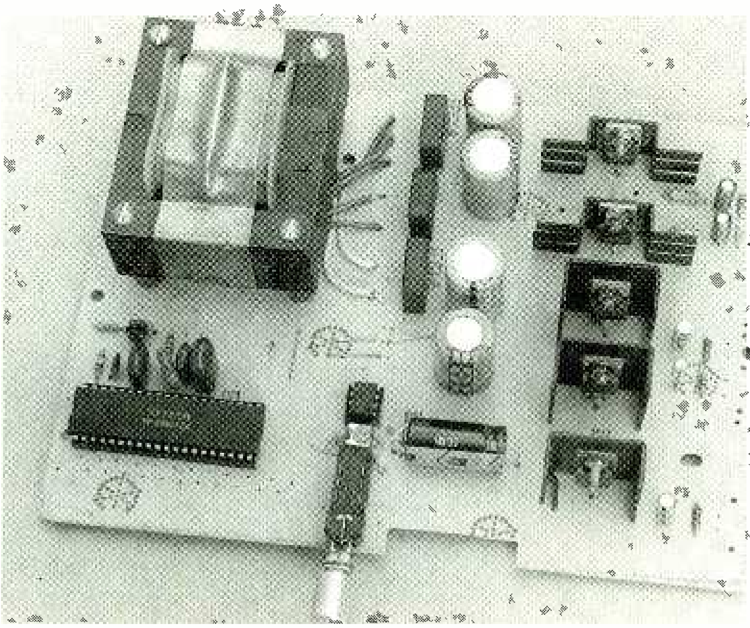


FIG. 4—THE COMPLETED PC BOARD. Be sure to observe the proper polarity on the bridge rectifiers, diode, and electrolytic capacitors.

Pole A of S4 is connected to one pole of DPDT switch S5 so that the signal can be routed directly to the meter for voltage readings, or to the LM741 current-to-voltage converter IC7 for current readings. The second pole of S5 is connected to the +5-volt supply. This pole is switched to the second decimal point of the display in the voltage mode or to pin 7 of the LM741 in the current mode.

The heart of the digital meter is the Harris ICL7107 A/D converter (see Fig. 2). The 7107 contains all the active devices needed to construct the voltmeter. These include the segment decoders and LED display drivers. The optional pushbutton switch connected to pin 37 of the ICL7107 permits the display to be tested. When that pin is connected to +5 volts, the display will indicate "−1888," testing all of the segments. If a liquid-crystal display is pre-

PARTS LIST

All resistors are ¼-watt, 5%, unless noted.

R1, R2—5000 ohms, panel-mount potentiometer
R3, R4—220 ohms, ½-watt
R5, R6, R9, R16—1000 ohms
R7, R8—470 ohms
R10—470,000 ohms
R11—1 megohm
R12—100,000 ohms, PC-mount potentiometer
R13—22,000 ohms
R14—100,000 ohms
R15—500,000 ohms, PC-mount potentiometer

Capacitors

C1, C2, C9—1000 µF, 50 volts, electrolytic
C5, C6—470 µF, 50 volts, electrolytic
C3, C4, C7, C8—0.47 µF, 50 volts, electrolytic
C10—0.33 µF, 50 volts, electrolytic
C11—0.22 µF, polyester
C12—0.047 µF, polyester
C13—0.01 µF, polyester
C14—0.1 µF, polyester
C15—100 pF, ceramic disc

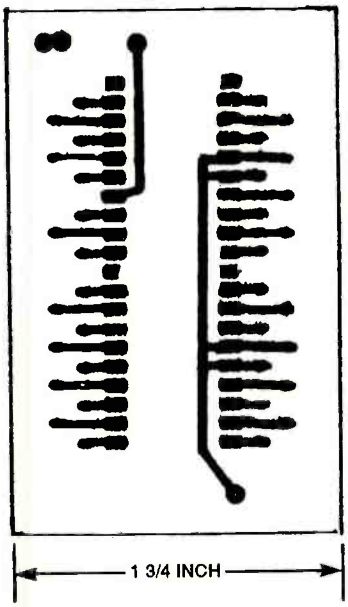
Semiconductors

IC1—LM317T positive adjustable voltage regulator
IC2—LM337T negative adjustable voltage regulator
IC3—LM7805T positive 5-volt regulator
IC4—LM7905T negative 5-volt regulator
IC5—LM7812T positive 12-volt regulator
IC6—ICL7107CPL A/D converter/LED display driver (Harris)
IC7—LM741 operational amplifier
BR1–BR3—200 PIV, 1.5-amp bridge rectifier
LED1, LED3—red light-emitting diode
LED1, LED2, LED4—green light-emitting diode
LED5—orange light-emitting diode
DISP1, DISP2—dual 7-segment common-anode LED display (MAN6710 or Equivalent)

Other components

S1–S3—SPDT switch
S4—2P6T rotary switch
S5—DPDT push-on/push-off switch
T1—120 VAC primary, 28/18/16-volt center-tapped secondary (Electronic Goldmine # G2713 or equiv., 602-451-7454)
F1—½-amp slow-blow fuse

Miscellaneous: five heatsinks for TO-220 devices, panel-mount LED holders, 8- × 6- × 2.5-inch instrument case (JDR Microdevices GPB862 or equiv.), control knobs, eight panel-mount banana jacks, panel-mount fuse holder, 6-foot grounded AC line cord and strain relief, 1- × 2-inch red display cover (optional), hardware, dry-transfer lettering to label the front and back panels, two 40-pin IC sockets, one 8-pin IC socket.



DISPLAY BOARD FOIL PATTERN.

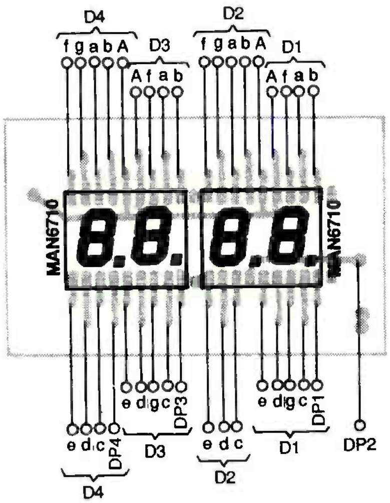


FIG. 5—DISPLAY BOARD PARTS PLACEMENT. Connect the display board to the main circuit board with a 24-conductor flat cable.

ferred, substitute an ICL 7106CPL for the 7107. All pin connections will be the same, except that pin 21 will become the backplane instead of the digital ground.

Building the circuit

The circuit can be built by point-to-point wiring on perforated construction board, but a printed circuit board will make construction easier. A foil pattern is included here if you want to make your own board. All components are mounted on the PC board except items on the front and back panels.

Solder all components to the board as shown in Fig. 3, starting with the discrete capacitors and resistors. Then add all the semiconductor devices. IC sockets are recommended for IC6 and IC7. Be sure to observe the proper polarity on the bridge rectifiers, diode, and electrolytic capacitors. Mount heatsinks on all of the voltage regulators to prevent them from overheating. Figure 4 shows the completed PC board.

The prototype is housed in an 8- × 6- × 2.5-inch instrument case, about the smallest commercial enclosure that will contain all of the parts. You can also make one of your own design. If the case is not ventilated, cut slots in the back, top, and sides to allow air to circulate to dissipate the heat.

All controls and jacks, except for the rotary mode-control switch, are mounted on the front panel. The mode switch is located on top of the case. Wire the front-panel connections with stranded No. 22 AWG hookup wire, except for the meter display and AC power lines. Wire any lines that carry the 120-volt AC voltage with 16-gauge stranded wire, and route them away from the main board.

A foil pattern is also provided here for the seven-segment, four-digit meter display circuit. Mount the parts for the display as indicated in Fig. 5, and connect the display board to the main circuit board with a length of 24-conductor No. 28 AWG flat cable.

Continued on page 93

VIDEO RECEIVER

continued from page 34

The tuner's local oscillator is controlled by a varactor diode. All diodes, including varactors, exhibit a change in capacitance as voltage is applied across them. As the voltage changes, so does the capacitance. This effect electronically tunes the circuits in the tuner. Figure 3 shows a typical UHF tuner's frequency vs. voltage curve.

The output of the tuner is an intermediate frequency (IF) of about 45-MHz. The signal from the tuner must first be amplified before being sent to the detector. The required gain is typically as high as +50 dB at 45 MHz. The amplified IF is then sent to a low-level video detector that demodulates the IF into baseband video signals. The detector is a fully balanced multiplier circuit that is tuned by another 45 MHz tank circuit.

The detector synchronously demodulates the IF into baseband video by internally dividing the signal into two channels. One channel is a limiting amplifier that provides the switching carrier for the synchronous detection, and the other channel is a linear amplifier. A common-collector, high-to-low impedance-matching buffer amplifier stage follows the detector to approximate the 75-ohm input of most video monitors.

Figure 4 is the schematic diagram of the video receiver circuit. The IF input from the tuner is fed into an MC1350 amplifier (IC1) through capacitor C4. The 56-ohm input resistor R8 approximates the impedance of the tuner's 50-ohm output. The IF amplifier is tuned by variable inductor L1 and capacitor C1, and its gain is controlled by potentiometer R5. The output of the IF amplifier is coupled into an MC1330 low-level video detector (IC2) through C5. The optional LC trap circuit, consisting of C8 and L3, can be adjusted to eliminate a specific signal, but the circuit will work well without the trap.

The MC1330 is also tuned with a tank circuit consisting of L2 and C9. The video outputs are biased with resistor networks. The noninverted video is fed into the base of a 2N3904

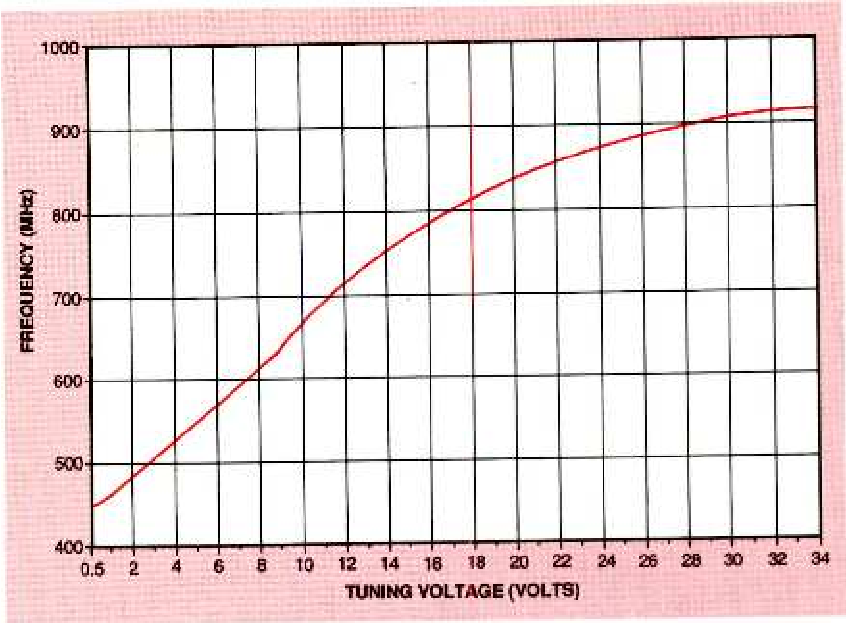


FIG. 3—THE TUNER'S LOCAL OSCILLATOR is controlled by a varactor diode. Here's a typical UHF tuner's frequency vs. voltage curve.

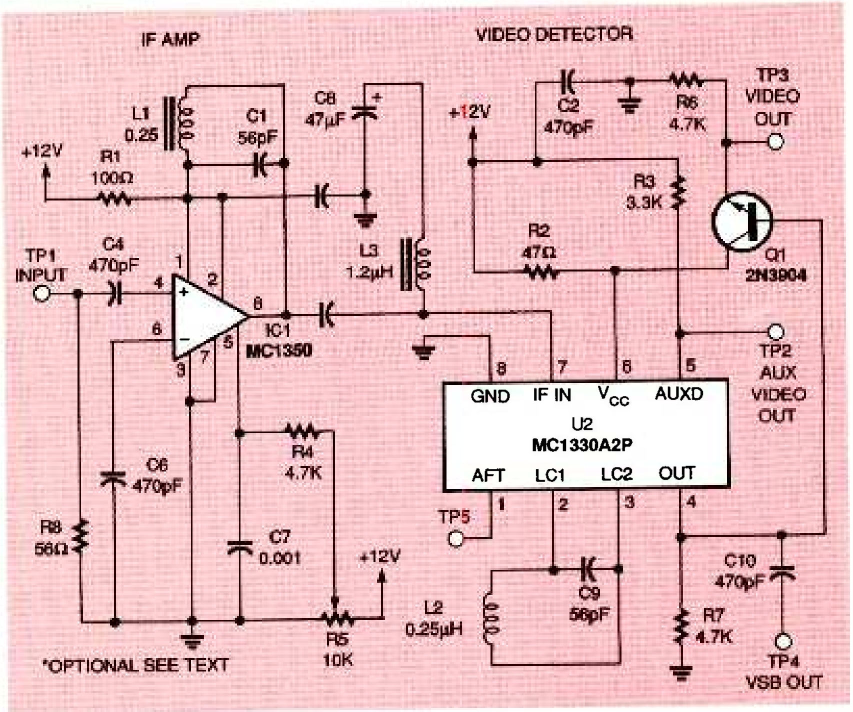


FIG. 4—VIDEO RECEIVER SCHEMATIC DIAGRAM. The IF input from the tuner is fed into an MC1350 amplifier (IC1) through capacitor C4. The 56-ohm input resistor R8 approximates the impedance of the tuner's 50-ohm output.

VIDEO RECEIVER SPECIFICATIONS

Input: 45.75 MHz IF, 50 ohms
Output: NTSC composite video, 75 ohms
Power: +12VDC, 22 mA
Gain: Approx. 80 dB

TUNER SPECIFICATIONS

Type: UHF
Output: 45.75 MHz IF, 50 ohms
Range: 450 to 912 MHz
B+: +12 VDC
AGC: +5 to +10 VDC
Tuning Voltage 0 to +30 VDC

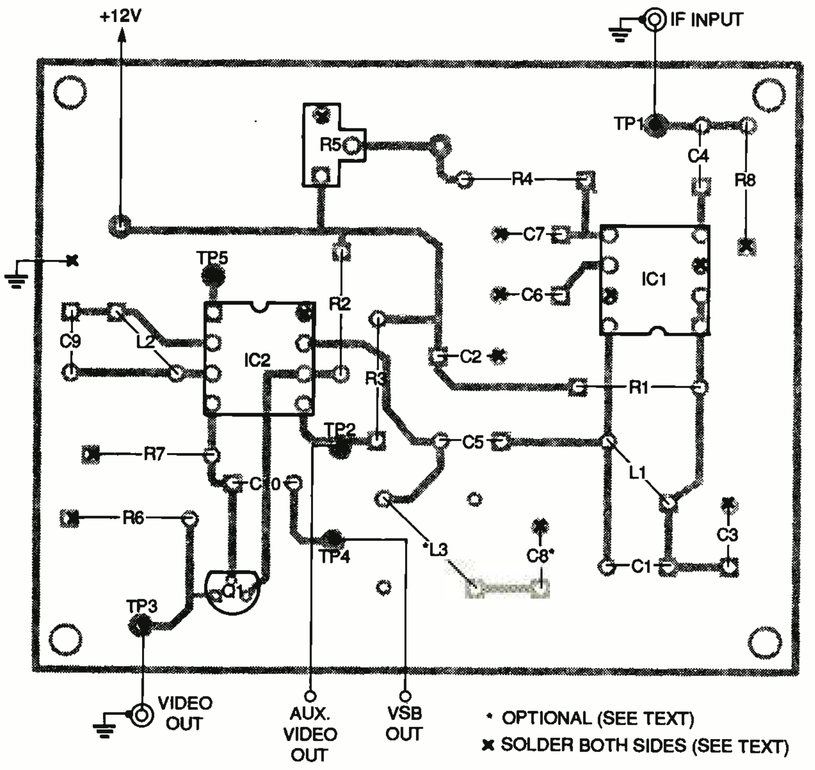


FIG. 5—PARTS-PLACEMENT DIAGRAM. The top side of the board is a ground plane. Make sure the grounded component leads (marked with an "X") are soldered to the top and bottom sides of the board.

NPN transistor Q1 configured as a unity-gain, common-collector, buffer-amplifier for impedance matching. The primary video output is taken from the top of Q1's emitter resistor R6, and the auxiliary video output is taken from pin 5 of IC2. The VSB output is an AC-coupled version of the primary output, and it can be used for any sound output you wish to use in the future. The switching carrier output can be used for automatic fine-tuning (AFT) circuits.

Building the receiver

The prototype was built on a small PC board. A foil pattern is provided here so you can make your own PC board. (The circuit will not function correctly if connections are made by wire wrapping.) The top side of the board is a ground plane. If you make your own PC board, use a double-sided blank and remove the copper from around the non-grounded pins on the ground-plane side. Be sure that the grounded component leads and pins are soldered to the top and bottom sides of the PC board. Remember to keep all component leads as short as possible. Figure 5 is the parts-placement diagram.

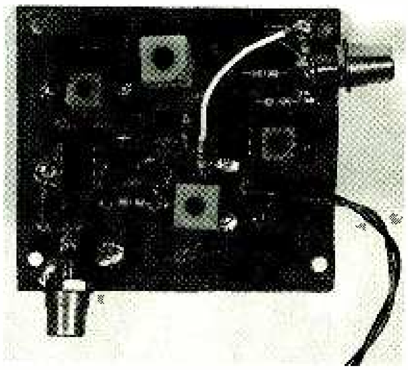


FIG. 6—THE COMPLETED BOARD. IC sockets are not recommended because it is difficult to solder the grounded pins on both sides with sockets in place.

If you are not able to buy the coils specified for L1 and L2, you can make your own. They are small air-core coils consisting of 10 turns of No. 26 AWG enameled magnet wire closely wound on a 3⁄16-inch drill bit. This coil can be tuned by distorting the windings. Toroid coils will work. They can be tuned by stretching and compressing the windings slightly. IC Sockets are not recommended for this project because it is difficult, if not impossible, to solder the grounded pins on both sides of the board with sockets in place. Figure 6 shows the completed board.

Aligning the circuit

Use a small plastic alignment tool to tune the slugs. A metal tool can influence the tuning frequency of the circuit, and could also damage the brittle tuning slugs.

To test the circuit, set up the receiver, antenna, and power supplies, as shown in Fig 1. Connect a monitor or oscilloscope to the video output and apply power. Set IF gain control R5 for 0 volts at pin 5 of IC1. If you see "snow" on the screen, the circuits are working. If that occurs, the circuit is ready for its fine tuning.

The best way to adjust the board is to introduce a 45.75 MHz signal with an amplitude of several microvolts into the board at test point TP1 and adjust the coils for maximum DC voltage on the video output at TP3. An alternative method is to make use of an over-the-air signal, with an oscilloscope connected to TP3.

Start with the slugs inserted all the way into the coils and the tuning voltage set to 0 volt. While observing the oscilloscope screen, begin tuning across the band until you see the largest signal. Then peak the output by adjusting L1. You should now see the characteristic video waveform, as shown in Fig. 7, on the oscilloscope, with sync pulses clearly visible. You should also be able to see video on the monitor screen.

If you tune up and down the band, other channels should be seen. Now tune to the lowest possible channel (typically near channel 2 or 14, depending on the band) in your receiving area by setting the V_{TUNE} voltage to about 0.5 volt. Tune L2 until this channel is visible. Finally, tune through the band to find

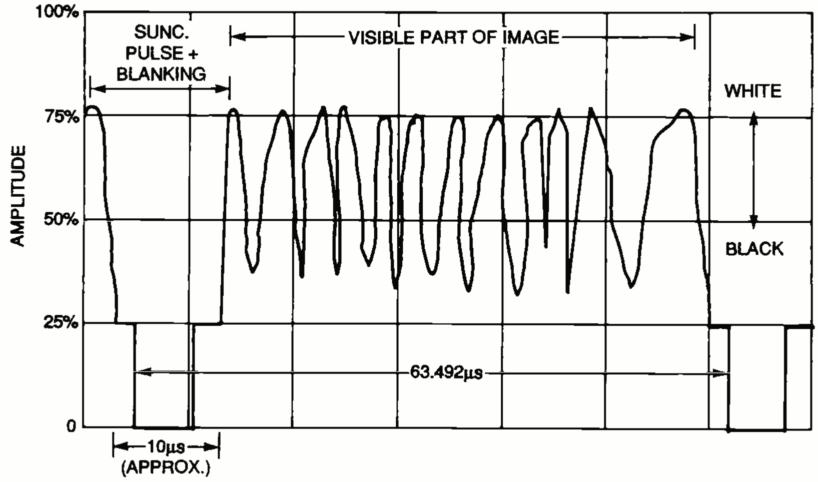
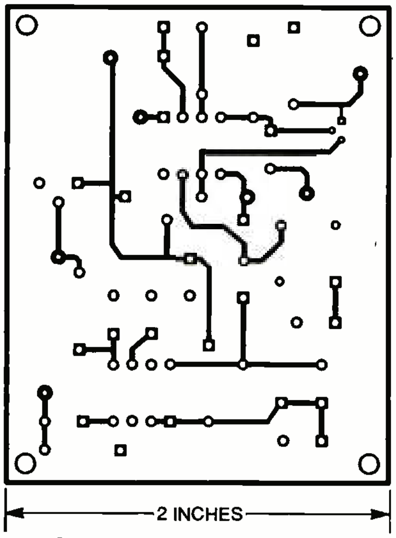


FIG. 7—WHEN YOU PUT A 45.75-MHz signal at TP1 and adjust the coils for maximum DC voltage on the video output at TP3, you should see the characteristic video waveform on an oscilloscope.

the weakest signal.

You can also connect a TV attenuator to the antenna terminals or simply adjust the gain potentiometer until a good video waveform becomes just barely visible. Now retune L1 for the sharpest picture, and reset the gain potentiometer. If all the received signals seem too strong (visible overcontrast and white smearing), back off the gain control until the picture looks good. You can also just experiment with the controls until you are satisfied with the the picture.

If you see two channels or wavy interference lines, it might be necessary to add L3 and C8 to the circuit or to adjust them if they are already in the circuit. If there is ripple on the tuning voltage, add a small-value capacitor between the wiper of the tuning potentiometer and ground. If you want high-impedance video, eliminate Q1 and R6, and connect a jumper between the emitter and base pads.



VIDEO RECEIVER FOIL PATTERN.

I don't see anything!

If you are still experiencing problems, examine the circuit board for inadvertent soldering errors and cold solder joints. Be sure that an antenna is attached and that the voltages for the tuner you have selected are correct. If you have your tuner's data sheet, make sure all of the connection requirements are satisfied.

Verify that the tuner's case is grounded and that the power supply is capable of the voltage and current requirements of the tuner. If the tuner has band-select pins (usually marked UHF, V-LO, and V-HI), band-select switching might be also be required. This can be determined by tying each of those pins, one at a time, to +12 volts.

If you have another source of video available, such as a video game with an RF modulated output in the tuner's range, try it as a test source. If you were trying to adjust the receiver using only a video monitor, be sure that the brightness and contrast controls are turned up. Try another monitor. If all else fails, substitute another tuner. However, if the tuner's output is not at 45 MHz, make any necessary adjustments in the actual frequency of the substitute tuner so that its output is at 45 MHz.

Using the receiver

Because the receiver does not have automatic gain control (AGC), some interesting effects can be seen. First, as aircraft fly over your receiver or cars pass by in the street, the picture will flutter because the signal reflections add and cancel. Next, because AGC circuitry is designed to work with strong signals as well as weak ones, the manual gain control might permit you to tune in stations not visible on some TV receivers. The better the antenna the better the results will be. There are many ways to achieve this with purchased or salvaged antennas.

Sound

There are several ways to add sound reception to the receiver. One is to make use of the vestigial sideband (VSB) audio channel. This would require the introduction of the 455-kHz FM IF signal at TP4. The disadvantage of this approach is that there will be some interaction between the audio and video. The second approach calls for installing a splitter on the output of the tuner, with one half going to the video receiver and the other half going to a circuit that downconverts the IF to a 10.7-MHz FM IF signal. You could also listen to a radio that broadcasts the audio portion of the television signal. Ω

SURPLUS TUNER SOURCES

- Surplus Sales of Nebraska, 1315 Jones St., Omaha, NE 68102, 402-346-4750 (Sony KV-1217 UHF/VHF tuner)
- Science Workshop, PO Box 310, Bethpage, NY 11714, 516-731-7628 (SW-5800 VHF tuner and several UHF units)
- Fair Radio Sales, PO Box 1105, E. Eureka St., Lima, OH 45802, 419-227-5673 (GE No. EP85X66 UHF tuner)

WHAT'S NEWS

Continued from page 4

at lower cost.

Some manufacturers plan to introduce the new videodisc systems in 1996 for around $500. Japan's consumer electronics manufacturers are hoping that the new digital video systems will win more market share for them, and help to pull their country out of its economic slump. They see the system as a possible successor to the VCR.

Despite their differing business interests, all participants in the agreement wanted to avoid of a recurrance of the introduction of two competing formats to the marketplace at the same time, as occurred when the VCR was introduced in the 1970s. Both the Beta and VHS formats were offered, but this led to consumer confusion and some anger, especially if customer had purchased a Sony VCR based its losing Beta format.

Not surprisingly, Toshiba gained the support of other large Japanese consumer electronics manufacturers including Matsushita Electric, Hitachi, and Pioneer Electronics for its proposal. Time Warner, on its part, is interested in the new digital video system as a new market for the movies produced by its Warner Brothers studio and Warner Home Video.

The Toshiba proposal is known as the Super Density Disc, or SD format. It can store as many as 5 billion bytes of information on one side of a disk, for a total of 10 billion bytes on both sides. The Toshiba disc will be made by bonding together two discs. This compares with the limit of 3.7 billion bytes that could be stored with the Sony-Philips format because only one side would be used.

The recording layer on the Toshiba disc is only 0.6 millimeter thick, half the thickness of the 1.2-millimeter layer on the proposed Sony-Philips disc. This is the same thickness as the recording layer of CD-ROMs. The 0.6-millimeter layer was favored by IBM because it lends itself to the use of lasers with shorter wavelengths that could increase storage capacity even more.

Although the Sony-Philips signal modulation technique is expected to reduce the storage capacity of Toshiba's SD disc by about 6 %, the prospect of making the discs more economically apparently overcame that objection.

IC boosts CRT resolution

A new family of ICs that combine a preamplifier, amplifier, and matching networks makes it easier to connect high-speed video signals to a CRT. A development of Maxtek Components Corp., Beaverton, Oregon, the devices, which operate in the 250- to 320-MHz range, can increase the resolution of VGA computer monitors to 2000 × 2500 lines.

The CRT driver accepts and feeds analog video signals to steer the CRT's electron gun. The devices work on the principle that the faster a CRT's electron heam can excite an individual pixel and reposition itself to excite the next pixel, the higher will be the resolution of the CRT. EN

WAVE GENERATING

continued from page 36

R_L, and the sinking current flows through transistor Q1. These distortion problems do not occur with a complementary emitter follower because that circuit can source or sink high output currents with equal ease.

Transistor oscillators

Figure 4 is a schematic for a Wien-bridge oscillator based on two transistors. It will generate 1-kHz sinewaves. The oscillator draws 1.8 milliamperes from a 9-volt supply, and has an output amplitude that can be widely varied with output potentiomer R7 up to 6 volts peak-to-peak. The circuit operates as follows:

Transistors Q1 and Q2 are a pair of direct-coupled complementary feedback, common-emitter amplifiers. They present a very high input impedance to the base of Q1 and a low output impedance from Q2's collector. They also present a noninverted DC-voltage gain of 5.5, obtained from the resistor relationship of R6 + R5/R5. (Substituting the resistor values shown in Fig. 4 of 10K + 2.2K/2.2K ohms gives a gain of 5.5.)

Transistors Q1 and Q2 also provide an AC voltage gain that is variable from 1.0 to 5.5 with potentiometer R6. Transistor Q2's collector load impedance (determined by R5, R6, and R7 is approximately 5 kilohms.

Red LED lamp LED1 conducts through R3 to generate a stable, low-impedance 1.5-volt bias source. That bias is fed to the base of transistor Q1 through R2. This biases Q2's output to a quiescent value of +5 volts. The Wien network (formed by R1-C1 and R2-C2 and connected between Q2's output and Q1's input) has an active impedance of about 15 kilohms and is driven by Q2's output. Potentiometer R7 can vary the oscillator's output amplitude widely.

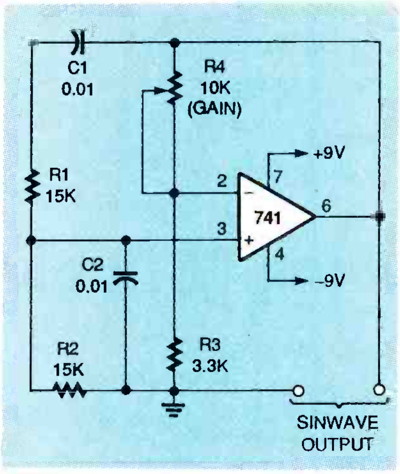


FIG. 6—A WIEN-BRIDGE oscillator based on an operational amplifier.

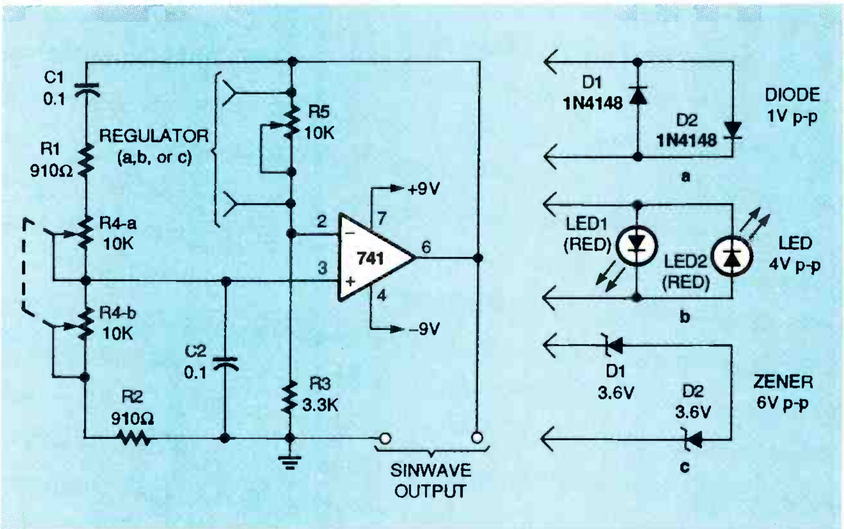


FIG. 7—AMPLITUDE OF SINEWAVES can be varied by a choice of three different voltage regulators in the 150-Hz to 1.5-kHz frequency range Wien-bridge oscillator.

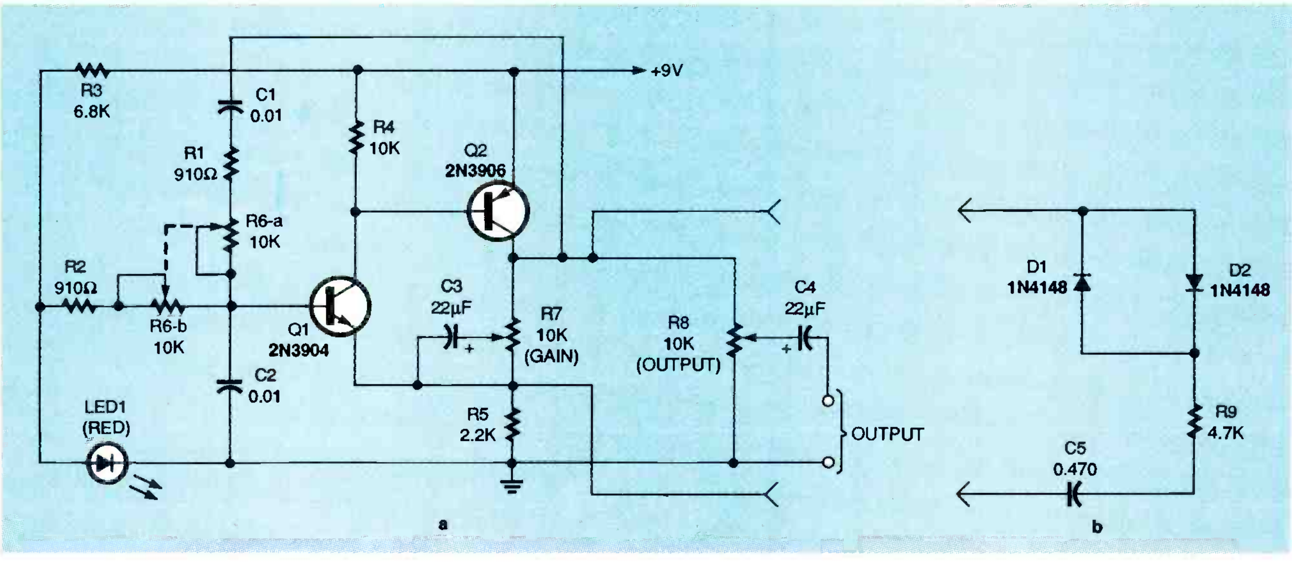


FIG. 5—THIS WIEN-BRIDGE OSCILLATOR will demonstrate its ability to generate variable frequencies between 1.5 and 15 kHz.

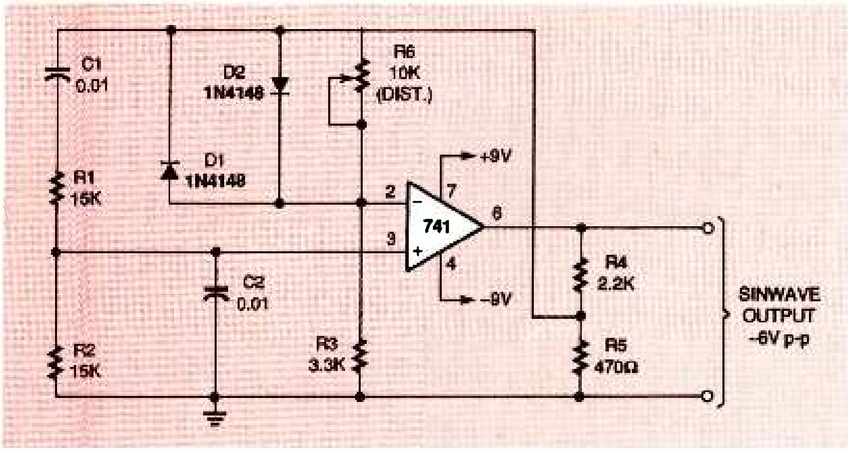


FIG. 8—A 1-kHz WIEN-BRIDGE OSCILLATOR with an amplified-diode regulator.

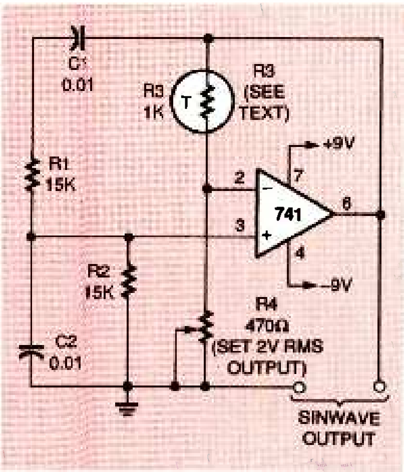


FIG. 9—A 1-kHz WIEN-BRIDGE OSCILLATOR with an NTC thermistor regulator.

To organize the oscillator in the Fig. 4 circuit, connect its output to an oscilloscope and adjust potentiometer R6 so that a stable, clean waveform is generated on the oscilloscopes's screen. In this condition, oscillation amplitude is limited only by the onset of positive-peak clipping as the amplifier encounters saturation.

This clipping occurs at a peak-to-peak amplitude of about 6 volts. The clipping is a kind of distortion-generated automatic gain control (AGC) that reduces the oscillator's loop gain below the critical unity level as the waveform's amplitude reaches a specific peak value. If potentiometer R6 is carefully adjusted, this clipping can be reduced to an almost imperceptible level. The result will be high-quality sinewaves with less than 0.5% total harmonic distortion (THD).

The Wien-bridge oscillator circuit in Fig. 4 is versatile and inexpensive in fixed- and switched-frequency applications where a single-ended power supply is required. However, the values of resistors R1 and R2 must not be less than 5 kilohms. The R1-R2 and C1-C2 values can be varied over a wide range to give alternative operating frequencies. Moreover, small frequency changes can be obtained by altering the value of either R1 or R2.

Figure 5 is a schematic for a Wien-bridge oscillator, a modification of the Fig. 4 schematic. The oscillation frequency of the circuit is fully variable from 1.5 kHz to 15 kHz with dual potentiometer R6. The circuit can be both a practical sinewave generator and a Wien-bridge oscillator demonstrator. The Wien bridge is made up of C1-R1-R6-a and C2-R2-R6-b.

To demonstrate the Wien-bridge oscillator with this circuit, build it as shown in Fig. 5-a, and connect its output to an oscilloscope. Set output potentiometer R8 for maximum output, and set dual potentiometer R6 to its maximum resistance value to provide the lowest frequency. Then carefully adjust potentiometer R7 so that clean, stable waveforms appear on the oscilloscope. When set up this way, the Wien network presents a high impedance and is easily driven by transistor Q2. As a result, oscillation amplitude is limited only by the onset of positive-peak clipping at an amplitude of about 6 volts, peak-to-peak, as described earlier.

Progessively increase the operating frequency by reducing the resistance of R6 while retrimming R7 as necessary to maintain oscillation, until the maximum frequency is obtained. Under this condition, the waveform's peak-to-peak amplitude drops to about 3 volts, and slight distortion is visible on the falling halves of the waveform. This is caused by transistor Q2 losing its ability to drive the Wien network cleanly as its impedance drops below a few kilohms. The result is a form of amplitude-limiting, distortion-generated AGC.

This distortion can be overcome, at the expense of a large increase in the circuit's quiescent current, by inserting a 1.5-kilohm resistor between transistor Q2's collector and ground. This increases Q2's output drive capability. However, with this modification, the waveform's amplitude is again limited by clipping at about 6 volts, peak-to-peak.

To finish setting up the network as a demonstration unit, remove the 1.5-kilohm resistor from Q2's collector, and connect the network formed by diodes D1 and D2, resistor R6 and capacitor C5, as shown in Fig. 5-b across potentiometer R7, at the two jacks.

Vary the wiper of potentiometer R6 across the whole frequency band, and trim potentiometer R7 to find a position where you obtain a clean sinewave with an amplitude of about 1.2 volts peak-to-peak, at all settings of R6. Resistor R6 and the two diodes, D1 and D2, introduce a form of gain control. At the start of each half-cycle, the circuit's loop gain is greater than one, so oscillation starts. However, as soon as the waveform amplitude approaches a peak value of about 600 millivolts, either D1 or D2 will conduct, shunting 4.7-kilohm resistor R9 across R7, thus reducing the loop gain to unity.

This is a gentle form of limiting that causes less than 1% THD. The version of Fig. 5 circuit with the D1, D2, R9, and C5 network plugged in becomes an

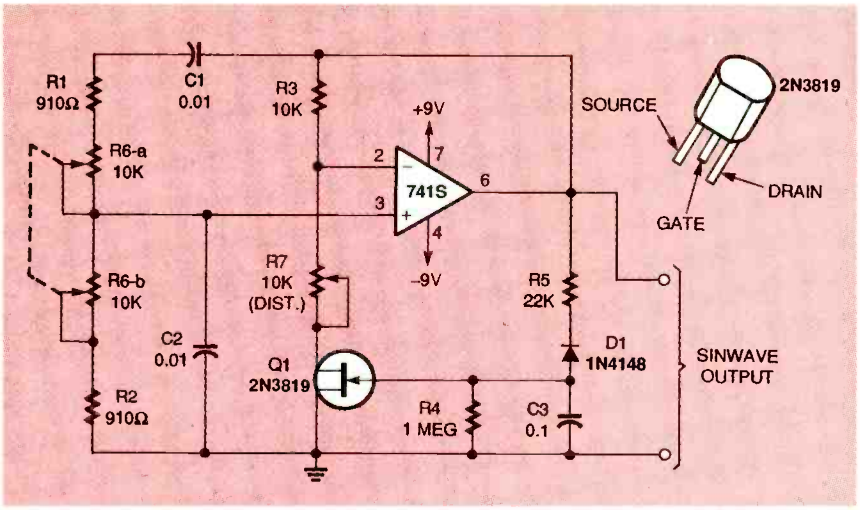


FIG. 10—A JFET-REGULATED 1.5- to 15-kHz Wien-bridge oscillator.

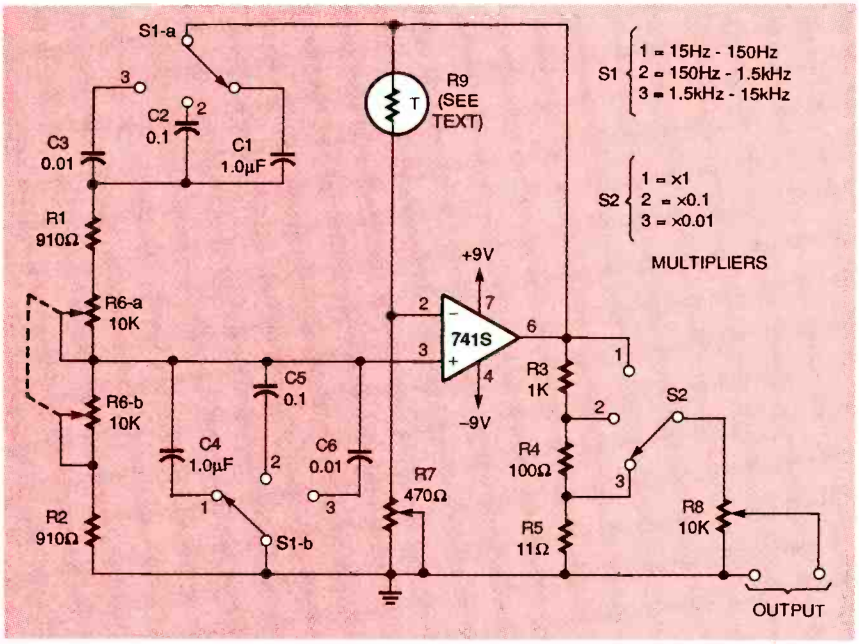


FIG. 11—A THREE-DECADE (15 Hz to 15 kHz) Wien-bridge oscillator.

inexpensive but effective variable-frequency sinewave generator whose frequency range can be changed by substituting different values for capacitor C1 and C2.

Oscillators with op-amps

Standard integrated-circuit operational amplifiers offer high voltage gain, high input impedance, and low output impedance. They are excellent amplifiers for Wien-bridge oscillators. Figure 6 is a schematic for a simple 1-kHz oscillator. Resistor-capacitor pairs R1-C1 and R2-C2 form the Wien-bridge network. Trimmer potentiometer R4 and resistor R3 control the operational amplifier's closed-loop gain.

The circuit oscillates when R4 is adjusted, but its waveform amplitude is limited only by the onset of peak clipping as the op-amp encounters saturation. If R4 is adjusted carefully, clipping can be reduced to an insignificant level, so that the output sinewaves are clean. However, this technique is useful only in fixed-frequency applications. Where variable frequency is desired, some form of gain control must be provided so that there will be amplitude limiting with minimal distortion.

Figure 7 shows three ways to regulate waveform amplitude with diodes providing the distortion-generated AGC, as described earlier. The simple plug-in, back-to-back 1N4148 diode regulator, shown in 7-b, is the least expensive solution. However, its output is limited to 1 volt, peak-to-peak, for low-distortion levels.

The light-emitting diode plug-in regulator (Fig. 7-c) gives a 4-volt peak-to-peak output and the series Zener diode plug-in regulator (Fig. 7-d) gives a peak to peak output of 6 volts. With any of these plug in regulators in position, adjust trimmer potentiometer R5 for the minimum setting that gives sustained oscillation across the whole frequency band. If the Wien bridge components are well matched, THD might be less than 0.5%.

Figure 8 shows a diode-regulated Wien-bridge oscillator that is well suited for fixed-frequency applications. Here, both the Wien-bridge and regulator-feedback loop are taken from the output junction of resistors R4 and R5. This is an alternative to taking it directly from the output of the operational amplifier. This simple modification effectively amplifies the diode regulation voltage by a factor determined by the ratio of the value of (R4 + R5)/R5. In the Fig. 8 circuit, the sinewave output is about 6 volts, peak-to-peak. If trimmer R6 is adjusted carefully, THD levels of 0.1% can be obtained.

Linear AGC circuits

The Wien-bridge oscillators shown in Figs. 6, 7, and 8 rely on distortion-generated AGC to control waveform amplitude. Those circuits can maintain a constant and jitter-free amplitude as the frequency is increased and decreased across the available band.

There is an alternative based on automatic linear gain control. Oscillators with this feature usually generate negligible distortion. However, they suffer from amplitude "bounce" when the frequency settings are shifted up and down the available band. The AGC system hunts for the correct gain value. Fig-

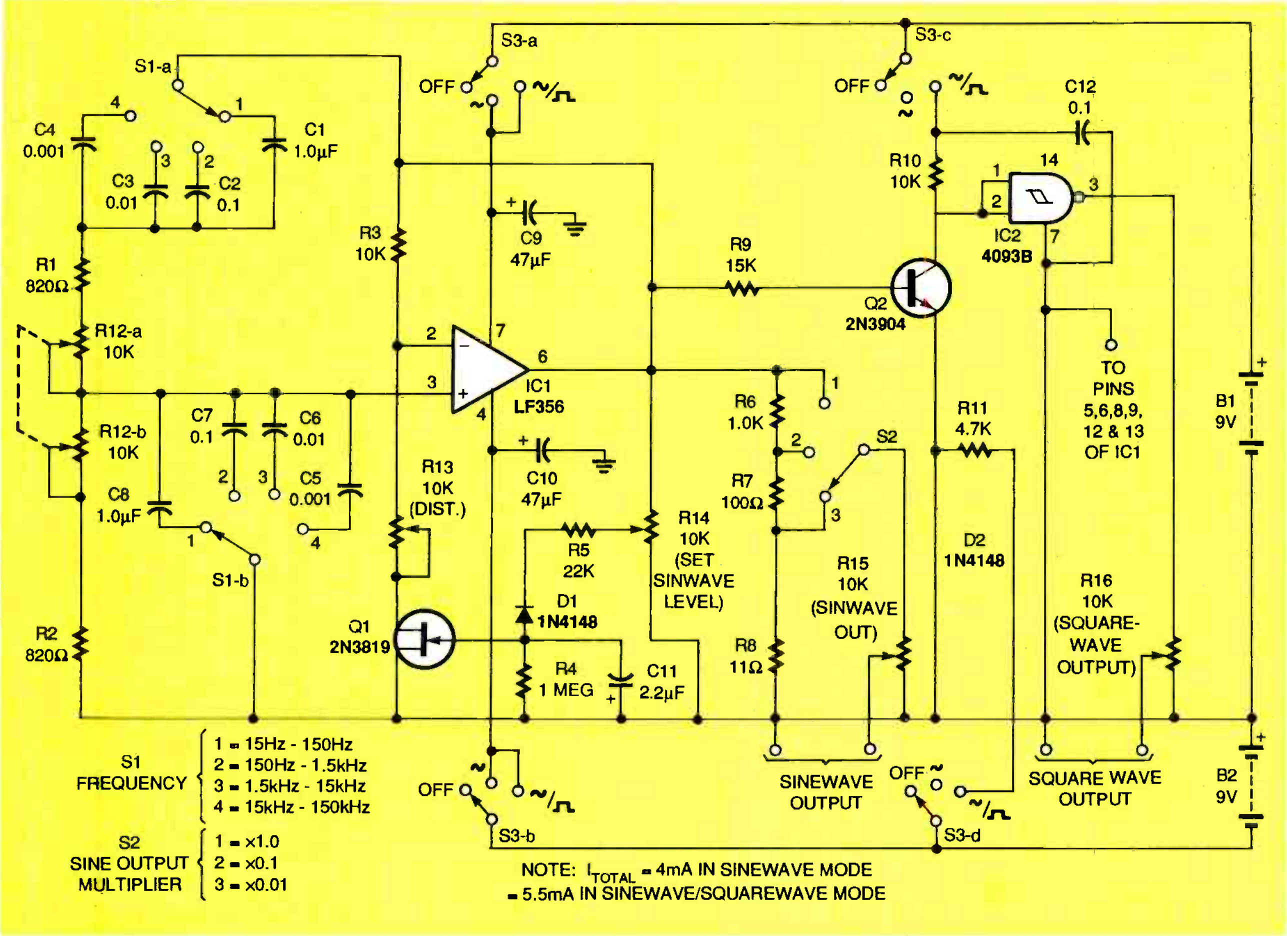


FIG. 12—THIS SINE/SQUAREWAVE generator covers the 15-Hz to 150-kHz band.

ures 9, 10, and 11 show three circuit schematics that contain linear AGC circuits.

Figure 9 is the schematic for a 1-kHz oscillator circuit whose output amplitude is stabilized by a negative temperature coefficient (NTC) thermistor. It is shown here as R3, a resistor symbol in a circle containing the letter T. The resistance of an NTC thermistor decreases as temperature increases. Typical resistance values for NTC thermistors devices range from 200 ohms to 50 kilohms. Thermistor R3 in series with trimmer potentiometer R4 becomes a gain-determining feedback network. The value of R3 is 1 kilohm.

Thermistor R3 is heated by the output signal's average power. At the desired amplitude, R3 has a resistance value double that of the 470-ohm trimmer potentiometer R4, thus giving the circuit an overall gain of unity. If the output amplitude starts to rise, R3's temperature rises and its resistance falls. This response reduces the gain and restores the original output level. The reverse action occurs if the output starts to fall, and the original output level is again restored. This oscillator generates negligible distortion.

Figure 10 is the schematic for an alternative circuit that consumes only a few milliamperes. In this circuit, JFET Q1 serves as a variable resistance that is voltage-controlled by the oscillator's negative peak amplitude. This is detected by the series network of resistor R5, diode D1, and capacitor C3 in parallel with resistor R4.

The drain-to-source path of JFET Q1 acts as a low resistance when Q1's gate is biased to zero volts. However, the resistance of the path approaches infinity when Q1's gate is biased to a negative pinchoff value of a few volts. When dial potentiometer R6 is suitably adjusted, the circuit oscillates and generates very little distortion in its output with a peak-to-peak value of X volts.

If the output tries to rise above a set value (X), the detected change automatically increases Q1's resistance value. This response reduces the operational amplifier's gain, bucking the attempted rise in output. However, if the output tries to fall below the X value, an opposite response occurs—gain increases to maintain a constant output level.

To organize the Fig. 10 circuit, connect its output to an oscilloscope and adjust trimmer R7 to the lowest setting that will give stable oscillation without visible distortion of the waveform over the 1.5 kHz to 15 kHz band. If the Wien bridge components are well matched, THD could be less than 0.1%. The output signal amplitude depends on the pinchoff characteristics of the 2N3819 JFET, a value that is typically between 2.5 and 7 volts, peak-to-peak.

Alternatively, the pinchoff level can be preset to 8 volts, peak-to-peak, by connecting a 10-kilohm potentiometer across the operational amplifier's output and supplying resistor R5 from its wiper.

The AGC system's charge/discharge time constants are controlled by R5 and C3 and R4 and C3. The R4-C3 time constant must be long with respect to that of the generated waveform cycle for low distortion. If the oscillator is to generate signals with frequencies as low as 15 Hz, the value of capacitor C3 must be increased to 2.2 µF. However, if capacitor C3 is removed, the circuit will have a simple distortion-generated gain control.

Wide-frequency oscillator

The frequency ranges of the oscillator circuits in Figs. 6 to 10 can be changed with different values of capacitors C1 and C2. For example, increasing those values by a factor of 10 reduces the frequency by a factor of 10. Those circuits can become wideband multidecade oscillators by installing switches for selecting alternative decade capacitor values.

The maximum useful operating frequency for this kind of circuit is restricted by the slew rate limitations of the operational amplifier. The useful frequency limit for the low-cost 741 operational amplifier is 20 kHz. That limit is raised to 80 kHz with a 741S, 120 kHz with a National Semiconductor LF355, and 250 kHz for a National Semiconductor LF356.

If you build a variable-frequency Wien-bridge oscillator, be sure that the two tracks of the frequency-control potentiometer are well matched if you want low-distortion and stable-amplitude performance. In multidecade oscillators, the values of the Wien-bridge capacitors should be as closely matched as is practical on all ranges. If these capacitors are not well matched, it might be necessary to install an AGC GAIN or DISTORTION switch for each range.

Figure 11 is the schematic for

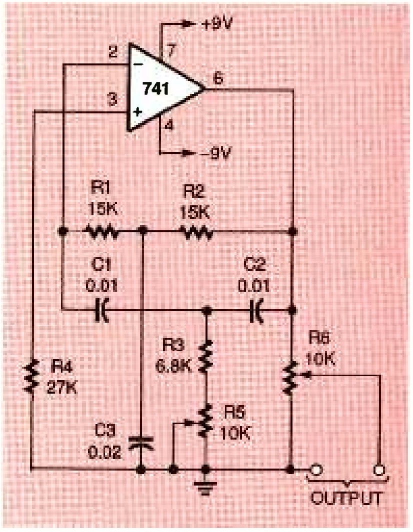


FIG. 13—THIS TWIN-T OSCILLATOR generates a 1-kHz output.

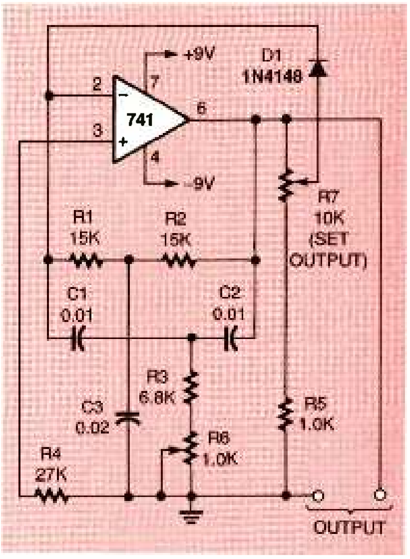


FIG. 14—A TWIN-T OSCILLATOR with diode regulation.

a variable-frequency Wien-bridge oscillator whose output covers the 15-Hz to 15-kHz frequency band in three switched decade ranges. The circuit includes thermistor stabilization, as previously described, and it generates an output with low-distortion. The frequency output of the oscillator can be switched with rotary switch S1 in three bands: 15 Hz to 150 Hz, 150 Hz to 1.5kHz, and 1.5 kHz to 15 kHz. The amplitude of the output signal can be changed with switch S2.

The frequency limit of this oscillator can be increased to 150 kHz by replacing the 741S operational amplifier with a National Semiconductor LF356 operational amplifier and adding a pair of switch-selected 0.001µF range capacitors.

Figure 12 is the schematic for JFET-regulated version of the circuit in Fig. 10, modified to form an economical sine/squarewave generator. It covers the 15 Hz to 150 kHz frequency range with four settings of switch S1. Sinewave potentiometer R14 permits the sinewave's peak -to-peak output level to be preset to 8 volts. The squarewave generator section consists of common-emitter amplifier Q2 and Schmitt trigger IC2. The base of transistor Q2 is driven by the sinewave output of IC1 through R9, and Q2's emitter is biased to about −600 millivolts through diode D2 and resistor R11.

As a consequence, transistor Q2 is driven on or off whenever the sinewave swings more than a few millivolts above or below the zero-volt level. Transistor Q2 then generates a symmetrical squarewave output, and IC2 reduces the rise and fall times to less than 100 nanoseconds. The final squarewave output is available from R16. Switch S2 is the output multiplier. To conserve battery power, the squarewave generator can be switched off with switch S3-b and S3-d when the circuit is not in use.

Twin-T oscillators

The twin-T oscillator is another popular RC network-based sinewave oscillator that is useful in fixed-frequency applications. It is made by connecting a twin-T network between the output and input of an inverting operational amplifier, as shown in Fig. 13. The twin-T network consists of resistors R1 and R2 shunted by capacitor C3, and capacitors C1 and C2 shunted by resistor R3 in series with potentiometer R5.

These components form a balanced network because they are in the ratios R1 = R2 = 2(R3 + R5), and C1 = C2 = C3/2. They give a zero output at a center frequency, f of $1/2\pi \times R1 \times C1$, and a finite output at all other frequencies. If the Twin-T is imperfectly balanced, it gives a feeble output at its center frequency, and its output phase depends on the direction of the imbalance. In other words, if the imbalance is caused by low values of R3 + R5, the output phase is inverted with respect to the input.

The twin-T network in Fig. 13 can be adjusted by R5 so that a small phase-inverted output at a center frequency of 1 kHz can be produced. Consequently, overall phase inversion takes place around the feedback loop, and the circuit oscillates at 1 kHz. Potentiometer R5 can be adjusted so that oscillation is barely sustained. Under this condition, sinewave amplitude is limited to about 5 volts RMS by the onset of operational amplifier clipping. The output has less than 1% THD.

Figure 14 is a schematic for a simple twin-T oscillator that will have lower output distortion. Diode D1 provides distortion-generated automatic gain control. To organize this circuit, set the wiper of potentiometer R7 to the output of the operational amplifier, and adjust R6 so that oscillation is just sustained. A sinewave output of about 500 millivolts, peak-to-peak, will be produced. Ω

JACOB'S LADDER

continued from page 59

to those found on the schematic Fig. 1. The cores and bobbins for this transformer are from Philips (Ferroxcube) Components, Saugerties, NY). The cores are No. E187 made from 3E2A ferrite material. The plastic molded bobbins are Part No. E187PCB1-8. These parts are available from the source given in the Parts List.

Transformer T1: Wind the first 30 turns trifilar (three wires in parallel) from No. 30 AWG magnet wire and the remaining 30 turns as single wire turns. Solder the ends of the windings to the pins, insert the E-core, and tape the assembly together securely.

Transformer T2: The core of transformer is No. 4162S from Samhwa USA, Chatsworth CA, with matching seven-segment bobbin, cup and primary bobbin. These parts are also available from the source given in the Parts List.

Start winding the secondary bobbin by securing the magnet wire to a pin insulated on the bobbin end and wind between 300 and 400 turns of No. 37 AWG magnetic wire on each of seven segments. Snap the cup in place and solder the output leads. Fill the cup with epoxy or RTV silicone when you are satisfied that the transformer has been wound correctly.

Wind eight turns of No. 30 twisted wires on the primary bobbin and tape the windings in place. Form the air gap of the primary section with 0.005-inch thick Milar tape and form the air gap for the secondary section with 0.010-inch thick Milar tape. Tape or clamp the two sections together with a heavy rubber band. Ω

VIDEO NEWS

Continued from page 6

Digital Camcorders Here

If you have a couple or three thousand dollars to spend on really top-notch video reproduction, you now can buy a digital camcorder using the standard DV (digital video) format from either Sony or Toshiba, with JVC waiting in the wings. In this column we've carried a lot of information about that DVC format (now called DV). The available camcorders produce breathtaking pictures and are ideal for professional or "prosumer" videographers.

Panasonic's model has three CCD pickups, while Sony has two models, one with three pickups and one with a single CCD. The Sony model has a digital interface and utilizes an optional feature of the DV system—a cassette with a built-in chip that stores data on tape specifications and records the date of recording and provides easy access to any scene. EN

IR LOGIC PROBE

continued from page 72

prepare the cable ends in the same manner as before. Solder the leads of the cable to the circuit board as shown in Fig. 2. Attach a 9-volt battery to the connector and turn on the power. The unit can be tested with an infrared remote control or an infrared LED and current-limiting resistor connected to the output of a pulse or function generator. (The IR LED can be coupled to the probe's tip with a length of ¼-inch heat-shrink tubing for test purposes.)

The tricolor LED should glow red; if not check D1 and the battery or its polarity. Point the IR LED at the probe's tip and make sure both LED indicators are functioning. If there is no indication, check the photodiode's polarity, IC1, and its associated components. If the tricolor LED does not flash amber, check IC2 and its associated components. Connect an oscilloscope to J1, and verify that a waveform is present.

Once the circuit has been checked out, join both halves of the enclosure. Be sure that the battery wires do not tangle around the LED indicators. A piece of foam rubber cut to fit the bottom of the battery compartment will keep the battery from rattling around in the case.

Using the probe

If light from windows and incandescent lamps interferes with the probe's operation, either remove the source of interference or move the work area. Ambient room light should not create problems, especially if its source is florescent fixtures.

The probe's plastic light pipe is most sensitive at the screwdriver-shaped tip. The light reflects within the walls of the light pipe (as in fiber optic cable), conducting the light to the photodiode. The probe will indicate if high-frequency pulsed IR LEDs are working, but the photodiode will integrate the pulses to a steady-state level. Ω

continued from page 38

The trim feature permits a single DC-to-DC converter to work in many different applications. It also allows the converter to function in control applications where a ramp, step, or other output function is required.

Series configuration. Higher output voltages can be obtained from modular DC-to-DC converters by connecting the outputs of two or more units in series, as shown in Fig. 7. The gate terminals synchronize the converters. Adequate wire gauge is required on the inputs and outputs to ensure that each unit carries its share of the load.

Parallel configuration. Higher output currents can be obtained from modular DC-to-DC converters by connecting the outputs of two or more units in parallel, as shown in Fig. 8. The gate terminals synchronize the units. Again, wire of adequate gauge is required on the inputs and outputs.

Redundant configuration. Reliability is a primary concern in most power systems, particularly those used for data processing and life-support applications. A redundant configuration, such as that shown in Fig. 9, will assure maximum reliability. One converter will power the system if the other unit fails. The survivingt unit will not be burdened by the failed unit because of the presence of isolation diodes.

As many DC-to-DC converters as desired can be connected in this manner. The diodes should be rated for twice the maximum expected voltage and current to ensure circuit reliability. Again, a Schottky diode is recommended here because of its low forward voltage drop.

Constant current configuration. Most modular DC-to-DC converters are configured to provide a constant output voltage. The configuration shown in Fig. 10 provides a constant-current output. This is useful in applications where the load impedance might change, but the same current is desired. The operational-amplifier voltage rating must be greater than the DC-to-DC converter's output voltage.

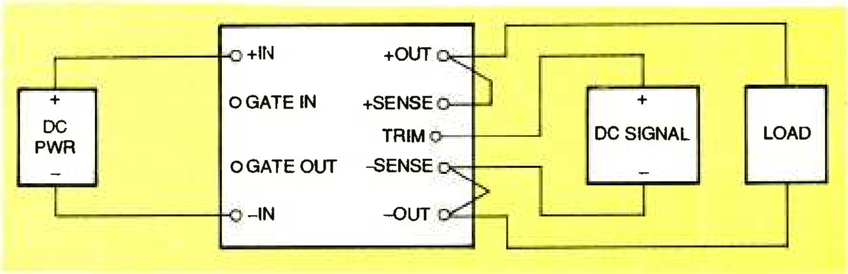


FIG. 6—MANY DC-TO-DC CONVERTERS have an output voltage that can be adjusted by setting a voltage at the trim terminal.

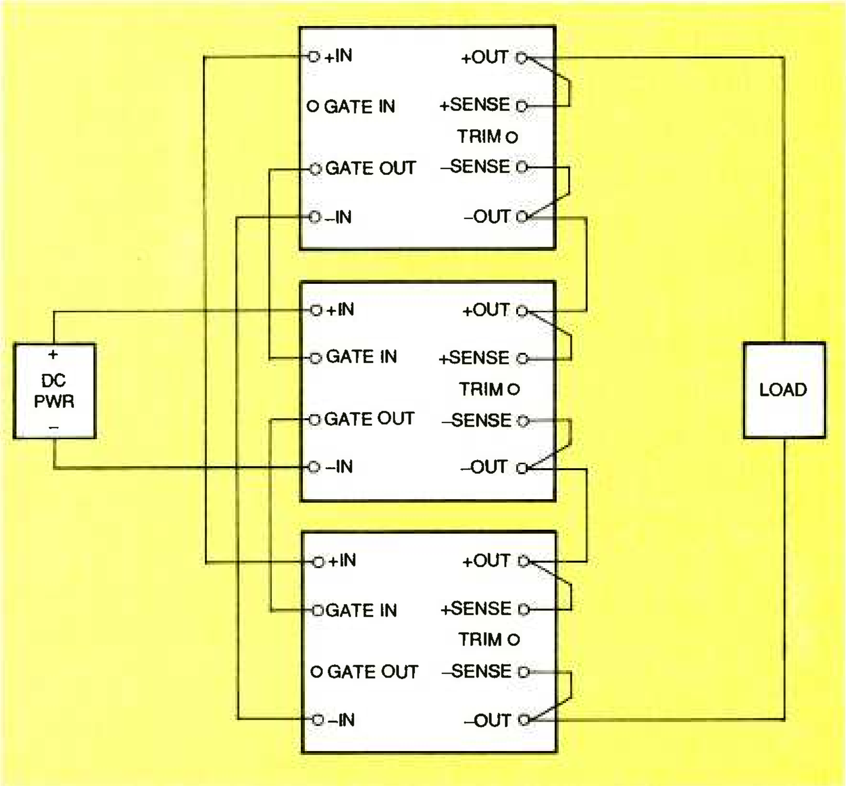


FIG. 7—SERIES CONFIGURATION. Higher output voltages can be obtained by connecting the outputs of one or more units in series.

Filtering

Because DC-to-DC converters are switching devices, the input and output lines will have electrical noise on them. This might be acceptable in some applications, but in most cases it is not, so some filtering is visually necessary.

As a minimum, an input capacitor should be installed. The capacitor will conduct any high-frequency transients from the DC line to ground. A 0.1μF bypass capacitor is a typical value for this application. Its voltage rating should be twice that of the maximum expected input voltage.

Commercial filters that are effective in attenuating noise are available from many suppliers. A typical filter configuration is shown in Fig. 11. Manufacturer's specifications for the filter will indicate the attenuation at the desired frequency.

Loads such as lamps and motors require no output filtering. For critical applications, however, it might be necessary to reduce output ripple with an output filter. That filter can be as simple as a capacitor con-

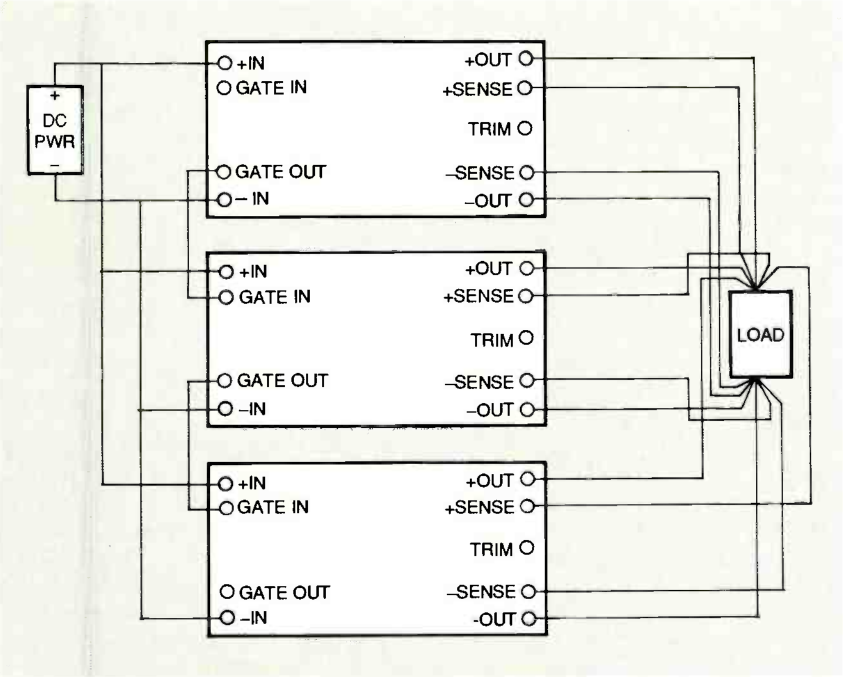


FIG. 8—PARALLEL CONFIGURATION. Higher output currents can be obtained by connecting the outputs of multiple units in parallel.

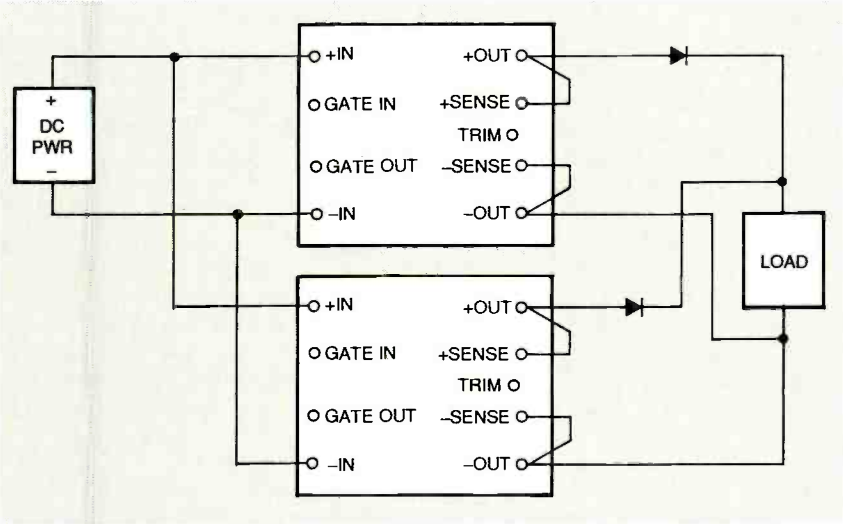


FIG. 9—REDUNDANT CONFIGURATION. One converter will power the system in the event that the other unit fails.

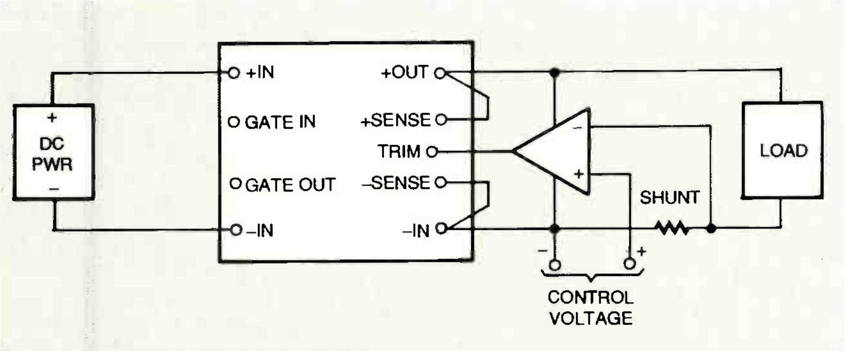


FIG. 10—CONSTANT CURRENT CONFIGURATION. This is useful in applications where the load impedance at the output may change, but it is desired that the same current be delivered.

DC-TO-DC CONVERTER MANUFACTURERS

Abbott Electronics, Inc.
2727 La Cienga Blvd.
Los Angeles, CA 90034

Advanced Power Solutions
5994 W Las-Positas Blvd.
Pleasanton, CA 94588

Analogic Corp.
8 Centennial Drive
Peabody, MA 01960

Calex Manufacturing Company, Inc.
3355 Vincent Rd.
Pleasant Hill, CA 94523

Computer Products, Inc.
7900 Glades Rd.
Boca Raton, FL 33434

Conversion Devices, Inc.
15 Jonathon Dr.
Brockton, MA 02401

Datel, Inc.
11 Cabot Blvd.
Mansfield, MA 02048

Delta Products Corp.
3225 Laurelview Ct.
Fremont, CA 94538

International Power Devices, Inc.
20 Linden St.
Boston, MA 02134

International Power Sources, Inc.
200 Butterfield Drive
Ashland, MA 01721

Interpoint Corp.
10301 Willows Rd.
P.O. Box 97005
Redmond, WA 98073

Lambda Electronics, Inc.
515 Broad Hollow Rd.
Melville, NY 11747

Total Power International Inc.
418 Bridge St.
Lowell, MA 01850

Vicor Corp.
23 Frontage Rd.
Andover, MA 01810

Volgen America
32980 Alvarado-Niles Rd.
Union, City, CA 94587

nected in parallel with the output terminals or an inductor in series with the load. The converter manufacturer might provide an add-on output filter that retains the remote sense and output voltage trim features.

Thermal circuit

Although most modular DC-to-DC converters are efficient, the heat losses must be dissi-

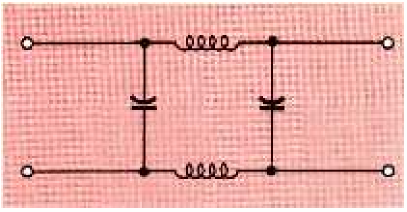


FIG. 11—FILTERS CAN ATTENUATE NOISE. A typical filter configuration is shown here.

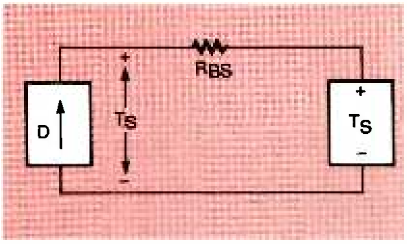


FIG. 12—THERMAL CIRCUIT DUE TO CONDUCTION. Conduction will transfer heat from a DC-to-DC converter to a heatsink.

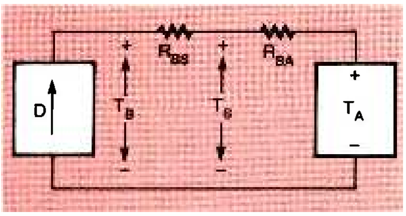


FIG. 13—THERMAL CIRCUIT DUE TO CONVECTION. Convection is the transfer of heat from a surface into cooler surrounding air.

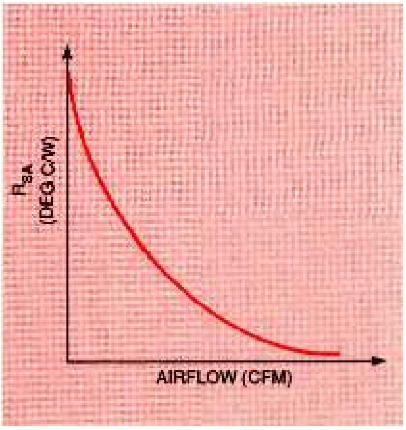


FIG. 14—FORCED CONVECTION is accomplished by using a fan. The effect of air flow on the heatsink thermal resistance is shown here.

pated properly for good performance and high reliability. Efficiency is the ratio of delivered output power to converter input power. Heat is transferred from regions of high temperature to regions of low temperature by radiation, conduction, convection or combinations of these methods.

Radiation is the spatial transfer of heat, conduction is the transfer of heat through a solid medium, and convection is the transfer of heat through a fluid medium, such as air. Radiation usually accounts for less than 10% of heat transfer in most DC-to-DC converter applications. It is usually neglected so that any cooling by radiation is considered a bonus.

Conduction is an effective means of transfer. Conduction will transfer the heat from a DC-to-DC converter to a heatsink. A good conduction path is maintained by providing close metal-to-metal contact. Heat-conducting compound should be used to fill any surface irregularities. The thermal circuit due to conduction is shown in Fig. 12. The expression for conduction is:

$$T_B = T_S + (D \times R_{BS})$$

where T_B is the DC-to-DC converter base temperature in degrees Celsius, T_S is the heatsink temperature in degrees Celsius, D is the DC-to-DC converter heat dissipation in watts, and R_{BS} is the DC-to-DC converter base-to-heatsink thermal resistance in degrees Celsius per watt.

Convection is the most common way that heat is transferred. Natural convection is the transfer of heat from a surface into cooler surrounding still air. Forced convection is the transfer of heat from the source by a moving stream of air. The thermal convection circuit is shown in Fig. 13.

The heatsink-to-air thermal resistance depends on a number of factors including material, geometry, air temperature, air density, and air flow. Heatsink manufacturers provide specific thermal-resistance data.

Natural convection is inexpensive and reliable, but it requires a larger heatsink area than one for forced convection. The heatsink is selected by determining the heat dissipation of the DC-to-DC converter with following the expression:

$$R_{SA} = (T_B - T_A)/D - R_{BS}$$

where R_{SA} is the heatsink-to-air thermal resistance in degrees Celsius per watt, T_B is the DC-to-DC converter base temperature in degrees Celsius, T_A is the air temperature in degrees Celsius, D is the DC-to-DC converter heat dissipation in watts, and R_{BS} is the DC-to-DC converter base-to-heatsink temperature in degrees Celsius per watt.

Do your calculations with a base temperature well within the safe operating area of the DC-to-DC converter and a maximum ambient temperature. Select a heatsink with the lowest thermal resistance that's compatible with the application. Reducing the ambient temperature around the DC-to-DC converter slightly will greatly improve its reliability.

Forced convection is usually accomplished with a fan or blower. Fans can be noisy, inefficient, and unreliable, but they supplement the cooling provided by a heatsink alone. The thermal resistance of a heatsink is usually given by the manufacturer for forced convection as well as for natural convection. The effect of air flow on the heatsink thermal resistance is shown in Fig. 14. Increased air flow greatly reduces the thermal efficiency of the heatsink.

Summing up

Modular DC-to-DC converters provide a compact, regulated isolated voltage source at the required location. They can greatly improve circuit performance, safety, and reliability.

Always be sure to follow a few simple precautions when installing modular DC-to-DC converters. Provide adequate wire size for the input and output circuits. Prevent the input voltage from exceeding the maximum rating. Use a surge arrestor if the input power stability is questionable. Prevent an input reverse-polarity condition. Provide a good thermal environment for the DC-to-DC converter with proper heat sinking. Ω

BUYER'S MART

SATELLITE TV

FREE catalog — Lowest prices worldwide. Satisfaction guarantee on everything sold - Systems, upgrades, parts, all major brands factory fresh and warrantied. **SKYVISION,** 1012 Frontier, Fergus Falls, MN 56537. 1 (800) 334-6455. Outside US (218) 739-5231.

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.

SATELLITE TV organizer for DOS. Two diskettes & instructions. Database software for quick changing transponders. $19.95 plus $3.00 S&H. **HUMANFORM ROBOTICS,** PO Box 158486, Nashville, TN 37215.

BUSINESS OPPORTUNITIES

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. (520) 428-4073. Visa/MC.

B + J COMPUTER Build your own computer and save. Call or fax for your free screensaver and price lists. (203) 484-7565.

EARN money from home with new CD-ROM! 600 How-to-books, reports & guides you can reprint and sell. Complete text of all 600 on Windows CD-ROM. Just $99.00. **1 (800) 600-0612.** Visa/MC/COD.

EDUCATION & INSTRUCTION

ELECTRONIC engineering. 8 volumes complete. $109.95. No prior knowledge required. Free brochure. **BANNER TECHNICAL BOOKS,** 1203 Grant Avenue, Rockford, IL 61103.

LEARN VCR repair. Great profits. Home study. **P.C.D.I.,** Atlanta, GA. Free literature. 1 (800) 362-7070 Dept. VRP342.

LEARN PC repair-troubleshooting, servicing. Home study. Free literature. **P.C.D.I.,** Atlanta, GA 1 (800) 362-7070 Dept. JJP342.

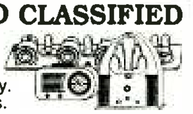
MICROWAVE oven manual, to become a technician. Award winner edition. USA $42.95, all foreign countries $69.00. **RANDALL,** Box 2168 R, Van Nuys, CA 91404.

LEARN locksmithing. Approved home study. Free career literature, **P.C.D.I.,** Atlanta, GA. 1 (800) 362-7070 Dept. LKP342.

TODAY'S Electronics. Don't get left behind! Top home-study courses developed by U.S. Military. Free catalog. **FEDERAL TECHNICAL PUBLISHERS,** Box 1218, E Glen Lake, MN 55345.

KNOWLEDGE CARDS. Tables. Formulas. Fun and educational. Package $2.00. Box 12238, Lexington, KY 40581-2238.

ANTIQUE RADIO CLASSIFIED
Free Sample!
Antique Radio's
Largest Circulation Monthly.
Articles, Ads & Classifieds.



6-Month Trial: $17.95. 1-Yr: $34.95 ($51.95-1st Class).
A.R.C., P.O. Box 802-L15, Carlisle, MA 01741
Phone:(508) 371-0512 VISA/MC Fax:(508) 371-7129

FREE ★ **1995 CATALOG** ★ **FREE**
OF THE WORLD'S MOST FAMOUS CB ANTENNAS & ACCESSORIES
— FIRESTIK : FREE CATALOG OFFER —
2614 E. Adams · Phoenix, AZ 85034
Write or Call, 602-273-7151

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 book (BP107 & BP113) only $11.90 plus $4.00 for shipping. USA and Canada only. US funds. **ETT, INC.,** PO Box 240, Massapequa Park, NY 11762-0240.

CRYSTAL set Handbook — Visit antiquity by building the radios your grandfather built. Assemble a "Quaker Oats" rig, wind coils that work and make it look like the 1920's! Only $10.95 plus $4.00 for shipping and handling. **CLAGGK INC.,** PO Box 4099, Farmingdale, NY 11735. US funds only! USA and Canada — no foreign orders.

ALL-in-one catalog. AM/FM/ham/spy, transmitters, amplifiers, receivers. Voice scramblers/disguisers, audio, TV, Tesla coils, plans, "secret" books, kits, imports, exports and more. Start your own licensed or unlicensed radio station. 60 full pages for $1.00. **PAN-COM INTERNATIONAL,** PO Box 130-F12, Paradise, CA 95967.

FIBER Optic educational experiments kit includes: tutorial, w/experiments. 40ft. fiber assortment. + cutting tool. $19.95 + S/H **(609) 468-1660.**

BREATHALYZER Secrets Police, consumer, coin-operated, schematics, operation methods, software techniques, parts sources. Send $20.00. Kits or ready made available. **KINGSGATE TECHNICAL,** Box 693, Bolton, Ontario, Canada L7E 5T5.

FREE catalog. Nearly 100 leading-edge kits. KI, PIC. Full instructions, source code SASE. **SCIENCE FIRST,** 95 Botsford Place, Buffalo, NY 14216.

SURVEILLANCE
& COUNTERSURVEILLANCE Electronic Devices
Covert Video Cameras • Transmitter Kits • Voice Changers
Bug and Phone Tap Detectors • Shotgun Mics • Micro Recorders
• Vehicle Tracking • Locksmithing • AND MORE!
16 - Hour Telephone Recorder - silently tapes incoming/outgoing phone calls automatically. **$199.00**
SPY OUTLET FOR CATALOG SEND $5.00 TO... CREDIT CARDS WELCOME
P.O. Box 337, Buffalo, NY 14226 (716) 691-3476

CABLE TV TURN-ON CHIPS

SUPER Cable TV "Test Chips". Provides full service activation. Excellent instructions & illustrations. **Jerrold Starcom:** DP(V)5..DP(V)7.. DPBB7..CFT-2000 series. **Pioneer:** BA-5000 thru BA-6700. **Scientific Atlanta:** 8500 thru 8600. **Tocom:** 5503-VIP..5507. **Zenith:** ST-1000 thru ST-5000. **Call now!! MASTER COMPONENTS. 1 (800) 233-0570.**

PATENT SERVICES

PATENT protection can be crucial to capitalizing on your invention. If you are interested in patenting your invention please call **JON M. JURGOVAN,** (registered patent attorney) for free initial consultation. (404) 951-0931 D (404) 240-0979 E.

FOR SALE

TUBES: "oldest", "latest". Parts and schematics. SASE for lists. **STEINMETZ,** 7519 Maplewood Ave., EN 46324, Hammond, IN 46324.

FIBER-Optic Projects — Swing into the new technology by assembling tried and true projects recently published. "Practical Fiber-Optic Projects" only $9.95 (price includes shipping) **ELECTRONICS TECHNOLOGY TODAY INC.,** PO Box 240, Massapequa Park, NY 11762-0240.

CABLE TV Test Chips for Jerrold, Tocom, Pioneer, Scientific Atlanta, etc...**Quick installation** New Multi-Mode modules available. Prices from $5.00 each. **1 (800) 786-9025.**

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,** PO Box 669, Seabrook, TX 77586. For Visa/MC, COD's (713) 922-3512 any time.

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 $6.00 for shipping. USA and Canada only. US funds. **ETT, INC.,** PO Box 240, Massapequa Park, NY 11762-0240.

RESTRICTED Information: Surveillance, Locksmithing, Cable, Hacking, Investigation, Transmitter kit, Etc. **MENTOR,** Box 1549-Z, Asbury, NJ 07712.

THE Case Against the Patents. Thoroughly tested and proven alternatives that work in the real world. $28.50. **SYNERGETICS PRESS,** Box 809-C, Thatcher, AZ 85552. (520) 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.

CABLE TV equipment & accessories. Wholesalers welcome! 30 day moneyback guarantee! Free catalog! **PERFORMANCE ELECTRONICS, INC., 1 (800) 815-1512.**

TV Notch filters, free brochure, **MICRO THINC.,** Box 63/6025, Margate, FL 33063. (305) 752-9202.

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 descramblers. Bargain headquarters. Below wholesale prices. Absolutely the lowest prices! Money back guarantee. Nobody beats us! **RP ELECTRONICS,** 1 (800) 304-3604.

SURVEILLANCE Privacy security protection. Catalog $5.00. **SPY EMPORIUM,** 6065 Hillcroft 413, Houston, TX 77081. (713) 774-1000.

CATV Test Chips as low as $8.95 for testing converter boxes in full service modes. Jerrold, Tocom, Scientific Atlanta, Pioneer BA5XXX/BA67XX cubes clears E2-E5, **MICRO MASTERS,** 1 (800) 360-7654.

CB Radio modifications! Frequencies, 10M, sliders, FM, amplifiers, books, kits, repairs, high-performance accessories. The best since 1976! Catalog $3.00. **CBCI,** Box 31500EN, Phoenix, AZ 85046.

WHITE Noise generator, complete with case and power supply. Perfect for getting to sleep and lab projects. Only $29.95 (plus $3.50 S&H) Visa/MC call 1 (800) 357-2199, or send check/MO to **COASTAL WINKS,** 6755 Mira Mesa Blvd., #123-282B, San Diego, CA 92121.

POWER SUPPLY

continued from page 75

The fuse holder is mounted on the rear panel, and the panel allows access for the 120-volt AC line cord. A No. 14- or No. 16-AWG, three-conductor linecord is recommended. Connect the green ground lead to the frame of the transformer. Figure 6 shows the inside of the completed power supply.

Calibration

With switch S4 set to the positive variable voltage position and S5 set to the voltage mode, adjust R1 for any desired voltage, and measure the output with a voltmeter. Adjust R12 until the built-in digital display shows the same voltage. Move S5 to the *current* position, and connect a resistive load of about 10 kilohms in series with an ammeter to the output. Adjust R15 so that the ammeter and the built-in meter both read the same current value. The power supply is now complete and ready for you to use on your test bench. Ω

ELECTRONIC SHOPPER

ADVERTISING INDEX

Electronics Now does not assume any responsibility for errors that may appear in the index below.

ADVERTISING SALES OFFICES

Gernsback Publications, Inc.
500 Bi-County Blvd.
Farmingdale, NY 11735-3931
1-(516) 293-3000

Larry Steckler
publisher (ext. 201)

Christina Estrada
assistant to the publisher (ext. 209)

Arline Fishman
advertising director (ext. 206)

Adria Coren
credit manager (ext. 208))

For Advertising ONLY

EAST/SOUTHEAST
Stanley Levitan
Eastern Advertising
1 Overlook Ave.
Great Neck, NY 11021-3750
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
Hutch Looney & Associates, Inc.
6310 San Vicente Blvd.
Suite 360
Los Angeles, CA 90048-5426
1-213-931-3444
Fax 1-213-931-7309

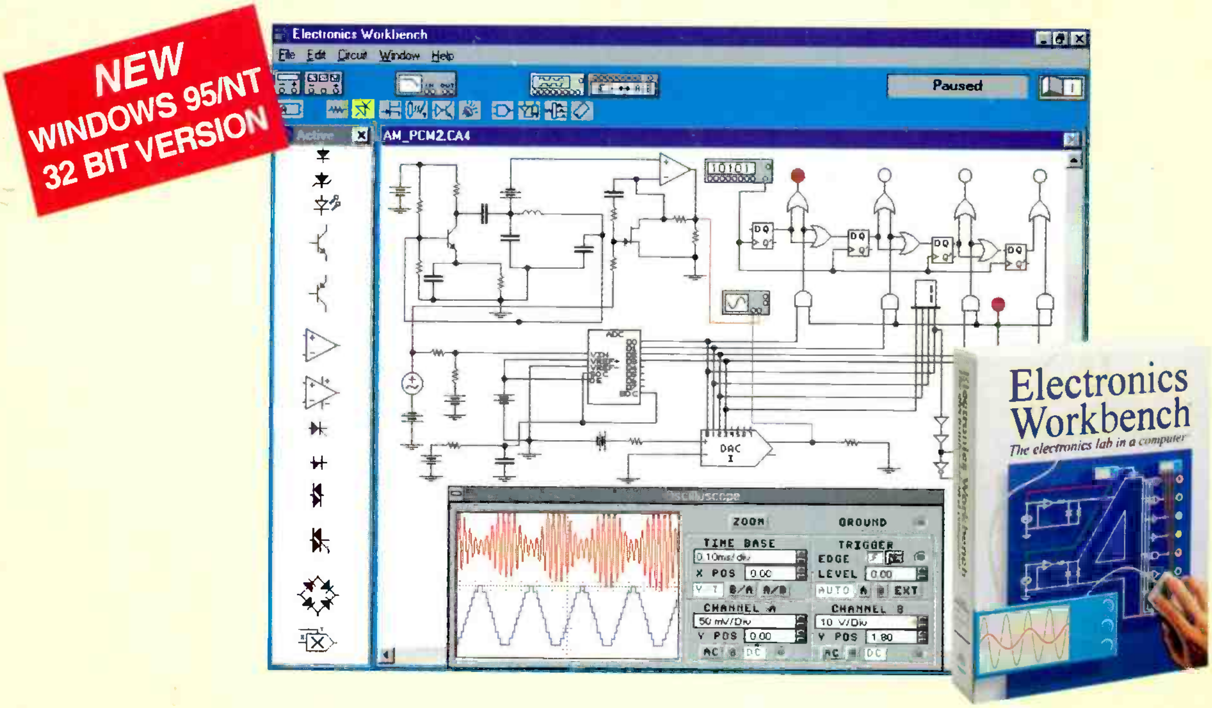
Electronic Shopper
Joe Shere
National Representative
P.O. Box 169
Idyllwild, CA 92549-0169
1-909-659-9743
Fax 1-909-659-2469

Megan Mitchell
National Representative
1201 N. Rainbow Blvd., #50
Las Vegas, NV 89128
1-702-259-7043
Fax 1-702-259-7043

Subscriber Customer Service
1-800-288-0652
7:00 AM - 6:00 PM M-F MST

Electronics Workbench®

Version 4.1



Design and Verify Circuits Faster

Join over 20,000 customers using the affordable mixed-signal simulator

Design faster with Electronics Workbench. Mix the analog and digital components and ICs in any combination. And with a click of the mouse, try 'what if' scenarios and fine tune your designs. The built-in SPICE simulator gives you real-world waveforms.

All without programming or netlist syntax errors.

And in minutes. Not hours or days.

You'll be up and running sooner. And create better designs faster with Electronics Workbench. We guarantee it!

Electronics Workbench: $299

- Click & drag schematic capture
- Mixed analog/digital SPICE simulator
- Instant Bode plots and scrollable waveforms
- 50 analog components with 350 models
- 140 digital components and ICs in TTL and CMOS
- Windows 95/NT/3.1, DOS and Macintosh versions
- Free unlimited technical support
- 30-day money-back guarantee

Engineer's Pack: $599

- Electronics Workbench
- 2,450 models
- Import/Export SPICE netlists
- Export to PCB packages

To discover more about *the* affordable mixed-signal simulator, call us today at:

INTERACTIVE IMAGE TECHNOLOGIES LTD.
908 Niagara Falls Blvd. #068, North Tonawanda, NY 14120-2060
Telephone: 416-977-5550 BBS: 416-977-3540
CompuServe: 71333,3435 E-mail: ewb@interactiv.com

800-263-5552

Fax: 416-977-1818
Internet: http://www.interactiv.com

Australia: 2-519-3933 • Brazil: 11-453-5588 • Cyprus: 2-62-1068 • Czech Replubic: 19-224308 • Denmark: 33-25-0109 • Finland: 0-297-5033 • France: 14-908-9000 • Germany: 711-62-7740 • Greece: 1-524-9981 • Hungary: 1-215-0082 • India: 11-544-1343 Indonesia: 21-470-0815 • Israel: 3-647-5613 • Italy: 11-437-5549 • Japan: 3-3382-3136 • Malaysia: 3-774-2189 • Mexico: 5-593-5260 • Netherlands: 18-031-7666 • New Zealand: 9-267-1756 • Norway: 22-16-7045 • Philippines: 973-27-0118 • Portugal: 1-81-46609 Singapore: 777-2303 • Slovenia: 61-317-830 • South Africa: 331-68309 • South Korea: 2-2-222-3431 • Spain: 1-383-8335 • Sri Lanka: 1-86-5970 • Sweden: 8-740-5500 • Taiwan: 886-2-366-0080 • Thailand: 66-2-398-6952 • UAE: 4-453505 • UK: 203-23-3216

INTERACTIVE

9EA3FP95

CIRCLE 126 ON FREE INFORMATION CARD