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SUMMER 1995

ELECTRONICS EXPERIMENTER'S handbook™

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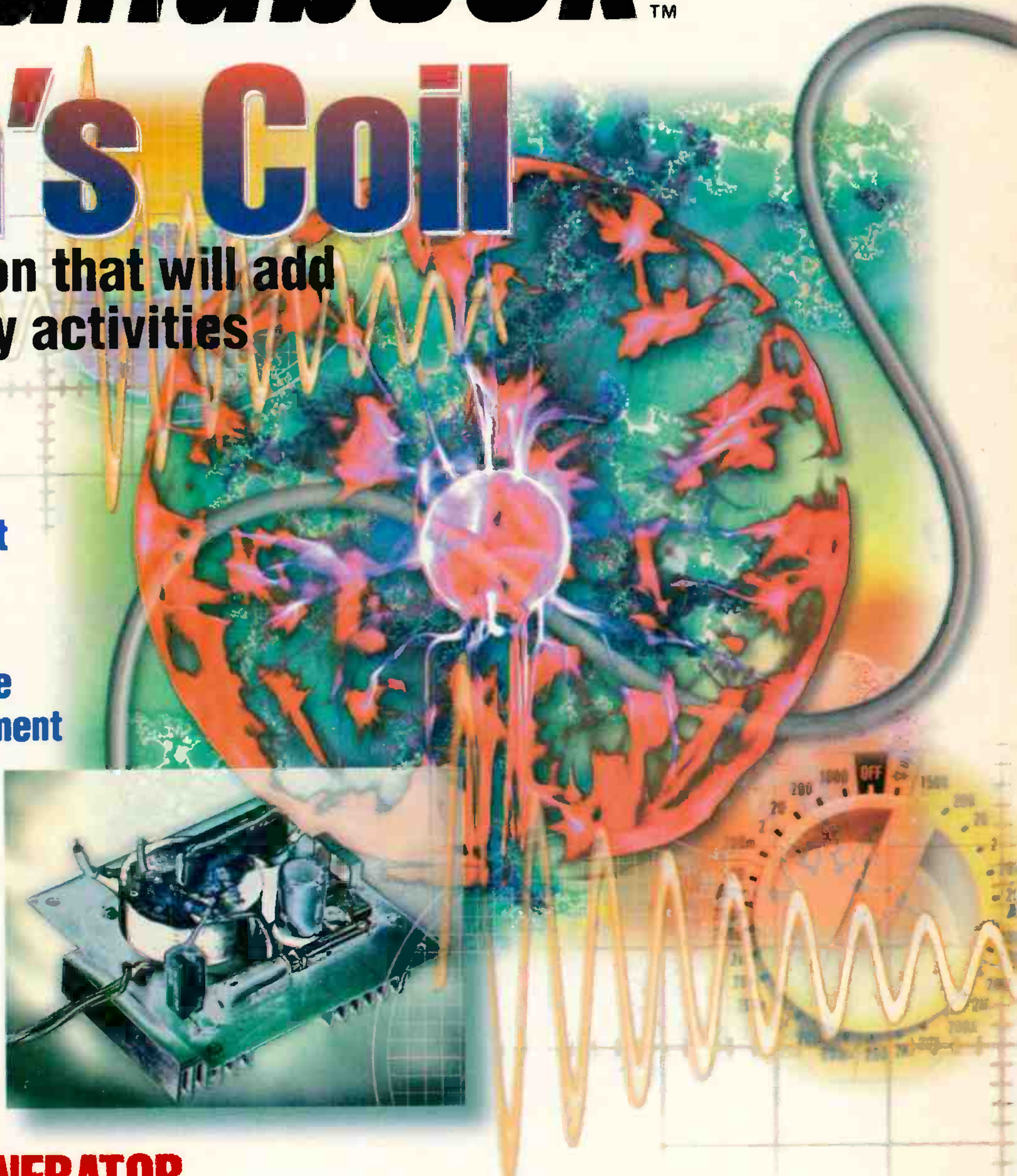

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Block access to 900 and 976 phone numbers and save bucks

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Just wave your hands and create weird and unusual sounds

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- Power up Night-Vision Scopes
- Make PC Transcripts of TV Programs
- Rechargeable LED Flashlight
- Build our own Computerized Game
- Grab Bag of Simple Circuits

TECHNOLOGY UPDATE

New device turns any electrical outlet into a phone jack

Engineering breakthrough gives you unlimited phone extensions without wires or expensive installation fees

By Charles Anton

You don't have to have a teenager to appreciate having extra phone jacks. Almost everyone wishes they had more phone jacks around the house.

When I decided to put an office in my home, I called the phone company to find out how much it would cost to add extra phone jacks. Would you believe it was $158?

No more excuses. Today, there are a thousand reasons to get an extra phone jack and a thousand excuses not to get one. Now an engineering breakthrough allows you to add a jack anywhere you have an electrical outlet. Without the hassle. Without the expense. And without the miles of wires.

Like plugging in an appliance. Now you can add extensions with a remarkable new device called the Wireless Phone Jack. It allows you to convert your phone signal into an FM signal and then broadcast it over your home's existing electrical wiring.

Just plug the transmitter into a phone jack and an electrical outlet. You can then insert a receiver into any outlet anywhere in your house. You'll be able to move your phone to rooms or areas that have never had jacks before.

Clear reception at any distance. The Wireless Phone Jack uses your home's existing electrical wiring to transmit signals. This gives you sound quality that far exceeds cordless phones. It even exceeds the quality of previous devices. In fact, the Wireless Phone Jack has ten times the power of its predecessor.

Your range extends as far as you have electrical outlets: five feet or five hundred feet. If you have an outlet, you can turn it into a phone jack—no matter how far away it is. The Wireless Phone Jack's advanced companding noise reduction features guarantee you crystal-clear reception throughout even the largest home.

Privacy guarantee. You can use The Wireless Phone Jack in any electrical outlet in or around your home, even if it's on a different circuit than the transmitter. Each Wireless Phone Jack uses one of 65,000 different security codes. You can be assured that only your receiver will be able to pick up transmissions from your transmitter.

Is the Wireless Phone Jack right for you?

The Wireless Phone Jack works with any single-line phone device. Almost anyone could use it, especially if...

- **Few jacks.** *You want more phone extensions without the hassle and expense of calling the phone company.*
- **Bad location.** *You have jacks, but not where you need them most, like in the kitchen, garage, home office or outside on the deck.*
- **Renting.** *You want to add extensions, but you don't want to pay each time you move.*
- **Other phone devices.** *You have an answering machine, modem or fax machine you want to move to a more convenient place.*

The Wireless Phone Jack System consists of a transmitter (right) and a receiver (left). One transmitter will operate an unlimited number of receivers.

Unlimited extensions—no monthly charge. Most phone lines can only handle up to five extensions with regular phone jacks. Not with the Wireless Phone Jack. All you need is one transmitter, and you can add as many receivers as you want. Six, ten, there's no limit. And with the Wireless Phone Jack, you'll never get a monthly charge for the extra receivers.

Works with any phone device. This breakthrough technology will fulfill all of your single-line phone needs. It has a special digital interface for use with your fax machine or modem. You can even use it with your answering machine just by plugging it into the Wireless Phone Jack receiver.

The Wireless Phone Jack lets you add a phone, modem, fax machine or answering machine almost anywhere.

Special factory-direct offer. To introduce this new technology, we are offering a special factory-direct package. For a limited time, the transmitter is only $49. One transmitter works an unlimited number of receivers priced at $49 for the first one and $39 for each additional receiver. Plus, with any Wireless Phone Jack purchase, we'll throw in a phone card with 30 minutes of long distance (a $30 value) for only $9.95!

Try it risk-free. The Wireless Phone Jack is backed by Comtrad's exclusive 30-day risk-free home trial. If you're not completely satisfied, return it for a full "No Questions Asked" refund. It is also backed by a one-year manufacturer's limited warranty. Most orders are processed within 72 hours and shipped UPS.

Wireless Phone Jack transmitter ...$49 $4 S&H
Wireless Phone Jack receiver ....$49 $4 S&H
save $10 on each additional receiver—$39

30-minute long distance phone card.......~~$30~~
$9.95 with Wireless Phone Jack purchase

Please mention promotional code 017-ET-1112.

For fastest service, call toll-free 24 hours day
800-992-2966

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2820 Waterford Lake Drive, Suite 106
Midlothian, Virginia 23113

ELECTRONICS EXPERIMENTER'S handbook™ Summer 1995

An **Electronics NOW**® Publication

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Electronics NOW®

ELECTRONICS EXPERIMENTER'S handbook™

Summer 1995

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Gernsback Publications, Inc., 500-B Bi-County Blvd., Farmingdale, NY 11735. 516-293-3000

Editorial

While in grade school I read a story about an old man who secretly saved odd lengths of string. He knew that one day that string would be valuable to him. As the story goes, a lady of wealth, not necessarily manner, lost a string of pearls somewhere on a road. The old man's wagon traveled that road and he was seen hopping off the wagon to pick up and put away a rope-like object in his pocket. Naturally, he was accused of stealing. No one believed his story that the object was a length of string. He would have been banished from his town had not another villager discovered the string of pearls the next day. There's a moral to this story that I don't recall; however, I tell the world about my spare parts box and ask everyone to contribute their new and used parts to me.

During the past year I dug deep into my spare parts box (actually they are three large boxes) and found some 3000-volt, silver-mica capacitors that were just right for a Tesla coil I was building. I also discovered a bag of 1000-volt disc capacitors that are like hen's teeth for those with budget pocketbooks. Dosn't let me get started on wire. I have all sizes and colors. IC's? You can bet I have a bushel full.

So why am I talking up my spare parts box. Put it this way: I made a rough calculation and discovered I saved over $800 last year by using parts that I squirreled away. Not only that, think of the phone calls and trips to stores that weren't made. Imagine the time I saved not waiting for shipments to come in.

There's a moral to my spare parts box story. It is: A part in the box is worth a page in any parts catalog. I urge you to start salvaging parts whenever possible from old projects and equipment. Only go one step better than me, use your computer to catalog the items you have. It's too late for me, I have just too much!

Julian S. Martin,
Editor

PC TRAINING KITS. The Tech-Knowledge system is intended for teaching personal computer servicing, troubleshooting, and networking. Offered by Heathkit Educational Systems, it is now available in a single, comprehensive package, the EZS-400 for PC servicing, troubleshooting, and networking, or as three separate complementary units. They are the EZS-401 for PC Servicing, the EZS-402 for PC Troubleshooting, and the EZS-403 for PC local area networking.

CIRCLE 20 ON FREE INFORMATION CARD

Each training unit is complete with hardware, software, and course materials. The system is based on an IBM-compatible personal computer with an Intel 486 microprocessor. The PC can be upgraded by replacing the 486 processor with an Intel P24T Pentium processor.

The personal computer servicing course covers substantially all a student needs to know about servicing, maintaining, upgrading, and optimizing a personal computer. Hands-on exercises reinforce each topic covered in the textbook.

Students will be able to study the operation of various computer circuits with the guidance offered by manufacturer's technical manuals and schematics. That knowledge can be applied to troubleshooting personal computers with the aid of diagnostic software and standard test equipment.

Instruction is also given in specifying, installing, and troubleshooting local area networks. The course also explains how to install and configure modems and communications software. It includes Microsoft Windows for Workgroups Software and Novell Personal NetWare.

The courses include seven of Heathkit's fault insertion and removal modules (FIRMs), circuit boards with DIP switches that permit the simulation of circuit faults without altering the training computer or its peripherals. Each course includes a student text book, student work book, instructor's guide and course experiment parts packages.

The complete EZS-400 package includes two Zenith Data Systems computer trainers with multifrequency color monitors, 210 Mbyte hard-disk drives and PS/2 compatible keyboard and mice. If purchased as separate units, the EZS-401 and EZS-402 packages each contain one computer and monitor. The EZS-403 package includes two computers and two monitors.

The pricing of the instruction packages is as follows: EZS-400—$7495, EZS-401 and EZS-402—$2495, and EZS-403 — $5995.

Heathkit Educational Systems
455 Riverview Drive
Benton Harbor, MI 49022

CONSTANT-CURRENT POWER SUPPLY. The Model 930 constant-current power supply from Calex has a temperature coefficient of 0.001%/°C and an output impedance of 10 megohms. Its power requirements are +12 to +32 volts. It is sold with a mounting kit that includes a potentiometer for setting constant current from 0 to +50 milliamperes.

The Model 930 can function as a bridge excitation supply. By adding a 10,000-ohm resistor, the supply becomes a stable 100-microampere current source for resistance-temperature sensors (RTD).

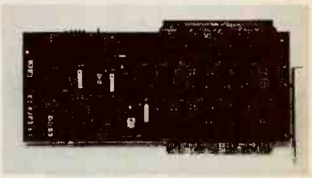
CIRCLE 22 ON FREE INFORMATION CARD

The Model 930 is priced at $115.

Calex Manufacturing Company, Inc.
2401 Stanwell Drive
Concord, CA 94520
Phone: 800-542-3355
Fax: 510-687-3333

SMART EISA EXTENDER CARD. The EISA-EXT EISA extender card from ICS Electronics allows EISA and ISA bus add-on cards for IBM or compatible personal computers to be tested and debugged in the PC card cage without powering the computer up and down to change cards.

The EISA-EXT card protects the computer against power-supply overloads caused by the card under test. Solid-state switches on all signal lines permit the card under test to be changed while the computer is running. The card can be operated either by a switch on the card or by I/O commands from the test program.



CIRCLE 23 ON FREE INFORMATION CARD

The turn-on sequence applies power and signals to the card under test in a sequence that avoids any conflict with the computer bus signals. The card continuously monitors the power lines to the card under test and shuts down all power and signals if an overcurrent condition is detected. Light-emitting diodes on the card indicate power, signal connection, and overcurrent.

NEW PRODUCTS

The EISA-EXT card, including a disk with sample control programs and integrating software for Windows, is priced at $595.

ICS Electronics Corporation
473 Los Coches Street
Milpitas, CA 95035
Phone: 408-263-5896

ULTRA-THIN TEST CLIPS. The Ultra-Thin Micrograbber series test clips from ITT Pomona are intended for microcircuit packages with finely spaced pins with up to 0.050 inch pitch. Narrow bodies that measure 0.12 inches permit close stacking of the clips.

The clip wiring is flexible to permit easy access from

CIRCLE 24 ON FREE INFORMATION CARD

different angles. Serrated surfaces on the plunger and finger tabs improve the holding ability of the test clips. The contact pincers open to 0.024 inch to grip the leads.

Two styles of test clips are available: single-ended and double ended. Single-ended clips with 40-inch lead wires are available in 10 colors. Double-ended clips (contacts on both ends) are available with black or red lead wires in 10-, 20-, or 30-inch lengths.

Ultra-Thin Micrograbber test clips are priced from $4.50 each.

ITT Pomona Electronics
1500 East Ninth Street
Pomona, CA 91766
Phone: 909-469-2928
Fax: 909-629-3317

VIDEO COMPUTER DISC CHIP SET. Texas Instruments has introduced the industry's first video CD chipset that is expected to simplify the design of Moving Picture Experts Group-1 (MPEG-1) video and audio decompression subsystems. The chip set decodes, synchronizes, and decompresses audio/video data that has been encoded to the MPEG international compression standard.

CIRCLE 21 ON FREE INFORMATION CARD

Capable of introducing a full-motion video (FMV) subsystem to home-entertainment products such as CD-based movie players, video games, and karaoke systems, the set consists of the TMS320AV220 MPEG-1 video decoder, the TMS320AV120 MPEG audio decoder, and the TMS320AV420 National Television Standards Committee (NTSC) encoder.

Those three devices, installed with a 4-megabit DRAM and a digital-to-analog converter for the converting the audio output, will turn a CD player into a video CD player. The set produces a video signal encoded in the NTSC format for broadcast TV and an audio signal that can be played back either over TV or through a stereo system for CD-quality digital sound.

The audio encoder is packaged in either a 44-pin plastic leaded-chip carrier (PLCC) or an 80-pin quad flatpack (QFP). The video decoder is packaged in a 160-pin QFP, and the NTSC encoder is packaged in an 80-pin QFP.

The high-volume pricing for the complete set is under $40.

Texas Instruments Incorporated
Literature Response Center
SC-94035
P. O. Box 172228
Denver, CO 80217
Phone: 1-800-477-8924, ext. 4500

DEOXIDIZER/CLEANER/PRESERVATIVE TREATMENT. DeoxIT from Caig Laboratories is a fast-acting, one-step deoxidizing solution for cleaning, preserving, lubricating, and enhancing conductivity of metal connectors and contacts on products such as switches, potentiometers, and relays.

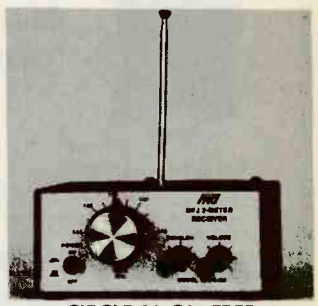
The solution contains deoxidizers, preservatives, conductivity enhancers, anti-tarnishing compounds, and arcing and RFI inhibitors. It is effective in the temperature range of −34°C to 200°C.

CIRCLE 26 ON FREE INFORMATION CARD

DeoxIT is sold in spray and liquid containers and in wipes and pen applicators. Prices start at $3.95 for a 2.3-milliliter vial.

Caig Laboratories, Inc.
16744 West Bernardo Drive, San Diego, CA 92127-1904
Phone: 619-451-179
Fax: 619-451-2799

TWO-METER REPEATER MONITOR/RECEIVER KIT. The MFJ-8400K repeater monitor receiver kit from MFJ Associates is intended for the circuit builder who wants to build a two-meter receiver that will rival



CIRCLE 29 ON FREE INFORMATION CARD

factory-made units costing hundreds of dollars more.

The completed monitor receiver offers a low-noise, high-gain, radio-frequency preamplifier for hearing weak signals. An air-variable tuning capacitor with a smooth 6:1 reduction drive simplifies receiver tuning. A dual-conversion superheterodyne receiver with ceramic filters and a crystal-controlled second oscillator is said to provide excellent selectivity and stability.

A 19-inch, ¼-wave whip antenna is included in the kit. A 50-ohm antenna input accepts an external groundplane or Yagi antenna array.

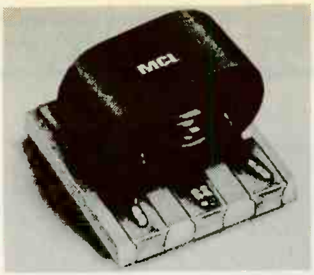
The MFJ-8400K kit with a circuit board, metal cabinet, and an instruction manual is priced at $69.95. A wired and tested receiver (MFJ-8400W) is priced at $89.95.

MFJ Enterprises, Inc.
P. O. Box 494
Mississippi State, MS 39762
Phone: 601-323-5869
Fax: 601-323-6551

MINIATURE SURFACE-MOUNT TRANSFORMER. The miniature TC4-1W RF transformer from Mini-Circuits has a bandwidth of 3 to 800 MHz and features DC isolation between its primary to secondary windings. Recommended for impedance matching and land-mobile radio, it measures only 0.16 × 0.16 × 0.16 inch.

The surface-mountable transformer was designed for circuit-board placement with pick-and-place machines. The transformers are available taped on reels for placement with those machines.

The TC4-1W transformer is priced at $4.95 each.

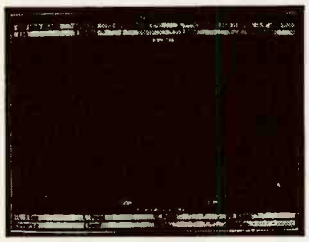


CIRCLE 25 ON FREE INFORMATION CARD

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

FILTER DESIGN PROGRAM. The Filtech filter design program from Number One Systems is an aid for designers of active and passive filters. It can synthesize both active and passive filters up to sixth order with a frequency range extending from fractions of a hertz to more than a gigahertz.

Filtech can indepen-



CIRCLE 60 ON FREE INFORMATION CARD

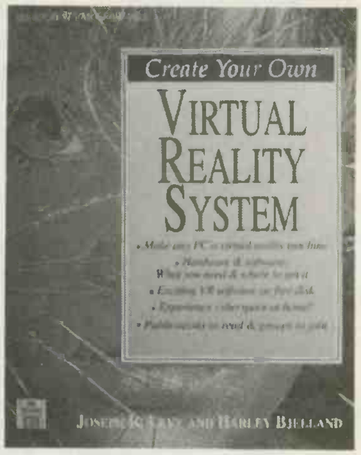
dently analyze the synthesized filter circuits and display a graphic plot of the calculated frequency response superimposed on the specified filter limits. This feature quickly confirms the accuracy of the synthesis design process.

The designer need only key in passband and stopband frequency limits, ripple and attenuation levels, and terminating impedances. Filtech will then complete the design.

Filtech software complete with a manual con-

(Continued on page 107)

NEW LITERATURE



CIRCLE 41 ON FREE INFORMATION CARD

Create Your Own Virtual Reality System; by Joseph R. Levy and Harley Bjelland. Windcrest /McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 800-233-1128; Fax 717-794-2103; Paper $32.95, Hard $44.95; 320 pages, 62 illustrations; includes disk.

Virtual reality (VR), now a common high-tech "buzz" word, refers to the combined computer and video technologies that place the observer in computer-generated situations for obtaining new and exciting visual experiences vicariously, training in the operation of moving vehicles, gaining insights into architectural structures, and yes, even—playing games.

This book by Levy and Bjelland provides an excellent introduction to the concepts of VR, yet it does not require that the reader have training and experience in the technologies discussed. Experiments in VR are now taking place in some of the most advanced research laboratories in the world. An accompanying disk will help the reader to grasp the fundamentals.

Included in the book are descriptions of consumer-grade VR hardware and software products now on the market. It gives prices along with the addresses, telephone and fax numbers of the suppliers. Chapters in the book explain how to build and install head-mounted displays, "data gloves," stereoscopic glasses, audio speakers, and other VR components. The authors also explain how to play interactive VR games, generate real-time VR images, and carry out many different interesting VR experiments.

The book discusses the limitations and advantages of desktop VR systems. It also includes information on how to obtain free or low-cost VR demonstration disks and how to contact VR-related organizations and publications. Finally, the book looks beyond the existing equipment and technology to explore the future of VR and its applications in science, medicine, commerce, entertainment, and other human activities.

I Need a Cellular Phone ... But Where Do I Start? Motorola Cellular Information Center; Phone: 800-331-6456, extension 2504; free.

A cellular phone is a valuable time-saving convenience for anyone who must travel extensively and yet stay in touch with a home office or operations base, customers, clients, or prospects. But buying a phone, subscribing to a cellular telephone company, and selecting a service plan can be daunting even

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Train with and keep the most advanced computer in home study today

NRI's unique training has you explore a top-notch computer system and its peripherals, beginning with the 486DX2 Intel CPU and Pentium Overdrive-ready motherboard.

Your computer features 8 meg RAM, 420 meg hard drive, and fax/modem to store, receive, and send huge amounts of data.

You'll also appreciate the brilliant display of your Super VGA color monitor, the drama of your CD-ROM drive and 16-bit sound card, as well as the cutting-edge technology of Windows 95.

Plus learn to use Ultra-X professional diagnostic hardware and software to pinpoint problems on any IBM-compatible machine.

No experience needed, NRI builds it in

Studies show that jobs for computer service technicians will be up by 38% in the next 10 years. Even if you've never worked with computers before, NRI's interactive training builds such a solid foundation of know-how and practical experience that tomorrow's jobs can be yours.

Right from the start, hands-on experiments reinforce concepts presented in NRI's bite-sized lessons. And because your work is reviewed by your personal instructor, you know for certain that you can apply theory to real-world demands.

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If the coupon is missing, write to: NRI Schools, McGraw-Hill Continuing Education Center, 4401 Connecticut Avenue, NW, Washington, DC 20008.

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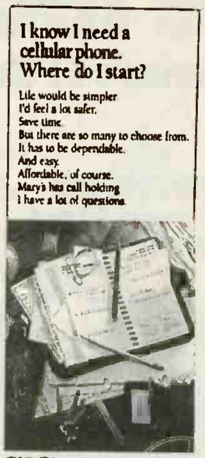
NEW LITERATURE



CIRCLE 52 ON FREE INFORMATION CARD

for sophisticated people.

Motorola's brochure lists tips to keep in mind when buying a cellular phone. It explains the different categories of cellular phones. Mobile phones, which are permanently installed in a vehicle, consume three watts of power and are ideal for those people who must spend a lot of time in their cars.

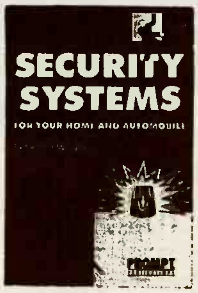
Transportable phones have self-contained batteries so they can be moved from one vehicle to another. They are a better choice for those who are likely to drive several different cars each day or must spend a lot of time away from their cars.

Portable, lightweight, handheld phones, can be carried in a purse or briefcase. They are recommended for those who are continually on the move, who switch from private to public transportation, or who must walk around a lot during the day.

The brochure outlines the six key points to investigate when buying a cellular telephone: talk time, sound quality, range, comfort, special features, and price. A glossary of cellular phone terms is included.

Security Systems for Your Home and Automobile; by Gordon McComb. Prompt Publications, 2647 Waterfront Parkway, East Drive, Indianapolis, IN 46214-2012; Phone: 800-428-7267 or 317-298-5710; Fax: 317-298-5604; $16.95.

This book explains how to save money by installing your own security system. Modern security systems can deter property theft, vandalism, property boundary violations, and unwanted home intrusion. They even warn of fire and smoke danger.



CIRCLE 56 ON FREE INFORMATION CARD

McComb explains everything you'll need to know about selecting and installing a security system in your home or car with readily available tools. The book describes the basics of home and automotive security systems, and explains how to determine which system is right for your needs.

System components, including controllers, sensors, and warning alarms are explained. The book also discusses self-contained home and automotive security systems.

Looking Good with CorelDRAW! Third Edition; by Sheldon Nemoy and C.J. Aiken. Ventana Press, P. O.

Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $27.95.

This book explains how to get the most out of version 5 of CorelDRAW! This updated third edition contains hundreds of illustrations and step-by-step instructions for creating attractive graphics with CorelDRAW! 4 or 5.

A section of the book covers fundamental elements and program calls. It gives instructions for and examples of advanced techniques for constructing those elements. Icons on the screen indicate instructions that are specific to versions 4 or 5.

Nemoy and Aiken offer a wealth of practical advice for producing graphics including posters, book jackets, newsletters, and brochures. Examples show

CIRCLE 48 ON FREE INFORMATION CARD

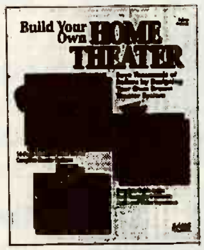
how to include graphic effects like clouds, chrome, and glass in your drawings.

The authors also explain how to save time with the program's tabbed dialogs, accent art work, and perform color, shading or texture fills. You'll also learn how to make 3D extrusions with up to three light sources.

Build Your Own Home Theater; by Robert Wolenik. Sams Publishing, Div. of Prentice Hall Computer Publishing, 201 West 103 Street, Indianapolis, IN 46290; Phone: 317-581-3500. $16.95.

This book explains how to assemble a complete home theater from standard, off-the-shelf, audio and video components.

Wolenik describes the many options available for building a home theater including stereo, broadcast and cable television, VCR, laserdisc player, satellite receiving antenna, surround-sound speakers, and camcorders.



CIRCLE 44 ON FREE INFORMATION CARD

The author goes into technical detail in explaining the differences between the many products in each of the entertainment product categories. For example, you'll learn what some of the important differences are between rear-projection, front-projection, and direct-view television receivers.

He also explains the importance of color, clarity, and resolution for pleasurable viewing, and the difference between Dolby Surround and Dolby Pro-Logic. You'll even learn how to place your speakers for the optimum surround-sound effect with encoded programming.

In addition to discussing the manufactured products, Wolenik includes guidance on the selection of the optimum room in

(Continued on page 111)

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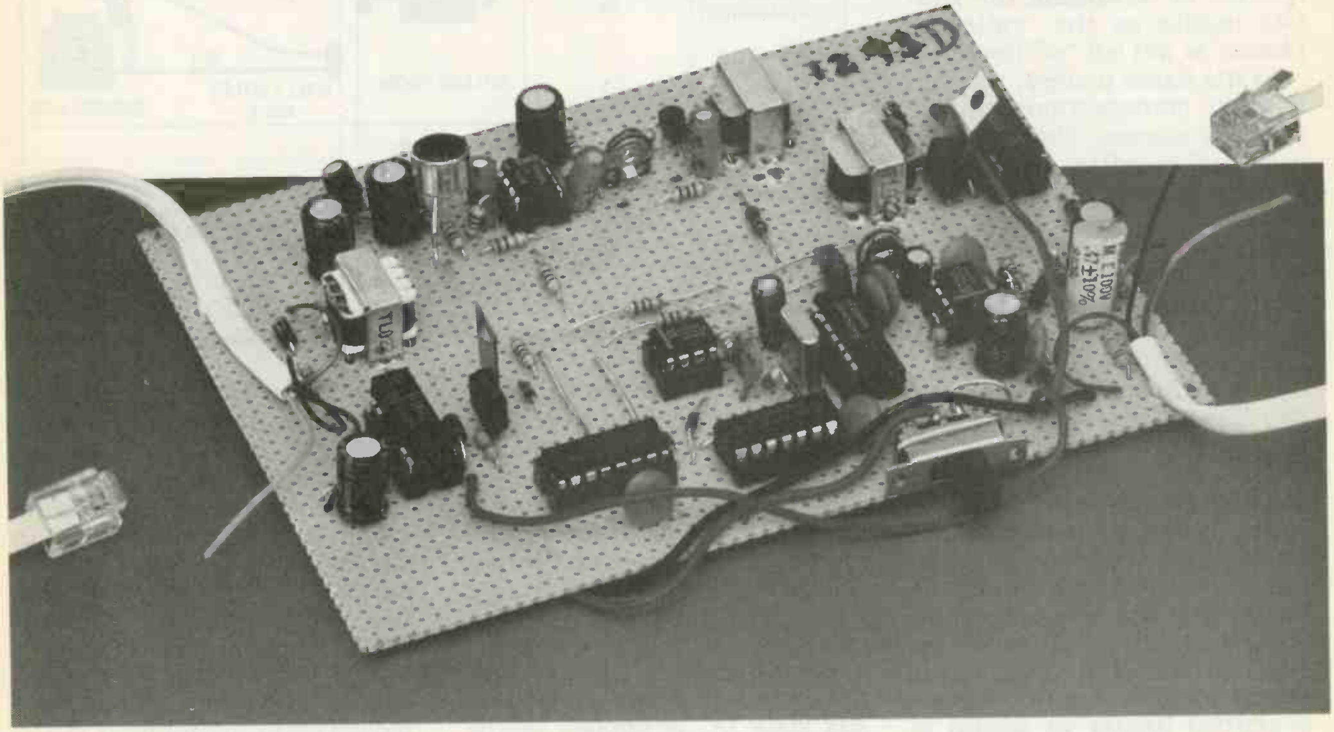
TELEPHONE LINE GRABBER



This listening circuit can be called from a remote phone so you can intercept phone conversations or monitor room activities

ROBERT IANNNINI

TELEMIKE IS A TELEPHONE CIRCUIT that, when located in a room miles away, permits you to listen in on the activities that are taking place in that room. It also permits you to listen to or interrupt a conversation on a separate phone line located wherever Telemike can gain access to it.

Telemike contains a sensitive microphone which is activated by calling the telephone number assigned to the outlet where it is plugged in and entering a code. It also contains circuitry that will permit it to access a telephone on a separate line terminating in the same room or even at the place where the phone line enters the home or building. Sequential pressing of the pound (#) key cycles the circuit to the next mode, that of intercepting a second telephone line and the third mode that resets the circuit after it has been in either of its listening modes.

The "called to" telephone can be miles away, in the same home or building as Telemike, or any-

> **WARNING**: The publisher makes no representations as to the legality of constructing and/or using the Telemike telephone security device referred to in this article. The construction and/or use of the device described in this article may violate federal and/or state law. Readers are advised to obtain independent advice as to the propriety of its construction and the use thereof, based upon their individual circumstances and jurisdictions.

where Telemike can gain access to the "called from" number. The Telemike circuit can be located anywhere in the room where the "called to" phone jack is located or at the entry point of the phone line—conspicuous or inconspicuous.

Figure 1 gives the number of times the pound (#) key must be pressed in sequence to initiate Telemike's two operating modes. It also shows the third key pressing needed in sequence to terminate the first two modes so the "called to phone" is not left "off hook."

In the *listen* mode 1, you can listen to conversations, music, security alarms, the sound of essential building service machinery, or even the sounds of intruders. To make use of the *intercept phone conversation* mode 2, you must have access to its phone wires or jack for plugging in the second plug from Telemike. The circuit forms a "bridge" between the two lines. Then by keying the pound (#) key twice, you will be on line with both parties of the intercepted phone line.

If you own your own business or vacation cottage that is located some distance from your home, or if you are away from your own home, an installed Telemike will let you find out if a security alarm is sounding, an essential heater or pump is working, or if unwanted persons are present in the room. It could also be useful in unobtrusive monitoring of a bed-ridden patient or child, a teenagers rock and roll party or a romantic adventure in progress.

The *intercept phone conversation* mode will permit you to interrupt a call in progress to announce a call waiting, emergency, or some other event from wherever you are located—in the house or miles away.

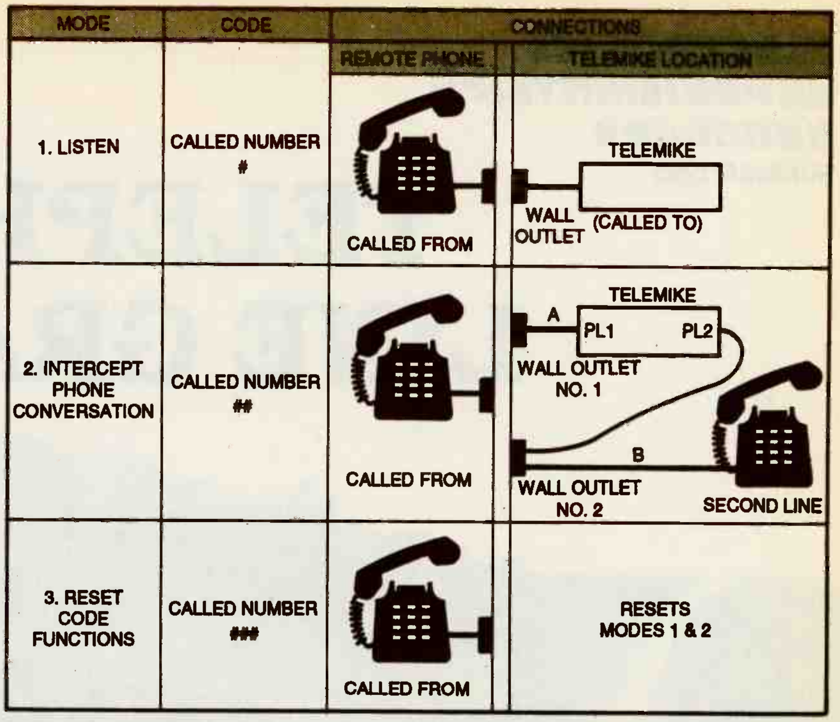


FIG. 1—CODES AND OPERATING MODE for the Telemike telephone line monitor.

Adaptation required

Telemike was designed to be compatible with the AT&T Corporation's ESS electronic switching system. Consequently, there might be differences in its performance if it is installed in a telephone operating system based on a different design.

This article does not provide details for packaging the Telemike circuitry. However, the circuit can be housed in any suitable metal or plastic project case with provision for mounting the on-off switch on the outside, a battery pack inside, and openings for the phone cords.

Circuit function

Refer to the schematic Fig. 2. Six volts DC is applied to the circuit by switching S1 ON. With this voltage applied, the 555 timer IC3 momentarily holds a high and resets NAND gate IC4-a to zero, "priming" the circuit.

To initiate the *listen* mode 1, call the number of the "called to" telephone line that is connected to plug PL1. A negative ring signal triggers 555 timer IC1, causing transistor Q1 to conduct. That sends current through the coil of reed relay RY1 and closes its contacts, connecting transformer T1 to the telephone line.

A tone signal initiated by pressing the pound (#) key of the "called from" phone immediately after you have keyed in the "called to" telephone initiates a response after Telemike has been primed. The tone is decoded by dual-tone multiple frequency DTMF filter/decoder MC145436 IC2. It is a silicon-gate CMOS LSI IC containing the filter and decoder for the detection of a pair of tones conforming to the DTMF standard.

The output of IC1 indexes the CD4017 decade counter IC5 to the logic 1-state, latching transistor Q1 ON. This response then turns on the 741 operational amplifier IC6.

Any sounds in the room where Telemike is located are picked up by microphone MIC1, amplified, and fed back through transformer T2 to transformer T1 from which they are sent over the phone lines. A person listening on the "called from" phone can then hear any sounds or voice within the range of the microphone. This is the *listen* mode.

The Telemike circuit can be switched to the *intercept phone conversation* mode by pressing the pound (#) key a second time. This sequence connects the "called from" phone through the to the second phone line through plug PL2 of Telemike. This permits any conversation on the second line to be interrupted or monitored from the "called from" phone.

A second pressing of the pound (#) key causes decade counter IC5 to index its count to mode 2. That sets pin 4 high which holds Q2 in a conducting state, energizing relay RY2 and closing its contacts. This connects transformer T1 to plug PL2, the connection to the "called to" phone.

Any audible signals at plug PL2 are now connected by the telephone line at plug PL1, allowing you at the "called from" phone to interrupt a conversation on that line or just listen. Complete DC isolation between the two telephones connected to plugs PL1 and PL2 is achieved by the isolated contacts of relay RY1.

The third *reset code functions* mode is achieved by pressing the pound (#) of the "called from" phone a third time. This indexes decade counter IC4 and turns off Q2 and all other functions, restoring normal telephone operation. Diode D14, connected across RY1's coil, clips the inductive pulse that occurs when relay RY2 is turned off. *Caution*: the "terminate function" must be keyed in before hanging up the "called from" phone or the "called to" telephone might remain off-hook. The telephone company will terminate service if it is not corrected within a reasonable length of time.

If you fail to rest Telemike properly before hanging up the "called from" phone, you must reset the circuit manually by going to it and turning it off and on again. This is an obvious inconvenience if you are miles away from the "called to" telephone or its jack.

To make the most effective use of all of the three modes of Telemike, you should subscribe to a dedicated telephone line. (about $15 per month in most locations).

It is important that *initial access time* be selected properly if you intend to use only a single line. This will be discussed later in this article.

Circuit construction

Refer to the schematic Fig. 2 and the parts placement diagram Fig. 3. The components of the prototype circuit were wired point-to-point on a rectangular piece of perforated board measuring 6¼ × 4½

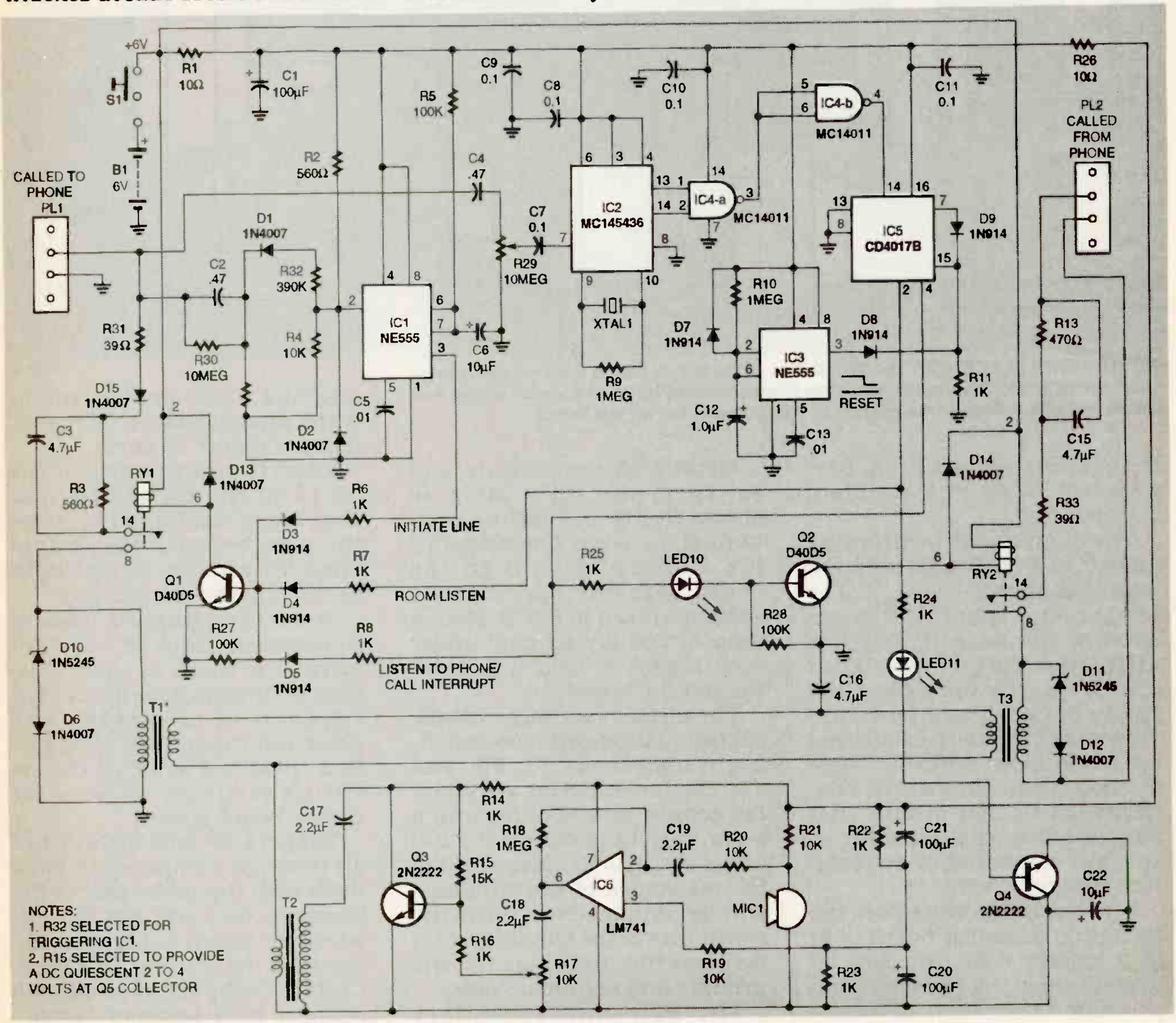


FIG. 2—SCHEMATIC FOR TELEMIKE. All of the integrated circuits and reed relays are inserted in DIP sockets.

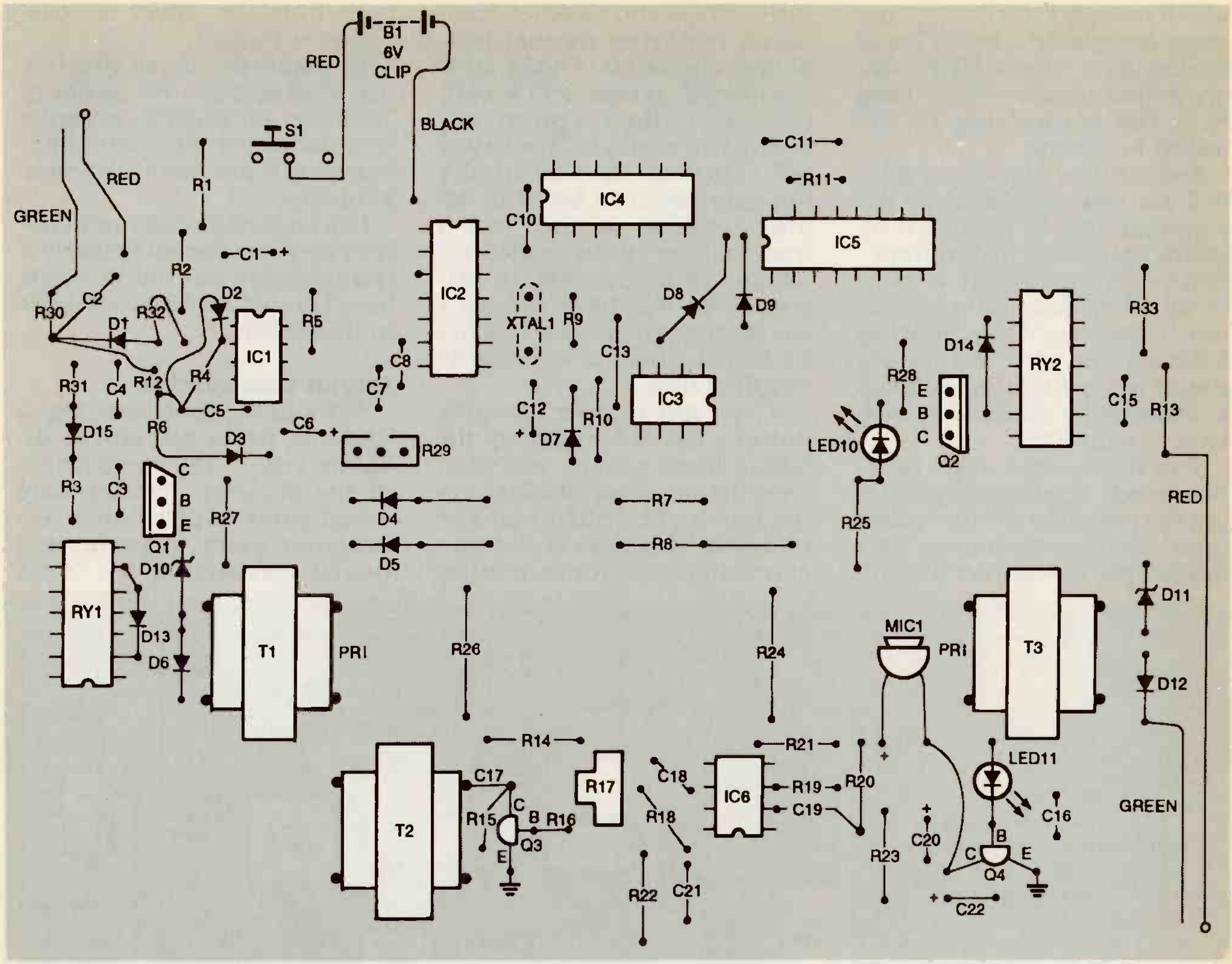


FIG. 3—PARTS PLACEMENT DIAGRAM. The entire circuit fits on a 5⅝ × 4-inch perforated circuit board. The components are interconnected by point-to-point wiring and power and ground bus wires. Switch S1 can be mounted off the board.

inches with 0.42-inch prepunched holes in a standard 0.1-inch grid.

The component positioning shown in Fig. 3 generally follows that shown in Fig. 2. The component spacing was selected to minimize the length of interconnecting wires without unnecessarily cramping the space between components. This would make the soldering operation more difficult. There are no critical component relationships in this circuit that dictate either close spacing of specific components or isolation between them.

If you want to construct the circuit on a smaller board to fit in a smaller case, you can reduce the spacing between components. However, it is recommended that component orientation remain the same.

Identify all components and set them out on a table as shown in Fig. 3. Start by positioning the seven IC sockets (for ICs and reed relays) on the board with the approximate spacing shown in Fig. 3. Place a drop of fast-drying glue under each socket to hold it in position on the board.

The circuit has three identical isolation/impedance-matching transformers T1, T2, and T3. They are rated for a primary impedance of 600 ohms and a secondary impedance of 1200 ohms at 1000 Hz. Measure the DC resistance of the windings with an ohmmeter to verify the continuity of the windings, and confirm the markings for the primary and secondary sides.

The 600-ohm secondary turns should have an approximate DC resistance of 50 ohms, and the 1200-ohm primary turns should have a DC resistance of about 75 ohms.

Insert the transformers in the board in the correct orientation, being careful not to stress the pins because that might break the winding connections, destroying the transformer.

Start inserting all passive components from left to right across the board in small clusters, noting the polarity and orientation of all diodes and polarized capacitors. (Suggestion: position some of the resistors vertically to conserve circuit board space.)

Temporarily fold the leads of all inserted components back flush with the solder side of the board so they will not fall out when the board is handled. Do not trim the leads at this time. Certain component leads will connect with adjacent component leads as part of the complete circuit.

Solder the leads of the components that have been inserted in small groups before proceeding with the next group. Form the power and ground buses from bare copper wire, and solder them as shown in Fig. 3.

Solder in the clip for the four-cell battery pack, with the red wire to plus (+) and black wire to negative (−).

Strip back the jacketing from both ends of the telephone cords to expose the multi-colored wires. Strip back the insulation from the red and green wires and solder them to the proper locations on the circuit board, as shown in Fig. 3. The red wires go to the ground bus and the green wires go to the input points. Trim off the other two black and yellow wires flush with the ends of the cord jacket. Assemble the RJ-11 plugs PL1 and PL2 to the other ends of the telephone cords and crimp them in position.

Verify that all diodes, polarized capacitors and transformers have been inserted correctly with their correct orientation and polarities observed. Examine all soldered joints to be sure they are clean and shiny, and that there are no inadvertent solder bridges. Resolder any "cold" solder joints that appear as dull gray, irregular solder bonds. Trim any leads that overlap or form inadvertent short circuits.

Insert the two reed relays, RY1 and RY2, in their sockets. Insert the ICs only as directed in the circuit test procedures.

Circuit test

Measure the continuity between the following points and the circuit board ground bus.: IC1—pin 1; IC2—pin 8; IC3—pin 1; IC4—pin 7; IC5—pins 8 and 13; IC6—pin 4; emitters of transistors Q1, Q2, Q3, and Q4; T1 secondary.

Connect the four AA cells which form the 6-volt DC battery pack to the battery clip. Verify that 6 volts appears between the following test points and the ground bus with a voltmeter. (The current drawn should be 0.1 to 0.2 milliamperes):
IC1—pins 4 and 8; IC2—pins 3, 4 and 6; IC3—pins 4 and 8; IC4—pin 14; IC5—pin 16; IC6—pin 7, collectors of transistors Q1 and Q2.

Plug PL1 into a telephone jack connected to a "test" telephone. (It might be necessary to obtain a modular duplex jack such as Radio Shack's 279 386.)

Insert both the 555 timer IC1 and transistor Q1 in their sockets. Connect one lead of a voltmeter set on the 10-volt DC scale to the collector of Q1, and verify a reading of 6 volts.

Short-circuit plug P1 and observe the voltmeter scale to see if the voltage momentarily drops to near zero. Resistor R32 is specified as 390 kilohms, but it might be necessary to substitute a lower value for reliable

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise specified.
R1, R26—10 ohms
R2, R4, R19, R20, R21—10,000 ohms
R3—100 ohms
R5, R12, R27, R28—100,000 ohms
R6, R7, R8, R11, R14, R16, R22, R23, R24, R25—1000 ohms
R9, R10, R18—1 megohm
R13—470 ohms
R15—15,000 ohms
R17, R29—10 kilohms trimmer potentiometer, PCB mount
R30—10 megohms
R31, R33—39 ohms
R32—390,000 ohms

Capacitors
C1, C20, C21—100 µF, 25 volts, aluminum electrolytic, radial
C2—0.47 µF, 100 volts, polyester
C3, C15, C16—4.7µF, 100 volts, non-polarized aluminum electrolytic
C4—0.47 µF, 50 volts, film
C5, C13—0.01 µF ceramic disk
C6, C22—10 µF, 25 volts, aluminum electrolytic, radial lead
C14—deleted
C7, C8, C9, C10, C11—0.1µF, 25volts, ceramic disk
C12—1 µF, 25 volts, aluminum electrolytic, radial leaded
C17, C18, C19—2.2 µF, 25 volts, non-polarized, aluminum electrolytic, radial leaded

Semiconductors
D1, D2, D6, D12, D13, D14, D15—1N4007 silicon rectifier diode
D3, D4, D5, D7, D8, D9—1N914—silicon signal diode
D10, D11—1N5245, 16 volts, Zener
LED10, LED11—light-emitting diodes, red, T-1¾ (optional, see text)
IC1, IC3—NE555N, Philips or equiv.
IC2—MC145436P, dual-tone multiple frequency receiver, Motorola or equiv.
IC4—MC14011BCP, NAND gate, Harris or equiv.
IC5—CD4017B decode counter, Harris or equiv.
IC6—LM741CN operational amplifier, DIP package, National or equiv.
Q1, Q2—D40D5, NPN power transistor, TO-220 package, Harris or equiv.
Q3, Q4—2N2222 NPN transistor

Other components
MIC1—microphone, omnidirectional, electret, 20 to 15,000 Hz, Radio Shack 270-090 or equiv.
PL1, PL2—RJ-11 modular telephone plugs
RY1, RY2—relay, 1 form A SPST NO DIP reed, Mouser D31A310
S1—slide switch, SPST, Radio Shack 275-401 or equiv.
T1, T2, T3—transformer, audio, isolation, interstage, 1200 ohm primary, 600 ohm, Mouser TLO22 or equiv.
XTAL1—crystal, 3.579 kHz, metal, radial-leaded case, MTRON ot equiv.

Miscellaneous—perforated circuit board; project case (see text); three 8-pin DIP sockets; two 14-pin DIP sockets; one 16-pin DIP socket; holder for four AA power cells; four alkaline AA power cells; solid, tinned copper wire (22 AWG), insulated hookup wire (22 AWG), two lengths of telephone cord; 12-volt battery clip; cable ties; solder.

Note: The following items are available from Information Unlimited, P.O. Box 716, Amherst, NH 03031; phone 603-673-4730, Fax 603-672-5406:
• Complete kit including perforated board, all active and passive components, and telephone cords and plugs.—$99.50
Include $5.00 for shipping and handling. Allow two to four weeks for delivery.

triggering of IC1 via pin 2. However, make that substitution in gradual increments because if the value is too low, the reed contacts of RY 1 will chatter and the circuit will not work.

Switch off the 6 volts with switch S1, insert the DTMF decoder IC1 in its socket, and set trimmer potentiometer R29 to its midrange. Restore power with S1.

Verify that a logic high appears on pins 13 and 14 each time the pound (#) key is pressed on the connected test telephone to verify the operation of decoder IC2.

Switch off the 6 volts with S1 and insert NAND gate IC4. Restore power and verify a logic low on pin 3 each time the pound (#) key is depressed. Measure the inverted signal at pin 4 to perform this test.

Switch off the 6 volts with S1, and insert the second 555 timer IC3. Verify that there is a momentary 5 volts on pin 3 each time power is restored with S1.

Switch off the 6 volts with S1, and insert the decade counter IC5. Restore power and verify that pins 2 and 4 are at logic low and pins 3 and 15 are at logic high.

Press the pound (#) key and verify that pins 2 and 4 of IC5 show alternating logic levels, each repeating every third keying step. These tests verify the proper operation of the logic, reset digital processing, and function counter.

Switch off the 6 volts with S1, insert op-amp IC6, set trimmer potentiometer R17 to midscale, and turn on the power. Press the pound (#) key on the test telephone and listen for any sounds picked up by the microphone to verify the operation of the *listen* mode.

Connect the leads of a voltmeter to the collector pin of Q2 and ground to verify the presence of 6 volts. Press the pound (#) key of the test telephone, and observe that the voltmeter shows a momentary dip to zero. This energizes relay RY2 for the *intercept phone conversation* mode.

Press the pound (#) key of the test telephone and observe a logic high on pin 3 of IC5. This verifies the operation of the *reset code functions* mode. Pins 2 and 4 of IC5 should be at a logic low.

If all of these tests have been passed successfully, the correct functioning of all Telemike controls has been verified.

The following procedure requires two separate telephone lines in the room where the testing is performed. Line A and line B.

Plug the RJ-11 phone plug PL1 into the outlet jack of Line B. (A telephone need not be connected to this jack.) Set a voltmeter on the 100-volt DC scale and connect it to measure 50 volts across the red ring and green tip telephone wires, and look for the expected 50 volts. Switch on S1 and verify that there is no change in the 50-volt reading on the voltmeter other than a momentary drop. Repeat this step making the measurements at the plug.

Pick up the handset from the Line A test phone and key in the number of the Line B phone. It is important that you press the pound key immediately to access the line during its receptive interval. You should be able to hear low-level sounds in the room where Telemike is located clearly. Turn on a radio in the same room if you want a steady audio signal source.

Press the pound (#) key a second time, putting Telemike in its *intercept phone conversation* mode (non functioning at this time), and then key it a third time to reset the Telemike.

Intercept function

The next test requires a third telephone line (the one to be intercepted).

Plug PL2 into the jack of the third telephone line in the room so you can intercept and monitor any conversations on that line. Switch on S1 and verify that 50 volts DC appears across both ring and tip wires.

Call the Line B phone from the test Line A phone, and access the second phone line by pressing the pound key (#) twice. You should hear a dial tone from the second phone line indicating that you have gained access. This tone indicates that you have intercepted the line and will be able to hear any conversation on it.

Make arrangements for two other persons to converse over the second phone line, and then call the "called to" number and key the pound sign twice to listen in on an actual call in progress. When you are ready to quit this mode, be sure to press the pound key again to reset Telemike.

Note: The audio level on the intercepted conversation might be weak in this mode, forcing you to listen very carefully. If you intend to interrupt a conversation with a message, you might have to speak loudly to be heard.

Telephone compatibility

Not all telephones have the same encoding signal output levels. This could cause circuit unreliability when accessing a second telephone line. If that occurs, you might be able to correct the problem by setting trimmer potentiometer R29 on the Telemike.

Dedicated line

Consider leasing of a dedicated line to Telemike as part of a permanent installation. This will eliminate possible ring signal "sneak through" and the critical timing of the 555 IC1 for allowing access control. Nevertheless, it would still permit all incoming calls to be completed and would have no effect on outgoing calls.

Timer values

The initial access time established by the time constant of resistor R5 and capacitor C6 can be set in most systems to permit a normal incoming telephone call to be made. If this time is too long, and an "off-to-on" hook condition is created that will disable the connection. If it is too short, the encoding tones might not pass. This condition should not interfere with outgoing calls. In most cases, the longer time constant will assure encoding control. Ω

Minute Marker

DEV PALMER

The inexpensive Minute Marker can generate variable-duration output pulses with selectable polarity and a wide range of time intervals.

MANY HOBBY PROJECTS REQUIRE the timing of intervals between a fraction of a second and a minute. This article describes the Minute Marker, a simple device that uses low-voltage 60-hertz AC from a power-supply transformer for synchronization. It provides a variable-duration output pulse with selectable polarity and a wide range of time intervals.

Figure 1 shows a block diagram of the Minute Marker. The power supply generates the required 5-volts DC for the circuit, and also provides a 60-hertz signal for the clock generator, which generates a 60-hertz square wave. The square wave is fed to the decoder, which counts cycles and decodes the desired time interval. The output pulse generator, as you probably guessed, generates the output pulse.

Figure 2 shows the schematic of the Minute Marker. The output of transformer T1 is 12.6-volts AC at 60 hertz, which is rectified by D1 and regulated by IC4, an LM7805 regulator, to provide 5-volts DC for the circuit. The unrectified AC is bandpass-filtered by R1, R2, R5, C1, and C2. Resistors R2 and R5 also form a DC-voltage divider which biases the input of Schmitt trigger IC3-a to 2.5 volts. The Schmitt trigger generates a 60-hertz square-wave output, which is fed to the input IC1, a CD4040 12-stage binary counter.

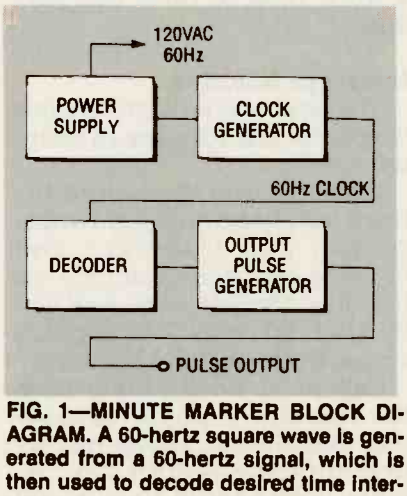


FIG. 1—MINUTE MARKER BLOCK DIAGRAM. A 60-hertz square wave is generated from a 60-hertz signal, which is then used to decode desired time intervals.

The outputs of the counter are decoded a 4081 quad AND gate (IC2), and the decoded output is fed back to the reset input of the counter, which resets the counter when the desired count is reached. Table 1 shows some useful time intervals that can be decoded with four decoder outputs or less; the desired outputs are simply AND-ed together. (The schematic in Fig. 2 is shown with the decoder outputs wired for a one-minute interval.)

The pulse from IC2-d is inverted by Schmitt trigger IC3-d, and passed along to the output pulse generator. The output pulse is generated by two Schmitt triggers cross-connected as an RS flip-flop (IC3-b and IC3-c). The output of the flip-flop is fed to R3, R4, and C3, whose values set the output pulse duration. The output pulse duration (T) can be approximated by the formula T =

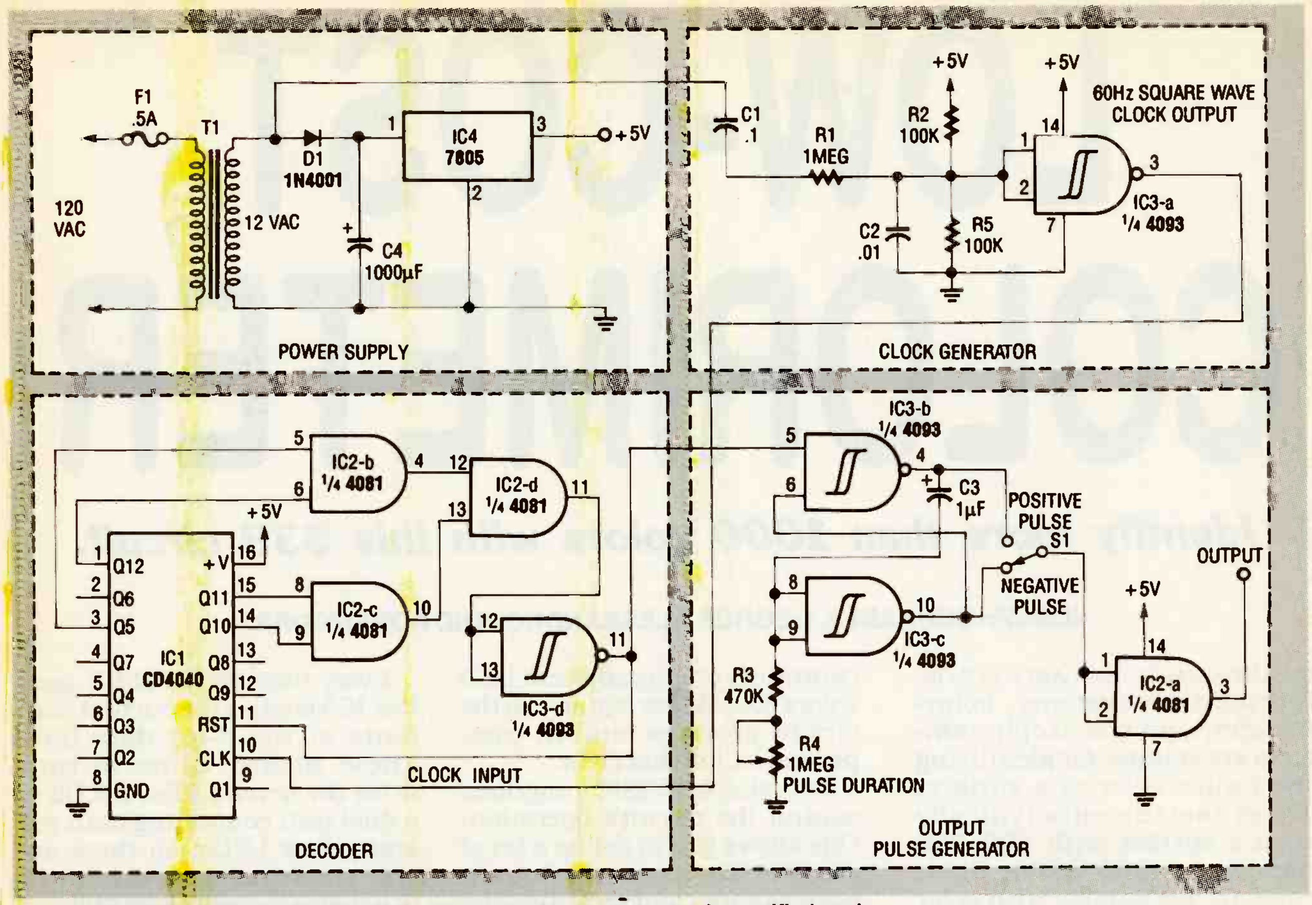


FIG. 2—MINUTE MARKER SCHEMATIC. 12.6-volts AC, at 60 hertz, is rectified and regulated to 5-volts DC for the circuit. Unrectified AC is fed into a Schmitt trigger, which generates a 60-hertz square wave. The square wave is fed to a CD4040 12-stage binary counter, which decodes time intervals.

PARTS LIST

All resistors are ¼-watt, 5%
R1—1 megohm
R2, R5—100,000 ohms
R3—470,000 ohms
R4—1 megohm, potentiometer
Capacitors
C1—0.1 μF, ceramic
C2—0.01 μF, ceramic
C3—1.0 μF, electrolytic
C4—1000 μF, electrolytic
Semiconductors
IC1—CD4040 12-stage binary counter
IC2—CD4081 quad two-input AND gate
IC3—CD4093 quad two-input NAND Schmitt trigger
IC4—LM7805 5-volt regulator
D1—1N4001 diode
Other components
F1—0.5-amp fuse
T1—120/12.6 VAC transformer
S1—SPDT switch
Miscellaneous: Project case, perforated construction board, wire wrap, solder, etc

TABLE 1—TIME INTERVALS

Interval Seconds	Number of 60-Hz Cycles	Decoded Outputs
0.1	6	Q2, Q3
1.0	60	Q3, Q4, Q5, Q6
10.0	600	Q4, Q5, Q7, Q10
60.0	3600	Q5, Q10, Q11, Q12

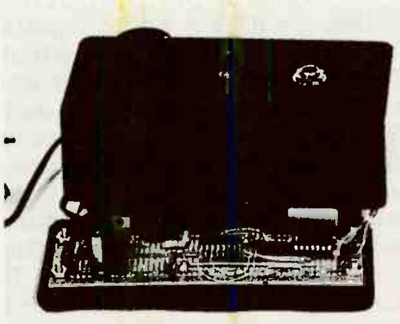


FIG. 3—COMPLETED PROTOTYPE. The wired project is capable of generating timing intervals between a fraction of a second and a minute.

1.2 × C3 × (R3 + R4). A positive- or negative-going pulse is selected by S1, and buffered by the remaining AND gate (IC2-a).

Building the marker

Construction is not critical, but be careful when working with AC voltages. The circuit can be built on perforated construction board using point-to-point wiring. The selected time interval can be hard-wired to IC2, or you can use a DIP switch or header to make changing the time interval easy. The output-pulse duration and polarity can be left adjustable, or the polarity can be fixed, and R3 and R4 can be replaced with a single resistor to suit a specific application. Figure 3 shows the author's completed prototype installed in a common plastic hobby case. Ω

LOW-COST COLORIMETER

Identify more than 1000 colors with this $39 circuit.

JOSEPH SCHNABLE, GEORGE ALESSANDRO, AND ROBERT ORR*

COMMERCIALLY AVAILABLE COLOR-formulation systems, colorimeters, and spectrophotometers are suitable for identifying the visible color of a surface. These instruments typically scan a surface with 400–700 nanometer (nm) visible light, compare the sample with color references, and determine the best color match based on a set of built-in standards. Most commercial instruments depend on expensive optics and cost $1000 or more. This article describes a $39 color-identifier circuit that can easily identify 1000 or more colors with 100% accuracy. For $39 it's impossible to build a very intelligent device. However, most of us own personal computers; why not use it as the brain? That's what we did here.

A hardware/software combination activates, in turn, one of several LEDs; each emits a portion of the visible spectrum. A phototransistor measures the light reflected by the surface being measured, and an 8-bit analog-to-digital converter (ADC) translates the phototransistor's output into a digital format that the computer can interpret. Seven LEDs (blue, aqua, green, yellow, orange, crimson, and red) provide a range of readings across the visible spectrum. Lack of spectral continuity among adjacent LED colors could skew results, so the circuit provides built-in compensation for this error.

Two simple BASIC programs control the circuit's operation. One allows you to define a set of standards by measuring known color samples and recording the values with an associated name. The other program measures unknown samples and provides the best match with the defined standards, as well as a relative error factor.

Circuit description

Figure 1 shows the complete circuit. Three ICs do the work. First is IC1, a 74HCT688 8-bit comparator that provides a low-going signal on pin 19 when the values on IC1's P and Q inputs are equal. That happens when there is no direct-memory access (DMA) occurring (i.e., AEN is low), when address line A9 is high, and when address lines A3–A8 are low. If you work out the math, you'll see that this occurs whenever any I/O port in the range 512–519 is accessed. If those port addresses are used on your system, you can easily change the values by connecting different Q inputs to ground and +5-volts DC. You will also need to change the value of ADR as defined in line 2 of both BASIC programs.

Every time pin 19 of IC1 goes low, IC3 latches the current contents of the 8-bit data bus. These latched values in turn drive the seven LEDs. (LED2 is a dual unit containing both red and yellow LEDs, so there are only six actual devices.) Pin 19 of IC1 also drives the $\overline{RD}$ input of IC2, an 8-bit ADC. That causes IC2 to sample the voltage appearing at its input pin 6.

That voltage depends primarily on the amount of light shining on Q1, a general-purpose phototransistor. The authors used a PN168PA-ND sold by Digi-Key Corp. The phototransistor must be mounted so that when a measurement is taken, it will only detect light from the LED array. The input voltage to the ADC also depends on the state of pin 19 of IC3. When that pin is low, resistor R3 is effectively in parallel with R2, thus changing the bias on the phototransistor, hence the voltage at pin 6 of the ADC. The ADC's clock frequency depends on the values of R1 and C1, which gives a frequency of about 400 kHz.

Note that an A/D conversion occurs whenever the system accesses I/O port 512–19. But other events happen as well, depending on whether an I/O read ($\overline{I/OR}$) or an I/O write ($\overline{I/OW}$) has occurred.

If CPU signal $\overline{I/OR}$ goes low, pin 3 of the ADC in turn goes low,

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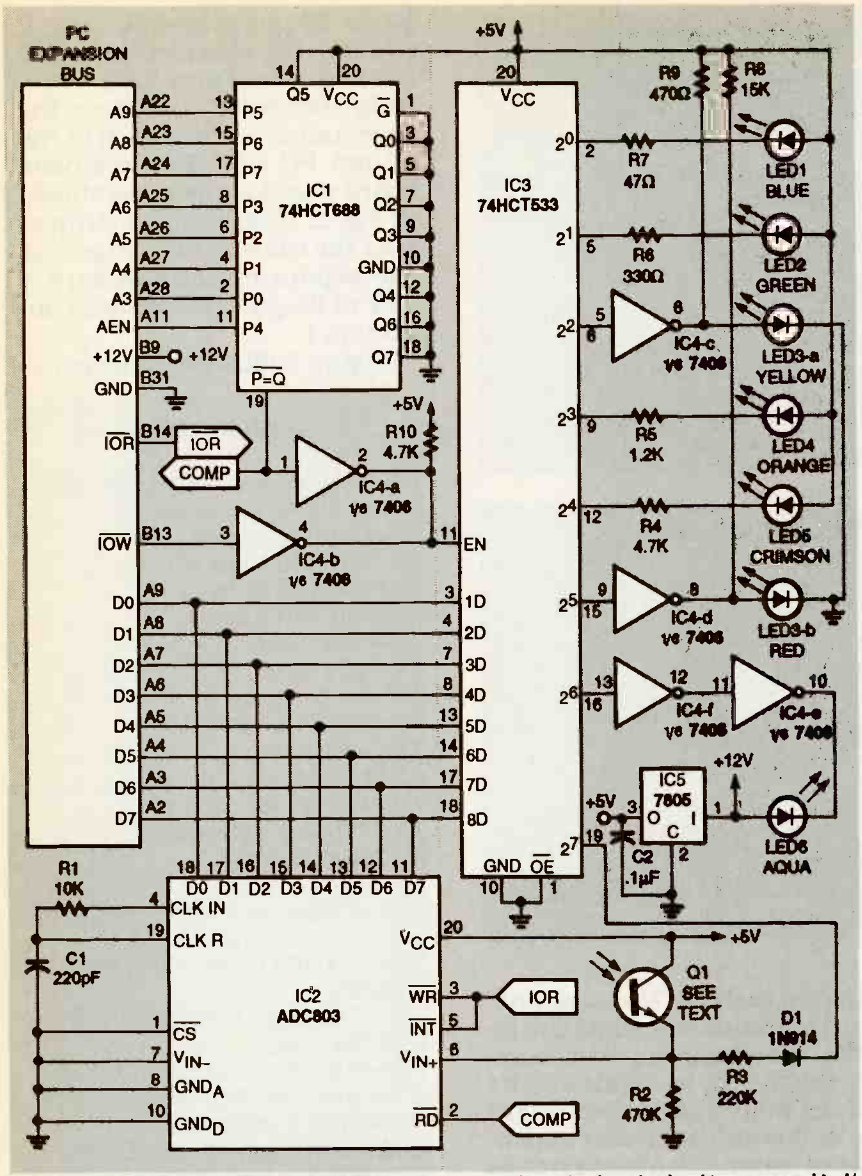


FIG. 1—COMPLETE SCHEMATIC. IC1 is an address decoder hard-wired to respond to I/O ports 512–519. IC2 is an A-to-D converter that measures the voltage across R2, which depends on the amount of light shining on Q1. IC3 is an 8-bit inverting latch that the software drives to successively light each LED during a scan.

forcing the ADC to present its most recently collected value to the data bus. On the other hand, if CPU signal $\overline{IOW}$ goes low, pin 11 of IC3 goes high, thereby latching the values on the data bus into IC3. Each register in IC3 provides a latched, inverted output capable of sinking 35 milliamperes.

LEDs

Table 1 summarizes important information about the LEDs. The activation code is the value that must be set into the assigned I/O port to activate or deactivate a given LED. Values can, of course, be summed to enable or disable several LEDs at once.

Note that LED6, the aqua emitter, requires direct connection to +12V. At $12.50, it was rather expensive when first introduced, but the price has dropped slightly. (The LED is available, as part 48-6E for $10.26 plus shipping from Parts 1, 1995 County Rd. B2, Roseville, MN 55113; 800-424-6204.)

Both LED3 and LED4 are dual units. The circuit includes both the yellow and red units in LED3, but it uses only the orange unit in LED4.

The values of R4–R9 were selected to provide an ADC response range from approximately 5 (for a black surface) to 200 (for a white surface) for each LED. That will provide a maximum response range for most colors. Higher ADC values might cause the phototransistor to saturate, thereby preventing the circuit from reliably distinguishing different colors.

Although there is some overlap between the two, there is a large spectral gap between the aqua (LED6, 482 nm) and green (LED2, 560 nm) LEDs. We solved the problem by energizing both LEDs simultaneously and decreasing ADC sensitivity. By keying a value of 194 (128 + 64 + 2), both LEDs are turned on and R3 is enabled via diode D1. This increases the number of colors that can be identified from a few hundred to more than 1000.

The authors used a separate 7805 voltage regulator, driven by the host computer's +12-volt supply, to power the other ICs in the circuit. This minimized inconsistent results obtained by running the circuit in different computers with slightly different +5-volt supplies. Thus calibration is generally much machine independent.

Software considerations

Listings 1 and 2 present the calibration and identification programs, respectively. (These files are available on the *Electronics Now BBS*, 516-293-2283, 9600 baud, as file 1KCOLOR.ZIP.) The calibration program uses two external files, CAL1 and CAL2, to store information. CAL1 stores standard values, and CAL2 stores corresponding names.

TABLE 1—LED COLORS AND CODES

LED	Wavelength	Color	Activation Value
LED1	470 nm	Blue	$2^0=1$
LED2	560 nm	Green	$2^1=2$
LED3-a	590 nm	Yellow	$2^2=4$
LED3-b	700 nm	Red	$2^3=8$
LED4	630 nm	Orange	$2^4=16$
LED5	665 nm	Crimson	$2^5=32$
LED6	482 nm	Aqua	$2^6=64$

LISTING 1—CALIBRATION PROGRAM

```
10 'CALIBRAT.BAS calibration program
20 CLS:KEY OFF:N=0:ADR=512:OPEN"R",1,"CAL1",16:OPEN"r",2,"cal2",24
30 FIELD 1,2AS B$,2AS G$,2AS Y$,2AS O$,2AS C$,2AS R$,2AS A$,2AS AG$
40 FIELD 2,24AS ID$
50 PRINT "reference number",N+1:OUT ADR,255:BEEP:INPUT "Enter Name of Standard
or 'E' To End";TEMPID$
60 IF TEMPID$="E" OR TEMPID$="e" THEN N=0: GOTO 200
70 IF TEMPID$="n" THEN INPUT"enter n to redo ",N:N=N-1:GOTO 50
80 N=N+1:FOR H=0 TO 7:K=0:IF H<7 THEN Z=2^H ELSE Z=194
90 OUT ADR,Z:FOR I=1 TO 500:NEXT I
100 FOR J=1 TO 50:K=K+INP(ADR):NEXT J
110 IF H=0 THEN LSET B$=MKI$(K)
120 IF H=1 THEN LSET G$=MKI$(K)
130 IF H=2 THEN LSET Y$=MKI$(K)
140 IF H=3 THEN LSET O$=MKI$(K)
150 IF H=4 THEN LSET C$=MKI$(K)
160 IF H=5 THEN LSET R$=MKI$(K)
170 IF H=6 THEN LSET A$=MKI$(K)
180 IF H=7 THEN LSET AG$=MKI$(K)
190 NEXT H:LSET ID$=TEMPID$:PUT 1,N:PUT 2,N:CLS:GOTO 50
200 N=N+1:GET #1,N:GET #2,N:IF N>(LOF(1)/16) THEN END
210 B=CVI(B$):G=CVI(G$):Y=CVI(Y$):O=CVI(O$):C=CVI(C$):R=CVI(R$):A=CVI(A$):
AG=CVI(AG$)
220 PRINT N,ID$:GOTO 200
```

LISTING 2—IDENTIFICATION PROGRAM

```
1 'IDENTIFY.BAS  identification program
10 ADR=512:OUT ADR,255:PRINT:INPUT "Hit Enter To Scan/Identify Unknown
Color";A
20 IF A=9 THEN RUN"fcal"
30 ERP=1E+20:OPEN"R",1,"call",16
40 FOR H=O TO 7:K=0:IF H<7 THEN Z=2^H ELSE Z=194
50 OUT ADR,Z: FOR I=1 TO 500:NEXT I
60 FOR J=1 TO 50:K=K+INP(ADR):NEXT J
70 IF H=0 THEN BU=K ELSE IF H=1 THEN GU=K ELSE IF H=2 THEN YU=K
80 IF H=3 THEN OU=K ELSE IF H=4 THEN CU=K ELSE IF H=5 THEN RU=K
90 IF H=6 THEN AU=K ELSE IF H=7 THEN AGU=K
100 NEXT H:BEEP
110 OUT 512,255:OPEN"r",2,"cal2",24:FIELD 1,2AS B$,2AS G$,2AS Y$,2AS O$,2AS
C$,2    AS R$,2AS A$,2AS AG$:B=LOF(1)/16
120 FOR N=1 TO B:GET #1,N:IF ABS( CVI(B$)-BU)>400 THEN 140
130 ER=(CVI(B$)-BU)^2+(CVI(G$)-GU)^2+(CVI(Y$)-YU)^2+(CVI(O$)-OU)^2+(CVI(C$)-
CU)^    2+(CVI(R$)-RU)^2+1*((CVI(A$)-AU)^2)+2*((CVI(AG$)-AGU)^2):IF ER<ERP
THEN ERP=    ER:NN=N
140 NEXT N
150 FIELD 2, 24AS ID$: GET #2,NN
160 CLS:PRINT "Best Color Match",ID$:PRINT"Relative Error",ERP:PRINT"reference
number",NN:RUN
```

To create the calibration files, run CALIBRAT.BAS. The program will ask you to enter the name of a standard, or press "e" to end calibration. If you enter "e," the program will end, displaying a list of currently calibrated color standards. Otherwise, it will create a new standard using the name you entered. It creates the standard values by enabling each LED (or the LED2/LED6 combination) in turn, then reading 50 times in succession the value sensed by Q1. Each color value (which is summed in variable K) is plugged back into the appropriate field of the data file in lines 110–180, then written to disk in line 190. If you want to re-do a standard value, enter "n" at the prompt. The program will ask you the numerical value of the standard you want to re-do, and then update the appropriate numerical values.

To identify an unknown color, run IDENTIFY.BAS. As in the calibration program, IDENTIFY samples each LED (or combination) 50 times and sums the results. The program then compares the sum against the values stored in the standard file and finds the closest match. The program calculates error as the sum of the squares of the differences, with double weighting given to the dual (aqua/green) LEDs. On a 20-MHz 286-based PC, it takes less than three seconds to determine the closest match from a list of 1000 values.

Construction

The authors built the prototype on two cards. One is an interface card that can be inserted in any standard 8-bit PC expansion slot. This card contains everything except the LEDs and phototransistor. They are located in a separate box called the reflectance probe; it connects to the interface card via a 12-conductor ribbon cable.

To save money, the authors built the interface card on a $4.99 72-pin prototype card. If you use the specified interface card (see the Parts List), *carefully* file exactly ½" from the edge connector to make it fit the 62-pin PC slot. The complete board should appear as shown in Fig. 2. (Note that the authors split the cable in two, attaching the separate sections with a pair of 25-pin, D-style, I/O connectors.)

Figure 3 illustrates the reflec-

PARTS LIST

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

R1—10,000 ohms
R2—470,000 ohms
R3—220,000 ohms
R4, R10—4700 ohms
R5—1200 ohms
R6—330 ohms
R7—47 ohms
R8—15,000 ohms
R9—470 ohms

Capacitors

C1—220 pF disk capacitor
C2—0.1 µF disk capacitor

Semiconductors

D1—1N4148 diode
IC4—7406A hex inverter with open collector outputs
IC1—74HCT688E octal comparator
IC3—74LS533E octal latch with inverted outputs
IC2—ADC803LCN analog-to-digital converter (Burr-Brown)
IC5—7805 5-volt regulator
LED1—470 nm blue LED (DigiKey 103CR-ND or equiv.)
LED2—560 nm green LED (DigiKey P312 or equiv.)
LED3—590/700 nm yellow/red LED (DigiKey P394 or equiv.)
LED4—585/630 nm green/orange LED (DigiKey P509 or equiv.)
LED5—665 nm crimson LED (DigiKey P405 or equiv.)
LED6—482 nm aqua LED (Ledtronics, Torrance, CA, L200CWGB6 or equiv.)
Q1—phototransistor (Digi-Key PN168PA-ND or equiv.)

Miscellaneous: 14-pin DIP socket (1), 20-pin DIP sockets (3), 5-foot length of 14-conductor ribbon cable, box (Radio Shack 270-230 or equiv.), plug-in PC board (Radio Shack 276-192 or equiv.), hookup wire, wire cutters, soldering iron, solder, drill, ½" drill bit, small drill bit, file, glue gun, and black plastic electrical tape.

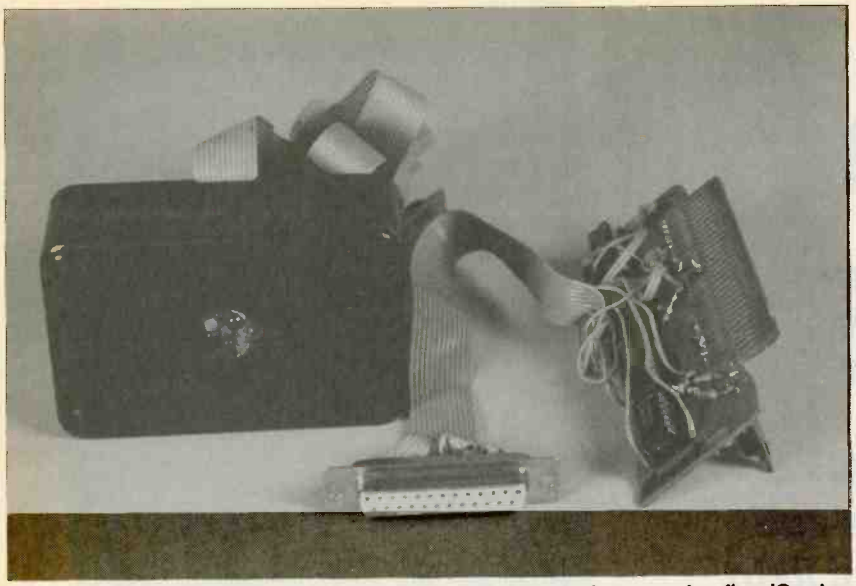


FIG. 2—THE PC INTERFACE CARD requires just enough space for five ICs, ten resistors, a couple of capacitors, and a diode. The reflectance probe contains six LEDs and the phototransistor cemented together with hot-melt glue and sealed in a light-tight box.

tance probe, which contains the six LEDs arranged in a circle around the phototransistor. All components are mounted on perforated construction board, which could be removed from the top of the interface card. Each LED must be tilted so that the brightest emission from each LED illuminates the sample and reflects back into the phototransistor. Tilt angle is particularly critical for the blue LED.

Glue a 6-centimeter (cm) piece of perforated construction board into the bottom of the box with the solder pads up. Then drill a small pilot hole, followed by a larger ½ inch hole, through both the board and the box, in the approximate center of the box. Cut the shorter leads of the LEDs and phototransistor to about a 1 centimeter length, and the longer leads to about 1.5 cm. Spread the phototransistor leads 180° and solder the phototransistor so that it points straight out the center of the hole. Now solder in the LEDs. All devices should be almost flush with, but not protrude through, the bottom of the box.

Connect all the common LED leads and the collector of the phototransistor to a common +5-volt line. Connect the remaining LED and phototransistor leads to the individual wires of the ribbon cable.

Testing and final assembly

Test the unit before gluing the optics in place. First check all wiring carefully. An inadvertent wiring error or short circuit could cause your PC to crash, or even damage it. Turn off PC power, install the circuit card, turn the power back on, and start BASIC. By typing a series of statements in the following form, you should see each LED light up in turn.

```
out (512,n)
```

where 512 is the address at which you wired IC1 to respond (default=512), and N is 1, 2, 4, 8, 16, 32, or 64, which should in turn illuminate the blue, green, yellow, orange, crimson, red, or aqua LED.

Now run the calibration program (Listing 1) and calibrate a few values. Next run the IDENTIFY program (Listing 2) and verify that the unit works. Read the usage notes before concluding that it doesn't work.

When you're satisfied that it works correctly, seal the LEDs and phototransistor in the box with hot-melt glue. Attach the cover on the box with screws, and seal the box with electrician's black vinyl tape to prevent stray light from leaking in and corrupting the results.

Usage notes

Thermal stability is an issue with this circuit. You should always turn it on several minutes before using it. The larger the number of standard colors you have defined, the longer you should let the tester warm up. The authors found that with a 1000-sample standard file, a warm-up time of one hour was required for accurate results. The authors also found that the best thermal stability was achieved by leaving the LEDs on. This is the reason for the OUT ADR,255 instructions in the initialization sections of both programs. Of course, during a scan, the software turns on only one LED at a time.

The methodology paid off. After it was calibrated, the authors' prototype was able to identify 900 shades of Sears' standard paint colors, plus an additional 100 "Weatherbeater Premium" paint sample colors. In addition, the circuit gives reasonable matches for typical random color samples. For example, the best match to the blue background on page 37 of the September 1992 issue of *Radio-Electronics* was identified as "Oriental Blue."

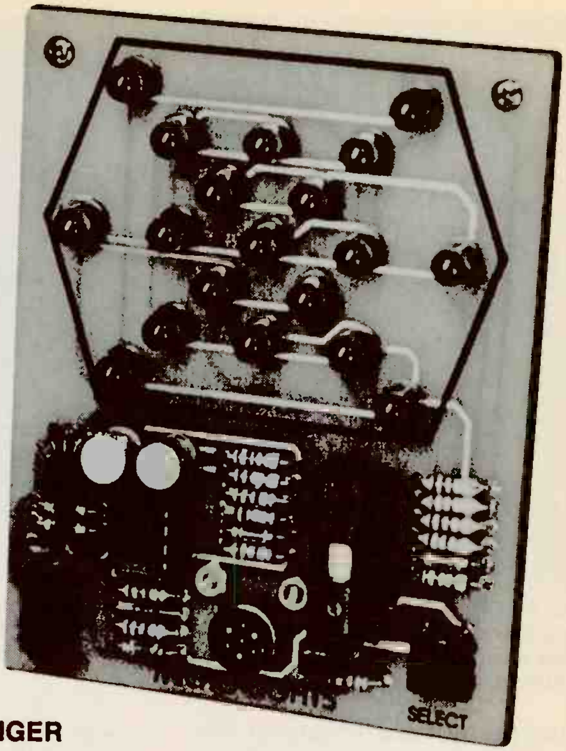
Magazines typically print colors as discrete dots of a specific color, not as continuous tones. Under normal circumstances, the dots shouldn't affect the color-matching process. If the dots are very large, or if for any other reason you have trouble getting consistent results, try covering your sample with a thin sheet of clear plastic.

"Gloss" and texture are, however, subjects of concern. Samples with slight texture or gloss can usually be matched fairly well, but don't use textured, glossy, or plastic-covered samples for calibration.

Identifying 1000 colors with 100% accuracy is an impressive feat for so simple a device. We hope that someone will develop the idea further by improving the statistics, writing the software in a language more powerful than BASIC, developing a serial (RS-232) version for laptop computers, and even a pocket-size EPROM version. Ω

MICRO LIGHTS

Learn how the PIC16C71 microcontroller works and produce your own mini light show with Micro-Lights.



DAN RETZINGER

FLASHING LIGHTS ATTRACT THE ATtention of people and can lure or warn them. Police cars and ambulances are equipped with flashing lights. Retail stores use strobe lights to attract attention to opening day and special sales, and aircraft strobe lights call attention to them day or night. This article describes how to build a pocket-sized miniature light show called Micro-Lights. It's a neat little project that's sure to get the attention of anyone passing by your desk or coffee table. The cigarette-pack-sized device is controlled by a versatile PIC microcontroller.

The display is composed of 19 LED lamps arranged in a geometric pattern. A microphone built into Micro-Lights makes it responsive to sound. A pushbutton selects one of eight preprogrammed sound-display routines. The circuit is powered from a 9-volt battery, so it's completely portable.

The circuit

Figure 1 is the schematic diagram of the Micro-Lights circuit. At the heart of the circuit is a Microchip Technology PIC16C71 eight-bit, CMOS microcontroller with built-in EPROM. The PIC16C71 is packaged in an 18-pin DIP package that contains a central processor, clock, EPROM, RAM, eight-bit analog to digital converter, 13 TTL/CMOS-compatible input/output (I/O) lines, and a timer.

An electret microphone (MIC1) is connected to the noninverting input of dual, low-power operational amplifier IC2-a, and a National Semiconductor LM358, which amplifies the microphone signal by a factor of about 1000. The-op amp's output feeds two inputs to the PIC16C71. Both inputs can be internally routed to the A/D converter inside the microcontroller. The signal on one input (RA0) is partially filtered by D1, C5, and R7, making the sound amplitude easier to distinguish. The other input (RA1) is fed directly from the op-amp. Software determines which input will be selected at any given time.

An LED array—19 LEDs arranged in a snowflake-like pattern—is connected to nine of the PIC's I/O lines. Resistors R10 through R13 limit the LED current, and help to reduce power drain. The LEDs are multiplexed under software control, with each column of three or four LEDs turned on (if dictated by the display routine) for 20% of the total display time, or about 1 millisecond. A complete display refresh occurs every 5 milliseconds, or 200 times a second. This rate is fast enough so that the human eye will see no visible flicker.

The select pushbutton is connected to I/O RA3 (pin 2). The pin is routinely sampled under software control. By repeatedly pressing the select pushbutton, the circuit cycles through all eight of Micro-Light's display routines.

The PIC16C71's clock circuit can be controlled by a standard quartz crystal, a resonator, or a simple RC combination. For power considerations and simplicity, an RC clock was selected. Resistor R8 and capacitor C7 form the PIC's clock which runs at approximately 100 kilohertz.

Switch S2 turns power on and off. A 78L05 regulator (IC3) supplies power to the circuit. Capacitors C1 and C2 stabilize the regulator output.

The PIC16C71

Figure 2 is a block diagram of the PIC16C71. Only 35 single-word instructions make up the microcontroller'sRISC-like instruction set.

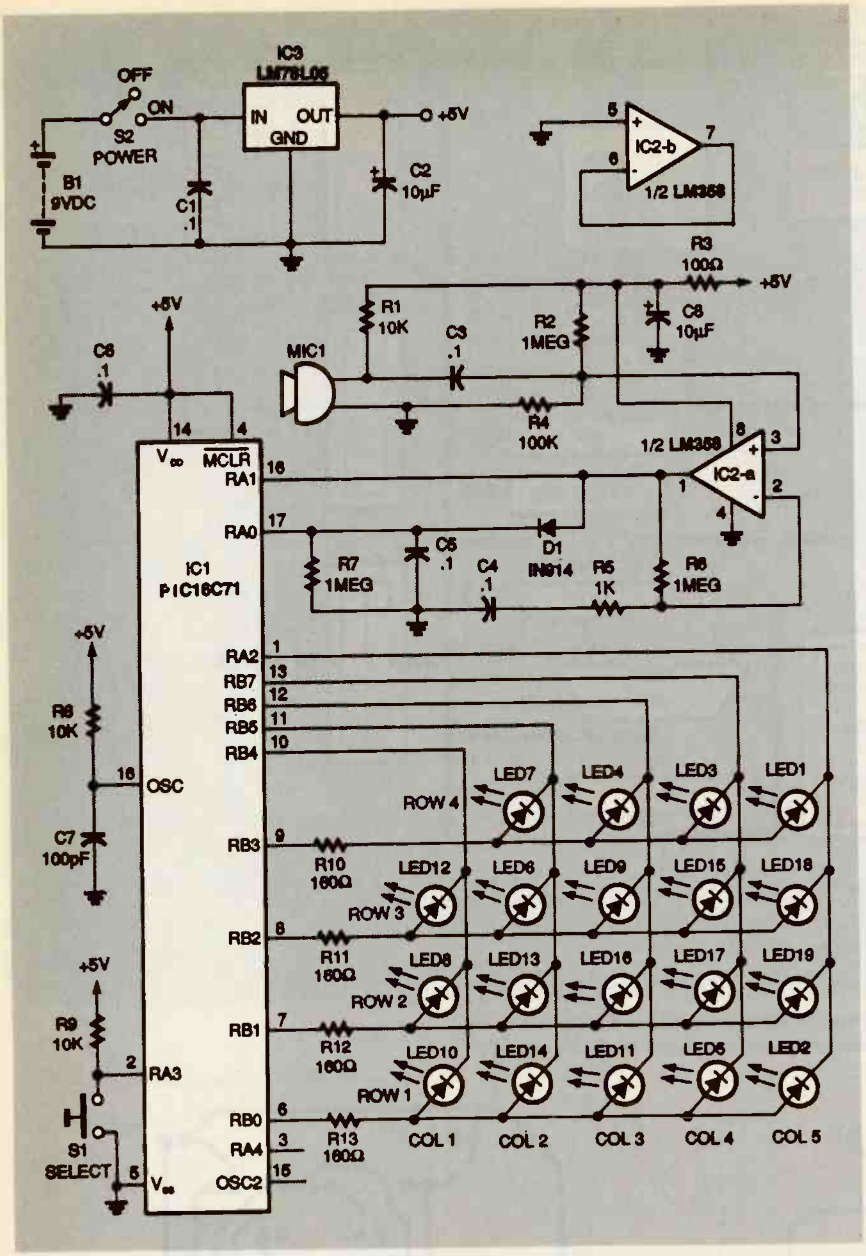


FIG. 1—MICRO-LIGHTS SCHEMATIC. At the heart of the circuit is Microchip Technology's PIC16C71 8-bit, CMOS microcontroller with built-in EPROM.

PARTS LIST

All resistors are ¼-watt, 5%.
R1, R8, R9—10,000 ohms
R2, R6, R7—1 megohm
R3—100 ohms
R4—100,000 ohms
R5—1000 ohms
R10-R13—160 ohms

Capacitors
C1, C3-C6—0.1 µF, 50 volts, ceramic
C2, C8—10 µF, 16 volts, radial electrolytic
C7—100 pF, 50 volts, ceramic disc

Semiconductors
IC1—PIC16C71 microcontroller (Microchip Technology)
IC2—LM358 dual op-amp (National Semiconductor or equivalent)
IC3—78L05 100 milliampere, 5-volt regulator
D1—1N914 diode
LED1-LED19—green light emitting diode, T1¾ package

Other components
S1—Pushbutton switch, PC-mount
S2—Slide switch, SPST PC-mount
MIC1—Electret condenser microphone (Panasonic WM54BT or equivalent) B1—9-volt alkaline battery

Miscellaneous: PC board, 9-volt battery clip, 9-volt battery holder (Keystone part No. 71), one 18-pin IC socket, one eight-pin IC socket, PC board backing material, four No. 2 screws and nuts, solder.

Note: The following parts are available from Silicon Sound, P.O. Box 371694, Reseda, CA 91337-1694 (818) 996-5073:
- **Starter kit (includes PC Board and programmed PIC16C71 microcontroller)—$39.00**
- **Complete kit (includes all parts)—$59.00**
- **Assembled and tested Micro-Lights—$69.00**

Please add $3.50 for shipping and handling. California residents add 8.25% sales tax.

The PIC16C71's 13 I/O pins (made up of RA0–RA4 and RB0–RB7) can be programmed individually as inputs or outputs. Configured as outputs, each pin can source 20 milliamperes of current or sink 25 milliamperes. This feature is very convenient for driving LED lamps directly.

The PIC16C71 has four interrupt sources and an eight-level hardware stack. The A/D converter has four channels, eight-bit resolution, built-in sample-and-hold circuitry, and can perform a conversion in under 30 microseconds.

Software

The Micro-Lights software takes advantage of several PIC features. Figure 3 is a simplified flow chart. The key to controlling the LED display is a timed interrupt routine. Immediately after power-up, an initialization routine presets and enables a timer within the microcontroller. The timer continuously counts up, and upon overflow causes an interrupt routine to be executed. At approximately 1-millisecond intervals, the interrupt software reads internal RAM locations (LED buffers) and outputs on/off states for each LED corresponding to the bit values in the RAM. One column of LEDs is updated per interrupt. Within 5 milliseconds all LEDs are refreshed. The select switch is also sampled during the interrupt.

The main program loop decides which display routine will be entered. The display routines decide which LEDs will be lit by writing to the same internal

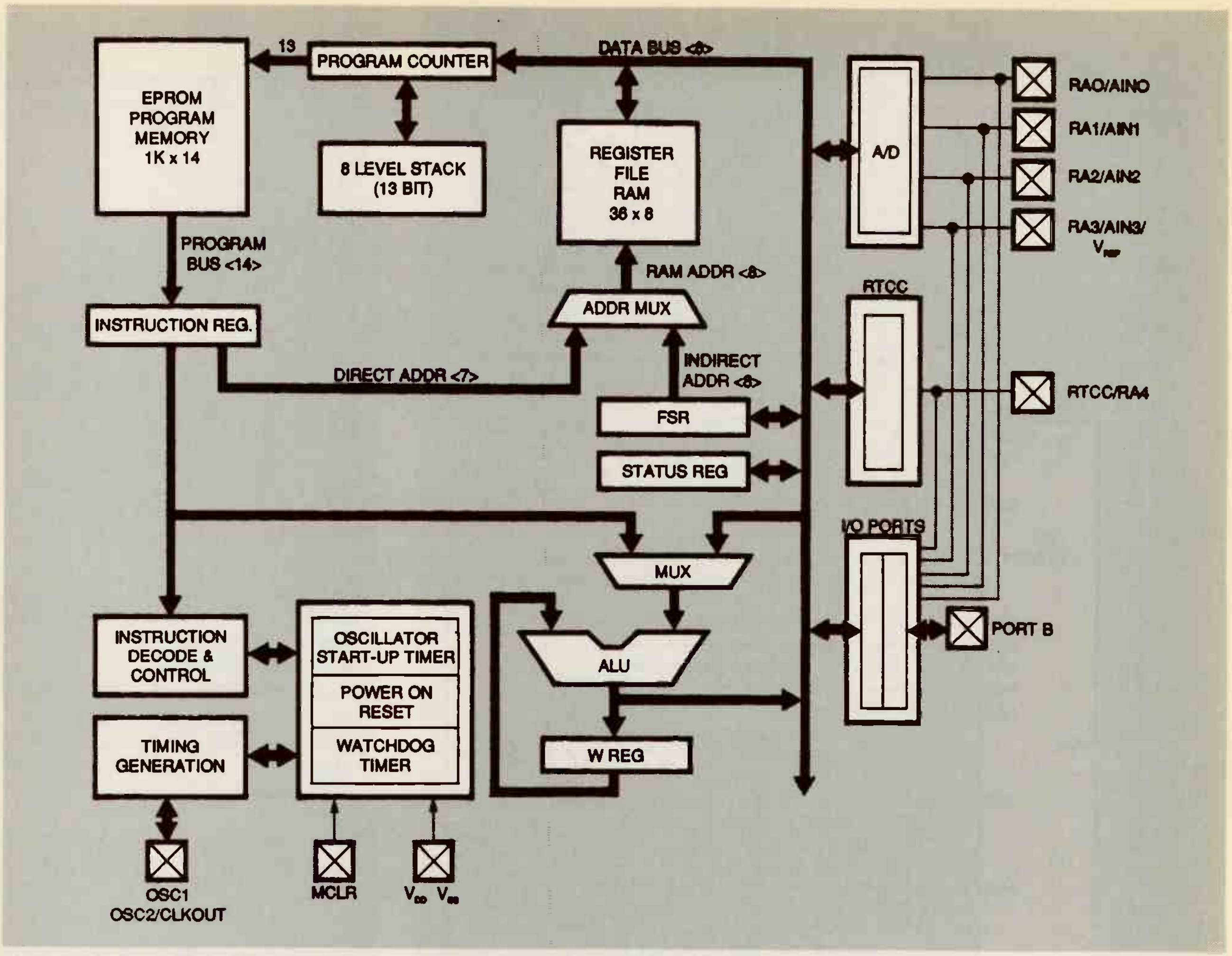
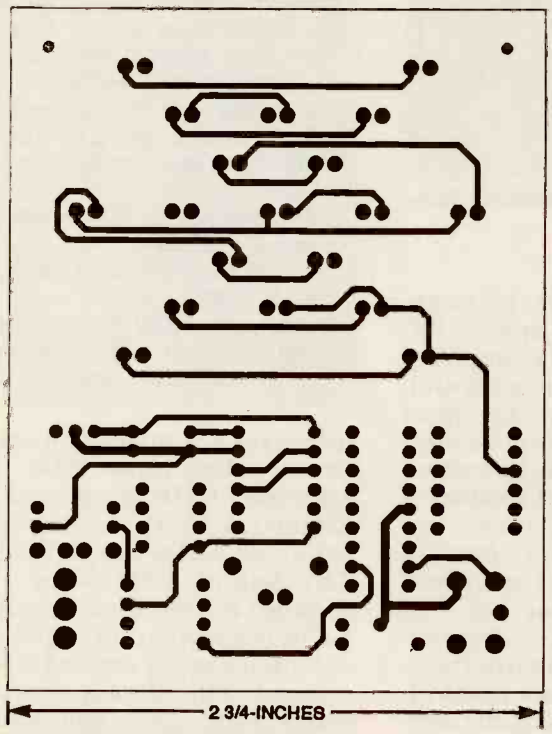
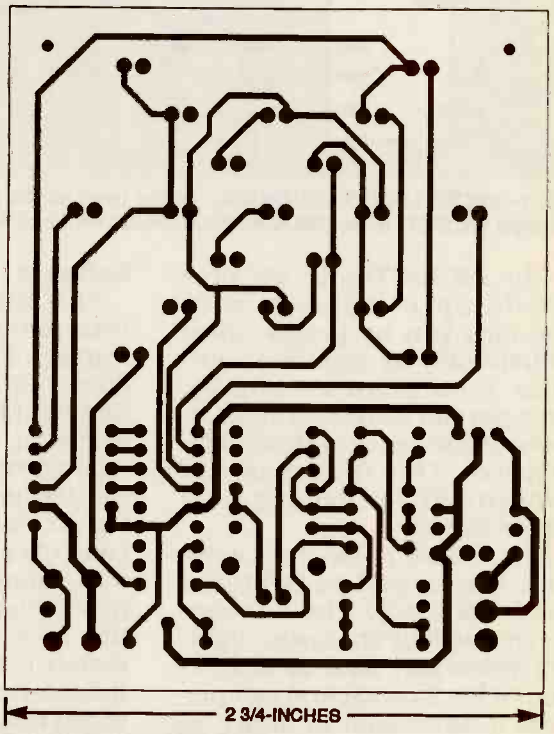


FIG. 2—PIC16C71 BLOCK DIAGRAM. The chip includes fully static CMOS circuitry, flexible I/O pin programming, timed interrupts, and a built-in eight-bit A/D converter.



MICRO-LIGHTS COMPONENT SIDE.



MICRO-LIGHTS SOLDER SIDE.

RAM locations accessed by the interrupt routine. The display routines have access to several subroutines: one reads the A/D converter, and the other generates a random number.

The value produced by the A/D converter corresponds to the sound intensity at the microphone. Some display routines distinguish between different values read from the A/D converter to determine how to turn on the LEDs, and others just look for a minimum amplitude for triggering a pattern. The frequency of sounds can be determined by rapidly reading the A/D amplitudes. A delay subroutine helps control the on and off duration of the LEDs.

Table 1 lists the eight Micro-Lights routines and includes a brief description of each. For example, look at the description for routine 2, "Random Single LEDs." When this routine is selected, the software controls the flashing of single LEDs, one at a time, in random locations on the LED array. When a sound of sufficient amplitude occurs, the rate at which the LEDs are lit is increased correspondingly. The effect is a pleasing twinkling pattern. The other seven routines produce their own unique effects, as mentioned in Table 1.

Listing 1 is a portion of the Micro-Lights source code. The complete source code (a file called MLIGHTS.SRC) can be downloaded from the Electronics Now BBS (516-293-2283, V.32, V.42bis) as part of a ZIP file called MLIGHTS.ZIP. The hex code (MLIGHTS.HEX) is also part of the ZIP file. Listing 1 shows the assembled code for the Star From Center routine 5, and Fig. 4 is the flowchart for that routine.

The status of the select push-

LISTING 1

```
                    ;Routine 5: Star From Center
                    ;Lights emanate from center, proportional to sound

024C  1C1E  r_5     btfss   bitvar,0    ;check pushbutton
024D  281C          goto    main        ;if pushed, we're done
024E  199E          btfsc   bitvar,3    ;check for auto select
024F  2A52          goto    r_5ok       ;ok to continue
0250  1A1E          btfsc   bitvar,4    ;0 = continue
0251  281C          goto    main        ;if 1, new routine
0252  2284  r_5ok   call    getad       ;get A/D value
0253  1996          btfsc   adata,3     ;skip if bit 3 low
0254  3001          movlw   0x01        ;value for center led
0255  1D96          btfss   adata,3     ;skip of bit 3 high
0256  0100          clrw                ;center led off
0257  008C          movwf   col_1       ;write to led buffer #1
0258  1A16          btfsc   adata,4     ;check bit 4 (A/D)
0259  300F          movlw   0x0f        ;value for 4 leds col_2
025A  1E16          btfss   adata,4     ;check bit 4
025B  0100          clrw                ;turn leds off
025C  008D          movwf   col_2       ;write to led buffer #2
025D  1A96          btfsc   adata,5     ;check bit 5 (A/D)
025E  300F          movlw   0x0f        ;4 leds col_3
025F  1E96          btfss   adata,5     ;check bit 5
0260  0100          clrw                ;turn leds off
0261  008E          movwf   col_3       ;write to led buffer #3
0262  1B16          btfsc   adata,6     ;check bit 6 (A/D)
0263  300F          movlw   0x0f        ;4 leds col_4
0264  1F16          btfss   adata,6     ;check bit 6
0265  0100          clrw                ;turn leds off
0266  008F          movwf   col_4       ;write to led buffer #4
0267  1B96          btfsc   adata,7     ;check bit 7 (A/D)
0268  300F          movlw   0x0f        ;4 leds col_5
0269  1F96          btfss   adata,7     ;check bit 7
026A  0100          clrw                ;turn leds off
026B  0090          movwf   col_5       ;write to led buffer #5
026C  0816          movf    adata,w     ;adata -> w
026D  3C40          sublw   0x40        ;is there sound?
026E  1803          skpnc               ;if sound, skip
026F  2A73          goto    r_5b        ;no sound
0270  3006          movlw   0x06        ;outside leds
0271  048C          iorwf   col_1       ;turn on leds
0272  2A75          goto    r_5c        ;skip turn-off steps
0273  108C  r_5b    bcf     col_1,1     ;turn off led 2
0274  110C          bcf     col_1,2     ;turn off led 3
0275  3007  r_5c    movlw   0x07        ;get hex 07
0276  0093          movwf   delay       ;set delay variable
0277  228A          call    delay1      ;wait, show leds
0278  2A4C          goto    r_5         ;continue with r_5
```

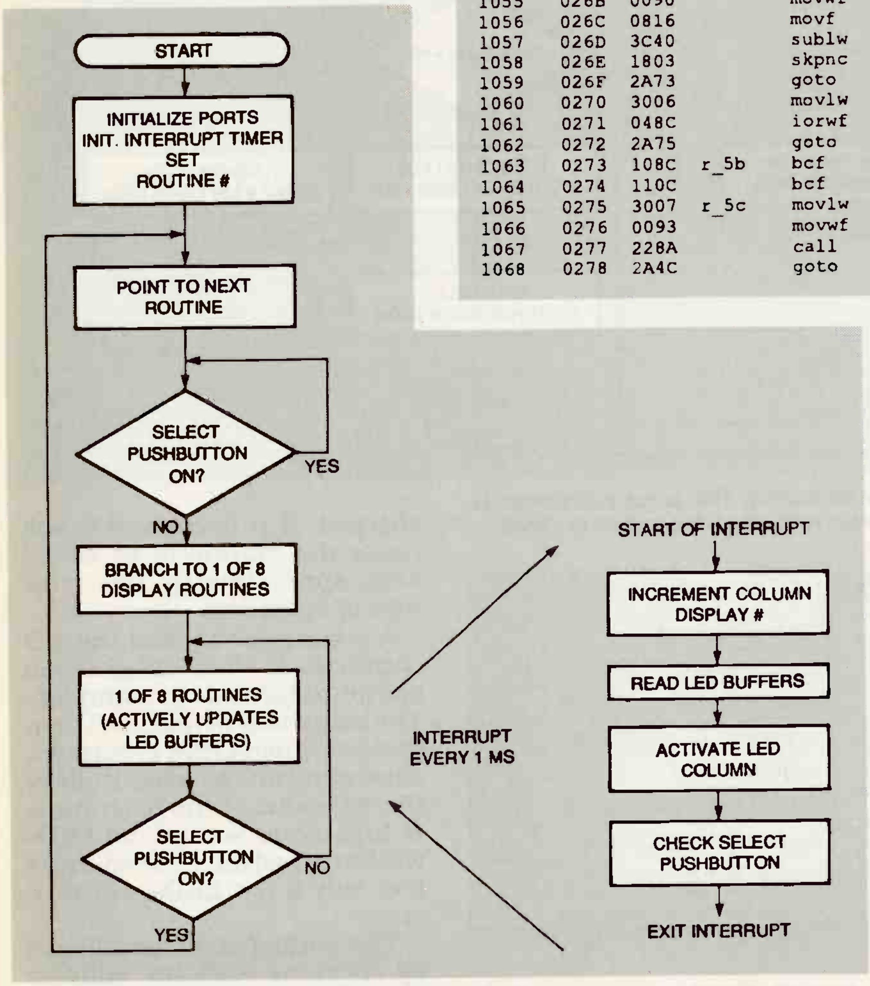


FIG. 3—SIMPLIFIED FLOW CHART. Immediately after power-up, an initialization routine presets and enables a timer within the microcontroller.

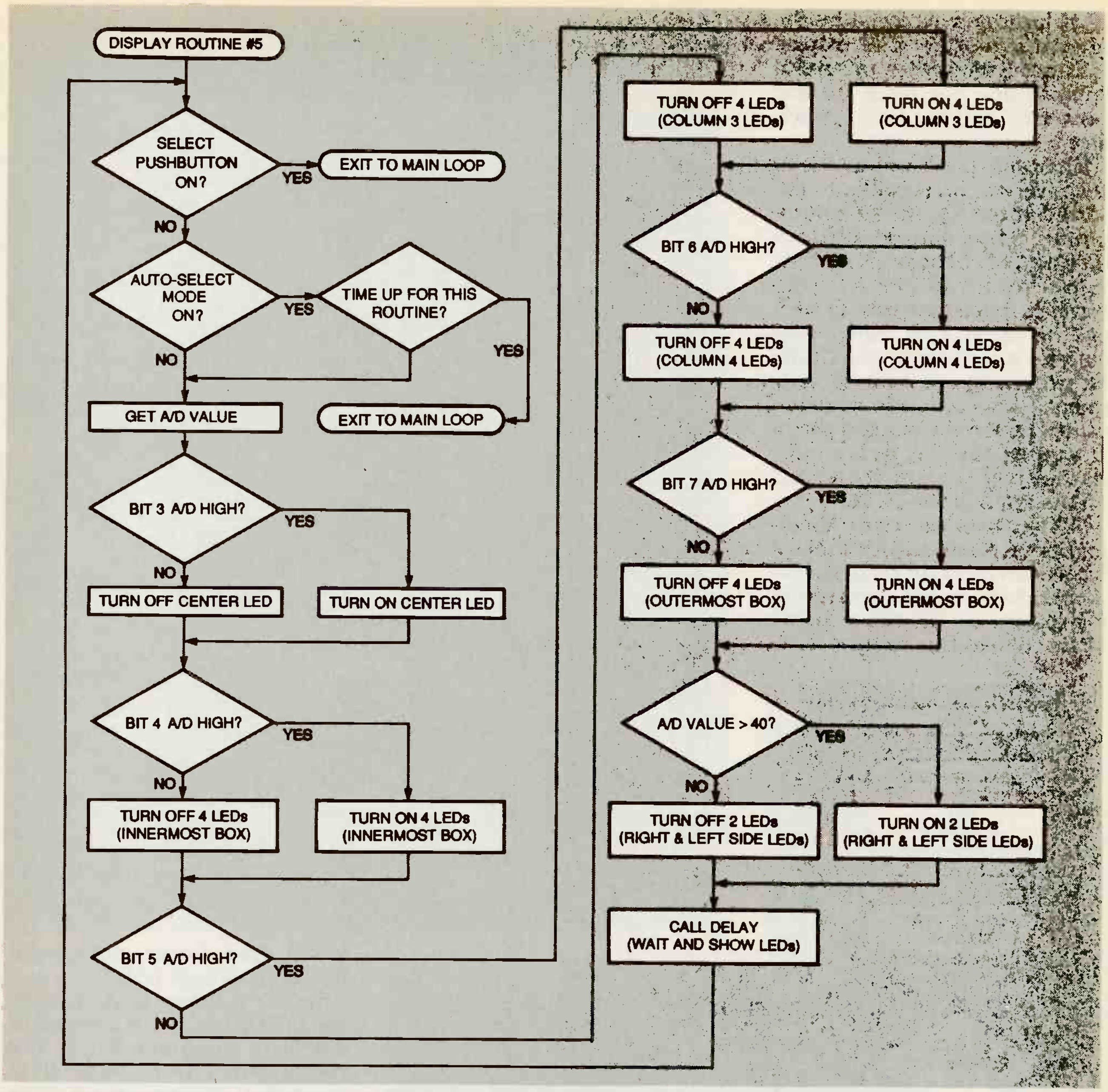


FIG. 4—FLOWCHART for the Star From Center routine. The select pushbutton is checked near the top of the routine; if the button is pressed, the routine is exited.

TABLE 1—MICRO-LIGHTS ROUTINES AND FEATURES

Routine	Features	Effect of Sound
1	Spinning Bars	Triggers Speed & Direction
2	Random Single LEDs	Triggers Speed
3	Bar Graph	Increased LEDs with Amplitude
4	Random Lights	Triggers Speed
5	Star From Center	LEDs Extend from Center
6	Boxes Hold	Triggers Various Groups
7	Worms Run Rampant	Selects "Worm" and Rate
8	Bars Hold	Selects Bar to Display

button is checked near the top of the routine; if the button is pressed, the routine is exited. Next, the autoselect mode is checked. If it is enabled it will cause the routine to be exited after approximately five minutes of operation.

A subroutine to read the A/D converter is then called when sound amplitude is sampled. The main body of routine 5 then decides which LEDs to turn on, depending on the magnitude of the A/D value. If the magnitude is high (loud sound), all LEDs will be turned on; if the sound is low, only a few LEDs will turn on.

The testing is accomplished by checking each bit value in the A/D's byte. When all LEDs have been turned on, a delay

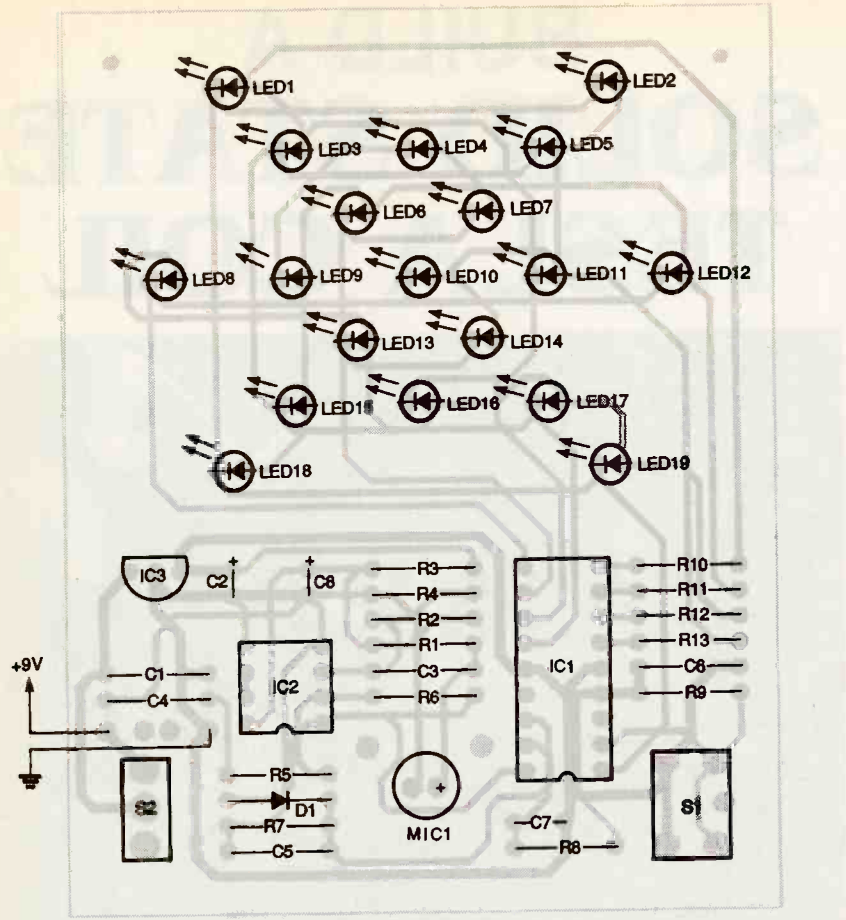


FIG. 5—PARTS-PLACEMENT DIAGRAM. Be sure to mount the LEDs flush with the board so that all cathodes face to the left.

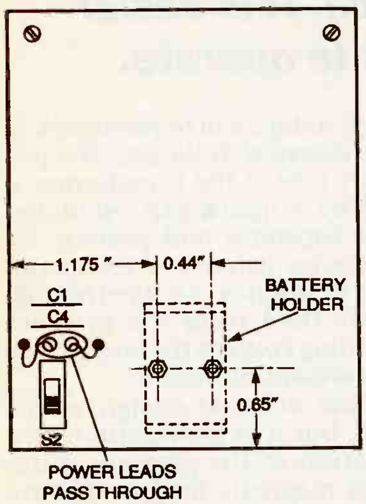


FIG. 6—DRILLING GUIDE. Four No. 2 screws and nuts hold the plastic backplate and battery holder in place.

routine is entered to freeze the display for a few milliseconds. The overall effect of routine 5 is a star that increases and decreases in size, according to sound intensity.

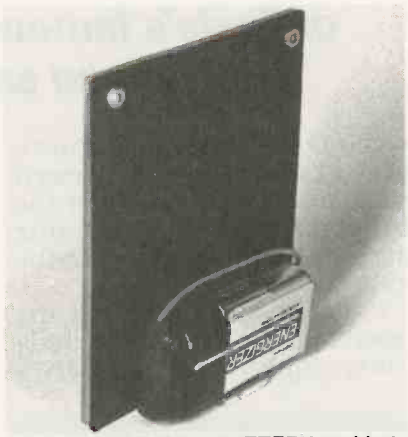


FIG. 7—THE 9-VOLT BATTERY and battery clip act as a stand.

Construction

There are no critical requirements in the construction of this circuit. All of the components are available from the source given in the Parts List, including a pre-programmed PIC16C71 microcontroller and a double-sided silk-screened PC board. The parts are available from many other distributors, as well. For the best finished appearance of the project, a printed circuit board should be used. Foil patterns are provided here for those who wish to make their own boards. Note that Micro-Lights is designed so that it does not require an enclosure.

Figure 5 is the parts placement diagram for Micro-Lights. Be sure to mount all the LEDs with their cathodes facing to the left (as you view the component side of the PC board). Any brand of LED lamp will work, although the best is a bright, diffused-lens lamp in the standard 5-millimeter (T1¾) plastic, radial-leaded package. Standard LEDs have flattened edges on their bases to indicate the cathode lead. Mount the LEDs flush with the PC board to protect the leads from being bent if the LEDs are bumped. Install sockets for the PIC16C71 and the op-amp.

To protect your fingers from any sharp edges of cut off leads on the back of the PC board, and to help make Micro-Lights look more like a professionally made product, install a plastic backing on the PC board. Install a 1/16- to 1/10-inch thick ABS or acrylic plastic rectangular piece cut to the outline dimensions of the PC board. As shown in Fig. 6, drill four holes and attach the backing with No. 2 screws and nuts.

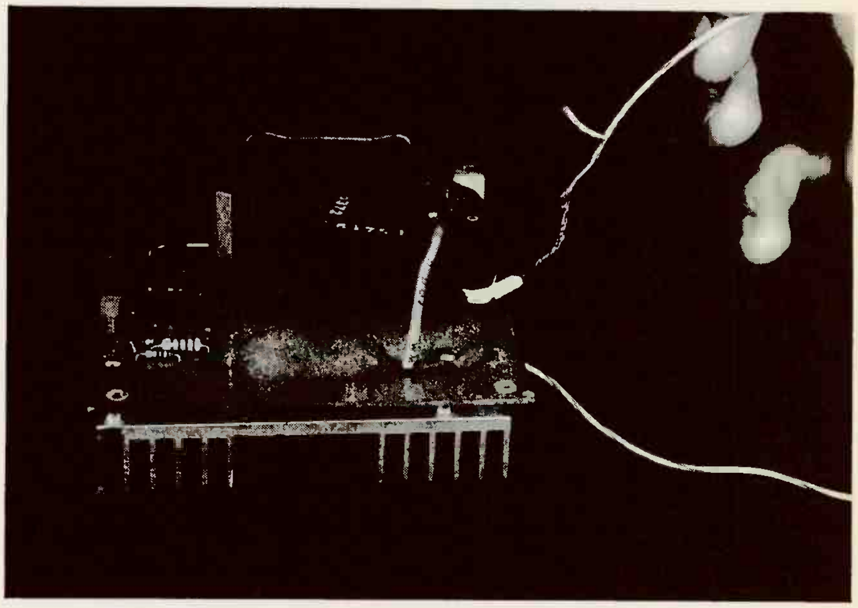
The two lower backplate mounting screws also secure the 9-volt battery holder in place. The 9-volt battery and battery clip act as a stand to support Micro-Lights when it is placed on a table for viewing (see Fig. 7). Be careful when positioning the holes for the battery holder. Their placement determines the angle at which the PC board will rest on a table. Figure 8 shows the completed Micro-Lights board.

Checkout

After you verify that all parts are installed correctly, connect a battery and turn on the power switch. Micro-Lights should immediately enter routine 1 and display a pattern of spinning bars. The bar's speed of rotation

(Continued on page 104)

BUILD A SOLID STATE TESLA COIL



Build a solid-state version of Tesla's famous coil. It is easier to build and safer to operate.

BRENT C. TURNER

NICOLA TESLA'S COIL IS ALIVE AND well today, living in school labs and hobbyist's workshops as a tool for learning and experimentation. The classical air-core transformer with a spark gap and capacitor produces a high voltage at high frequencies. However, new designs of that concept based on solid-state components and improved transformers make the construction of a Tesla coil easier and safer.

When Tesla devised his coil, the spark gap oscillator was the only practical method for generating the necessary radio frequency current across a transformer primary that would result in high-voltage at the secondary winding. However, the drawback of the classical Tesla coil is the ability of its high-voltage transformer to impart a life-threatening electrical shock to anyone experimenting with it.

Fortunately, high-voltage power transistors designed and built to meet the demand from switchmode power supply manufacturers are now readily available. Some power MOSFETs are capable of switching up to 1500 volts safely. Moreover, the task of building a suitable transformer has been simplified with the development of ferrite core materials that permit transformers to be made smaller and lighter and confine their magnetic fields.

How the Tesla coil works

The voltage output of a classical Tesla coil's secondary, a series-resonant circuit, is produced by oscillations in the secondary winding, as shown in Fig. 1. The Q or figure of merit for a resonant circuit and the applied frequency determine the voltage developed across the inductor.

If a voltage generated at the resonant frequency of the Tesla coil is coupled to its secondary, a high voltage will be produced. In the classical Tesla coil, the primary side of the transformer is fed by a spark-gap oscillator. The capacitor and primary inductance determine its operating frequency. An electromagnetic field from the primary winding couples the energy into the secondary system.

This original design works well, but it is inefficient; only a fraction of the primary winding's magnetic field is effective in inducing energy into the secondary. This inefficiency is caused, in part, by the expansion of the primary magnetic field. It was seen that if this field could be confined to a smaller volume, the system would be more efficient.

Ferrite transformer core materials make it possible to confine magnetic fields. Various

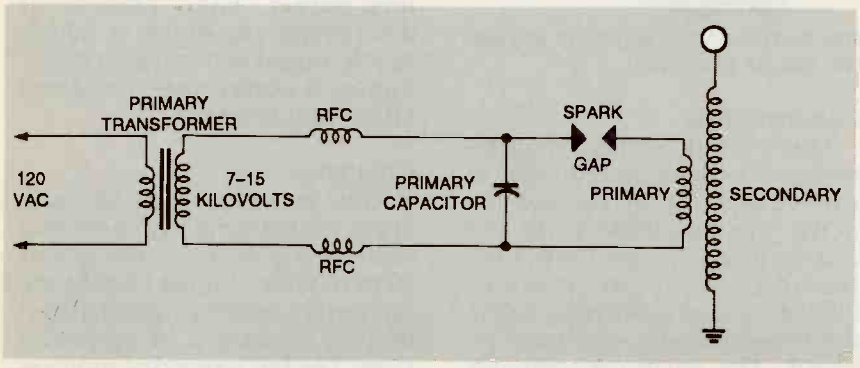


FIG. 1—IN A TESLA COIL, the voltage is produced by resonant oscillations created in a secondary winding.

powdered compositions of ferric oxide and other metals such as nickel or cobalt are compressed and sintered to form solid cores. Their high resistance makes eddy current losses very low at high frequencies, and coupling efficiency is improved.

The operating principle of the primary system in the solid-state coil design discussed in this article differs from the principle of the classical spark-gap design. If a spike of energy is applied, the coil responds with an oscillating burst that decays with time, analogous to the ringing of a bell when struck by the clapper.

If there is no instant damping of the ringing, it will occur at the natural resonant frequency of the coil. A higher voltage output will be produced by a phenomenon known as *Q factor multiplication*.

The solid-state Tesla coil includes a stock, off-the-shelf, high-frequency pulse transformer. It is essentially the same as the transformer that you will find in the high-voltage generation circuit of a standard television set.

The coil circuit

Refer to Fig. 2. The Tesla circuit consists of a pulse generator, a driver circuit, and a high-voltage transformer. The pulse generator, a 555 timer (IC1), is organized to run in its astable mode to generate a continuous pulse train. Resistors R1 and R2 determine the time duration that the output at pin 3 is off, while R3 and R4 along with R1 and R2 determine the on time. Inductor L1 and regulator IC2 provide a clean, stable power source for the timer.

Transistors Q1 and Q2 act as non-inverting buffers, effectively isolating IC1 from the highly capacitive load present on the gate of Q3. Resistor R8 determines the rise time based on the time constant developed by R6 and the inherent gate capacitance of Q3. Resistor R10 limits current so that excessive current will not damage T1's primary winding. Capacitor C4 absorbs some of the back EMF generated in T1's primary. Another function of C4 is to provide an extra kick to drive Q3 to an on state.

The pulse waveform from IC1 is applied to Q1 and Q2, which act as non-inverting buffers, providing the high current necessary to offset the high capacitance of Q3. When Q3 starts to conduct, current flows through T1's primary, building a magnetic field in the core. After a short time interval, the core saturates, preventing any further generation of magnetic flux. Prior to this, Q3 is switched off, causing the magnetic field to collapse and producing a sharp voltage spike in both windings.

Capacitor C4 partially absorbs the primary EMF, reducing the stress on Q3. The spike produced in the secondary creates a ringing oscillation. When this oscillation begins to decay, Q3 is once again switched into its on state. This dumps the energy store in C4, and builds the magnetic field in T1. If the timing of both the on and off states of the pulse train are adjusted correctly, the secondary of T1 produces a nearly con-

PARTS LIST

All resistors are ¼-watt, 5%, unless noted.
R1—7500 ohms
R2—10,000 ohms, potentiometer
R3, R6, R9—10 ohms
R4—5000 ohms, potentiometer
R5—180 ohms
R7—180 ohms
R8—150 ohms, ½-watt
R10—1 ohm, 5 watts

Capacitors
C1—220 µF, 25 volts, electrolytic
C2—0.0047 µF, 50 volts, Polyester
C3—0.05 µF, 50 volts, Polyester
C4—0.01 µF, 1200 volts, Polyester

Semiconductors
IC1—NE555 timer
IC2—LM7809, +9-volt regulator
Q1, Q2—2N2222 NPN transistor
Q3—SSM5N55 FET transistor (Samsung or equivalent: Minimum V_{ds} rating of 550 volts, maximum R_{ds}—on rating of 4 ohms)

Other components
L1—100 µH choke (Radio Shack No. 273-102 or equivalent)
T1—Flyback transformer (Penn-Tran No. 1-017-5372—or equivalent, provided that the high-voltage rectifier is not embedded within the transformer)

Miscellaneous: Heatsink for Q3, eight-pin socket for IC1, wire, high-voltage wire, perforated construction board.

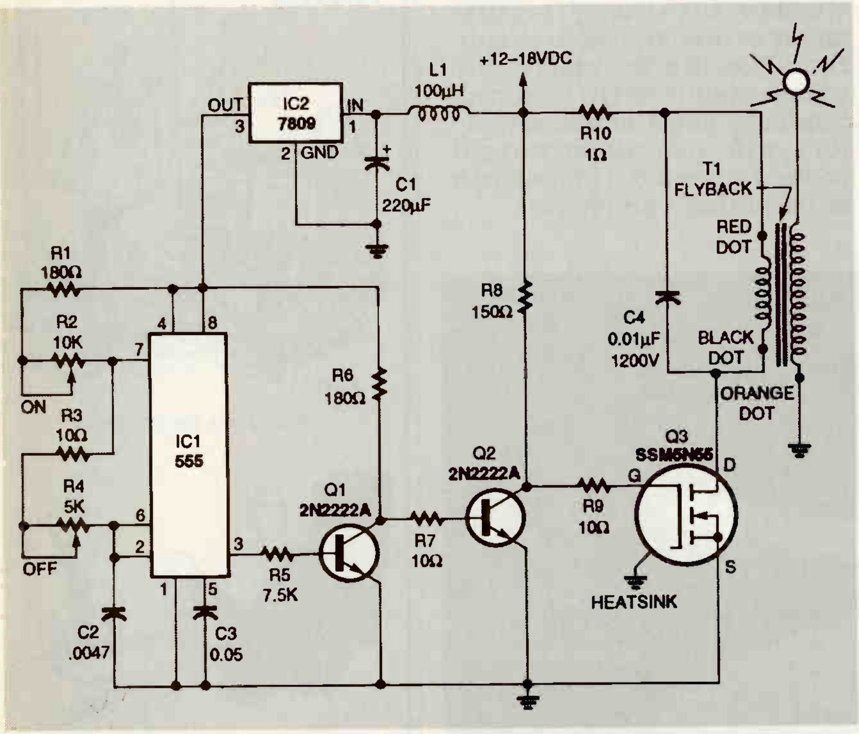


FIG. 2—THE SOLID-STATE TESLA CIRCUIT consists of a pulse generator, a driver circuit, and a high-voltage transformer. The 555 timer (IC1) runs in its astable mode, producing a continuous pulse train.

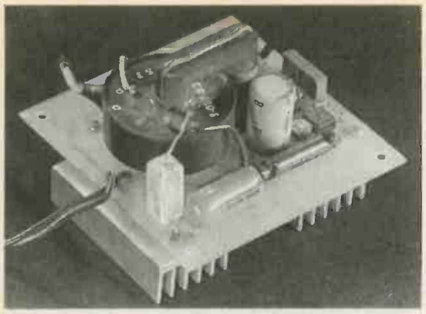
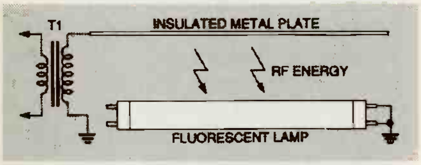


FIG. 3—THE PULSE GENERATOR can be built on a small piece of perforated construction board.



4—SUFFICIENT RF ENERGY is radiated to light small fluorescent lamps up to several inches away, without wires.

stant, high-frequency, high-voltage current.

Construction and adjustment

Begin construction with the pulse generator. It can be built on a small piece of perforated construction board. After installing all components, verify all connections, and apply 12 volts to the circuit. Verify that a pulse train is present at pin 3 of IC1 with an oscilloscope. While examining the waveform at pin 3, determine that both potentiometers (R2 and R4) function correctly by changing both the on and off time periods.

If that circuit works satisfactorily, turn off the power, insert the components, and wire the remainder of the circuit. Leave the connections to the primary winding of T1 open. Apply power and examine the waveform on the collector of Q2 with an oscilloscope. Verify that the waveform is the same as that present at pin 3 of IC1. (There might be slight rounding of the leading edges due to the capacitive effects of Q3.) Temporarily connect a 10-ohm, 10-watt resistor in place of the primary of T1. Verify that Q3 is switching the current on and off in sync with the signal at pin 3 of IC1.

If the circuit appears to be operating correctly, adjust R4 to produce an off time of about 10 microseconds (μs), and adjust R2 for an on time of 60 to 70 μs. Remove power and the temporary 10-ohm resistor. Connect T1 to the circuit and apply power, observing the current that the circuit draws. With all circuitry operating correctly, some corona should be visible on the high-voltage lead of T1, accompanied by a slight hissing noise. (There might also be a faint whistle from T1.)

Attempt to create an arc from the high-voltage lead of T1 with a grounded lead. The voltage should be high enough to strike an arc of over ½ inch in length. By adjusting R4, maximum voltage output can be obtained. Similarly, small adjustment to RT2 will also affect output power. Figure 3 is a photograph of the author's prototype.

Applications

Many interesting experiments can be performed with this circuit. By attaching a small brass drawer knob to the high-voltage lead, sufficient RF energy will be radiated to light low-wattage fluorescent lamps up to several inches away, without wires (see Figs. 4 and 5).

The solid-state Tesla coil has enough power to drive decorative plasma lamps. By adjusting R2 and R4, various discharge patterns can be obtained. A modulating voltage on pin 5 of IC1 will modulate the output and create more interesting visual effects.

The low-current output of the solid-state Telsa coil is not an extreme hazard to healthy adults. However, the high-voltage should still be treated with respect. The shock can be dangerous to people with heart problems, and the arc can easily start a fire.

Readers may write to author at P.O. Box 3612, Fullerton, GA 92634-3612. Ω

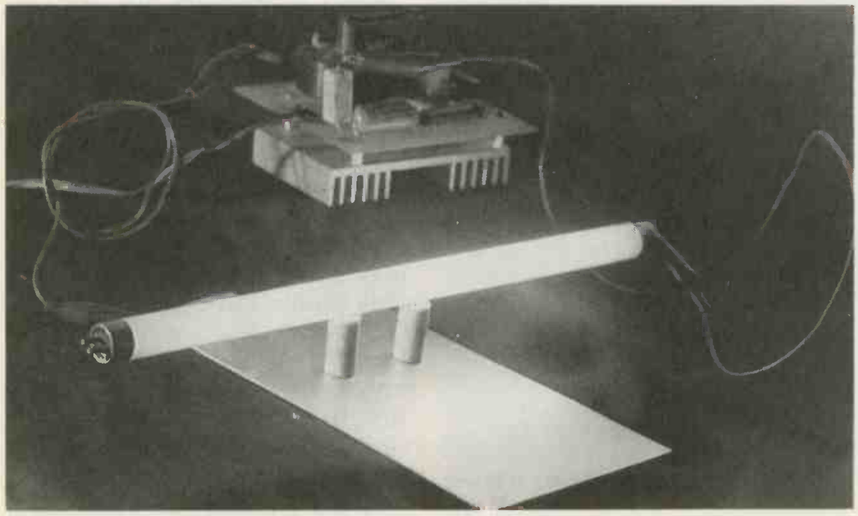


FIG. 5—THE FLUORESSCENT LAMP lights above the insulated metal plate.

It's a Boss's World

"First, Larry, the good news."

"Byron, when I asked you to build a time machine, I didn't mean a watch!"

Encourage young children to learn to play the piano or organ with this microcontroller-based training system.

JAMES E. TARCHINSKI

MUSIC BRINGS PLEASURE TO ALL OF us and adds to the quality of our lives. While most of us just listen to music, others play musical instruments for pleasure or profit. Parents, relatives, and friends of young children might want them to learn to play and enjoy music at an early age—even before they are old enough to profit from formal training in an instrument. Micro-Conductor overcomes this problem. This electronic trainer makes it possible for children to play simple tunes on a piano or organ without formal training.

Fifteen LED lamps on an indicator panel light up in the proper sequence under microcomputer control to prompt youngsters to press the associated keys to play nine familiar tunes. The tempo of the music can be regulated from slow to fast as children catch on, and a LED display identifies the tune being played.

The attraction of Micro-Conductor for children aged 4 to 6 is instant satisfaction. With a little practice in following blinking lights with their fingers, children—even those with short attention spans—are rewarded with the sounds of music. Moreover, Micro-Conductor should discourage children from randomly hammering on the keys of the family piano and driving even the most permissive parents to distraction.

The cable-connected indicator panel is placed just above the keyboard, and the circuit board is placed out of the way on top of the organ or piano, as shown in Fig. 1. Power for Micro-Conductor is obtained from an AC-to-DC adaptor that plugs into a wall outlet (saving you the expense of a lot of replacement batteries).

Micro-Conductor can be built from readily available components, and its microcontroller is programmed with nine tunes and musical scales. Moreover, it's a great starter project if you've never built a computer-controlled system. Pre-programmed chips are available from the source given in the Parts List if you prefer not to program the microcontroller.

Circuit operation

Figure 2 is the schematic for Micro-Conductor. The heart of the system is a Motorola MC68705P3 microcontroller which contains random-access memory (RAM) and field-programmable read-only memory (EPROM). Most of the chip's 28 pins perform input/output functions. Reprogrammable EPROM makes it easy to modify the operation of the trainer and add new songs when the first set has been overplayed.

The nine pieces and musical scales, numbered 0 to 9 and listed in Table 1, are programmed into the microcontroller. Number 9, scales, is the default tune when the unit is first powered up. The number of the tune being played is displayed on seven-segment LED display DISP2. It can be increased by pressing switch S3 or decreased by pressing switch S4. Whenever those switches are pressed, the circuit zeros an internal counter so that the new song begins to play on its first note.

To accommodate children of different ages and abilities, ten different tempos have been included: zero is the slowest and nine is the fastest, with the second value assigned to default. DISP1, another seven-segment LED display, shows the tempo selected. Tempo can be increased by pressing switch S1 and decreased by pressing S2. Unlike tune number, however, tempo can be changed at any time without restarting the piece being played.

Micro-Conductor's controls

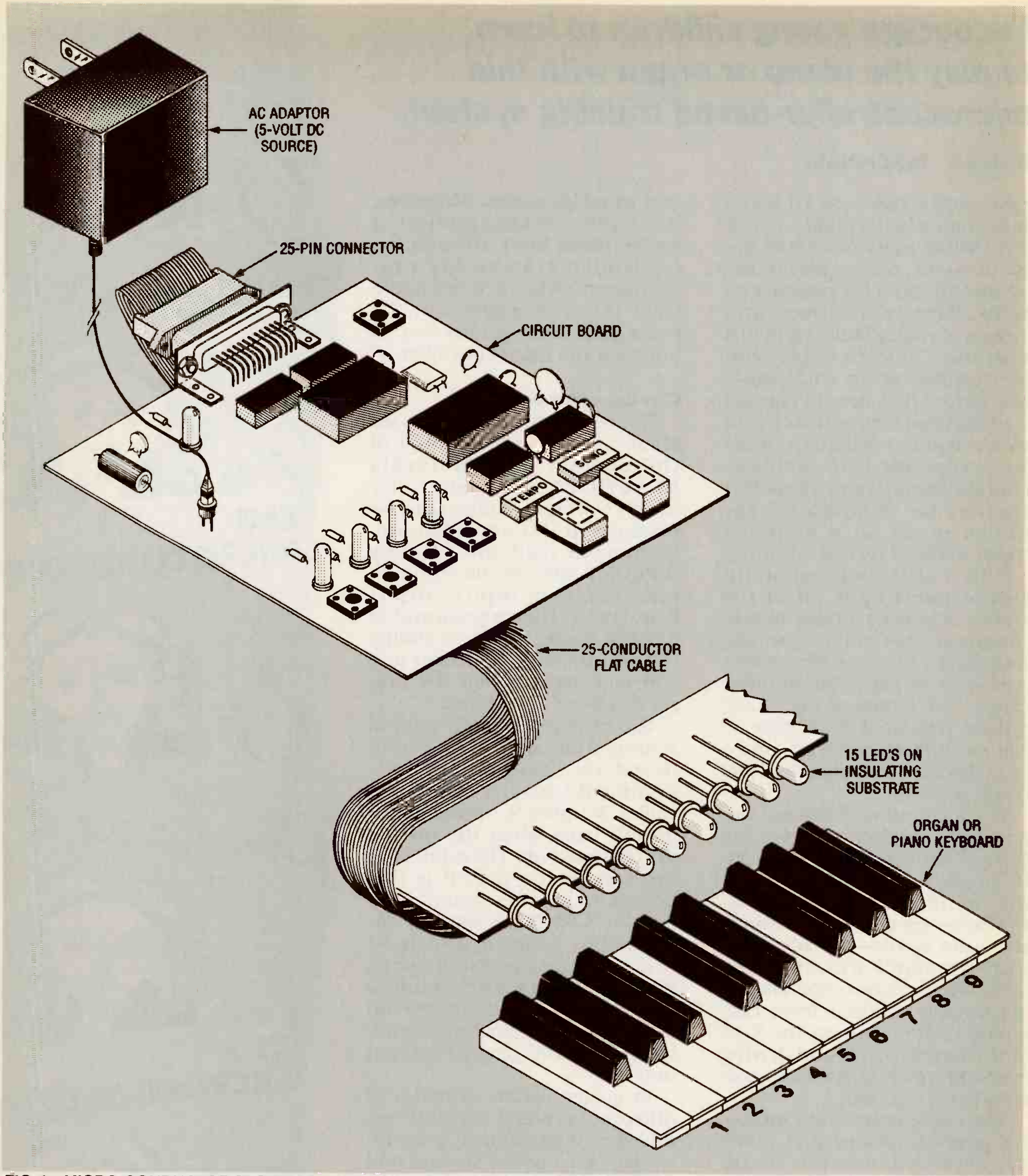


FIG. 1—MICRO-CONDUCTOR SYSTEM INCLUDES (top to bottom) outlet-mounted AC-to-DC adaptor, circuit board with microcontroller, function displays and switches, and a flat-cable connected indicator panel that is placed above the right keys on the piano or organ keyboard.

are simple enough to permit youngsters to operate the system by themselves. The four LED lamps on the PC board (LED1 to LED4) are not a required for the operation of the circuit, but were included to make software debugging easier. Microcontroller IC1's Port B (PB0 to PB7) controls input switches S1 to S4 and those four board-mounted LED's. Software (ORGAN5.S05) illuminates each of those LED's whenever the related pushbutton is pressed.

IC1's Port C (PC0 to PC3) does most of the work of Micro-Conductor although it only has only four of the 20 input/output pins. Port C drives IC2, a 74154 four-to-16-line demultiplexer. In response to the 4-bit input from IC1, IC2 drives the 15 LED's (LED6 to LED20) in the cable-connected indicator panel shown in Fig. 1.

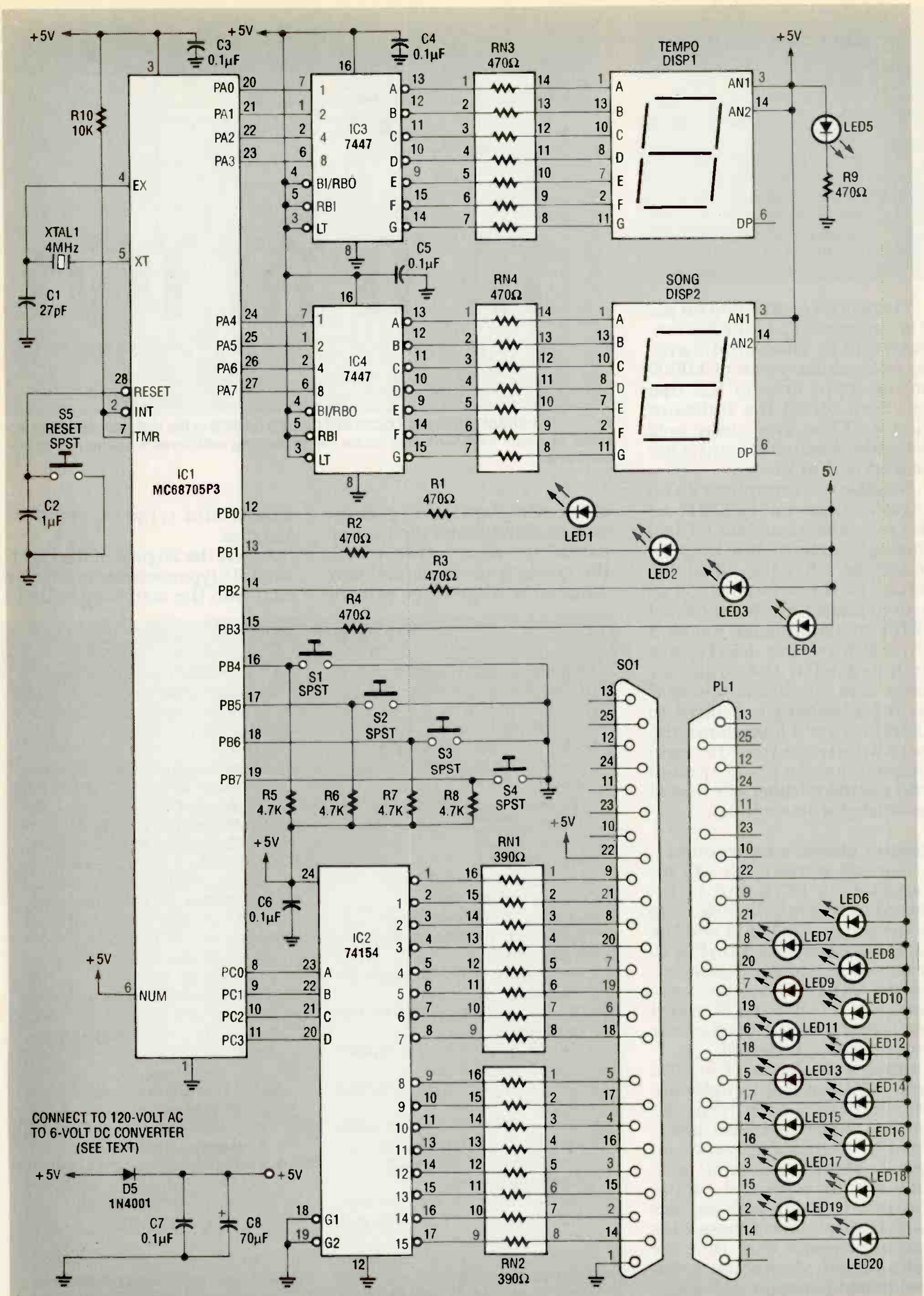


FIG. 2—SCHEMATIC FOR MICROCONTROLLER and indicator panel.

TABLE 1—SONG TITLES

0	Three Blind Mice
1	This Old Man
2	Twinkle-Twinkle Little Star
3	London Bridge
4	Mary Had A Little Lamb
5	Rock-A-Bye Baby
6	Yankee Doodle
7	Pat-A-Cake
8	Hickory-Dickory Dock
9	Scales

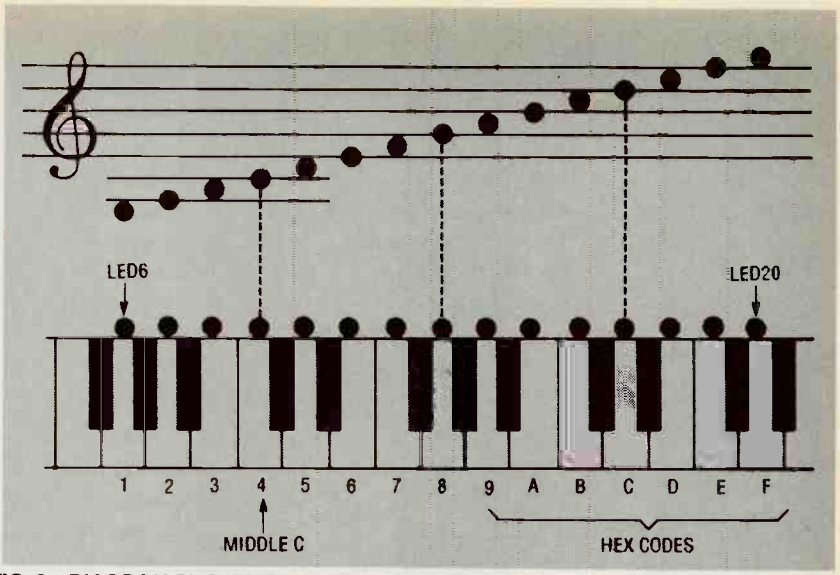


FIG. 3—DIAGRAM SHOWING LOCATION OF LED LAMPS in the indicator unit over the piano or organ keyboard. Hex codes permit coding additional tunes in the microcontroller.

There is no connection on pin 9 of connector PL1 for IC2's output 0 (pin 1). This permits a delay note, a binary code of %0000 on the input lines of IC2 that can turn off all the indicator panel's LED's. That delay note occurs between tunes and is imbedded within them.

Because IC2's outputs run on negative logic, the 15 LED's on the indicator panel are all tied through current-limiting resistors to +5 volts. When the voltage on the outputs of IC2 go to their low value, the connected LED's are illuminated. Figure 3 shows how the LED's are matched with the organ or piano keys. As shown, Middle C on the keyboard is related to LED9. Figure 3 also shows the four-bit single hexidecimal character code programmed into microcontroller IC1 that is associated with each key.

Control circuit construction

The foil pattern for Micro-Conductor's PC board is included in this article. Referring to the schematic Fig. 2 and the parts placement diagram Fig. 4, insert all resistors, resistor networks, capacitors, switches, and LED's 1 to 5 in the PC board and solder them. Trim all excess leads close to the board.

Bend both leads of crystal case XTAL1 at right angles approximately ⅛-inch from the bottom of the case and insert them in the holes as shown on Fig. 4. Then bend about a 4-inch length of tinned copper wire in a "U-"shape with its ends ½-inch apart. Insert those ends over the crystal case into the holes on both sides of the metalized shield patch on the underside of the board. Twist the ends of the wire together to pull the case snugly against the top surface of the board. Solder both the crystal case leads and wire strap ends where they exit the board and trim excess wire lengths.

Insert the 25 pins of the right-angle D-type socket comnnector SO1 into the matching holes of

PARTS LIST

All resistors are ¼-watt, 5 %
R1–R4, R9—470 ohms
R5–R8—4700 ohms
R10—10,000 ohms
RN1, RN2—390 ohms, eight-resistor DIP (CTS 8916 or equivalent)
RN3, RN43—470 ohms, seven-resistor DIP (CTS 8825 or equivalent)

Capacitors
C1—27 pF, 16-volt disc
C2—1 µF, 16-volt disc
C3–C7—0.1 µF, 16-volt disc
C8—470 µF, 10-volt electrolytic

Semiconductors
IC1—MC68705P3, microcontroller (Motorola)
IC2—74154N, 4-to-16 line demultiplexer
IC3–IC4—7447AN, 7-segment LED display drivers
LED1–LED21—red light-emitting diodes, 1¾
DISP1, DISP2—7-segment, common-anode LED displays in standard 14-pin DIP packages

Other components
XTAL1—4MHz quartz crystal, HC-18 case, (ECS, Digi-Key X006 or equivalent)
S1–S5—SPST momentary pushbutton switch, PC-mount, (Panasonic P8034S or equivalent)
SO1—25-pin, type-D connector with right-angle mounting brackets (Amphenol 177 or equivalent)
PL1—25-pin, type-D connector, MTIDC

Miscellaneous: Micro-Conductor PC board, 28-pin DIP socket for IC1, 24-pin DIP socket for IC2, two 16-pin DIP sockets for IC3 and IC4, length of 25-conductor 0.050-inch, 7 × 36 28 AWG flat cable (see text), AC-to-DC adapter, 120-volts AC outlet mounted, 6/7.5 volts DC, 700 mA, (Radio Shack No. 273-1655 or equivalent), DC jack (Radio Shack No. 274-1563 or equivalent), 4 PC board rubber feet with adhesive backing, strip of wood or plastic (see text), tinned copper wire, solder.

Note: The following software is avialable from James Tarchinski, P.O. Box 080133, Rochester, MI 48308-0133

- Programmed disk formatted for MS-DOS compatible computer containing all files: 5.25-in. disk—$6, 3.5-in. disk—$8.

Please include $2.00 for shipping and handling. Michigan residents must add 6% sales tax.

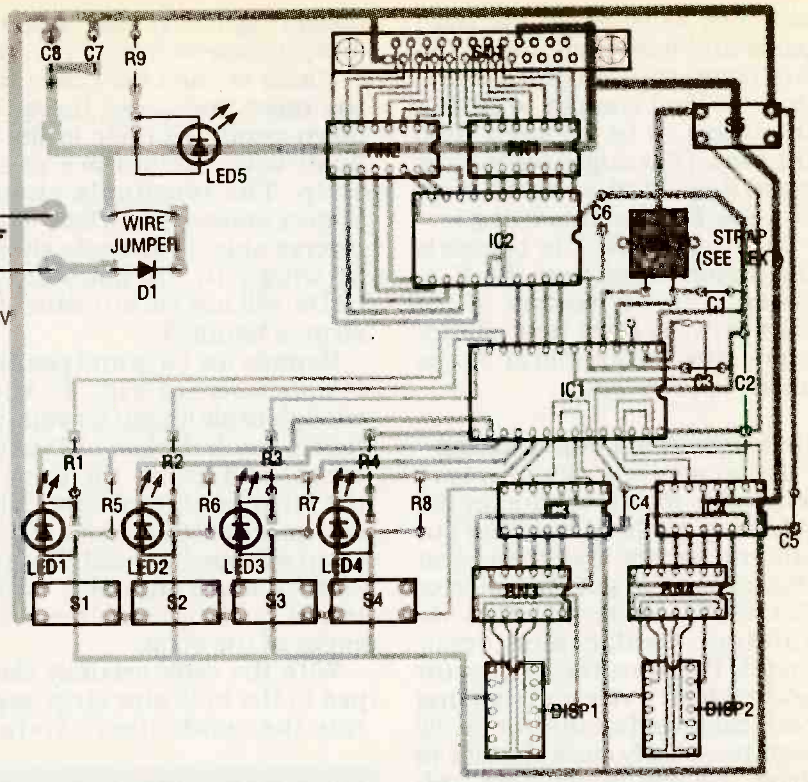


FIG. 4—PARTS PLACEMENT DIAGRAM. Integrated circuits IC1 to IC4 are mounted in sockets. Note wire clamping crystal XTAL1 case to board. A DC jack can be mounted in a drilled hole on the board (not shown).

the PC board and seat the connector flush with the edge of the board. Fasten the connector to the PC board with one of two methods. Drill two holes through the board using one of the two holes on each bracket as a template. (Be sure that you do not drill into a conductive trace on board underside.) Fasten the brackets with nuts and bolts, solder the conductors and trim excess lengths. Alternatively, place drops of epoxy or a suitable cement in the bracket holes to bond the brackets to the board after the leads are soldered and trimmed.

A socket is reqired for IC1 so that the microcontroller can be removed for reprogramming. While not mandatory, sockets are recommended for IC2 to IC4. Position the sockets, solder them, and trim excess leads.

The prototype has a jack for the coaxial plug from the AC-to-DC adaptor wired to the PC board with short lengths of insulated wire. However, you can cut off the plug, strip the wire ends, insert them in the holes, and solder them directly to the board as shown in Fig. 4. You can also drill a hole in the PC board and mount the jack directly on the board. (Be sure to observe the polarities for both adaptor plug and PC board.) Solder the connecting wires between board and jack, and trim excess lengths. Tape or pot the exposed jack terminals with RTV compound to insulate them.

Place the adhesive-backed rubber feet on the four corners of the underside of the PC board to elevate it board above any conductive surface that could short exposed traces and soldered joints. Insert the integrated circuits IC1 to IC4 in their sockets, taking all precautions to prevent IC damage from electrostatic discharge.

You can improve the appearance of the system and provide better protection for the circuitry by enclosing the circuit board in a suitable plastic or wood case. Its inside dimensions should accommodate the circuit board and allow adequete vertical clearance. However, if you elect this option you will need additional parts *not* listed in the Parts List. Also, the construction procedure given so far must be changed to allow for this alternative.

If you want to put the circuit board in a case, first drill holes at the four corners of the board for standoffs before doing any component assembly. Mount the LED displays on right-angle connectors and cut windows for them in the side walls of the case at the right locations. Also cut openings for the D-type connectors and drill a hole for the DC jack on a side wall. Mount

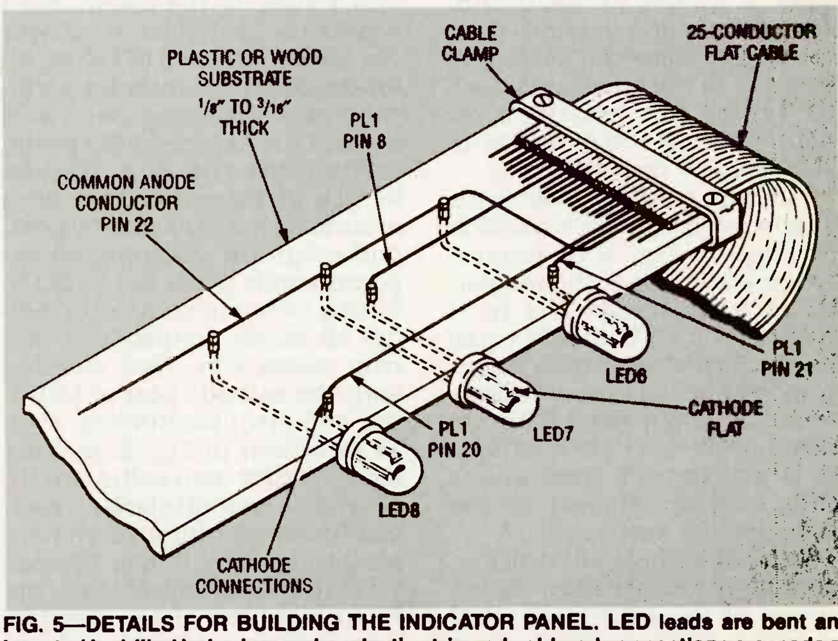


FIG. 5—DETAILS FOR BUILDING THE INDICATOR PANEL. LED leads are bent and inserted in drilled holes in wood or plastic strip and soldered connections are made as shown. Protect exposed conductors with tape or covers (not shown).

switches S1 to S5 on the front panel and wire them to the circuit board with lengths of hookup wire long enough to permit the board to be removed from the case. (You might want to replace them with switches more suitable for case mounting.)

When the board is complete but before inserting the IC's, fasten it to the bottom of the case with screws and standoffs—plastic or metal tubes about ½-inch long.

Indicator panel construction

Determine a satisfactory length for the 25-conductor flat cable (up to three feet) and cut one end square. Insert and seat that end in the slot of connector PL1 (with mass-termination, insulation-displacement contacts). Position the connector and cable in a vise and, holding both cable and connector firmly together, slowly close the vise to drive the row of contacts uniformly into the cable to form secure bonds with each of the conductors.

Referring to Fig. 5, select a suitable strip of wood or plastic from ⅛ to 3/16-inch thick, about 2 inches wide and up to 20 inches long. Determine the actual length by referring to Fig. 3. Add the center line distances between 15 keys on your piano or organ's keyboard, and allow about 2 inches on each end. Measure in about 2 inches from one end to allow for clamping the cable to the strip, and mark the center line locations for each of the 15 LED's (LED6 to LED20) to be mounted.

Carefully bend all LED leads at right angles (as shown in dotted lines on Fig. 5) to account for the thickness of the insulating strip selected. The bent ends of each LED should equal the strip thickness plus about 1/16 inch to act as exposed solder terminals when the LED's are seated. (Note that LED cathode leads are shorter than anode leads and are closest to the packages' flat surfaces.)

With a handheld pin drill and bit slightly smaller than the diameter of the LED leads, drill two rows of 15 holes in the strip for the leads as shown in Fig. 5, observing the proper spacing and alignment. Insert the bent sections of the LED Leads into the holes and press the LED's down gently so their leads are flush with the surface of the strip. The terminals should project above the surface of the reverse side. (The leads should fit snugly in the holes so the LED's will not fall out when the strip is handled.)

Reverse the strip and position it as shown in Fig. 5. Allow enough cable length for conductors to reach the last LED in the series, and clamp the cable to the strip as shown. The clamp can be an aluminum or copper strap wrapped around the strip and squeezed in a vise or fastened with screws near the edges of the strip.

With the cable securely clamped to the indicator strip, separate the conductors carefully with a razor knife back to about ⅛ inch from the clamp. Referring to the schematic Fig. 2, cut off the open-circuited conductors 13, 25, 12, 24, 11, 23, 10, 9, and 1 close to the clamp. Find conductor 22 and cut it off near the anode terminal of LED6, allowing about ½ inch for stripping and wrapping bare wire around the exposed LED posts.

Wrap one end of a 20-inch length of tinned-copper wire around the LED6 anode post, and continue wrapping all exposed anode posts to LED20 to form a common conductor. Solder all anode connections and trim excess wire. Now, starting with the cathode post of LED6, cut and strip conductors 21 to 14 as shown in Fig. 2, making allowance for increasing length. Also allow enough slack on each conductor to minimize overlapping and permit it to be pressed close to the surface of the strip. Wrap one turn of the stripped wire ends around each cathode post, solder the connections and trim excess wire.

Locate the indicator unit on an insulating surface so that no leads are shorted, and check all connections both visually and with a continuity meter to be sure that the LED's are connected in the specified order. Repair any errors and replace any faulty LED's. Protect the exposed conductors of the unit. They can be covered with vinyl electric tape or, for a more professional appearance, covers. Cut matching covers from suitable sheet plastic and drill holes along their lengths to permit them to fastened to both sides of the strip with nuts and bolts, forming a protective sandwich.

Microcontroller software

Due to limited space, only part of the assembly language program has been reprinted here. The complete program is available on the *Electronics Now BBS* (516-293-2283, V.32, V.42bis). Download file ORGAN5.ZIP, an archived file that must be "decompressed" with the PKUNZIP utility, which is also available on the system. (Note that the *Electronics Now BBS* is always free of charge.)

The four files of software are:

ORGAN5.S05—Source code file for the software.

ORGAN5.LST—Output listing file generated by the assembler.

ORGAN5.P05—Motorola S-record listing of the code that can be sent directly to a PROM programmer.

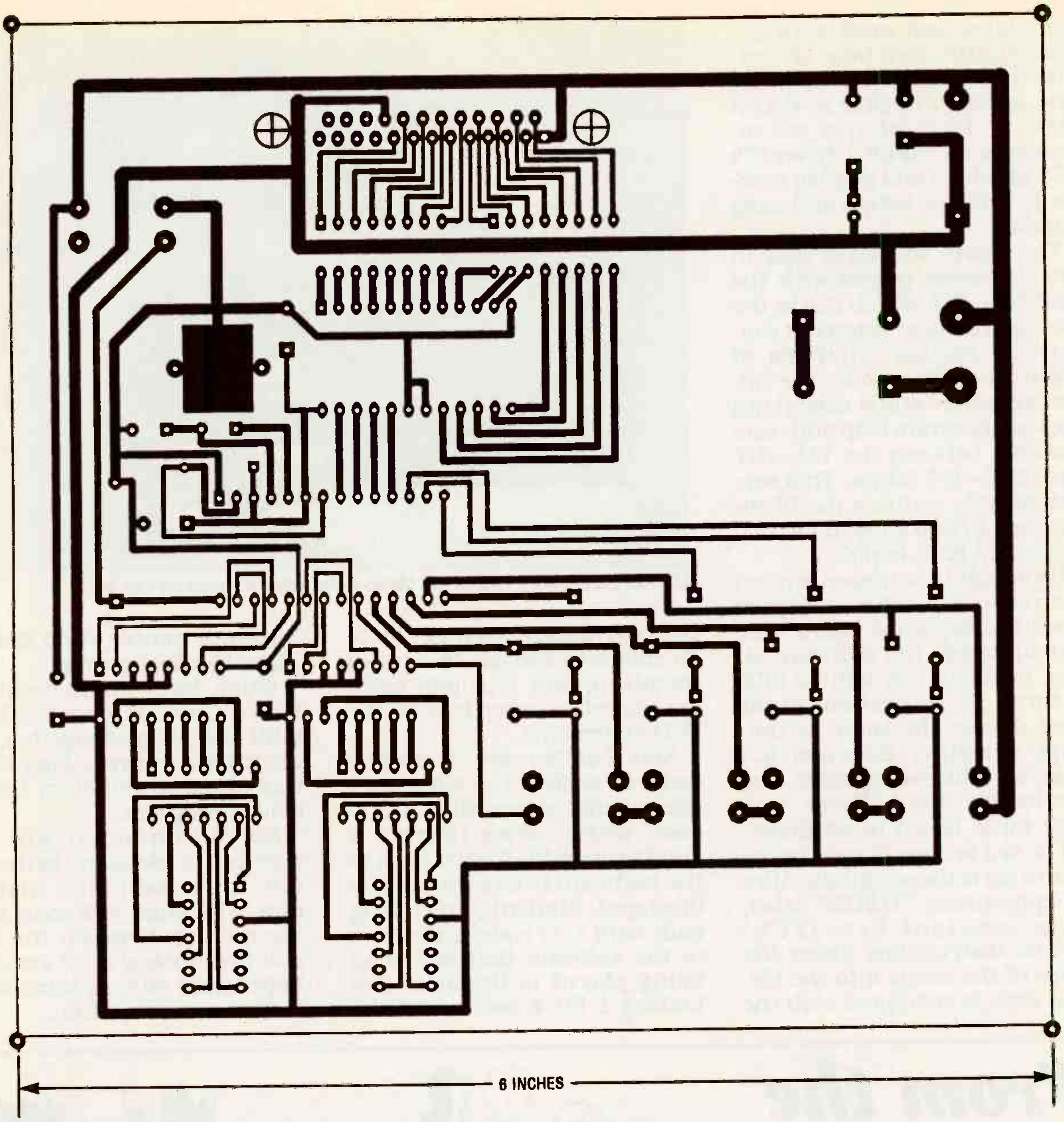
README.TXT—An ASCII file containing any important last-minute advisory notices.

To program microcontroller IC1 from your PC, follow the manufacturer's procedure. An article entitled *68705 Microcontroller* by Thomas Henry, Sept. 1989 R-E includes that procedure.

The assembly language code for Micro-Conductor is in five

LISTING 1—SOURCE CODE DEFINITION OF SCALES

```
* SCALES
TUNE9 FCB   $00,$12,$34,$56,$78,$9A,$BC,$DE,$F0,$FE,$DC,$BA,$98
      FCB   $76,$54,$32,$10,$FF
*
```



BOTTOM FOIL (SOLDER SIDE) for micro-conductor PC board, shown half size.

sections. The first contains all housekeeping functions for the program (e.g. title and version information, RAM variable assignments, general constant equate statements, and definitions of both the processor's mask option register and vector table).

Next, there is code section headed *Initialization*. When the microcontroller detects the end of a reset condition (i.e. when power is first applied), it starts to execute the START label, which is at the beginning of the initialization block. This section of code performs the following duties:

- Initialization of all I/O ports
- Clearing of the entire RAM memory to a value of $00
- Initialization of the registers for creating a regular interrupt frequency
- Setting of initial values for several RAM variables

When the microcontroller completes initialization, it switches to the main execution loop labeled MAIN in the source code. That loop handles all Port A and B I/O functions except enabling the 15 indicator unit LED's.

The first function of the MAIN loop is to read the state of the four input switches S1 to S4. After the inputs are debounced via software, the program checks each switch state in sequence. If a specific switch is pressed, either the SONG variable or the TEMPO variable are incremented or decremented by one. After changing either of these variables, the software automatically checks to prevent a user's attempt to call for a variable beyond the microcontroller's permitted range.

The last block of code in the MAIN section updates the LED displays DISP1 and DISP2. The four bits of the SONF variable are rotated over into most significant nibble within the accumulator and ORed with the four significant bits of the SPEED counter. The resulting byte is then available at Port A (PA0 to PA7) of the microcontroller for the LED driver IC's (IC3 and IC4) and display module to indicate tempo and song number.

The fourth section of code in the file source begins with the label TM—INT, which marks the start of the timer interrupt routine. At regular intervals of about 31 milliseconds, the microcontroller stops executing the MAIN program loop and runs the code between the TM—INT and RTM—INT labels. That section of code controls the 15 indicator LED's (LED6 to LED15) connected IC1's Port C.

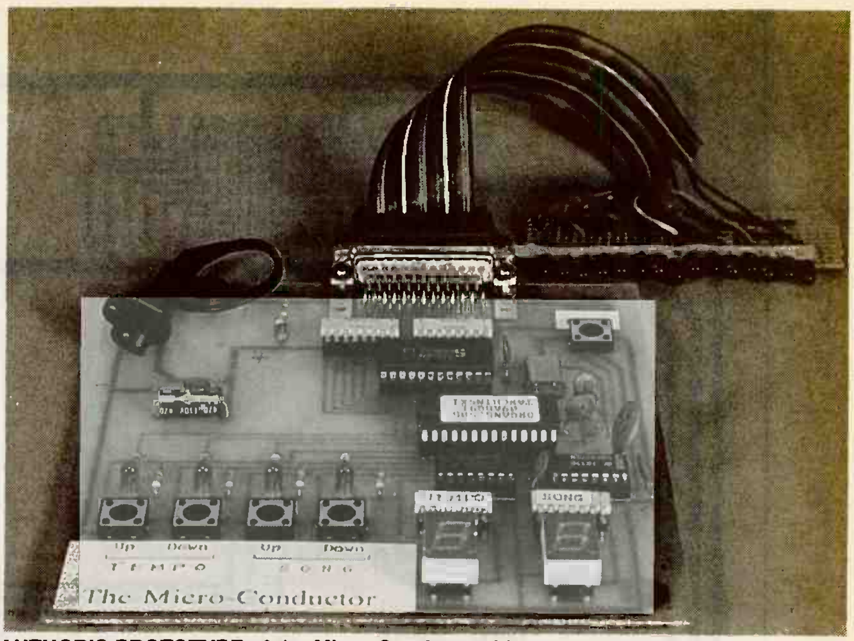
If enough time (dependent on the TEMPO setting) has elapsed since the keyboard LED's were last updated, the software either turns off any lighted LED or turns on the next one in the song due to the value of the NOTE variable. Because IC1 lacks an addressing mode that can handle 16-bit offsets, each tune must tested in sequence.

The last section of code in the source file is the song data. After an appropriate "TUNEx" label, form constant byte (FCB) pseudo instructions insert the notes of the songs into the file. This data is encrypted with the coding system shown in Fig. 3. To conserve PROM, two notes (requiring only four bits each) are placed in every byte of the FCB statements.

Note that there are two special codes in each of the ten songs. Every song begins with a $00 code, which allows time for a child to move his fingers back to the keyboard before the song is displayed. Similarly, every song ends with a ?? code, indicating to the software that last song being played is finished. See Listing 1 for a section of the project's source code that defines the Scales tune.

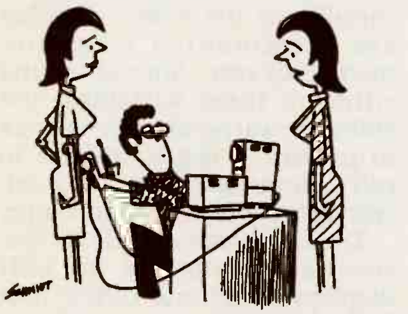
When both components of Micro-Conductor have been built and plugged together, it is ready for a test run. Plug in the wall-adaptor and start the included program.

Micro-Conductor will give children a pleasant introduction to formal music instruction. The child will soon learn the relation between the keys and the musical scale and, it is hoped, take an early interest formal music instruction. Ω

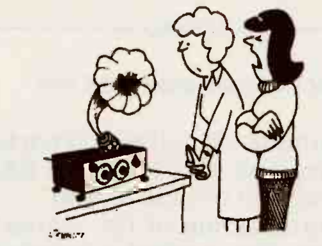


AUTHOR'S PROTOTYPE of the Micro-Conductor. It's neat as can be!

From the Women's Side



"When you said you were assembling a clone I thought you were talking about a computer."



"It's not really an antique . . . it's a kit that took him 43 years to finish."

"Yeah, I know. Roger's computer-controlled pancake flipper still has a few bugs in it."

"Just listen to that, Karen, now I know our line is tapped!"

BUILD THIS
TELEPHONE CALL RESTRICTOR

Restrict access to those expensive "900" and "976" numbers with this inexpensive call restrictor.

TERRY WEEDER

OVER THE PAST FEW YEARS, THE "900," "976," and "540" telephone exchanges have become an easy way for people to spend a lot of money—too easy, perhaps. Some of those numbers, which provide access to a wide variety of services from sports scores to sex chat lines, can cost several dollars per minute. You won't even see the damages—a huge phone bill—until the end of the month. What makes it worse is that anyone who has access to your phone can call these numbers, forcing you to pay the bill. Most people would not leave their credit cards lying around the house for anyone to use, but in a sense, that is what you are doing if you allow others to have dialing access to all phone numbers from your phone.

The Telephone Call Restrictor described in this article can block access to any particular telephone number, or any group of numbers beginning with a certain prefix. The numbers to be blocked are entered into the call restrictor's memory from a Touch-Tone phone. The restrictor can also be programmed to block all telephone numbers *except* those which you have entered into memory. That feature is ideal for your business if you want to allow incoming calls, but only outgoing emergency calls.

The restrictor can be plugged into any phone jack in your home or office to control all the phones on that line. The restrictor can be disabled on a single-

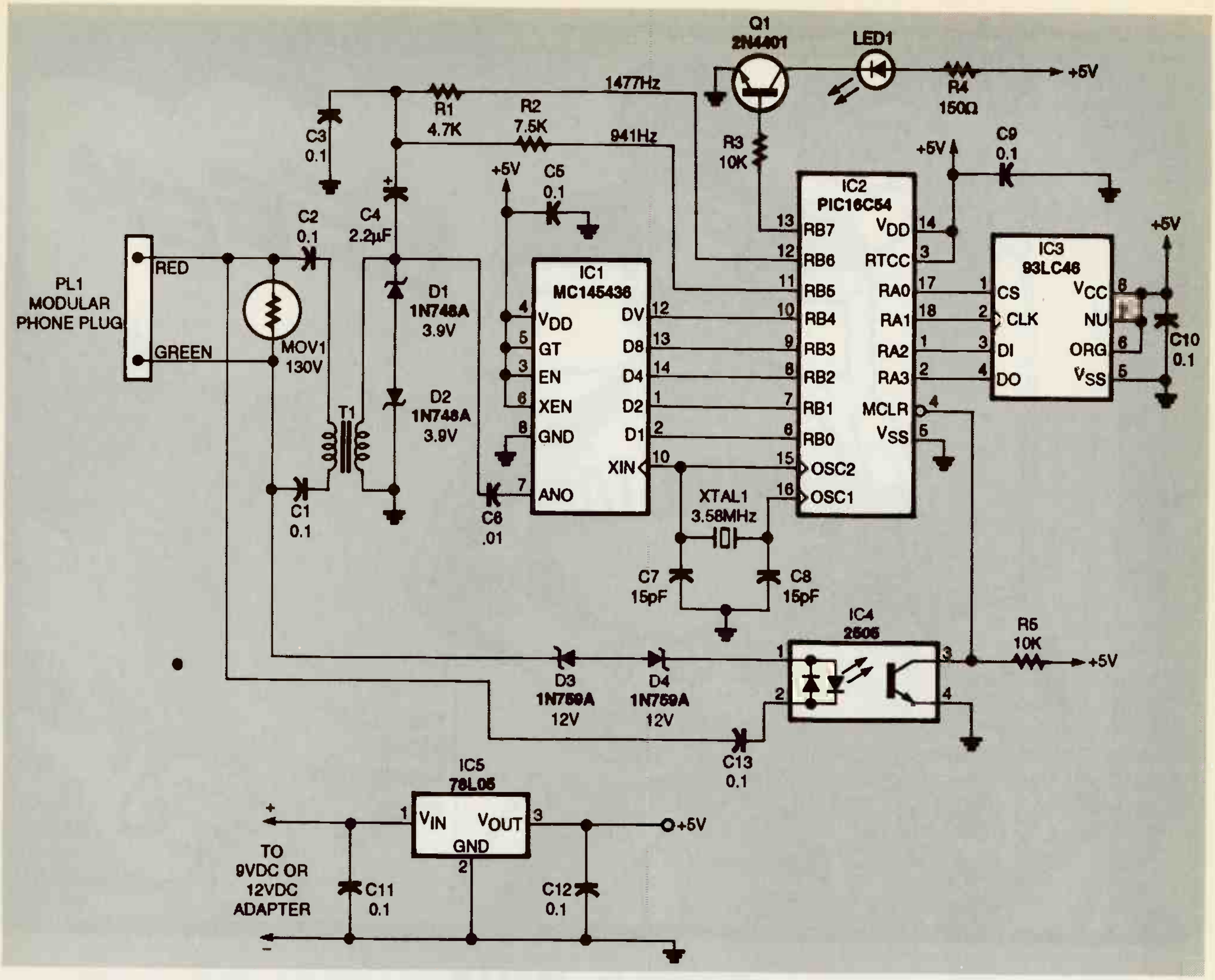


FIG. 1—THE MICROCONTROLLER (IC2) COMPARES the decoded DTMF tones from IC1 with the telephone numbers stored in the EEPROM (IC3).

call basis with a four-digit password. The password also prevents others from reprogramming the unit.

The restrictor is programmed from a Touch-Tone phone. An EEPROM provides non-volatile storage of the programmed information. Therefore, the restrictor will not lose its data because of a power failure or relocation of the unit.

Circuit theory

A schematic diagram of the call restrictor is shown in Fig. 1. Capacitors C1 and C2 and transformer T1 isolate the circuit from the phone line. Those components also couple the DTMF (dual-tone multiple frequency) tones from the phone to pin 7 of IC1, an MC145436 DTMF receiver. A metal-oxide varistor (MOV1) protects the circuit from high-voltage spikes on the line, and D1 and D2 provide protection from ringer voltages. The DTMF receiver converts the Touch Tones into 4-bit TTL-level data. The PIC16C54 microcontroller (IC2) processes the data from IC1, stores the user-entered telephone numbers in EEPROM (IC3), and generates the tones necessary to disable the telephone.

Optoisolator IC4 generates a reset pulse for the microcontroller every time the handset is picked up or put back on hook. The change in voltage from tip to ring (when the line goes from on-hook to off-hook or vice versa) causes current to flow through the optoisolator as C13 charges or discharges to the new voltage level. The current flow forward biases the transistor output of IC4, which pulls IC2's reset pin low. Diodes D3 and D4 provide a threshold voltage that is high enough so that voice or DTMF tones will not trigger a reset.

A low-current voltage regulator (IC5) drops the voltage from a 9- or 12-volt DC adapter to 5-volts DC; C11 and C12 stabilize IC5's output.

The disable tones generated by IC2 (discussed later) are attenuated by R1 and R2, smoothed out by filter capacitor C3, and then coupled to T1 by capacitor C4. Transistor Q1 turns LED1 on when pin 13 of IC2 goes high.

Microcontroller and EEPROM

The PIC16C54 is an 8-bit CMOS microcontroller manufactured by Microchip Technology, Inc. This microcontroller has one eight-bit I/O port, one four-bit I/O port, 512 × 12 bits of on-chip EPROM, and 32 × 8 bits of data RAM.

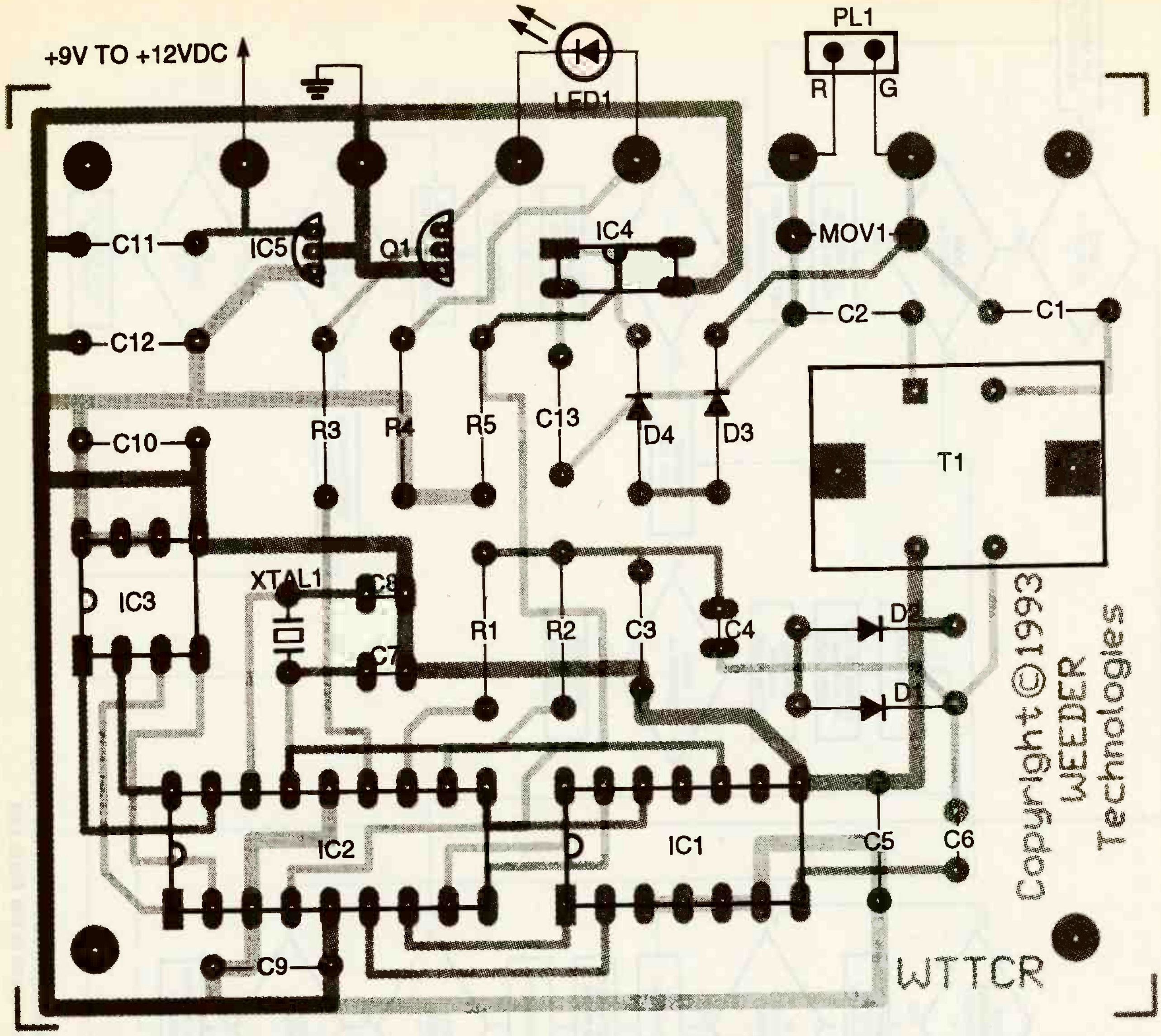


FIG. 3—PARTS PLACEMENT DIAGRAM. Mount components as shown here. Watch for solder bridges on Q1 and IC5.

The PIC16C54 contains a two-level stack, an eight-bit wide arithmetic logic unit (ALU), and a real-time clock/counter register with a prescaler. The instruction set consists of 33 single-word operations which require one cycle (four clock pulses) for execution. Instructions that force a program branch require two cycles. Each pin of the I/O ports can be configured individually as either an input or output through software. The PIC16C54 also has its own built-in "watch dog" timer (WDT) and "sleep" mode, but neither are used in this circuit because the chip is reset every time the handset is picked up. Also, the circuit is powered by an AC adapter so low-power operation is not essential.

A preprogrammed PIC16C54 is available from the source given in the Parts List. The source and object code files are available on the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) for those who wish to program their own microcontrollers. A programmer for the microcontroller was described in the January 1994 issue of *Electronics Now.*

The internal RAM of the PIC16C54 functions as working registers for the operating program. All user-entered data is stored in IC3, a 93LC46, 1K serial EEPROM, also manufactured by Microchip. The 93LC46 is connected to Port A of IC2 through four input lines: CHIP SELECT, CLOCK, DATA IN, and DATA OUT. After a high is detected on CHIP SELECT, data is then transferred to and from the 93LC46 on the positive transition of the clock signal.

Each transfer of data consists of one start bit, a two-bit opcode that identifies the function to be performed, then a 6-bit address, followed by the 16 bits of data which is being read from or written to that address. Immediately preceding and following all write operations, the microcontroller sends instructions to the 93LC46 that enable or disable the write function, thereby protecting the data.

The data in the 93LC46 is stored in 16-bit blocks, while the data output from the DTMF receiver is in 4-bits. To make

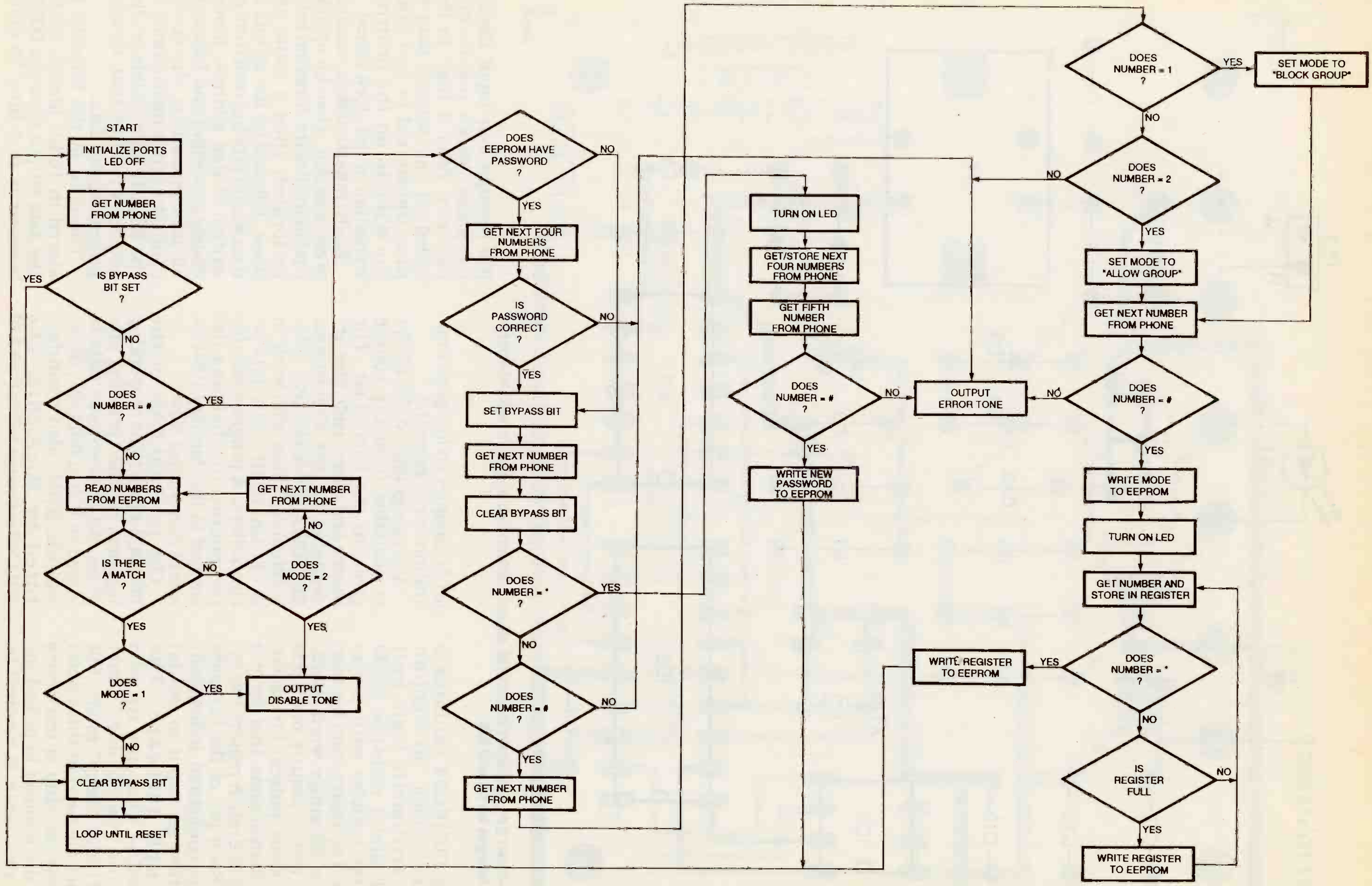


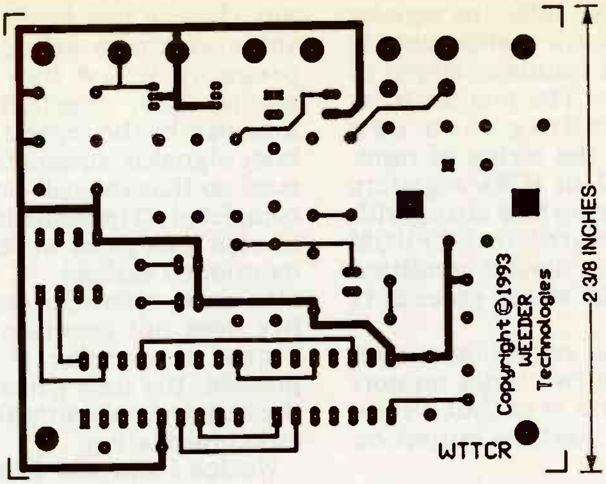
FIG. 2—FLOW CHART OF THE OPERATING PROGRAM. The source and object code files are available on the *Electronics Now BBS* for programming your own microcontroller, or you can purchase a pre-programmed chip from the source given in the Parts List.

PARTS LIST

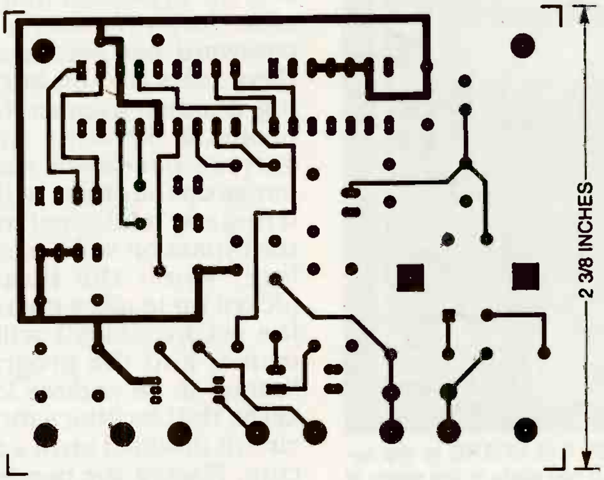
All resistors are ¼-watt, 10%, unless noted otherwise.
R1—4700 ohms
R2—7500 ohms
R3, R5—10,000 ohms
R4—150 ohms
Capacitors
C1–C3, C5, C9–C13—0.1 µF, Mylar
C4—2.2 µF, 16 volts, tantalum
C6—0.01 µF, Mylar
C7, C8—15 pF, ceramic disc
Semiconductors
IC1—MC145436 DTMF receiver (Motorola)
IC2—PIC16C54-XT/P microcontroller (Microchip)
IC3—93LC46 serial EEPROM (Microchip)
IC4—2505-1 optoisolator (NEC or equivalent)
IC5—78L05 low-power 5-volt regulator
D1, D2—1N748A 3.9-volt Zener diode
D3, D4—1N759A 12-volt Zener diode
LED1—light-emitting diode, any color
Q1—2N4401 NPN transistor
Other components
MOV1—130 VRMS metal-oxide varistor
T1—600-ohm primary, 600-ohm secondary, audio transformer
XTAL1—3.58 MHz TV colorburst crystal
Miscellaneous: Enclosure, PC board, IC sockets, wall adapter (9- or 12-volt DC), telephone cord with modular plug, hook-up wire, solder, hardware
Note: The following items are available from Weeder Technologies, P.O. Box 421, Batavia, Ohio 45103:
- **Double-sided PC board (WT-TCR-B)—$9.50**
- **Kit of all board mounted components including pre-programmed PIC16C54 (WT-TCR-C)—$25.50**
- **Pre-programmed PIC16C54 only (PIC-TCR)—$16.00**

All orders must include $3.50 for shipping and handling. U.S. and Canadian orders only. Ohio residents must add 6% sales tax.

use of all the memory available in the 93LC46, the microcontroller's software is written so that it will stack four numbers at the same address locations when storing the numbers in EEPROM, then extract the numbers in the correct order when reading back from the EEPROM.



COMPONENT SIDE of the call restrictor.



SOLDER SIDE of the call restrictor.

Software

A flow chart of the operating program is shown in Fig. 2. After IC2 resets (which occurs when the phone is taken off-hook), the chip looks for a number entered from the telephone. This microcontroller waits for a high on the DV (DATA VALID) pin of IC1, reads the 4 data lines, and then waits for a low on the DV pin. The microcontroller then checks to see if the pound (#) key is pressed. It indicates a request to program the EEPROM.

If a # is detected, IC2 looks for a password in EEPROM. Initially, a non-programmed 93LC46 EEPROM contains all 1's in its registers. Therefore, the microcontroller can determine if a password has been entered. If a password is found, IC2 reads the next four numbers from IC1 and determines if they match the password stored in EEPROM. If a valid password has been entered, the caller can then program the EEPROM. If an incorrect password is entered, or if a mistake is made in the programming sequence, an error tone is transmitted on the phone line. It continues until the phone is replaced on hook (causing a reset of IC2).

If the first number entered from the phone is not the # key (indicating that a call is being attempted), IC2 stores the number in one of its registers and then looks for a match in EEPROM. IC2 disables the telephone if there is a match, and then places the next number entered in an adjacent register and looks for a match making use of both numbers stored in its registers. The process is repeated, adding each new number to the string of numbers stored in IC2's registers and comparing this string with numbers stored in EEPROM until either a disable condition is met or the string exceeds 11 characters.

If a disable condition is met, IC2 outputs two tones on port B; 1477 hertz is output on pin 12 and 941 hertz is output on pin 11. The two tones are the same as those generated by pressing the # key on the phone. Upon detection of this tone pair by the central office, a busy signal is automatically issued so that the call cannot be completed. (The same tone pair is also indicates an error as mentioned earlier.)

In areas where the central office does not generate a busy signal when the # key is pressed, the tone generated by the restrictor will interfere with any conversation.

Notice from the flow chart that when programming the EEPROM, the microcontroller sets the bypass bit immediately after verifying that a correct password has been entered. It then clears that bit after receiving another number from the phone. If the caller enters the correct password and then hangs up the phone without entering any additional numbers, the bypass bit will be set. Therefore, when the handset is picked up to place the next call, the set bypass bit will be detected, and the program will branch to an endless loop that keeps the blocking action of the circuit disabled until a reset occurs. Placing the handset back on-hook resets the circuit.

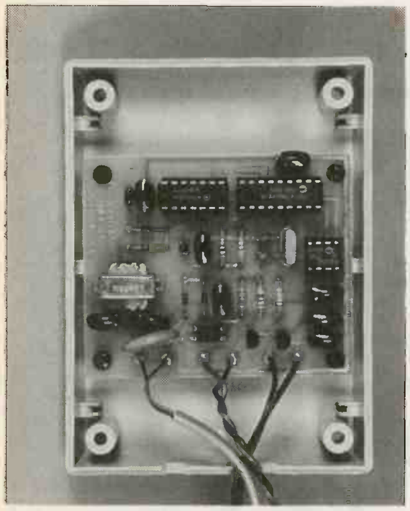


FIG. 4—MOUNT THE BOARD in the enclosure and cut two slots in the seam of the plastic case for the power cord and the phone cord.

TABLE 1—PROGRAMMING

To Change / Enter Password:
\# – Password – * – New Password – #

To Disable for Next Call:
\# – Password (hang up)

To Program "Block Group" Mode:
\# – Password – # – 1 – #
Number – # –
Number – # –
Number – # –
" (up to 248 characters)
Number – # – *

To Porgram "Allow Group" Mode:
\# – Password – # – 2 – #
Number – # –
Number – # –
Number – # –
" (up to 248 characters)
Number – # – *

Note: "Number" can be any telephone number (1 to 11 digits long).

Construction

The circuit fits on a double-sided, 2⅞- × 2⅜-inch printed circuit board. Artwork is provided here for those who wish to make their own boards. Manufactured boards can be purchased from the source given in the Parts List. Refer to the parts-placement diagram in Fig. 3 and start by inserting and soldering IC sockets for IC1 through IC3. Mount IC4 directly to the board and then solder Q1 and IC5 to the board, carefully avoiding solder bridges between the closely spaced pads.

Next, mount the resistors, capacitors and diodes. When soldering the crystal (XTAL1), leave a small space between the bottom of the crystal and the PC board. Caution: The metal case of the crystal could short the two solder pads together if it is pushed flush against the board when soldering. Finish assembly by mounting the transformer (T1) and the varistor (MOV1).

After all components have been soldered to the board, double check for solder bridges on both the top and bottom side of the board, and re-solder them if necessary. Carefully plug IC1, IC2, and IC3 into their sockets.

The board will mount directly in a plastic enclosure available from Digi-Key (Part No. SR131G-ND), but it is not essential that you use this case. Because this unit can be operated remotely with any Touch-Tone phone on the phone line, you might want to build the circuit without a case.

LED1 can be mounted to the top of the enclosure or soldered directly to the PC board. Use a phone cord with a modular jack on one end and solder the red and green wires to the correct locations on the board—you can cut off the black and yellow wires. After determining their polarity, solder the AC adapter's leads to the points labeled POS and NEG.

Mount the board in the enclosure and cut two slots in the seam of the plastic case for the power cord and the phone cord. Figure 4 shows the inside of the

(Continued on page 110)

BRANCO JUSTIC and PETER PHILLIPS

NIGHT-VISION SCOPES

View a scene in near total darkness with a passive night-vision scope, or illuminate it with infrared for an active scope

NIGHT-VISION SCOPES WERE DEveloped as military surveillance devices to permit viewing enemy activities and aiming weapons at night without revealing the observer's presence. The sensitivities of their principal components, image tubes, have been improved with fiber-optic lenses, more gain stages and better photocathodes. In addition, miniature, solid-state, extra high-voltage power supplies have reduced their size, weight and power needs.

Two night-vision scopes are described in this article. One is passive, meaning that it will work in faint natural light, and the other is active, meaning that it requires supplemental infrared illumination. They include surplus first-generation imaging tubes. Although they have been superseded by more advanced devices, they will, nevertheless, provide adequate sensitivity for most hobbyists and science experimenters.

The active scope will permit police to observe suspected criminal activity at night and citizens to monitor their homes or property without being detected. The scope will also permit hunting, nature study, marine navigation, and many other nighttime applications. The active scope is suitable for some of these activities, but the scene must be illuminated by an infrared source. Neither will disturb the eyes' adaptation to darkness.

The first night vision scopes were designed for use by forward observers, snipers, aviators, and tank crews. Some that were made as monoscopes to mount on rifles looked like the devices shown in Fig. 1; others were made as binoculars. The most sensitive passive units are called *starlight scopes*. *Night-vision goggles* are lightweight binoculars for helicopter crews that mount on their helmets.

Active night-vision scopes, such as the one shown in Fig. 2, depend on infrared illumination from sources such as lasers for aiming artillery, guided missiles, and "smart" bombs. Night-vision systems were considered military secrets for many years. After they were declassified, they could be sold as military surplus and commercial versions based on the technology were offered for police surveillance and as nighttime marine navigational aids at prices that often exceed $2000.

Both of the night-vision scopes described in this article are based on military surplus equipment that includes both an image tube and optics. The parts for the active unit cost $90, and parts for the active unit cost $220.

Night-vision scopes

Figure 3 illustrates a typical night-vision scope. The objective lens, positioned at the cathode end of the tube, focuses the image on the photocathode. It is selected for its intended application—long-distance or short-range viewing. The eyepiece at the anode is for viewing the enhanced image. It is a simple lens that magnifies the image on the screen. It can be removed and replaced by a television camera, camcorder, or film camera for transmitting or recording the image.

The image tubes are the hearts of the night-vision scopes. Before you start building one (or both), you might want to learn more about how they work. See the sidebar entitled "Image Converter and Intensifier Tubes."

The only electronics needed

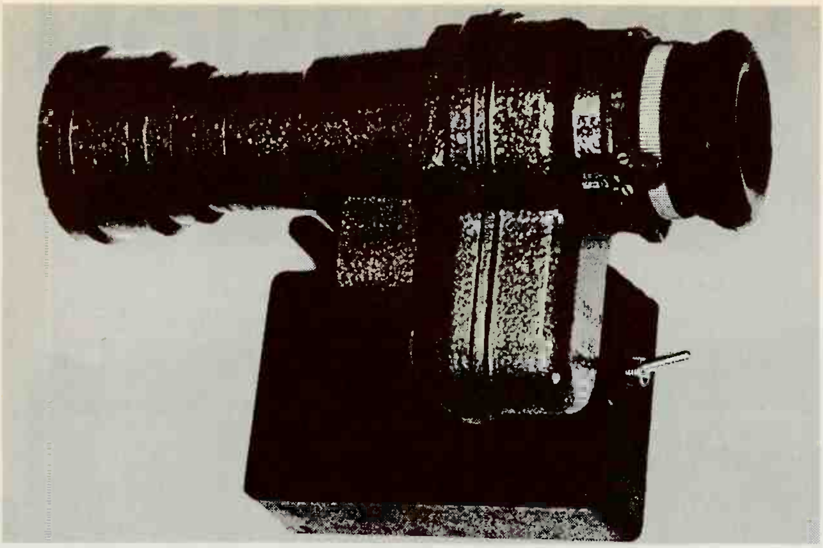


FIG. 1—A PASSIVE NIGHT-VISION MONOSCOPE made from half of a Russian night-vision binocular with an image intensifier tube and all optics.

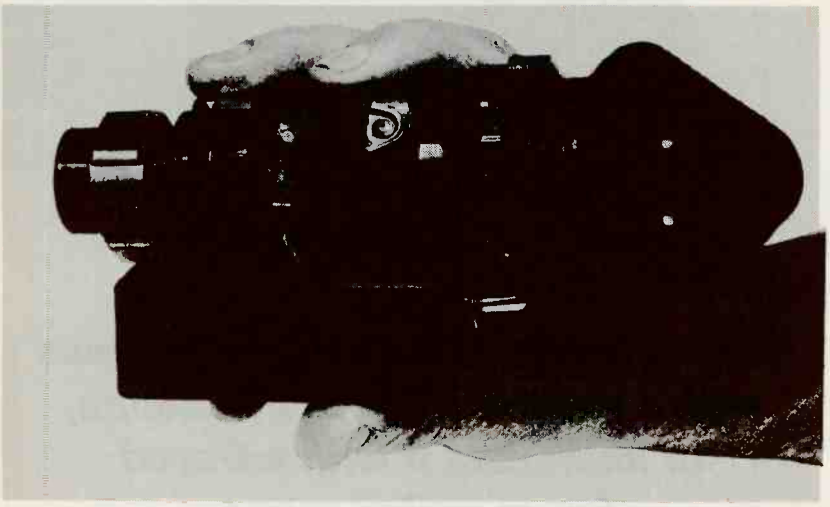


FIG. 2—THIS ACTIVE NIGHT-VISION SCOPE requires an infrared illumination source but it works from the same power supply as the scope in Fig. 1.

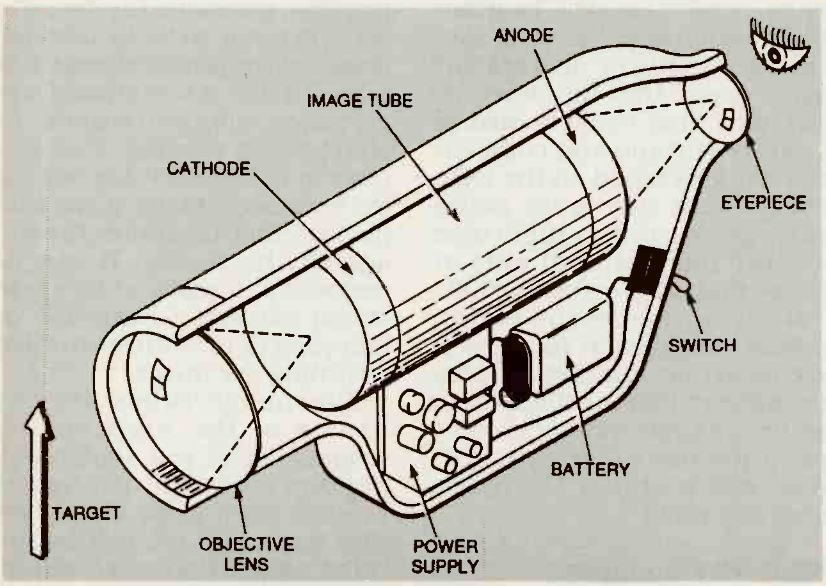


FIG. 3—ALL NIGHT-VISION SCOPES have objective and eyepiece lenses, an image tube, a high-voltage power supply, and a battery.

in both projects described in this article is a high-voltage power supply capable of providing a typical working voltage of 13.5 kilovolts. This efficient and compact regulated supply operates satisfactorily from a 9-volt, alkaline battery. The current drain of both tubes described here is small, so that their power consumption is low.

The compact power supply is built into a small plastic project case that is fastened directly to the surplus night-vision scope that contains the imaging tube. The Russian-made monocular viewer shown in Fig. 1 is actually one half of a binocular. It is complete with an objective lens and an eyepiece. This assembly includes a first-generation, single-stage *image intensifier tube*.

The active night-vision scope shown in Fig. 2 contains a single-stage *image converter tube*. Instructions on how to make several different low-cost infrared illumination sources are described in this article.

Active military night-vision weapons aiming systems typically include an infrared-emitting laser. It pinpoints the target for a heat-seeking weapon or for aiming other kinds of guns or missiles while also acting as a non-visible searchlight for the observer (bombardier or gunner) with an active scope. Various systems have been built for use on land, in the air, or on the sea at night.

Infrared-sensing missiles and "smart" bombs actually "home" on the IR-illuminated target which has been identified by the observer who directs the laser beam and watches it with the active scope. Needless to say, aiming and firing must be fast because enemy gunners with active scopes can also see the laser illumination and take evasive action or retaliate.

Power supply design

Figure 4 is the schematic for a high-voltage power supply that will power both night-vision scopes described here. It produces about 13.5 kilovolts from a 9-volt battery. The tubes draw about 20 milliamperes so about

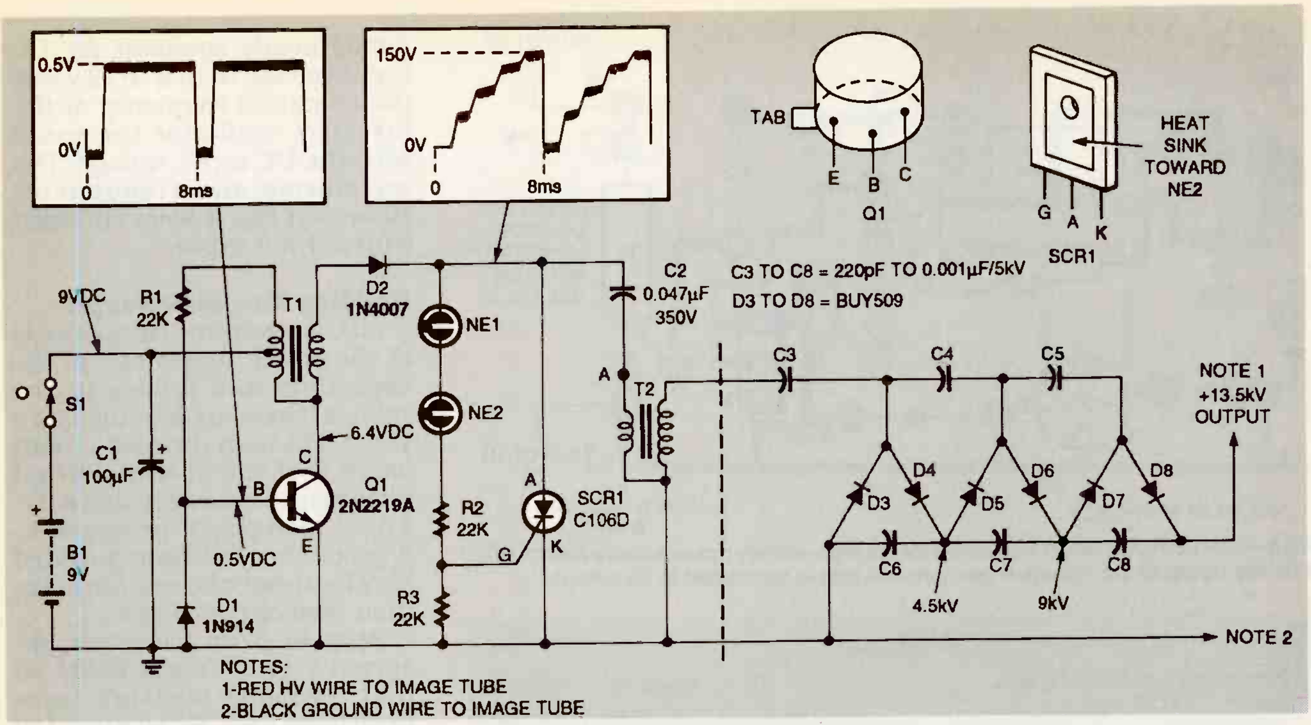


FIG. 4—THIS HIGH-VOLTAGE POWER SUPPLY has an inverter around Q1 that supplies 150-volt pulses to the converter of SCR1 and C2. The output of T2 is a 4.5 kilovolt pulse that is multiplied by the voltage-tripler network (right) to produce 13.5 kilovolts.

36 hours of useful life can be obtained from a 9-volt alkaline battery. The output voltage will remain essentially constant for battery voltages of 6 to 12 volts.

The power supply has three sections: the inverter, the converter, and the voltage multiplier. The inverter section, a ringing-choke oscillator, consists of transformer T1, resistor R1, diode D1, and transistor Q1. Resistor R1 provides bias current for starting the oscillator, and it also supplies the feedback to maintain oscillation.

Diode D1 protects the base-emitter junction of Q1 when the base voltage swings negative. The oscillator operates at about 120 Hz, set principally by the transformer. The resulting AC voltage at the primary of T1 is stepped up by the secondary turns. The secondary voltage, which is rectified by diode D2, charges C2 through the primary (low-resistance) winding of transformer T2.

When the voltage across C2 exceeds the breakdown voltage of the two series-connected neon lamps NE1 and NE2 (about 150 volts) the lamps turn on. This conduction triggers SCR1, and C2 is quickly discharged through SCR1 and the primary winding of T2. When C2 is discharged, the lamps extinguish, SCR1 turns off, and the charge cycle starts again.

During the discharge cycle of C2, a pulse with a peak-to-peak voltage of 4.5 kilovolts is produced at the secondary of trigger transformer T2. This pulse is applied to the three-stage Cockcroft-Walton or Greinacher voltage-multiplier circuit consisting of diodes D3 to D8 and capacitors C3 to C8.

The multiplier triples the 4.5-kilovolt input to provide the 13.5-kilovolt output with very low current. The capacitors and

LIGHT UNITS

The standard (SI) unit of light intensity is the lux, and a typical recommended minimum illumination level for a video camera is around 50 lux. However, some some video cameras will work with light levels as low as 1 lux. With this frame of reference, you can get a better idea about how sensitive night-vision systems are.

The recommended light level for the safe operation of these tubes is from 50 millilux down to 500 microlux (0.0005 lux)— very low light levels. Table 1 lists familiar light levels and their light intensity in lux units. By contrast, a typical first-generation image intensifier tube will not be damages if the illumination level is as high as 100 millilux (one tenth of a lux), but tube life will be reduced if it is exposed for long periods to that light level.

Sensitivity is the most important specification for of a night-vision scope. An average scope has a sensitivity of 10 millilux (mlx), a value that makes it effective in night lighting from a quarter moon. By contrast, a very sensitive night-vision scope can operate at 1 mlx, which corresponds to starlight conditions. For this reason, very sensitive scopes are called "starlight" scopes.

TABLE 1
RELATIVE VALUES OF NATURAL LIGHT SOURCES

Source	Illumination (lux)
Direct sunlight	100,000
Bright sunlight	10,000
Overcast day	1,000
Very dull day	100
Twilight	10
Deep twilight	1
Full moon	0.1
Quarter moon	0.01
Starlight	0.001
Overcast starlight	0.0001

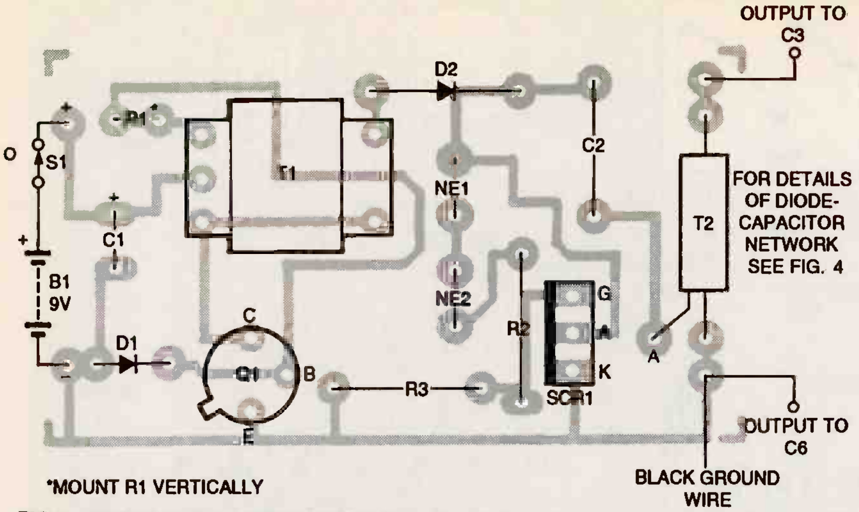


FIG 5—PARTS PLACEMENT DIAGRAM for the high-voltage power supply. Refer to Fig. 4 for the layout of the voltage-tripler network that is connected to its output.

PARTS LIST

Resistors are ¼-watt, 10%
R1, R2, R3—22 kilohms
Capacitors
C1—100 µF, 25 volts, aluminum electrolytic
C2—0.47µF, 350 volts, polyester
C3, C4, C5, C6, C7, C8—220 pF, 5 kV breakdown, ceramic
Semiconductors
D1—1N914 silicon signal diode
D2—1N4007, 1000V, 1A silicon diode (DO-41 case), Motorola or equiv.
BY509—silicon diode, 10 kV, 3 mA, Philips or equiv. (rating must be greater than 6 kV, 2 mA)
2N2219A—NPN transistor, Motorola or equiv.
MCR106-6 (C106D)—SCR, 400 V, 4 A in a T-126 package, Motorola or equiv.
Other components
NE1, NE2—neon tubes, miniature
T1—transformer, inverter, 3 kilohm CT, iron core, audio, miniature PC mount
T2—transformer, trigger type, 250 V primary, 6 kV secondary
Miscellaneous printed circuit board; passive night-vision monoscope with imaging tube and optics (see text); active night-vision scope with converter tube (see text); plastic project box (see text); 9-volt alkaline transistor battery, 9-volt transistor battery clip with wires; miniature toggle switch, PCB mounted; plastic sleeving; RTV silicone potting compound; tinned copper wire, 22 AWG; insulated hookup wire, 22 AWG, solder.

Note: The following items are available from Oatley Electronics, P.O. Box 89, Oatley, Sydney, NSW, Australia 2223: Phone 011 61 2 579 4985 (Time zones USA—East 7 PM to 2 AM, Central 6 PM to 1 AM, Mountain 5 PM to 12 AM, Pacific 4 PM to 11 PM), Fax 011 61 2 570 7910. Mastercard and Visa accepted with telephone or fax orders, International bank drafts and money orders accepted by mail. Customers please include phone and/or fax number.

- **Complete kit of passive night-vision scope and parts for the HV power supply—$220.00**
- **Complete kit of active night-vision scope and parts for HV power supply—$90.00**
- **Kit of parts for HV power supply only—$24.00**
- **Kit of non-standard parts (T1, T2, NE1, NE2, and C2)—$8.00**

Include $15.00 for shipping and handling, $6.00 for air mail from Australia.

diodes must be rated to withstand at least 4.5 kilovolts. For this reason, the capacitors are all rated at 5 kilovolts, and the diodes are high-voltage units.

The neon lamps regulate the output so that the voltage applied to the primary of T2 is constant at 150 volts, peak. Although the power supply output is nearly constant for DC input voltage from 6 to 12 volts, the operating frequency of the inverter/ oscillator increases with the DC input voltage. The waveforms and frequencies shown on Fig. 4 were obtained with a 9-volt input.

Building the power supply

All the electronic components of the power supply except the capacitors and diodes in the voltage tripler are mounted on a $1\frac{15}{16} \times 1\frac{1}{15}$-inch printed-circuit board that will fit with a 9-volt rectangular battery inside a 2 × 3¼ × 1-inch plastic project case. A foil pattern has been provided here for those who want to make their own circuit boards.

Refer to parts placement diagram Fig. 5. Insert SCR1 so that its metal heatsink faces neon lamp NE2. When inserting electrolytic capacitor C1 and diodes D1 and D2, observe their polarities. Mount resistor R1 vertically on the circuit board. Solder all components and trim excess lead lengths.

Refer back to the schematic Fig. 4, and wire the leads of capacitors C3 to C8 and diodes D3 to D8 together mechanically to form a rigid unit according to the schematic. Keep all exposed lead lengths about ¼-inch long. Then solder the network together as rapidly as possible to avoid applying damaging excessive heat to the capacitors and diodes. The cathodes of some diodes are identified with a red dot on the cathode lead.

Figure 6 shows the completed power supply with the tripler network to the right of the board. Battery B1 and switch S1, both off-board components, are not shown. Solder one lead from C3 and one lead from C6 in the tripler network to the terminal points on the circuit board, as shown in Fig. 5. (The tripler will be potted in silicone after the system has been tested.)

NOTE: The image converter tube in the active night-vision scope shown in Fig. 2 requires a positive ground. If you build this unit, reverse diodes D3 to D8 to convert the supply from one with a positive to a negative output with respect to ground.

Mechanical assembly.

Drill a hole in the body of the plastic project case for mounting the miniature toggle switch S1. The location of the switch is not critical, but it should not interfere with the other components. In the passive night-vision scope, it was positioned at the end of the case facing the eyepiece.

Drill the hole in the case for mounting it to the passive scope body with a single screw. The hole for this screw, already drilled and tapped in the body of the scope, is located under the coupling bracket. Drill another hole large enough to pass the power cable to the image tube. Its location will depend on the project you build. Mount switch S1 in the sidewall of the case. Fasten the case to the passive viewer with a screw. If you build the active viewer, cement the case to the scope body with epoxy, as shown in Fig. 2.

Cut the supply lead from the scope about 6 inches long, and strip back about 1 inch of the jacket to expose the braid and the insulated central conductor. Twist the braid into a lead and insulate it with a length of plastic tubing. Insert the cable lead into the project box, solder the braid to the ground connection of the circuit board, and solder the inner conductor to the high-voltage terminal of the tripler network, as shown in Fig. 4.

Verify that there are no short circuits in the construction of the tripler and that the leads are spaced by at least ¼-inch from each other. Wire toggle switch S1 in series with the positive lead from the battery clip. Cut the battery leads from the circuit board so they are long enough to permit lifting the circuit board out of the case. Insert the battery and wiring in the case, but leave the tripler network and circuit board outside temporarily.

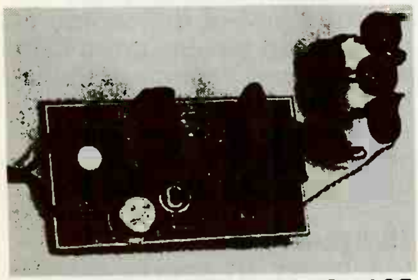


FIG. 6—COMPLETE HIGH-VOLTAGE power supply circuit board with the voltage-tripler, diode-capacitor network shown unpotted at right.

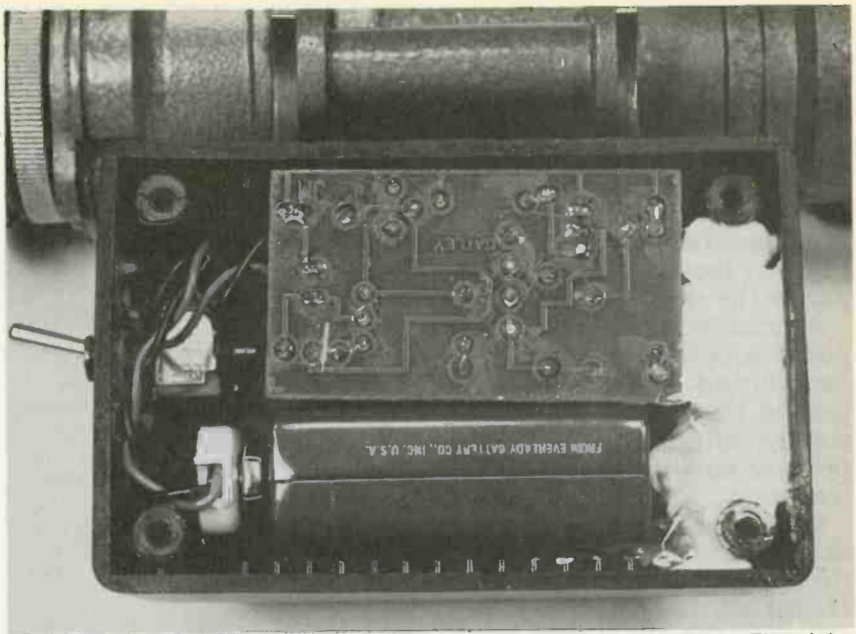
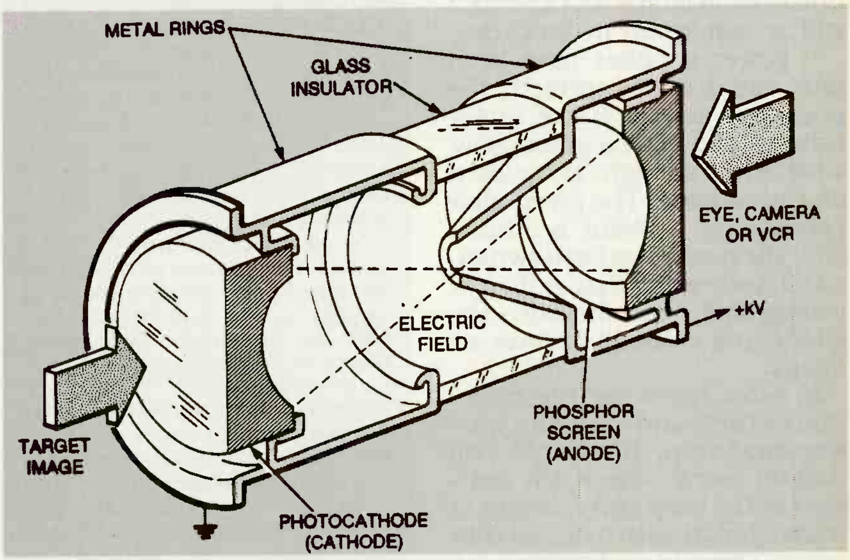


FIG. 7—POWER SUPPLY CIRCUIT, battery, and switch in the project case. The tripler network potted in silicone is shown as the white patch at right.

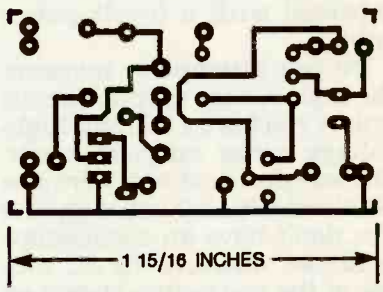


CUTAWAY VIEW OF SINGLE-STAGE image tube showing the position of its key parts.

Test and checkout

After rechecking your work and verifying the polarities and orientation of all components, snap the battery to the battery clip. The current drain on a 9-volt alkaline transistor battery should be about 20 milliamperesin a correctcircuit.

WARNING! The power supply described in this article produces an output voltage of about 13.5 kilovolts, and is capable of giving you a startling electric shock. While not normally life-threatening, it can have a temporarily debilitating effect. Consequently, treat it



FOIL PATTERN FOR POWER SUPPLY circuit board.

with respect and always make sure switch S1 is off and the capacitors are discharged before handling the circuit board.

When you switch on S1, a corona discharge might appear around the tripler network. This is non-destructive, but avoid electrical shock by keeping your hands away from that part of the circuit.

Alternatively, you can test the power supply by placing a wire connected to the circuit's ground bus close to the high-voltage output lead. It should produce an arc as much as ¼-inch long.

When the switch is off, connect the ground wire directly to the high-voltage output to discharge all the capacitors. Because of the short-duty cycle discharge pulses, the illumination of neon lamps NE1 and NE2 will be visible only in darkness.

If power supplies have been built and installed correctly, the phosphor screen of the image tube should emit a green glow, whether or not light is incident on the cathode. The green glow persists for a about a minute after the power has been switched off, indicating that sufficient voltage still exists between the anode and cathode to form an image.

If, after following the directions closely and checking your workmanship, the scope still doesn't work, check the voltages at the base and collector of transistor Q1 with a digital voltmeter. The values shown on the schematic, Fig. 4, are DC values expected with a 9-volt power supply.

Do not attempt to measure the high-voltage output directly unless you have a suitable high-voltage probe on your meter. The waveforms shown were also obtained with a 9-volt supply. If you don't have an oscilloscope available, measure the AC voltage at the test points shown on Fig. 4.

The reading on most digital voltmeters will be RMS values, but they will give you a valid indication if there is a signal. The AC voltage at the cathode of D2 (to ground) of the prototype measured about 45 volts RMS on a DMM. The AC voltage at the base of Q1 was about 0.45 volt RMS.

When the scope is working properly, switch off the power and wait for the tube to discharge completely. Insert the tripler section carefully inside the case as shown at the right side of Fig. 7. Encapsulate it with neutral-cure, room-temperature vulcanizing (RTV) silicone potting compound to prevent high-voltage corona and discharge, which increases with relative humidity. The compound will also fasten the tripler network inside of the case.

Viewing with the scope

The lens of the surplus Russian passive night-vision scope specified in this article is focused to infinity, making it useful for viewing images more than a few meters away. By loosening a small locking screw, the lens can be adjusted. This will permit viewing objects more than 100 meters away under near starlight illumination.

Imaging tubes will be damaged if they are exposed to bright light for long periods. Don't use either scope in sunlight, or even in well lighted rooms. Always cover both ends of a night-vision scope with suitable lens caps when it is not in use to keep the imaging tube in darkness. The monocular passive scope offered by the source given in the parts list has a rubber lens cap that can be snapped in place. It also has a focusing eyepiece.

Both of the night-vision scopes will detect IR energy, so they can verify the operation of stereo and TV remote controls. In a darkened room, point the emitting face of the control at the scope. A pulsing green light will be seen when any of the remote control's keys are pressed. A TV remote control can also serve as a temporary IR illuminator.

IR light source

A better IR source can be made by covering a flashlight with an IR filter. You can pur-

(Continued on page 57)

IMAGE CONVERTER AND INTENSIFIER TUBES

An image tube is a vacuum tube that converts an image in one part of the electromagnetic spectrum to another part of the spectrum, usually with an increase in intensity. If, for example, you want to convert a near-infrared (IR) image to a visible light image, you would use an *image converter tube*. This is the tube in the active night-vision scope described in this article. However, the scene must be illuminated by an infrared source if the scope is to function.

However, if you just want to intensify a scene in darkness you would use an *image intensifier tube*, the kind included in the passive night-vision scope described here. The figure shows a simplified cutaway view of this kind of tube. While it is also sensitive to near IR, it is still called an image intensifier.

Both tubes have photoemissive input surfaces at their cathode ends that form an electron image of the scene being viewed when a voltage of 4 to 20 kilovolts is applied between the cathode and anode. Photons from the scene or target are focused on the photocathode which triggers an avalanche of electrons. The anode accelerates the cascaded electron emission from the photocathode and focuses them on a phosphor screen to display the image.

Image tubes are now made in many different sizes with different photocathodes, electron focusing techniques, and gain mechanisms. The tubes in the night-vision scopes described here are examples of first (or zero) generation, single-stage converters that are electrostatically focused. More advanced tubes obtain higher gain by cascading two or more converter stages.

For night-vision applications, the earlier generations of image tubes had simple glass lenses and S25 photocathodes that closely match the peak sensitivity of the human eye. These tubes produce a high-definition black and green image. The latest versions now have fiber-optic lenses, gallium-arsenide photocathodes, and gain stages called *microchannel plates*.

In night-vision scopes, the image must be formed on the cathode by an objective lens similar to a camera lens, and the scene is viewed at the anode end with an eyepiece.

It is important to remember that no passive image intensifier tube will work in complete darkness. It must gain enough light from natural background sources to work. These might only be barely perceptible even to the night-adapted human eye. The sources could be faint sky glow on a cloudy night, starlight on a clear night or moonlight.

BUILD THIS LIGHT-CONTROLLED SOUND-EFFECT GENERATOR

Generate weird sounds with our sound-effect generator based on a light-controlled, tone-burst oscillator.

JOHN CANIVAN

SOUND EFFECTS MEAN BIG BUSINESS nowadays, from those intended to enhance home videos to silly ones for your phone-answering machine. In the past we've run articles on how to build very sophisticated—and expensive—sound generators, but this time we present a simple novelty sound-effect generator that's sure to give you and your children hours of fun.

The generator contains two photo cells that control a tone-burst oscillator circuit; tone is controlled by one photo cell and the burst interval is controlled by the other. All you have to do is wave your hands above the photo cells to generate all kinds of sounds.

Circuit theory

The tone-burst oscillator circuit uses a 556 timer IC and positive feedback to create the strange sounds. The 556 chip contains two completely independent 555's and, in our application, the output of one 555 controls the interval of oscillation—or the burst time—of the other.

Figure 1 shows the pinouts of both the 555 and the 556, and the equivalent circuit of a 555. Positive feedback, which controls the frequency and duty cycle of the 555 timer, is obtained from the charging and discharging voltage across capacitor C through resistors R_A and R_B. During oscillation, voltage across the capacitor changes from ⅓ V_{CC} to ⅔ V_{CC}, and back again.

The time it takes for the voltage on C to drop from ⅔ V_{CC} to ⅓ V_{CC} is known as the discharge time (t_D). When ⅓ V_{CC} is reached, the 555's flip-flop resets and allows C to charge across R_A and R_B. The time it takes C to charge to ⅔ V_{CC} is known as the charge time (t_C). When that level of charge is reached, the 555's flip-flop sets and causes C to discharge across R_B, and then the cycle begins again.

Figure 2 shows the complete circuit for our light-controlled tone-burst oscillator. You'll notice that two light-dependent resistors, or photocells, are used: R8 and R9. A photocell is basically a resistor whose value depends on the amount of light to which it is exposed. Its resistance is inversely proportional to the intensity of that light. In bright light, the resistance of a typical photo-cell can drop to 100 ohms, while in darkness its resistance can easily exceed 500 kilohms.

If we use a photocell to replace R_B (in Fig. 1), those minimum and maximum resistance values (100 ohms and 500K) can be used to calculate the range of frequencies that can be generated by the 555:

Cycle time $= 0.7(R_A + R_B)C + (0.7 \times R_B \times C)$

If R_B is very small, the cycle time equals $1.4 \times R_B \times C$. If C is 0.1 μF, the maximum cycle time equals 700 milliseconds to give a frequency of 0.7 hertz, and the minimum cycle time equals 0.2 milliseconds for a frequency of 5000 hertz.

The power supply for this project should be capable of supplying between 5 and 15 volts DC, and it should be able to provide at least 1 amp at 5 volts. The output should never

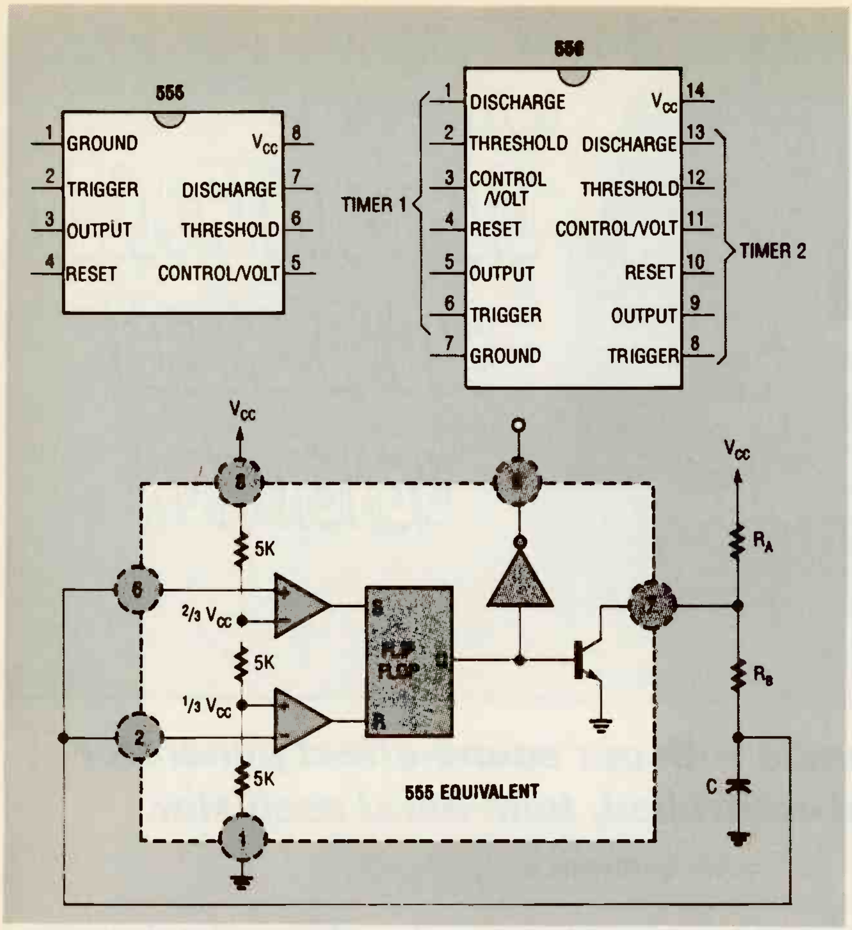


FIG. 1—PINOUTS OF THE 555 AND THE 556, and the equivalent circuit of the 555 timer.

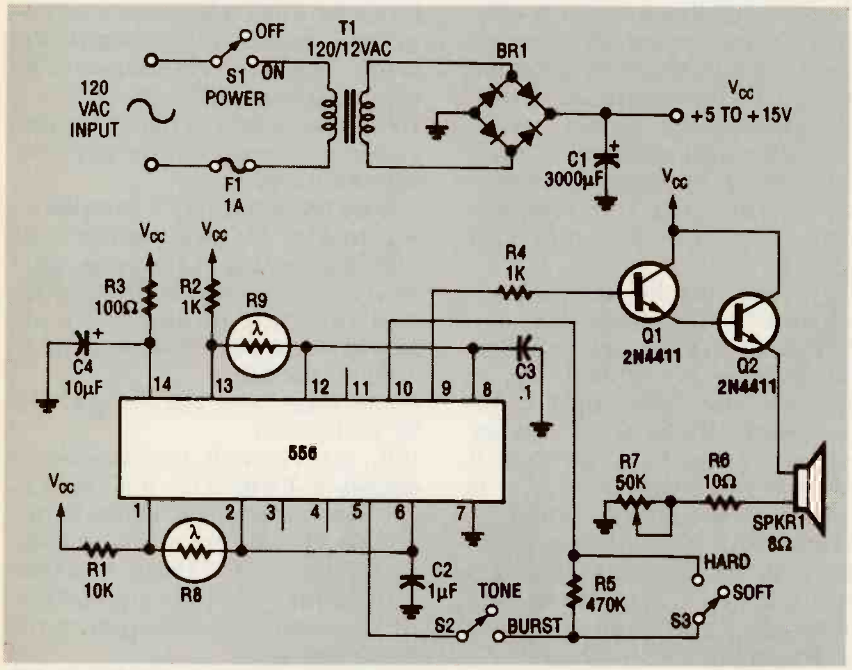


FIG. 2—LIGHT-CONTROLLED TONE-BURST OSCILLATOR. Two light-dependent resistors (R8 and R9) are used to create unusual sound effects.

exceed 15 volts under no-load conditions or else you risk damaging the circuit.

Construction

This project is very easy to build with any acceptable construction technique. The author mounted the components on a piece of perforated construction board and wired them point-to-point. The board, speaker, transformer, switches, and photocells were then installed in a homemade wood cabinet, as shown in Fig. 3. It's best to mount the photocells at least a foot away from each other so that one hand can control frequency while the other hand controls the burst interval. This avoids having motion from one hand interfere with the other hand.

Operation

The circuit should be used in room that has plenty of overhead light, because the frequency and burst intervals are

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—10,000 ohms
R2, R4—1000 ohms
R3—100 ohms
R5—470,000 ohms
R6—10 ohms, ½-watt
R7—50,000 ohms, 1-watt potentiometer
R9, R9—photo cells (values are not critical)

Capacitors
C1—3000uF, 25 volts, electrolytic
C2—1uF, 50 volts, Mylar
C3—0.1 µF, 50 volts, polyester
C4—10 µF, 50 volts, electrolytic

Semiconductors
IC1—556 dual timer
Q1, Q2—2N4411 NPN power transistor
BR1—50 PIV 1.5-amp bridge rectifier

Other components
F1—1-amp fuse and holder
S1-S3—SPST switch
T1—120/12VAC 1-amp power transformer
SPKR1—8-ohm speaker

Miscellaneous: perforated construction board, enclosure, 14-pin DIP socket, line cord, wire, hardware, etc.

Note: For complete operating instructions, set of sound recipes, schematic, and detailed plans for the cabinet, send $5 to John Canivan, 20 Tyler Ave., W Sayville, NY 11796

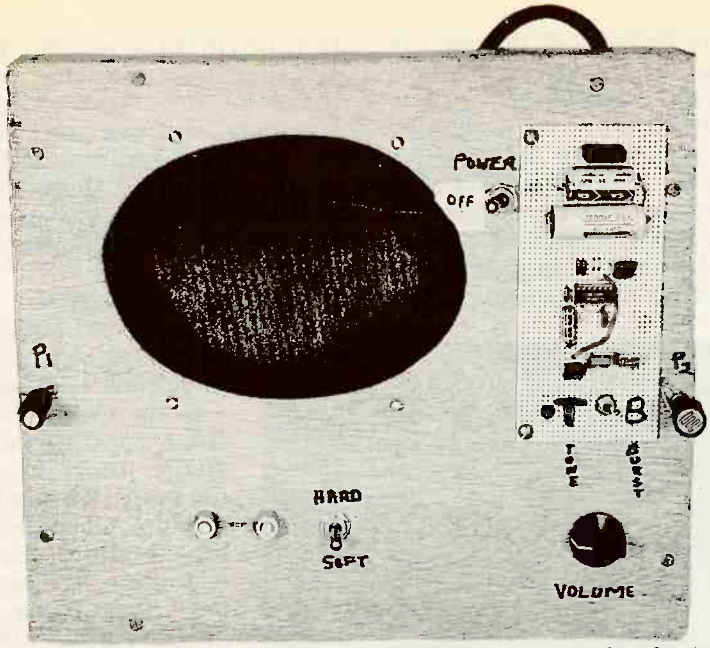


FIG. 3—THE AUTHOR MOUNTED THE COMPONENTS on a piece of perforated construction board and used point-to-point wiring. Everything was then installed in a home-made wood cabinet.

controlled by light intensity. The tone burst feature can be modified by opening and closing S3. That either makes a direct connection between the output of the burst timer and the reset of the tone oscillator, or replaces the direct connection with resistor R5 for a completely different sound effect. By opening S2, the burst feature is eliminated, and the pure tones which result can be controlled by hovering one hand above R9.

Remember that the amount of light striking photocells R8 and R9 is critical for proper circuit operation. Since the sensitivity of photo cells can vary, you should adjust the light to the range of frequencies desired. If the adjustment is not sufficient, you can adjust the range of available frequencies by changing the value of timer capacitors C2 and C3.

Sound recipes

The following is a list of different sounds you can make and instructions on how to make them:

- Police siren—Set TONE/BURST switch S2 on tone and raise and lower your right hand between 1 and 3 inches above R9, once every second.
- Old car starting—Set TONE/BURST switch S2 on burst and set HARD/SOFT switch S3 to hard. Place your right and left hands over the photocells and raise your left hand (or whichever hand is over R8) slowly.
- Airplane starting—Set TONE/BURST switch S2 on tone and place your right hand on photocell R9 and raise it slowly. Stop at 2 inches.
- UFO landing—Set TONE/BURST switch S2 on burst and set HARD/SOFT switch S3 on hard. Raise your hands above your head and lower them slowly onto the photocells.
- Birds chirping—Set TONE/BURST switch S2 on burst and set the HARD/SOFT switch S3 on hard. Place left hand 2 inches above photocell R8. Spread the fingers of your right hand and wave them across photocell R9 at a distance of about 2 inches.
- Ghosts moaning—Set TONE/BURST switch S2 on tone and set the HARD/SOFT switch on soft. Flutter your right hand above the photocell R9 while raising it up and down between 1 and 3 inches.
- Frankenstein—Set TONE/BURST switch S2 on burst and set HARD/SOFT switch S3 on soft. Raise your hands above your head and lower them slowly until you touch the photocells. Raise your left hand about 3 inches and then lower it to within 1 inch of the switch. At the same time, raise your right hand 3 inches. Repeat the process.
- Radiation warning—Set TONE/BURST switch S2 on burst and set HARD/SOFT switch S3 to hard. Cup your right hand 1 inch above photocell R9 and then cup your left hand about 2 inches above photo-cell R8.
- Foghorn—Set TONE/BURST switch S2 on burst and set HARD/SOFT switch S3 to hard. Place your right hand on photocell R9. Place your left hand on photocell R8.
- Smoke detector—Set TONE/BURST switch S2 on burst and set HARD/SOFT switch S3 to hard. Place your right hand 3 inches above R9, and place your left hand 1 inch from R8.

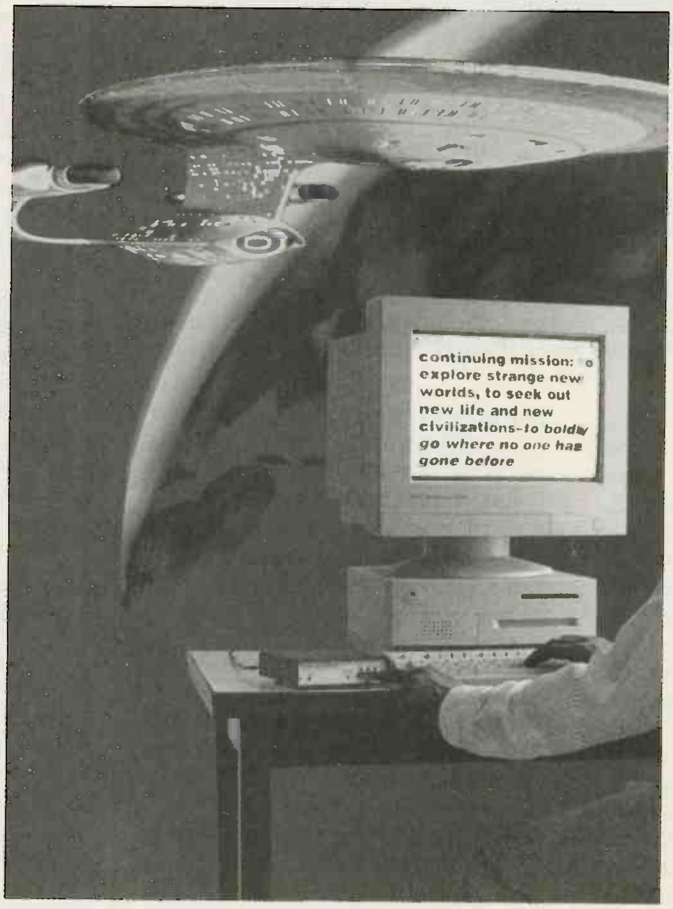
The light-controlled tone-burst oscillator is basically a musical instrument, and the quality of sound depends on the skill and creativity of the musician. If you've ever been searching for a circuit that can create special sound effects, then this project is right up your alley. Ω

NIGHT VISION SCOPES

Continued from page 54

chase a suitable IR filter at most retail camera stores, or you can stack four or five layers of completely exposed, developed film negatives between the incandescent lamp and flashlight lens. This film can be obtained as scrap from local photo developing shops. Cut four or five disks from this exposed film to fit inside the plastic or glass lens cap of your flashlight.

A complete kit of parts to build both of the scopes described in this article can be obtained from the source given in the parts list. If you elect to buy a surplus image tube to make a night-vision scope from scratch, purchase or obtain a "fast" camera lens and a magnifying glass for use as an eyepiece. You can then assemble all of these parts in a suitable metal or plastic tube. The power supply described here will power most imaging tubes, regardless of their size or country of origin. Ω



The TextGrabber

Make transcripts of your favorite television programs and download them to your PC.

KELLY McARTHUR

HAVE YOU EVER WANTED A HARD copy of the script from your favorite television program? Do you wish you could receive transcripts of important news programs without the trouble and expense of sending for them through the mail? The TextGrabber will let you capture a transcript of any closed-captioned television program for the hearing impaired. All you do is connect a video source to the TextGrabber, and connect the TextGrabber to your personal computer through its serial port. Then by running suitable communications software, you can capture the text encoded with the broadcast TV signals! Note that the TextGrabber works by itself, and does not require a separate closed-caption decoder.

VBI data transmission

Closed captions are added to the NTSC television signal as serial bit streams that occur on line 21 of the odd field during the vertical blanking interval (VBI). Figure 1 shows the data format in which two characters are sent on line 21. The text transmission rate of the VBI data system is determined by the number of VBI lines transmitted, the number of characters per line, and the frame rate of the television signal. For closed-captioning, the data rate is:

Two characters/line × one line/frame × 30 frames/second = 60 characters/second

VBI data transmission can deliver different kinds of information. With an inexpensive, settop, closed-caption decoder or a newer television set with built-in decoding, the hearing-impaired can read what is being said during the program as the words flash on the screen. Closed captioning is now included in most programming on the major networks.

Teletext information is also sent by the VBI transmission. In this mode, a decoder blanks normal programming and displays other information on the full screen. Teletext is not widely used in the United States, but it is popular in some countries in Europe.

Closed caption and teletext transmissions both use line 21 of the odd video field. Multiplexing permits the two data streams to be transmitted on the same television channel. Moreover, captions and teletext each support two different languages. Therefore, the following four separate data streams can exist on a single television channel simultaneously:

1) Captions Language 1
2) Captions Language 2
3) Teletext Language 1
4) Teletext Language 2

In the United States, Teletext and second language information is normally transmitted only during prime-time programming. The Teletext mode, for example, can transmit a programming guide listing upcoming shows that are closed-captioned. The second language mode (Language 2) usually displays a message advising the user to switch his decoder back to Language 1 to receive program captions. The vast majority of closed captioning is seen with a decoder set to the Caption mode for Language 1.

Figure 2 shows the format of the serial data in the VBI. Each "block" shown represents a start bit and two seven-bit characters with parity. Several of the important control codes are shown. Those are the only codes to which the TextGrabber responds. There are other control codes that affect different parts of the display of an on-screen caption decoder. Those include codes for italics, underlining, text color, and position. Those codes are ignored by the TextGrabber and eliminated from the output unless its "raw" data mode is selected. The TextGrabber has no use for those codes. The raw data mode is provided in case you have an application that can use them

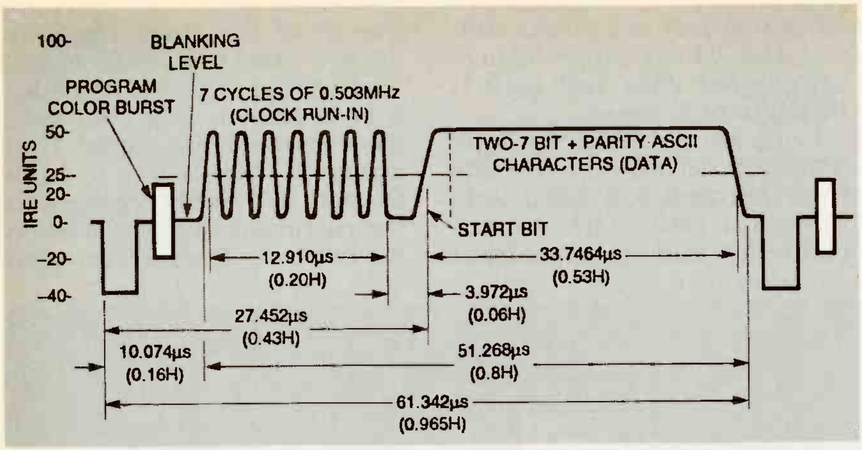


FIG. 1—CLOSED CAPTION DATA FORMAT. Captions are added to the television signal as serial bit streams that occur on line 21 of the odd field during the vertical blanking interval (VBI).

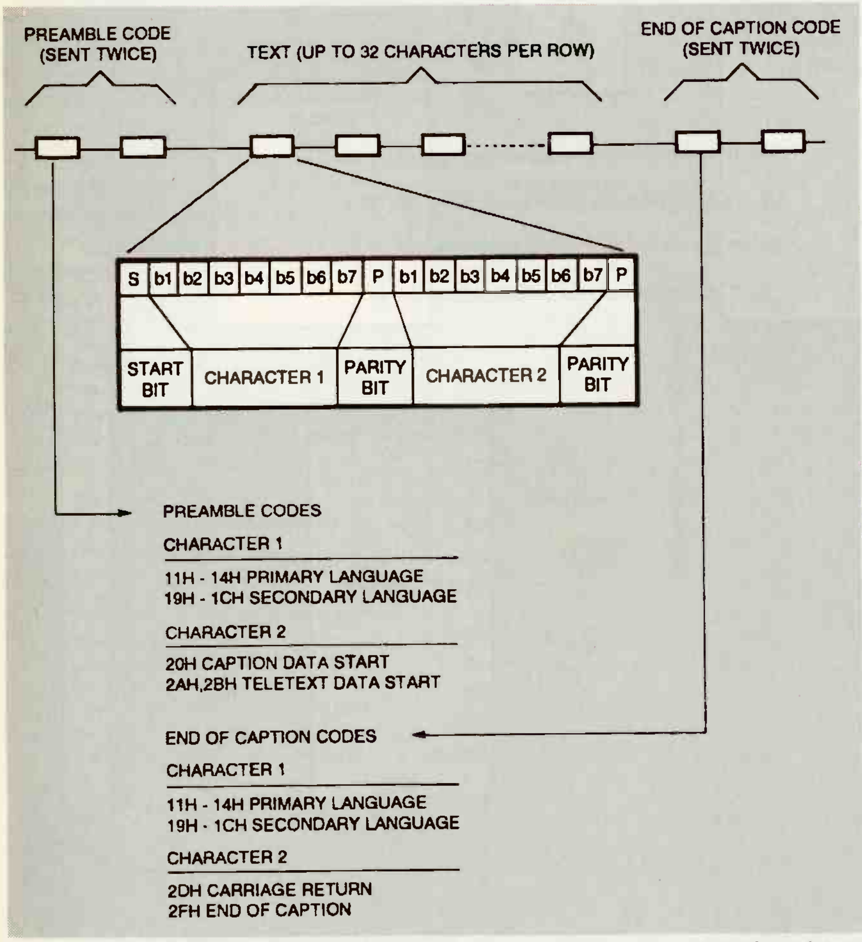


FIG. 2—VBI SERIAL DATA. Each "block" as shown represents a start bit and two seven-bit characters with parity.

TextGrabber hardware

Figure 3 shows a simplified schematic of the TextGrabber. A baseband video source such as a VCR is connected to J1. The video signal is terminated on the TextGrabber, and a buffer drives the video back out to J2. No termination is required if the output jack is left unconnected. Relay RY1 bypasses the buffer when the unit is turned off.

The video buffer and PLL section is shown in Fig. 4. Video is decoupled by capacitor C39 and then buffered by an amplifier formed by Q1 and Q2. Resistors R3 and R4 set the input bias level. The overall gain given by 1 + R6/R7 = 2. Amplified video is buffered to J2 by emitter-follower transistor Q3.

Unbuffered video is sent to IC1, an LM1881 sync-separator, which extracts timing information from the video signal. The following signals are extracted: $\overline{\text{CSYNC}}$ (composite sync), $\overline{\text{VSYNC}}$ (vertical sync), $\overline{\text{BURST}}$ (colorburst), and $\overline{\text{EFIELD}}$ (even video field).

$\overline{\text{CSYNC}}$ is applied to one-shot IC2-a, set to around 45 microseconds, and then to IC2-b, set to around 10 microseconds, to filter the serrations out of the composite sync signal and provide a clean horizontal sync signal ($\overline{\text{HSYNC}}$) for the counters.

The $\overline{\text{BURST}}$ signal from the sync separator momentarily closes analog switch IC7 during the colorburst signal, which applies the video signal to the sample-and-hold circuit formed by R19, C28, and IC8. The time constant of R19 and C28 is slow enough to filter out the 3.58-MHz color subcarrier present during the burst. As a result, C28 maintains a voltage equal to the black level of the video signal. Diode D1 is biased to provide a reference voltage equal to the voltage drop across the diode that tracks the variations in the black level. A voltage divider consisting of R29 and R30 provides a clipping level about 0.3 volt above the black level as a reference to the comparator IC5. Digital data is then extracted from the video and sent to the inputs of the shift registers shown in Fig. 5.

Positive-going $\overline{\text{HSYNC}}$ pulses are applied to the input of IC3, a 74HCT4046 phase-locked loop (PLL) IC. This PLL contains both an edge-triggered phase comparator and voltage-controlled oscillator (VCO). A low-pass filter consisting of R13, R14, C27, and C42 smoothes out the phase error signal and applies it to the input of the VCO at pin 9. The output clock signal is sent to counter IC4, which divides the signal by 32. A reference signal is then fed back to the second phase-comparator input, closing the loop. This response sets the operating frequency of the PLL to 32 times the video's horizontal frequency, or 504 kHz.

The digital data stream from the comparator is sent to a pair of serial-to-parallel shift registers, IC10 and IC11, in Fig. 5. The regenerated 504-kHz clock signal ($\overline{32H}$) drives the SRCLK pin (shift-register clock) of the shift registers, which causes them to sample the data and shift it through the registers.

Programmable array logic (PAL) IC9 decodes the five bits from counter IC4. It also detects a signal from the microcontroller that indicates that line 21 of the video signal is present, and the $\overline{EFIELD}$ signal that indicates that the odd video field is present. The PAL then asserts the RCLK signal that causes IC10 and IC11 to latch the data in the shift registers on the particular clock cycle when the two bytes from the sampled

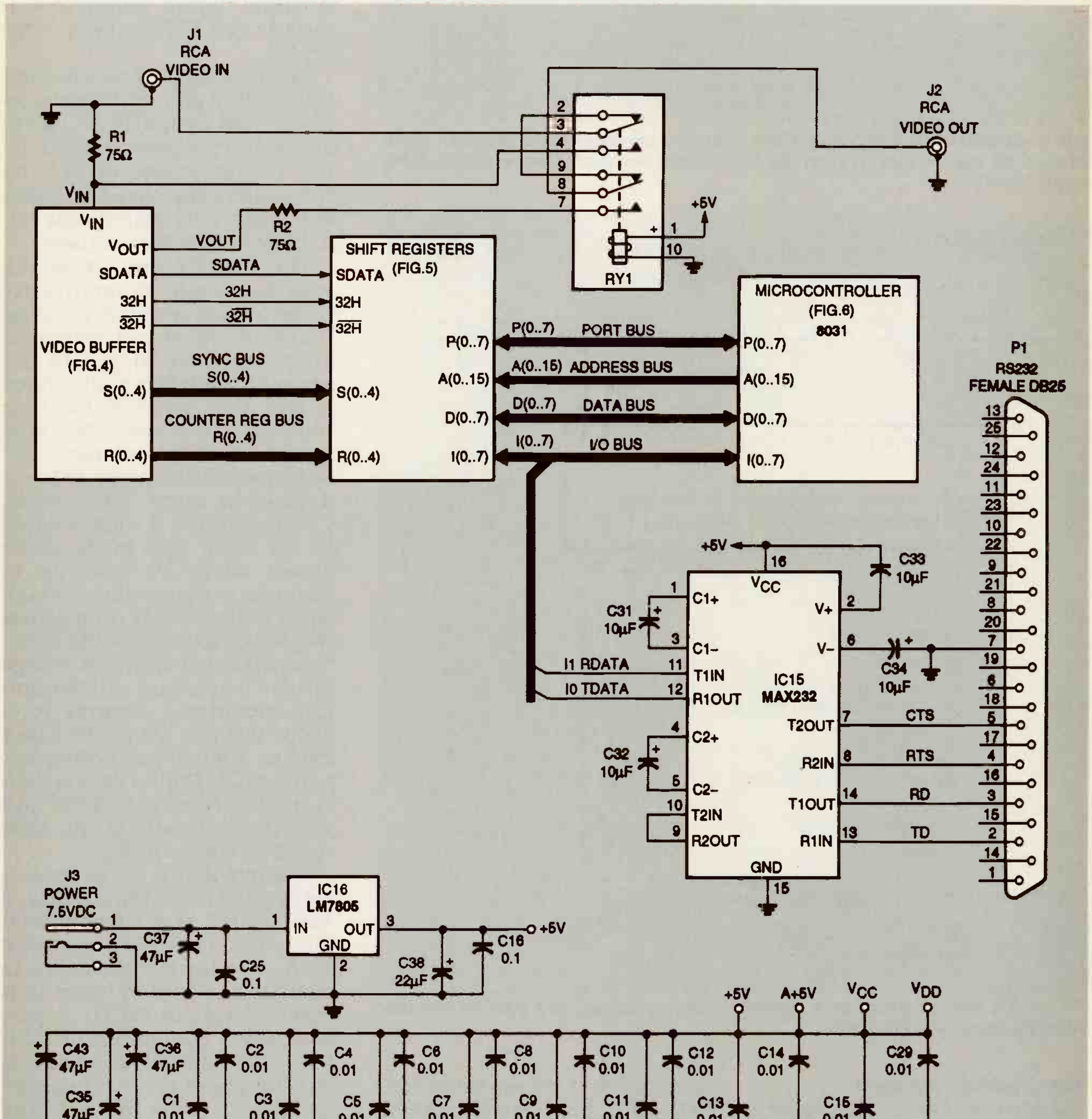


FIG. 3—TEXTGRABBER BLOCK SCHEMATIC. A base-band video source is connected to J1. The video signal is terminated on the TextGrabber, and a buffer drives the video back out to J2.

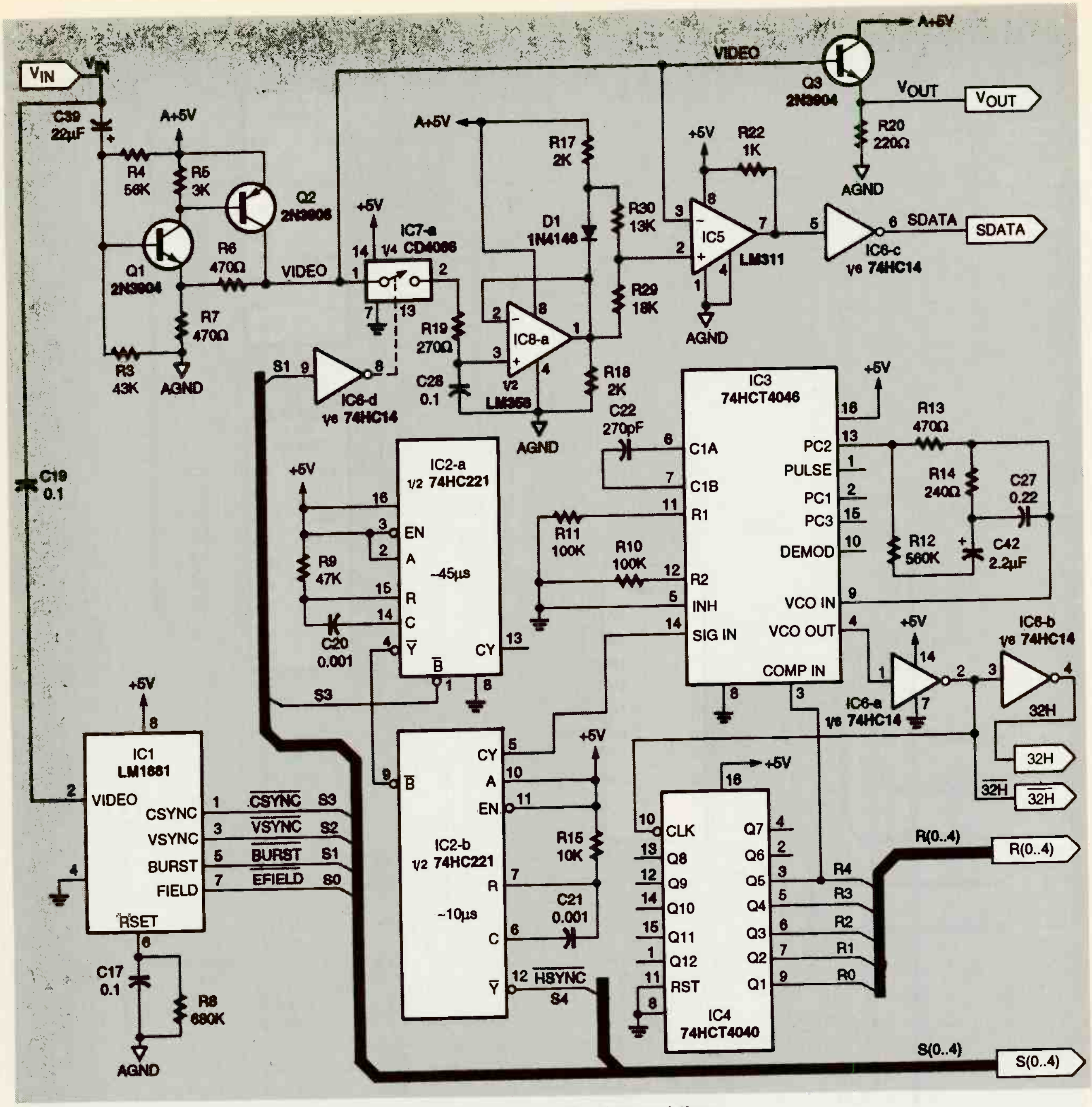


FIG. 4—VIDEO BUFFER AND PLL. Video is decoupled by capacitor C39 and then buffered by Q1 and Q2.

video "line up" with the two-byte wide registers of the 74HC595s.

The microcontroller now has a delay until the next odd field arrives to retrieve the data. The PAL also decodes some of the microcontroller's address lines to map the shift register's read ports into the microcontroller's external memory.

The firmware for the 8031 microcontroller is contained in EPROM IC14 (see Fig. 6). A 2764 has enough memory for the code, but jumper J4 permits larger EPROMs, such as a 27512 to be substituted. Programmed EPROMs and PALs are available from the source given in the Parts List. The source code can be downloaded from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) as a file called TEXTGRAB.ZIP.

The microcontroller tracks the video timing by monitoring $\overline{\text{VSYNC}}$, which is connected to External Interrupt 0, and $\overline{\text{HSYNC}}$ which is connected to Timer Input 0. When the vertical sync signal is detected, the internal counter starts counting down from 21. When it reaches zero, the processor toggles Port 1, Bit 0 (pin 1) high, so that IC9 latches the shift register data. Firmware running on the 8031 then extracts the captions from the data stream and sends them to the serial port at 9600 baud. A MAX232 chip (designated as IC15 in Fig. 3) provides the proper ±10-volt levels needed for RS-232C.

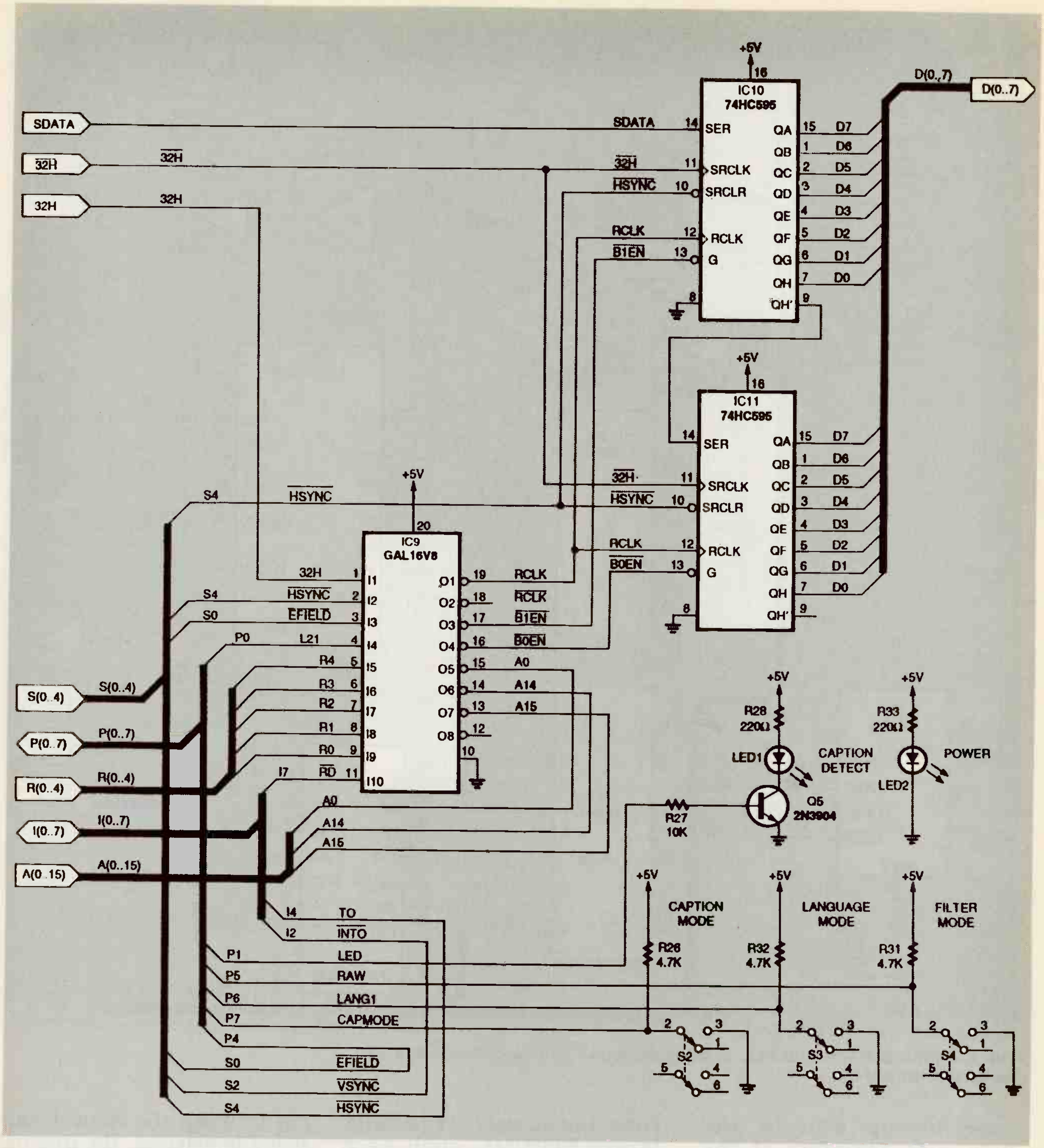


FIG. 5—THE DIGITAL DATA STREAM from the comparator is sent to a pair of serial-to-parallel shift registers, IC10 and IC11. PAL IC9 asserts the RCLK signal that causes IC10 and IC11 to latch the data in the shift registers.

Construction

A printed circuit board is recommendedfor the construction of the TextGrabber. You can fabricate a PC board yourself from the artwork provided in this article, or obtain an etched and drilled board from the source given in the Parts List. If you make your own board, be aware that there are several vias on the board where copper traces must jump from one side of the board to the other. Short lengths of bare copper wire must be inserted and soldered on both sides.

Install the components as shown in the Parts-Placement diagram in Fig. 7. If you have made your own double-sided board, be sure to solder all of the component leads on both sides of the board because many of the traces depend on component pins to provide a connection from one side to the other. Also, install a wire jumper in

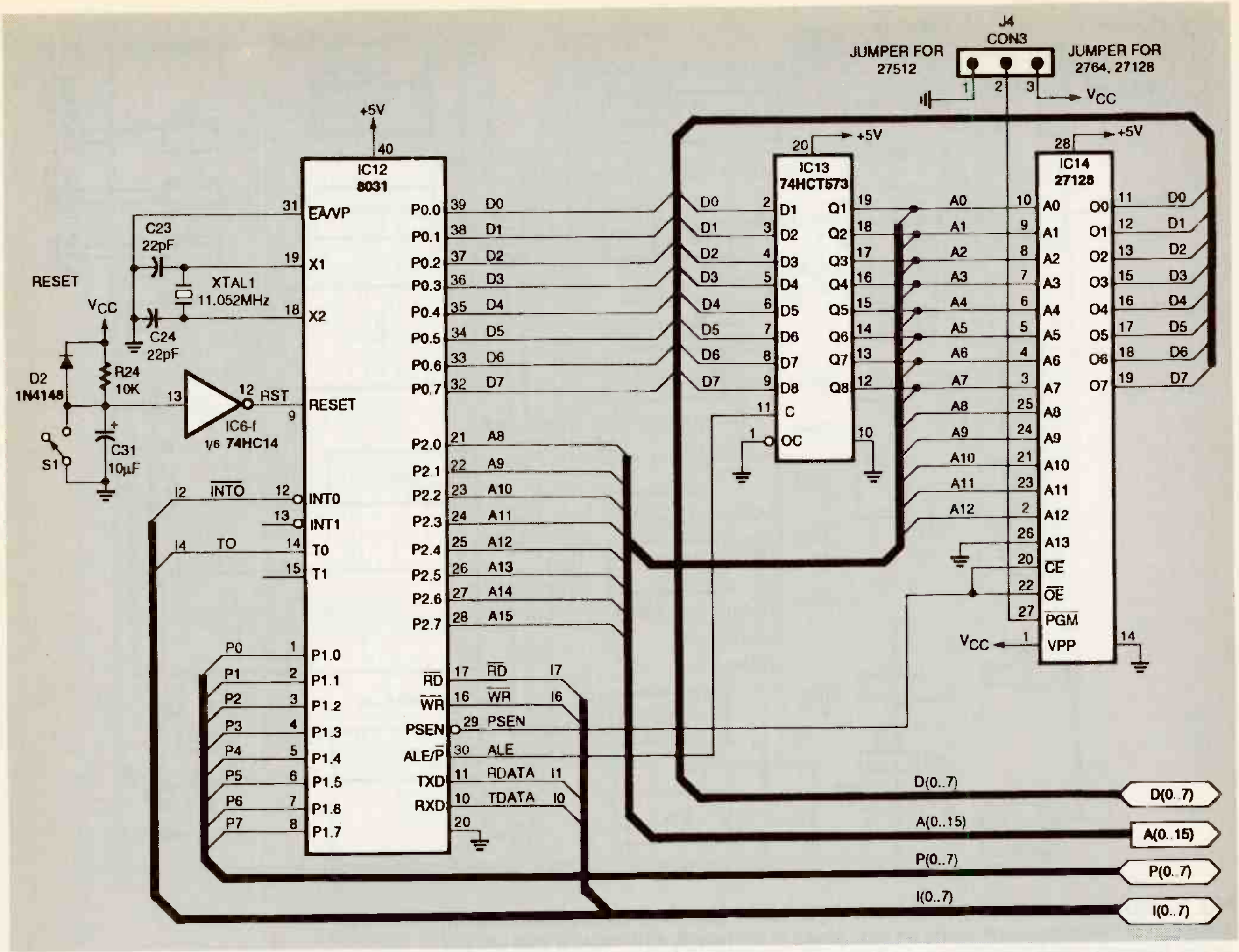


FIG. 6—FIRMWARE FOR THE 8031 MICROCONTROLLER is contained in EPROM IC14. Jumper J4 allows the use of larger EPROMs.

any through holes that don't contain a component lead. (Circuit boards purchased from the source in the Parts List have plated through-holes so that step is unnecessary.) Figure 8 shows the completed PC board.

Checkout

Connect a serial cable between the TextGrabber and a PC that is running a communications program. The software should be set to communicate over a direct connection at 9600 bps. Then connect a "clean" video source to the video input connector. Apply power to the TextGrabber; the message "<READY" will appear on the screen. This indicates that the microcontroller is up and running. If no video source is detected, the TextGrabber will also send "<NO VIDEO SIGNAL" to the terminal.

PARTS LIST

All resistors are ¼-watt, 5%.

R1, R2—75 ohms
R3—43,000 ohms
R4—56,000 ohms
R5—3000 ohms
R6, R7, R13—470 ohms
R8—680,000 ohms
R9—47,000 ohms
R10, R11—100,000 ohms
R12—560,000 ohms
R14—240 ohms
R15, R24, R27—10,000 ohms
R17, R18—2000 ohms
R19—270 ohms
R20, R28, R33—220 ohms
R22—1000 ohms
R26, R31, R32—4700 ohms
R29—18,000 ohms
R30—13,000 ohms

Capacitors

C1–C15, C29—0.01 µF, 25 volts, monolithic
C16, C17, C25—0.1 µF, 25 volts, monolithic
C18, C26, C29, C30, C40—not used
C19, C28—0.1 µF, 25 volts, Polyester
C20, C21—0.001 µF, 25 volts, Polyester
C22—270 pF, 25 volts, ceramic NPO
C23, C24—22 pF, 25 volts, ceramic NPO
C27—0.22 µF, 16 volts, tantalum electrolytic
C31–C34, C41—10 µF, 16 volts, Tantalum electrolytic
C35–C36, C43—47 µF, 16 volts, Tantalum electrolytic
C37—220 µF, 25 volts, electrolytic
C38, C39—22 µF, 16 volts, tantalum electrolytic
C42—2.2 µF, 16 volts, tantalum

Semiconductors

D1, D2—1N4148 diode
LED1—green light-emitting diode
LED2—red light-emitting diode
Q1, Q3, Q5—2N3904 NPN transistor
Q2—2N3906 PNP transistor
IC1—LM1881 sync separator
IC2—74HC221 multivibrator

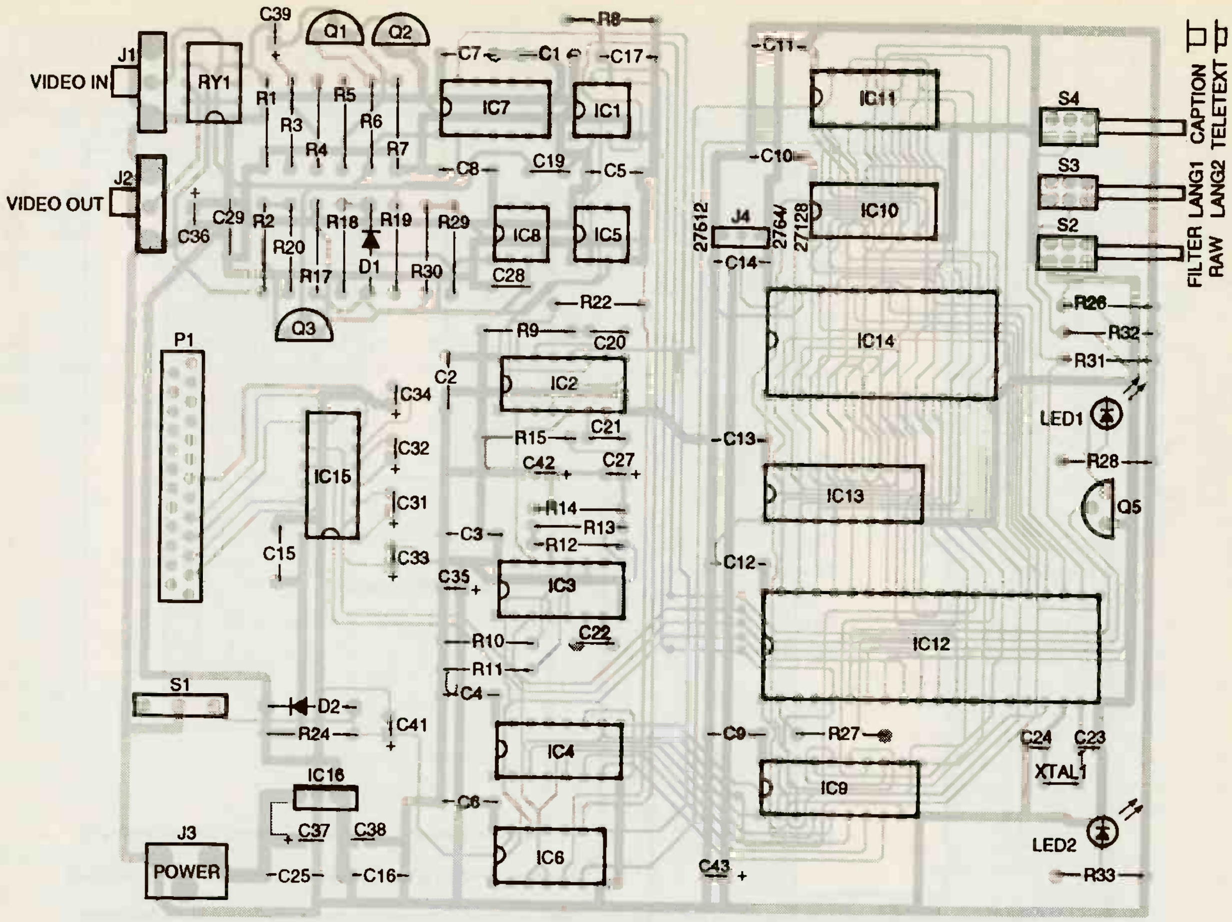


FIG. 7—PARTS PLACEMENT DIAGRAM. If you make your own double-sided board, solder all of the component leads on both sides of the board, and install a wire jumper in any through holes that don't have a component lead in them.

PARTS LIST *Continued*

IC3—74HCT4046 PLL
IC4—74HCT4040 counter
IC5—LM311 comparator
IC6—74HC14 hex inverter
IC7—CD4066B quad bilateral switch Harris or equiv.
IC8—LM358 op-amp National or equiv.
IC9—GAL16V8-25 programmable logic device
IC10, IC11—74HC595 shift register
IC12—8031 microcontroller
IC13—74HCT573 latch
IC14—27C64 EPROM
IC15—MAX232 RS232 transceiver
IC16—LM7805 voltage regulator

Other Components

J1, J2—PC-mount RCA connector
J3—PC-mount coaxial power connector
RY1—DPDT—relay, 5-volt coil
P1—PC-mount female DB25 connector
S1—SPST momentary-contact pushbutton switch
S2–S4—PC-mount DPDT switch (push-on, push-off type)
XTAL1—11.0592 MHz crystal

Miscellaneous: PC board, 7.5-volt DC 500 milliampere power supply, project case, cables.

Note: the following items are available from 5860 SW 18th, Portland, OR 97201:

- **Complete TextGrabber kit including PC board, and all electrical components (no case or power supply)—$149.95**
- **PC board—$20**
- **Programmed PAL and EPROM—$20**

Please add $5 for shipping and handling on the complete kit, $2 for PC board and PAL/EPROM orders. Check or money order only.

- **A fully assembled and tested TextGrabber with case and power supply is available for $249.95 from Sunbelt Industries, 1254 Fishhook Way, Ponte Vedra Beach, FL 32082; (904) 285-4788.**

If the microcontroller is working properly, check the video section by first examining the outputs of the sync-separator (IC1) with an oscilloscope to make sure they are active. Then follow the path of $\overline{\text{HSYNC}}$ through to the PLL, and verify that it is oscillating at the proper frequency (504 kHz), and that this clock signal is present at the shift registers (IC10 and IC11). If you have a two-channel oscilloscope, verify that the output of the sample-and-hold circuit (IC8 pin 1) tracks the black level of the buffered video signal, and that the comparator reference at pin 2 of IC5 remains about 0.3-volt above the black level.

Using the TextGrabber

Figure 9 shows a typical operating setup for the TextGrabber. The program being transcribed can be viewed either on a television connected to the VCR's RF

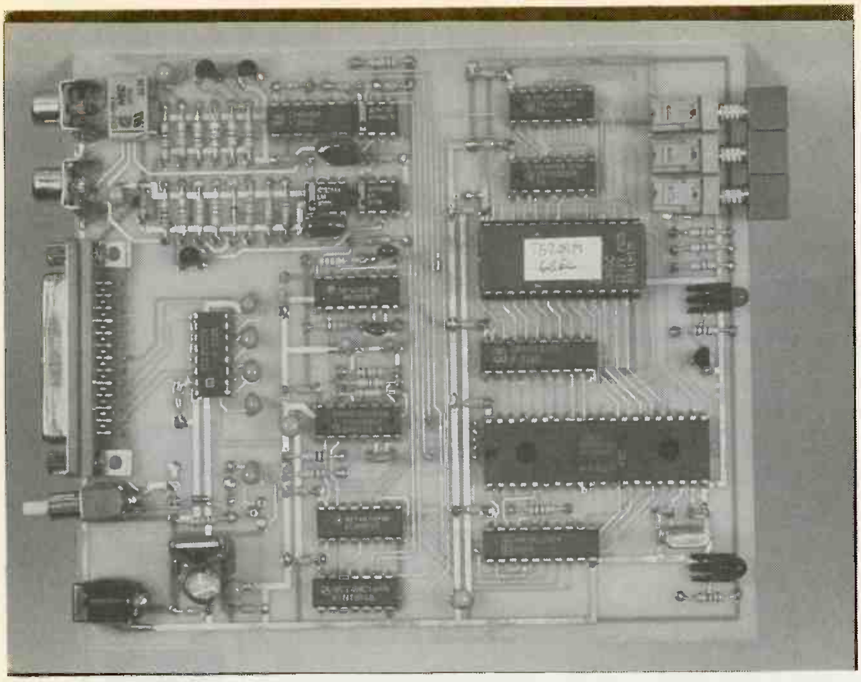


FIG. 8—FINISHED PC BOARD. This is an early prototype, so some of the parts might not be the same as those that you will be installing.

pass-through, or on a video monitor connected to the Text-Grabber's baseband video pass-through.

The computer is running terminal communication software set to 9600 baud, 8 data bits, no parity bit, and one stop bit (8N1). The data from the Text-Grabber is captured on the hard disk drive of the computer with the ASCII download feature of the terminal software being used.

The red LED on the left side of the front panel of the unit will indicate that the unit is powered. The green LED on the right side will indicate a Caption Detect. It lights whenever the unit detects a valid caption data stream, and it stays on while the data is being transmitted.

If the Caption Detect LED is not flashing periodically, then the television program you are watching probably doesn't have closed captions.

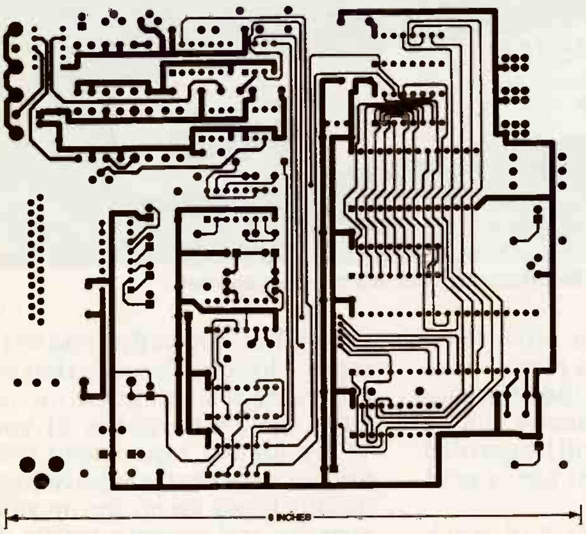
Three front-panel switches control various modes of operation. The FILTER/RAW switch (S4) allows you to select whether the TextGrabber sends just the ASCII captions to the terminal, or raw data which includes a stream of control characters and codes.

Also note that, because captions are generally transmitted in all capital letters, the Filter mode of the TextGrabber will convert all the characters to lower case except those at the start of a sentence.

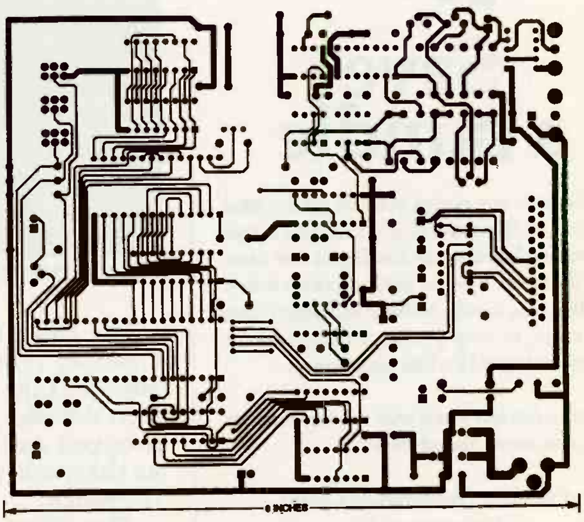
The LANG1/LANG2 switch (S3) selects the multiplexed language data streams to be displayed. At the present time, Language 2 data is not in wide use by any of the American broadcasters.

The CAPTION/TELETEXT switch (S2) selects either the closed caption data stream or the teletext data stream which is multiplexed onto the same channel. Again, Teletext mode is seldom used by American broadcasters, but the ABC television network programming sometimes transmits information on this channel. In general, you will find that the desired setting for each of these switches is in the "out" position.

The microcontroller will be reset by pressing reset button S1 on the back panel, and it will then transmit the "<READY" message. This feature is provided so that you can easily test the serial connection to the PC in the absence of a video signal that contains caption data.



COMPONENT SIDE of the TextGrabber PC board.



SOLDER SIDE of the TextGrabber PC board.

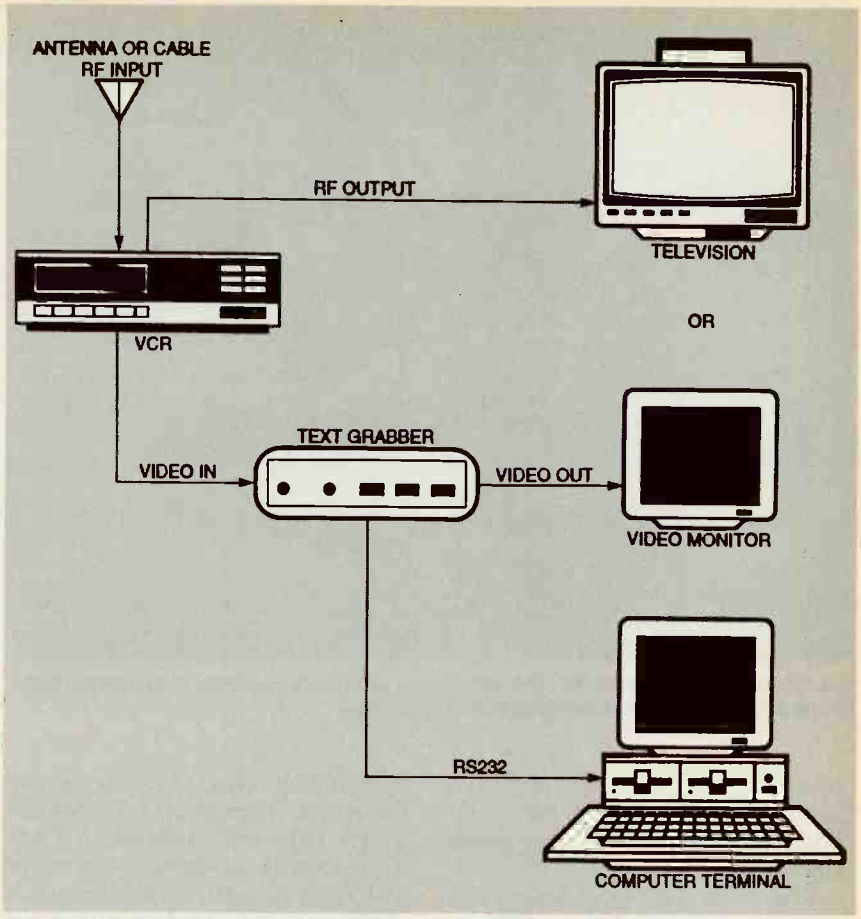


FIG. 9—TYPICAL TEXTGRABBER SETUP. The program being transcribed can be viewed either on a television connected to the VCR's RF pass-through, or on a video monitor connected to the TextGrabber's baseband video pass-through.

FIG. 10—THE TEXTGRABBER can be built in a compact cabinet.

For best results, the TextGrabber requires a clean video source. Like any other telecaption decoder, characters will be dropped and text will be garbled as the quality of the video signal degrades.

The TextGrabber will work with programs that have been recorded on videocassette tapes. However, be sure that you record tapes intended for use with the TextGrabber at your VCR's fastest tape speed (SP), and be sure that you have high-quality tapes for optimum video viewing and closed-caption decoding quality. Ω

CREATING CHAOS

This fascinating project whose moving ball can hypnotize and captivate you with its random (chaotic) motion.

ROGER SONNTAG

DO YOU WANT RELIEF FROM THE MOnotonony of routine activities that get you down—daily commuting, your job, or those pesky chores that you must do every day? What you need is a little chaos in your life—safe and controlled, of course—at desktop scale. How do you do this? Build the Bonker and go a little crazy watching its bouncing ball whirl and spin in random loops. Then you'll be ready to return to your dull routine.

Unlike a clock pendulum or that executive toy with all its little suspended bearings that clatter back and forth, Bonker's action is completely unpredictable. And you can turn it off when you've had enough chaos for the day. Chaos is defined as extreme confusion or disorder and the kind of formless matter and infinite space that is said to have existed before the universe was ordered. In short, it's the opposite of orderly and predictable.

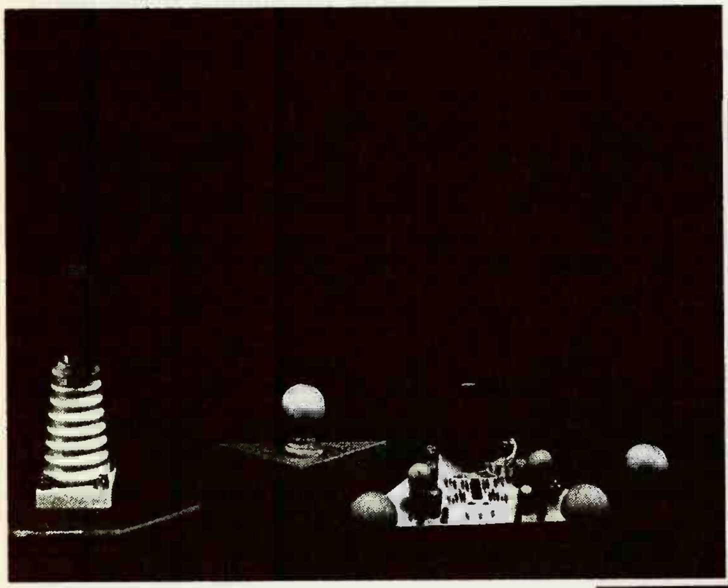
Figure 1 shows one Bonker setup. Small wooden balls on the end of wire springs are sent into wild gyrations by oscillating solenoids whose motion is controlled by a four-stage pulse generator. It's a fascinating and eye-riveting gadget that will evoke a lot of comments when it's running on your desk.

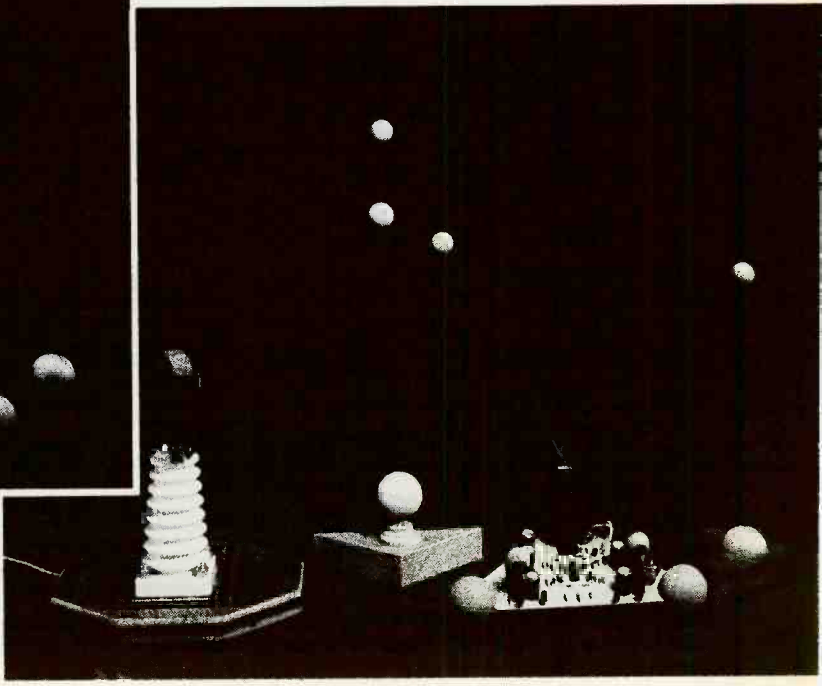
How does it work?

Figure 2 is a simplified schematic showing only one of the four pulse oscillator circuits that drive the rotary solenoid. Each oscillator is formed from an operational amplifier and a network of external components. Three other circuits similar to that shown on the left side of the diagram all feed the same common bus. The summed output of all four oscillators provides a variable pulsed drive signal for the MOSFET gate.

The MOSFET is in series with the solenoid's coil. When the MOSFET conducts, current flowing in the coil causes the solenoid shaft to oscillate back and forth within a limited angular sweep. Solenoid oscillation is controlled by the summed output of the four oscillator stages.

The op-amp shown in Fig. 2 is IC1-a, one of four op-amp circuits in a quad LM324 shown in Fig. 3, the complete schematic. Each of the four op-amp-based oscillators is identical except for different values of their *charge*





FIGS. 1A and 1B—WATCH THE DANCING ball on the end of the spring. An erratically oscillating solenoid on the Bonker sends the ball into unpredictable gyrations captured with time exposure (a). The Bonker at rest (b). Spring-mounted balls on stationary bases add to the chaotic effect.

and *discharge* resistors. In Fig. 2, R2 in the feedback loop of the op-amp is the charge resistor, and R1 is the discharge resistor.

Diode D2 couples the output of the oscillator to the base of Q1 through resistor R23. Diodes D4, D6 and D8 perform the same functions for the other three oscillator stages formed from op-amps IC1-b, IC1-c, and IC1-d. When the output of any two oscillators is positive, Q1 conducts.

Resistors R4 and R5 divide the 12-volt power from a wall outlet adapter to obtain 6 volts. Positive feedback through resistor R3 cleanly switches the oscillator at each output state. Resistors with identical values in the other three oscillator circuits perform the identical functions.

Figure 3, the complete schematic, shows each of the four oscillator stages that include a LED. The first and fourth stages include a trimmer potentiometer to introduce additional variation in the pulse train.

The differences in the value of resistors R1, R6, R11 and R25 in parallel with grounded aluminum electrolytic capacitors C1, C2, C3 and C4 provide different time constants for each oscillator. The approximately ± 20 % variation in tolerances of those capacitors imparts additional randomness.

The differences in the values of the discharge resistors R1, R6, R11 and R25 (25 to 180 kilohms) determine the pulse duty cycle, and the 1-kilohm values of the charging resistors R2, R7, R12, and R24 determines pulse width.

Bonker action is initiated by closing switch S1. Light-emitting diodes LED1 to LED4 give visual indications of the output from each oscillator. Linear potentiometers R27 and R28 control the swinging of the ball. They can adjust the motion from a gentle swing to a wild, eccentric movement. Electrolytic capacitor C5 shunts any AC transients that might appear on the 12-volt source to ground. Table 1 summarizes the variations in pulse repetition rate that can be be set in each oscillator stage, as well as variations that can be introduced by the capacitor tolerance.

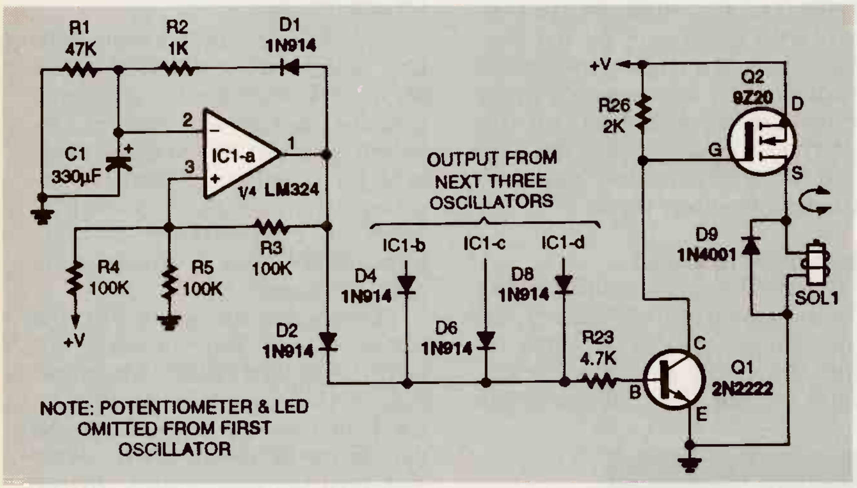


FIG. 2—A SIMPLIFIED SCHEMATIC to explain how the Bonker's solenoid drive circuit works.

Circuit construction

A printed circuit board is available from the source given in the Parts List. However, a foil pattern is included in this article for those who want to make their own circuit boards. There is nothing critical about parts placement in this circuit, so it could made with point-to-point wiring techniques if the parts placement diagram is followed.

Refer to the parts placement diagram Fig. 4. Begin assembly

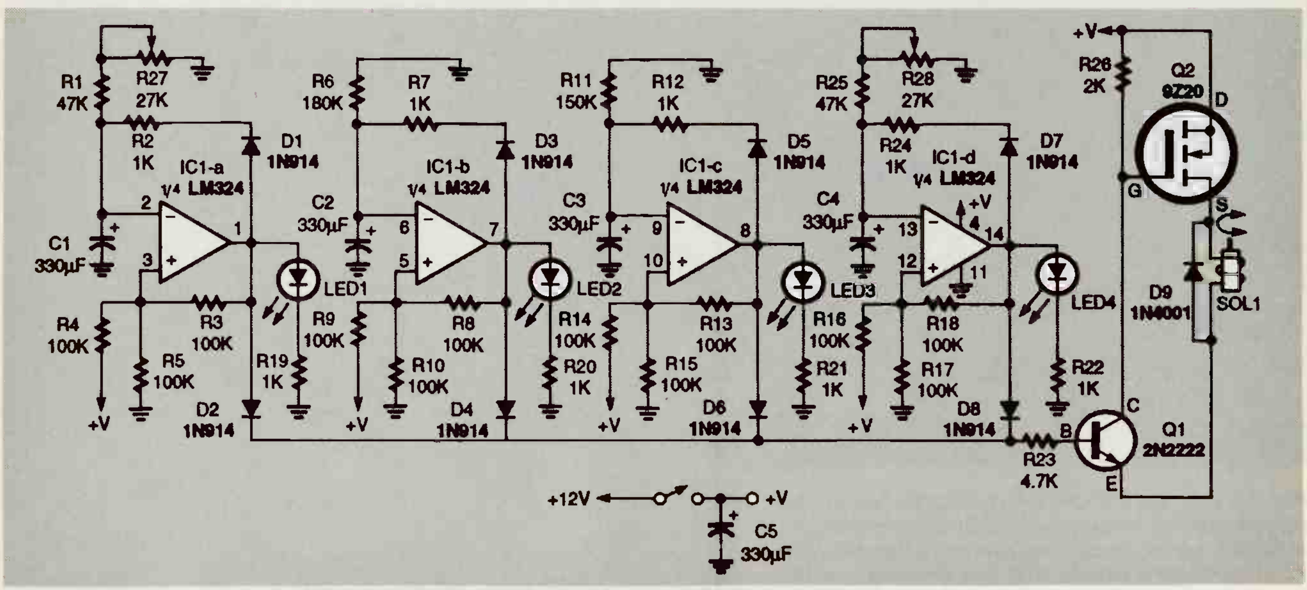


FIG. 3—SCHEMATIC FOR BONKER SOLENOID drive circuit. Four oscillator stages are formed from a quad LM324N op-amp IC. LEDs provide a visual indication of the pulse output of each stage.

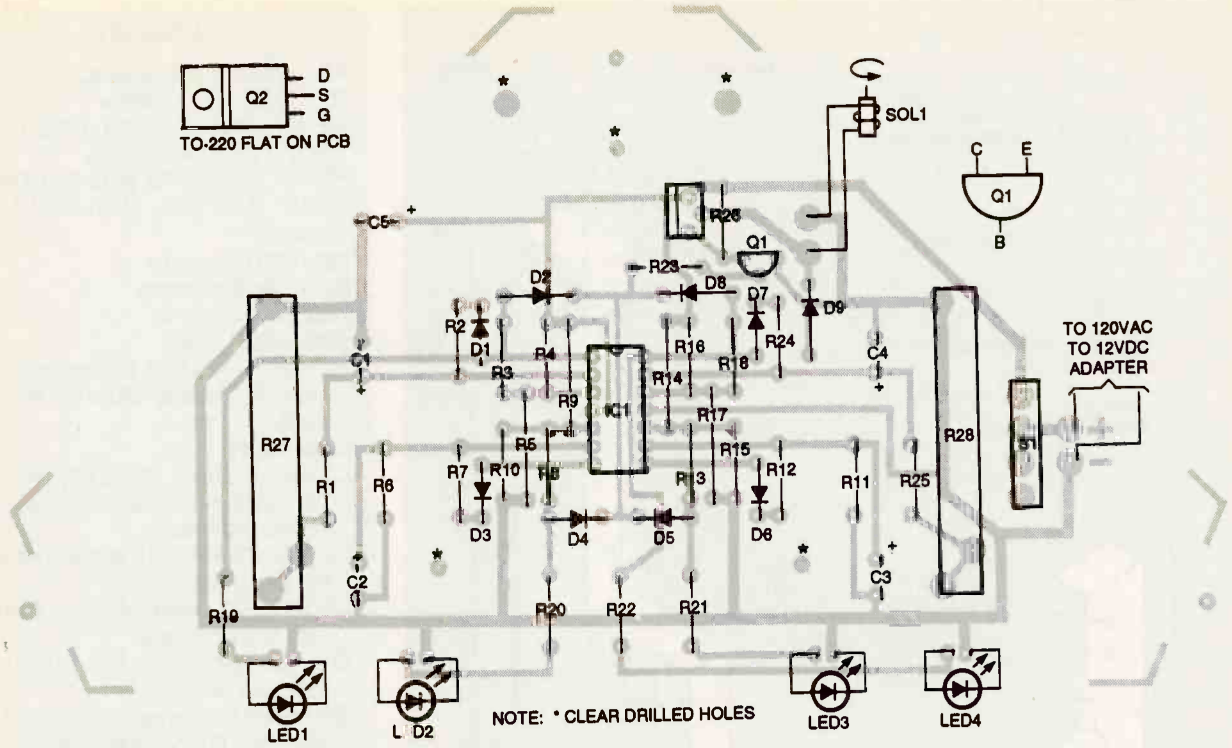
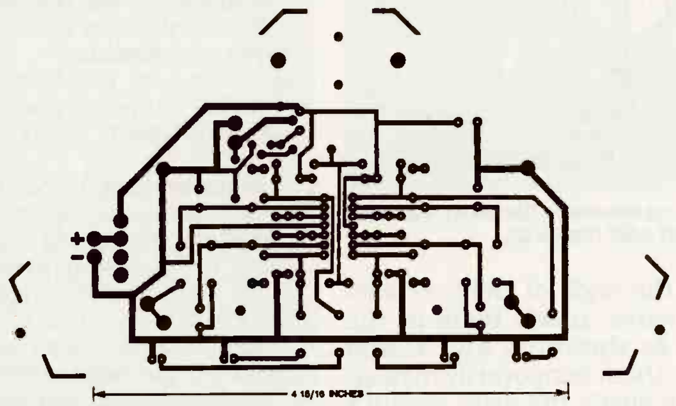


FIG. 4—PARTS PLACEMENT DIAGRAM for Bonker drive circuit. Bend the leads of MOSFET Q2 so it lies flat on circuit board.



FOIL PATTERN for Bonker drive circuit board.

TABLE 1 OSCILLATOR STAGE PULSE FREQUENCY	
Oscillator Stage	**Pulse Limits (Seconds)**
1	4 - 10
2	20 + 20%
3	26 + 20%
4	4 - 10

of the components to the circuit board by inserting all fixed resistors (R1 through R26) in the board as shown. Bend their leads together to clamp them in position close to the board.

Then insert the radial-leaded aluminum electrolytic capacitors (C1 through C5) observing their polarities, as shown in Fig. 4. Bend their leads inwards to clamp them to the board.

Then insert all diodes (D1 through D5), again observing the positions of their anodes, as shown on Fig. 4. Bend their leads to clamp them in position. Solder all of these components to the circuit board, but do not trim the leads at this time.

Next, insert transistor Q1 and bend its leads to clamp it temporarily. Bend the leads of power MOSFET Q2 at right angles so that the heat sink of its TO-220 package will lie flat on the board when the leads are inserted in the proper holes of the board.

Insert trimmer potentiometers R27 and R28 and the four light-emitting diodes (LED1 to LED4) as shown in Fig. 4, but do not twist their leads to clamp them. Now solder the leads of the second group of components inserted.

Carefully file or trim off about one-third of the width of each of the four flat terminals of slide switch S1 uniformly so that they can be press fit in the assigned holes in the circuit board. Insert the switch in the circuit board and solder it.

Identify the plus (+) and (−) wires of the DC output cable of a 120 VAC to 12-volt, 1 ampere, DC-regulated adapter, cut off the coaxial jack, and trim the insulation back on the two wires. Insert them from the component side of the board in the (+) and (−) positions (marked on the foil side of the board), and solder them in position. Trim all excess lead lengths close to the board.

Note: The circuit and solenoid can be run from a battery pack consisting of eight 1.5-volt C or

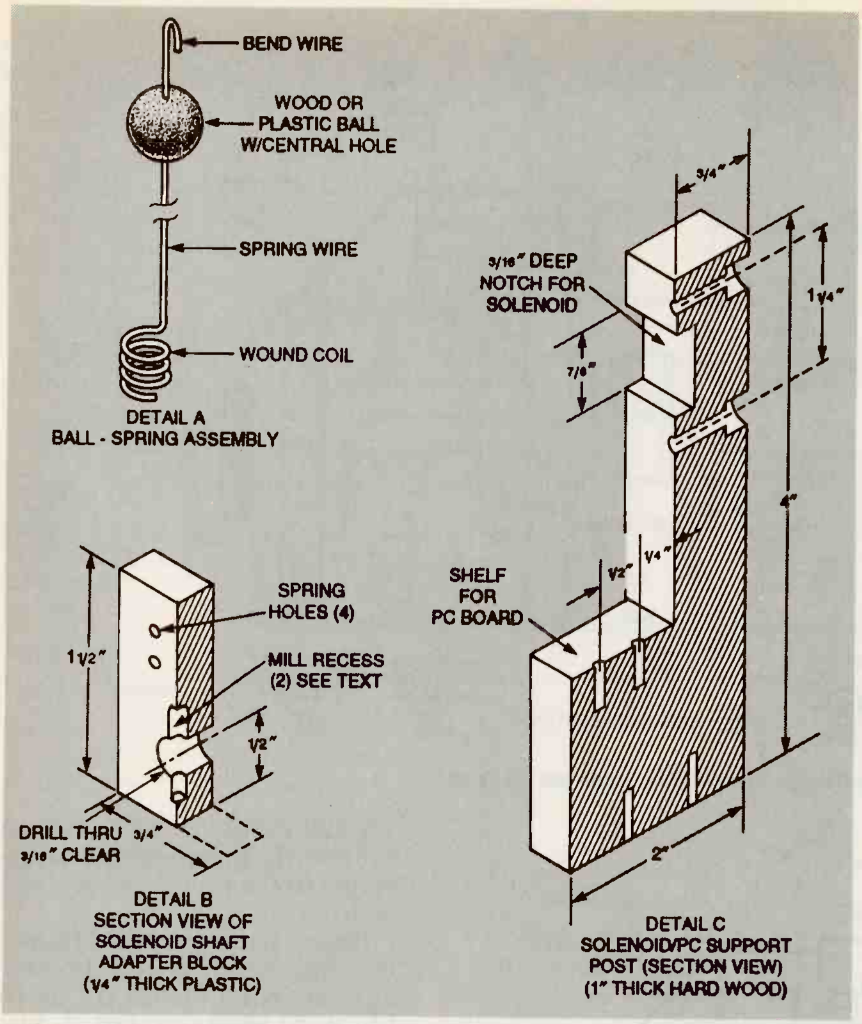


FIG. 5—DETAILS OF MECHANICAL PARTS: ball-spring assembly (Detail A); solenoid shaft adapter block (Detail B); solenoid/PCB support post (Detail C).

D alkaline cells, if you prefer not to run it from an adapter.

Turn on switch S1 to apply power. All of the LEDs should turn on and then go off. Then illumination patterns will be established: LEDs 1 and 4 will turn on every 4 to 10 seconds and continue to repeat that cycle, and LEDs 2 and 3 will turn on every 15 to 25 seconds and repeat that cycle. After you have verified this, turn off switch S1.

Place the rotary solenoid with its shaft side down and find the end of the spring that is coiled around the back end of the shaft within a slotted enclosure. With needle-nose pliers and a small screwdriver, pry up the end of the spring and re-insert it two places to the left (counterclockwise). Releasing the spring tension permits the solenoid to be operated from a 12-volt source.

Strip the insulation back from the ends of the two solenoid wires, insert them in the holes as shown on Fig. 4, and solder them temporarily in position to check the drive circuit's operation.

When S1 is switched back on, the shaft of the solenoid should oscillate back and forth over a limited angular sector. Check to see that a LED lights whenever the shaft oscillates. This response verifies that the circuit is operating properly.

Special mechanical parts

Refer to mechanical detail drawing Fig. 5, Detail A. Securely clamp the ¾-inch diameter wood ball in a vise and carefully drill a hole through its center with a No. 60 drill bit.

Clamp the end of an approximately 15-inch length of 0.028 steel piano wire in a vise and wrap the other end of the wire

PARTS LIST

All resistors are ¼-watt, 10 %

R1, R25—47,000 ohms
R2, R7, R12, R12, R19, R20, R21, R22, R24—1000 ohms
R3, R4, R5, R8, R9, R10. R13, R14, R15, R16, R17, R18—100,000 ohms
R6—180,000 ohms
R11—150,000 ohms
R23—4.700 ohms
R26—2000 ohms
R27, R28—25,000 potentiometer, slide, PC mount, Slide-Trol 112 or equiv.

Capacitors

C1–C5—330µF, 25 VDC, aluminum electrolytic, radial leaded

. **Semiconductors**

D1–D8—1N914/4148 silicon switching diode, 75 PIV
LED1–LED4—light-emitting diode, red, T-1¾ package
Q1—2N2222 silicon transistor, Motorola or equiv.
Q2—IRF9Z20 power MOSFET, N-channel, TO-220 package, International Rectifier or equiv.
IC1—LM324N quad operational amplifier, 14-pin DIP, National Semiconductor or equiv.

Other components:

SOL1—rotary solenoid, Ledex 188687-001 or equivalent.
S1—slide switch, SPST, 5A, PC mount

Miscellaneous: Wood or plastic base (see text); wood ball, ¾ diameter; steel spring wire (0.018 in.), 15 inches long; solenoid/circuit board mounting bracket (see text); 120 VAC to 12 VDC, 1 A, regulated wall-outlet adapter; round or pan head wood screws; insulated hookup wire; solder.

Note: The following options are offered by General Science and Engineering, P.O. Box 447, Rochester, NY 145603, 716-338-7001

- **Printed circuit board—$7.50**
- **Bonker kit including printed circuit board, all electronic components, rotary solenoid, spring wire with coil, and wood sphere—$38**
- **Finished Bonker ready to operate—$89.00**
- **Alternative wood bases and solenoid mounting posts: pine—$9.50; veneer—$12.00; oak—$16.00; ceramic insulator and oak base—$16.00**

Money order, Visa, or Master Card accepted. Add $3.00 S&H. New York State residents add local county sales tax.

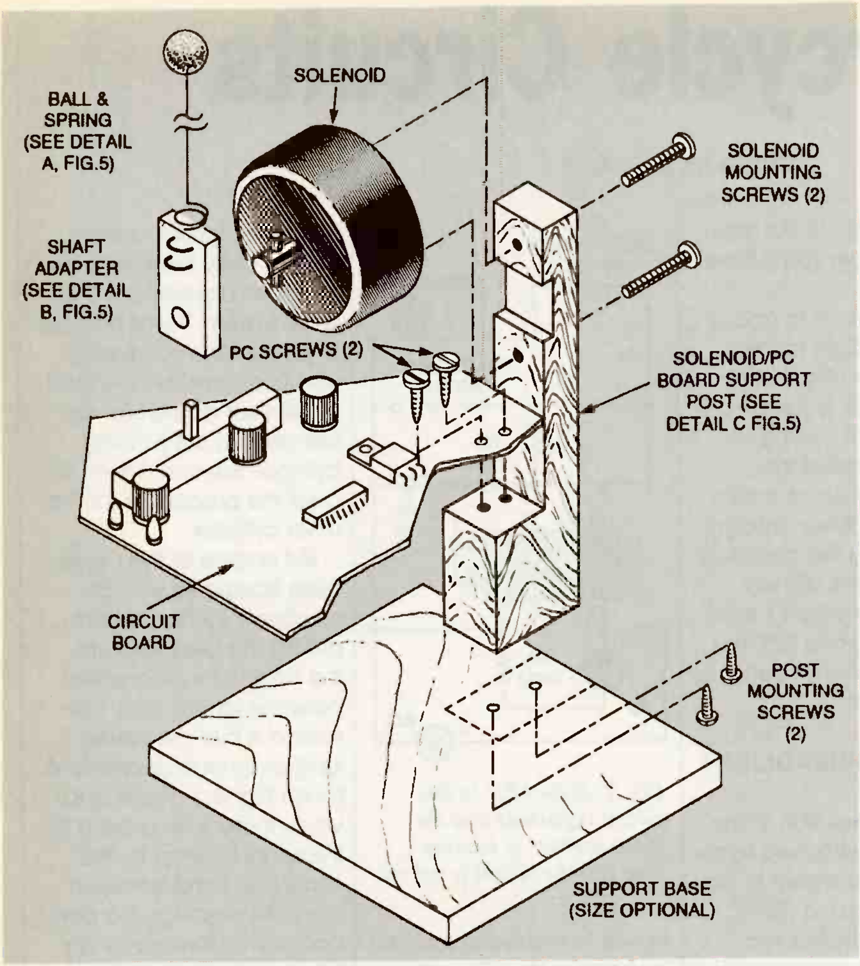


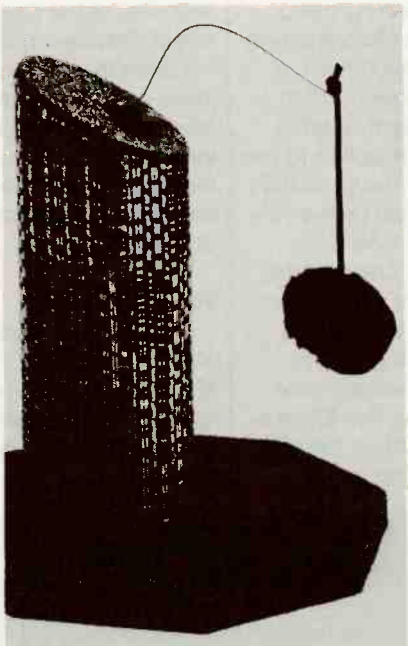
FIG. 6—ASSEMBLY DIAGRAM: The support base can be round or rectangular provided it is thick enouugh and has an area larger than about 30 square inches so it will be stable.

about eight times around a ⅛-inch dowel to form a coil spring with the aid of pliers. (Expect the diameter of the coil to expand after releasing tension on it.)

Insert the free end of the spring wire in the hole drilled through the ball, and then bend about ¼-inch of the end of the wire back on itself and push the bent end back into the drilled hole to assure a secure press fit.

Note: It is important that the ball be fastened securely to the wire so that it will not fly off when the solenoid is oscillating. If you want to paint or spray the ball with bright red or yellow enamel to make it more conspicuous, this a good time to do it.

Refer to Fig. 5, Detail B. Cut a rectangle measuring 1½ × ¾-inch from ¼-inch thick hard plastic and file the edges smooth. Drill a 3⁄16-inch hole through the block ½-inch in



THE BONKER CAN BE BUILT in many different configurations with a choice of base styles and materials. This one is designed to drive cats wild.

from one end (as shown) so that it can be press fit over the rotary solenoid shaft. Push the block onto the shaft and mark the ends of the cross-pin on the surface of the block.

Remove the block and cut or mill out short slots on both sides of the hole so that the cross pin and shaft will seat securely in the block. With a 1⁄16-inch diameter bit, drill four small holes in the block in a square pattern, and set it aside.

Refer to Fig. 5, Detail C. A supporting post that is fastened to a base board is suitable for mounting both the solenoid and the apex of the circuit board. The general dimensions for a post are shown in the detail. It is suggested that it be made of wood that is hard enough so that it will not split when drilling the holes in it and fastening the base and circuit board to it.

The general outline of the post can be changed to suit your taste, but it has some critical dimensions: the size and spacing of the drilled and countersunk holes for mounting the solenoid, the spacing between the drilled holes for mounting the circuit board to the shelf, and the width and depth of the notch for accepting the end of the solenoid. You might want to paint or varnish this post before assembling it to a base.

Bonker Assembly

Refer to the mechanical assembly drawing Fig. 6. The bonker must have a suitable, sturdy base. This can be cut from wood or plastic in a round square, or rectangular shape but should be large and heavy enough to provide a secure support for the solenoid and circuit board. (A minimum of 40 square inches of material that is at least ¾-inch thick is recommended.) Again, you might want to paint or varnish the base before proceeding.

Drill and countersink two holes near the edge of the base with the same spacing as the matching holes in the base of the support post (Detail C, Fig. 5). Fasten the post to the base

(Continued on page 104)

Motorcycle Circuits

CHARLES D. RAKES

With the temperatures warming and the days growing longer, it's a fit and fine time to go motorcycle riding. So what does that have to do with electronic circuitry you might ask? Stick around and you'll see, as we share a number of simple electronic accessories that you can build to add to your cycling pleasure.

HEADLIGHT MONITOR

Our first entry, see Fig. 1, could help keep you from harm's way, and save you from a ticket at the same time. The headlight on most newer bikes is keyed on with the ignition switch to guarantee that you are never underway without your headlight being on.

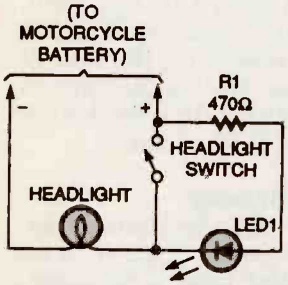


Fig. 1. With this simple circuit, you'll never again forget to turn your headlight on.

However, many older bikes have a factory headlight switch, and a growing number of the newer bikes are owner-modified in the same way. That switch is often added to lessen the load on the battery when starting up the bike, but the problem is that you must remember each time to turn the headlight switch back on before you get rolling. Riding without your light on will get you a ticket every time.

One solution is to add a simple headlight monitor like the one in Fig. 1. That circuit consists of just an LED and a current-limiting resistor wired across the headlight switch as shown in the figure. When the ignition is on and the headlight switch is off, the LED will glow. A super-bright jumbo-size LED (see Parts List) was chosen to be seen better in bright sunlight.

IMPROVED HEADLIGHT MONITOR

A second solution to the previously mentioned lights-off problem is shown in Fig. 2. In that circuit, a 555 IC timer is connected in a very-low-frequency oscillator circuit. That configuration adds an on/off flashing output to the LED and powers a piezo sounder that chimes in with a beep for each flash. When the ignition switch is on and the light switch is off, power is supplied to the 555 circuitry. The oscillator's frequency is set by the values of R1, R2, and C1 to about 1 Hz. Increasing the value of R2 or C1 will lower the oscillator's frequency and decreasing one of those values will increase the frequency. The IC's output at pin 3 drives the LED through R3 and sends

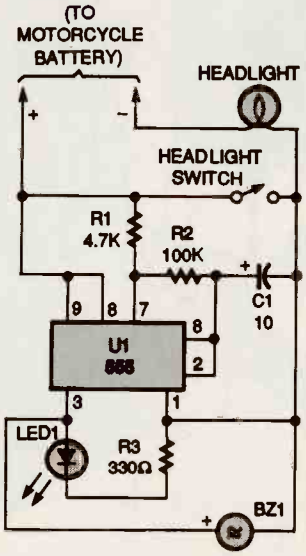


Fig. 2. If the LED in this circuit is flashing and the piezo sounder is buzzing, then your headlight is not on.

power to the piezo sounder.

Use a bright LED so that you will be able to see it in the daytime. If you use an LED other than the one specified in the Parts List, select a value for R3 that will allow the maximum-rated current of that LED to flow. Just divide the LED's maximum current into the supply voltage (12 volts) and use the nearest standard resistor value.

TUNE-UP AID

Our next item (see Fig. 3) can be a big help if you like to do your own carburetor tune-up and happen to own a newer twin-cylinder motorcycle that has an electronic ignition system. On the older twins, with the standard breaker-point ignition system, it was possible to just pull the spark-plug wire from one cylinder and make your carburetor adjustment on the running cylinder. You could then repeat the procedure for the other cylinder.

But on one of the newer bikes equipped with an electronic ignition system, pulling the plug wire with the engine running would blow the ignition coil. The reason is that the newer ignition systems generate a much higher voltage and, when there is no ground for the spark to jump to, the spark can jump between the coil's windings. If a carbon path is formed by an internal breakdown, the coil's output voltage will be greatly reduced and the coil could be ruined.

Our simple tune-up aid always supplies a gap and ground for the high voltage to jump to. In Fig. 3, a spark plug is shown mounted with nylon cable ties to one end of a ¼-inch thick piece of plastic or plexiglass (to provide adequate insulation).

Remove the ground gap tab located at the base of the spark plug. Make the fixed gap from a metal screw, or some similar item, and space it about 0.025 inches from the plug's end. Connect an end cap to the fixed gap and hold it in place with a couple of nylon cable ties. Also connect one end of a knife switch, S1, to the fixed gap and connect the other terminal to a grounding clip. Be sure that the knife switch has an insulated handle. Do

PARTS LIST FOR THE HEADLIGHT MONITOR (Fig. 1)

LED1—Jumbo light-emitting diode (Radio Shack 276-086 or equivalent)
R1—470-ohm, ½-watt, 5% resistor
Wire, solder, etc.

PARTS LIST FOR THE IMPROVED HEADLIGHT MONITOR (Fig. 2)

SEMICONDUCTORS
U1—555 timer, integrated circuit
LED1—Jumbo light-emitting diode (Radio Shack 276-086 or equivalent)

RESISTORS
(All fixed resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—4700-ohm
R2—100,000-ohm
R3—330-ohm, ½-watt

ADDITIONAL PARTS AND MATERIALS
C1—10-µF, 25-WVDC, electrolytic capacitor
BZ1—Piezo sounder
Wire, solder, IC socket, etc.

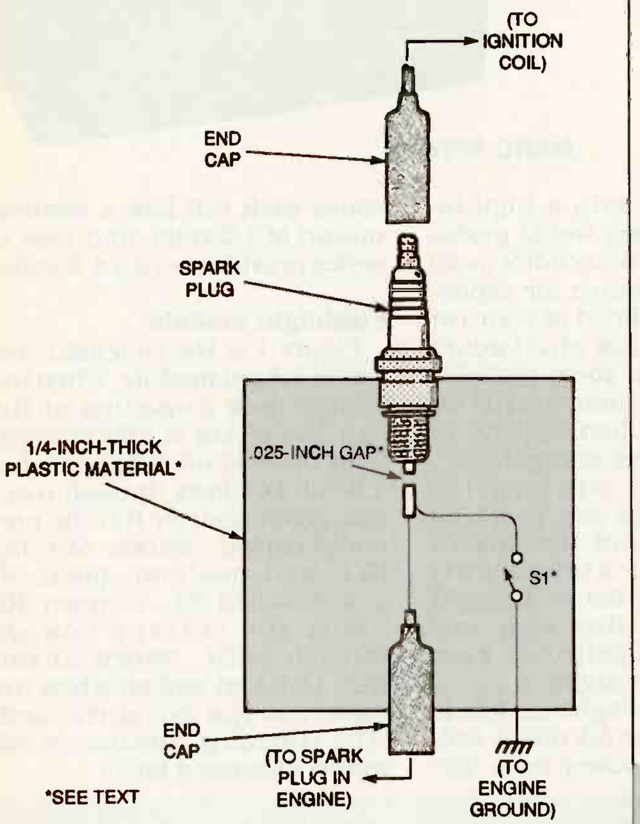


Fig. 3. Performing a tune-up on a newer bike is made a lot easier with this helpful circuit. Because of the high voltages present, make sure S1 has an insulated handle and that the fixture is grounded.

not use an old switch with a wood handle. It's no fun being the lightning rod for a high-tech ignition system!

With the ignition turned off, remove one of the spark plug wires and connect it to the spark plug on the fixture. Slip the fixture's end cap over the spark plug on the cycle and you're ready to go. Open S1 and start the engine. Then, close S1; the cylinder with the fixture should not fire and a spark should be seen at the fixed gap. Be sure that the fixture is connected to the engine ground.

BURGLAR ALARM

The simple burglar-alarm circuit shown in Fig. 4 will only cost a few bucks to build and could save your bike from being stolen or messed with. A 555 IC is connected in a one-shot timer circuit that turns on a FET transistor and either a siren or the bike's horn for a pre-set time period. S1 is used as an on/off switch.

Closing either of two switches, S2 and S3, will trigger the IC. When either switch closes, pin 2 of U1 goes low. That triggers the IC to produce a positive output at pin 3 and sounds the alarm for the time period set by R3. The mercury switch, S3, is the switch that activates the alarm should someone move your bike. Switch S2 can be used as a panic switch if you *(Continued on page 101)*

PARTS LIST FOR THE TUNE-UP AID (Fig. 3)

S1—Knife switch (see text)
Wire, solder, spark plug, hardware, end cap, plastic material (see text), etc.

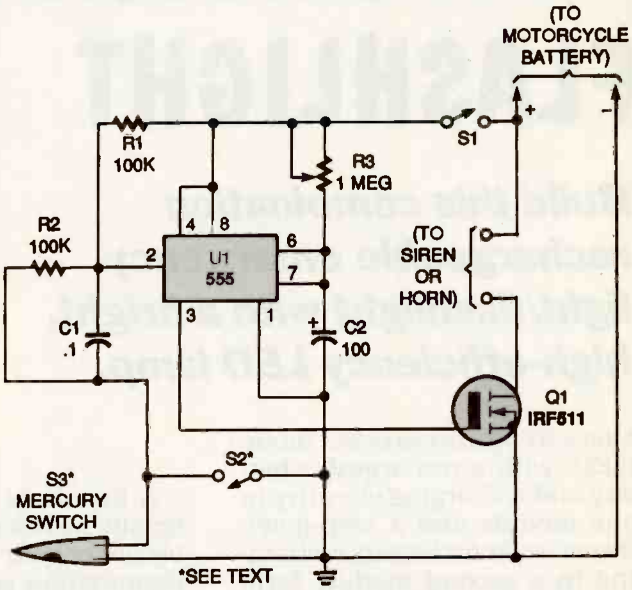


Fig. 4. Feel safer with this alarm circuit. When you're away, S3 makes sure no one touches your bike; when you're on it, S2 doubles as a panic switch.

PARTS LIST FOR THE BURGLAR ALARM (Fig. 4)

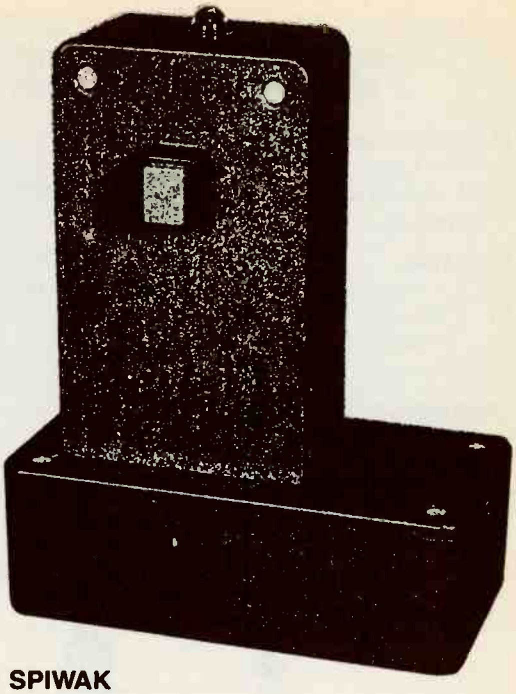
SEMICONDUCTORS
U1—555 timer, integrated circuit
Q1—IRF511 FET transistor

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1, R2—100,000-ohm
R3—1-megohm, potentiometer

CAPACITORS
C1—0.1-µF, ceramic-disc
C2—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1, S2—SPST switch
S3—Mercury switch
Wire, solder, IC socket, siren, etc.

AUTOMATIC RECHARGEABLE FLASHLIGHT



Build this combination rechargeable emergency light/flashlight with a bright, high-efficiency LED lamp.

MARC SPIWAK

A BRIGHT LIGHT-EMITTING DIODE (LED) with a rechargeable battery and recharging circuitry in one module and a step-down transformer for battery recharging in a second module form this unusual combination emergency light/flashlight, the subject of this article. The LED in the portable module turns on automatically when it is removed from the transformer module. Its light source is a high-intensity, aluminum gallium arsenide (AlGaAs) LED that can beam a saucer-sized red spot on a wall three feet away.

The Hewlett-Packard HLMP-8150 red, T4-size LED lamp emits a typical intensity of 15 candelas (cd) at 20 milliamperes. (This compares with about 4 millicandelas (mcd) from a typical gallium arsenide phosphide (GaAsP) red T1¾-size LED lamp.) See the sidebar "What is a candela."

The forward voltage of the LED is only 1.85 volts. It offers longer life and lower power dissipation and cooler operation than an incandescent lamp, the usual light source for most flashlights and emergency lights. Its clear, nondiffused, bullet-shaped lens focuses the light into a narrow, intense 4° beam. The LED's dominant red (637-nanometer) wavelength will not disturb the eye's adaptation to night viewing.

A flashlight with a high-intensity LED lamp would probably not be your first choice as an illumination source for exploring under the hood of your car at night to find out why it wont't start. Moreover, you'd probably find the light inadequate for searching for lost objects or summoning help at night.

However, it will provide enough light for you to read a roadmap or find the circuit breaker that kicked out, darkening your house. It might also help you find your way around a campsite, or even change a tire at night.

The LED flashlight module is powered by four AA nickel-cadmium (Ni-Cd) power cells. Because each cell has a nominal output of 1.2 volts, four cells in series provide about a 4.8-volts.

Flashlight module

Figure 1 is the schematic for the flashlight module. When the battery pack consisting of the four Ni-Cd cells is fully charged (and there is no voltage at J1), 4.8-volt DC flows through trimmer potentiometer R2, the normally closed contact of relay RY1, and push-on, push off power switch S1. Trimmer R2 limits the current flowing through LED1. Switch S1 can turn LED1 on and off when the battery is not being charged. (The trimming function of R2 will be discussed later.)

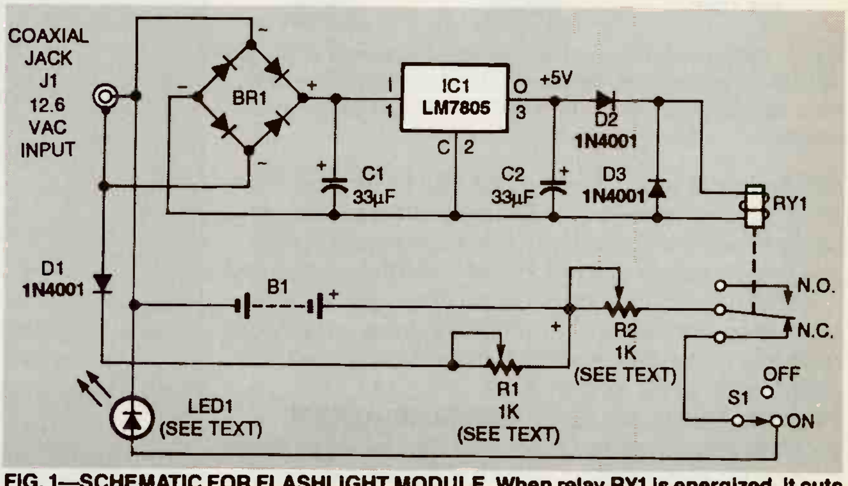


FIG. 1—SCHEMATIC FOR FLASHLIGHT MODULE. When relay RY1 is energized, it cuts the power to the LED; when power to the relay is removed, the LED lights.

If 12.6-volts AC is present at J1, it is full-wave rectified by bridge rectifier BR1. Capacitor C1 smooths the rectified AC ripple. Five-volt regulator IC1, a National Semiconductor LM7805, provides the 5-volt DC output.

This output, sustained by C2, energizes the coil of relay RY1, which opens the normally closed contacts. Diodes D2 and D3 stabilize the relay. When the NC contacts of the relay open, power to LED1 is cut off—even if S1 is in its ON position. The values of C1 and C2 in the prototype are 33 µF, but they are not critical values. Any capacitor from 20 to 40 µF would work.

When the relay is energized, AC power from J1 flowing through D1 is half-wave rectified to form a pulsed-DC output for charging the Ni-Cd cells. Potentiometer R1 limits the charging current to the cells. A voltage of 12.6 volts is enough to charge the 4.8-volt battery pack.

When the batteries are being charged, the relay is energized, inhibiting LED illumination. When charging current is removed, the relay provides a conducting path to the LED. Thus the LED turns on whenever the AC-line voltage is cut off if S1 is ON.

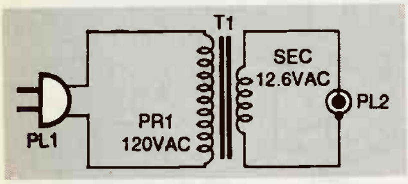


FIG. 2—SCHEMATIC for transformer module. The 12.6-volt output from coaxial plug PL2 powers the flashlight when it is mated with jack J1 on the transformer module.

Transformer module

Figure 2 is the schematic for the transformer module. Line voltage taken from a 120-volt AC outlet is transformed to 12.6-volt AC by transformer T1. The line cord is terminated with plug PL1, and the 12.6-volt AC appears at coaxial power plug PL2. The plug mates with coaxial jack J1 on the flashlight module for recharging. As long as the transformer module is plugged into the AC line, 12.6-volts AC appears. When PL2 is plugged into J1, 12.6 volts appears at J1.

Building the flashlight

Refer to Fig. 3. The modular case for the flashlight measures 4¾ × 2½ × 1⅜ inches, and has four raised round surfaces molded on its bottom surface that act as feet. Sand or file these bumps flush with the bottom surface so they will not interfere with the insertion or removal of the flashlight module from the transformer module.

Cut out an approximately ½-inch diameter hole in one end wall of the case to admit the LED lens and a second hole in the opposite end wall for jack J1, as shown in Fig. 3. When cutting the hole for the jack, be sure the center conductor rather than the body of the jack is centered on the end wall. Drill the two mounting holes for the jack.

Cut a piece of perforated construction board 3½ × 2¼ inches to fit snugly in the bottom of the case. Insert the electronic components for the flashlight on that board, and connect them by point-to-point wiring.

Mount LED1 on the end of the board, and solder it so that its leads can later be bent at right angles to permit the lens to extend through the hole in the case. Figure 3 shows the locations of the largest electronic components, but their locations are not critical.

Make only mechanical connections to potentiometers R1 and R2 so you can later put an ammeter in series with them to adjust both charging and LED forward current. Fasten the battery holder for four AA cells on the board with double-sided adhesive tape.

Cut a hole in the plastic cover,

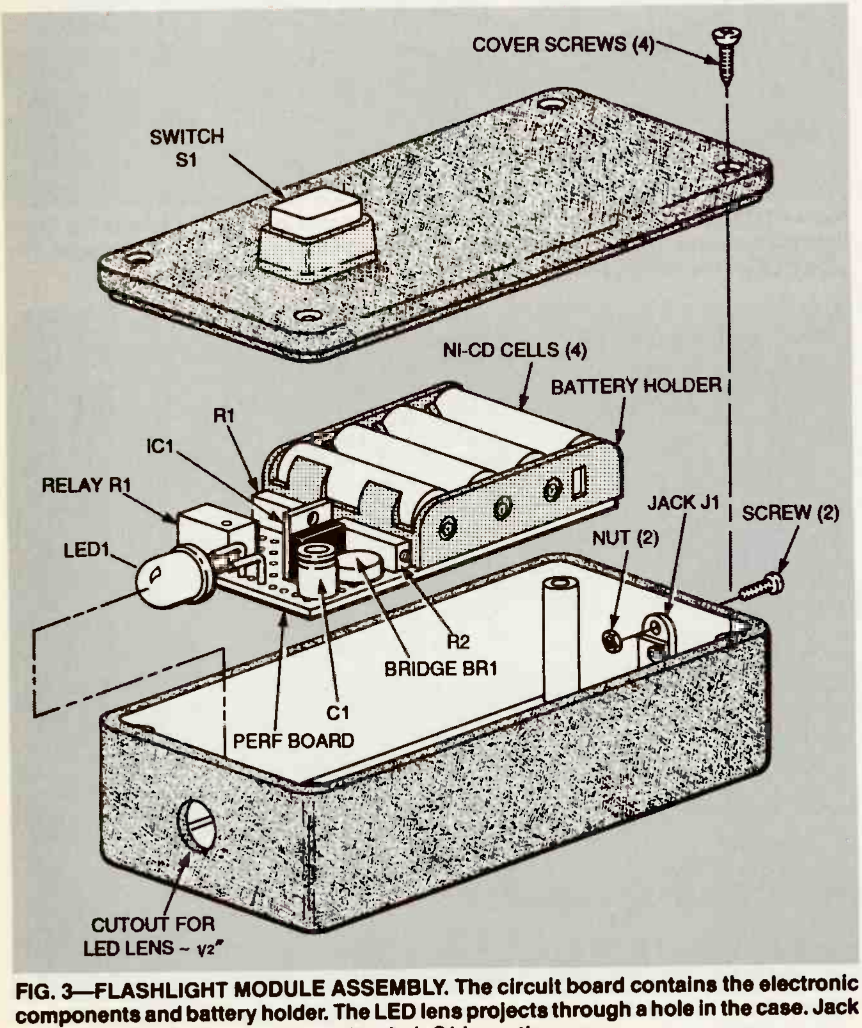


FIG. 3—FLASHLIGHT MODULE ASSEMBLY. The circuit board contains the electronic components and battery holder. The LED lens projects through a hole in the case. Jack J1 is at the other end of case, and switch S1 is on the cover.

and fasten the push-on, push-off switch S1 in position with a ring nut. Fasten jack J1 in the case with small screws and nuts.

Complete all of the wiring to the switch S1 and jack J1 according to schematic Fig. 1, allowing enough slack in the wires to permit the board to be removed for later adjustments. Fasten the circuit board to the bottom of the case with double-sided adhesive tape, and carefully bend the leads of the LED so that the lens projects through the end hole in the case.

Building the XFMR module

Refer to the transformer assembly drawing Fig. 4. Cut a ⅛-inch diameter hole at one end of a second plastic project case that measures 4¾ × 2½ × 1⅜ inches to admit the line cord terminated by line plug PL1.

Cut a rectangular hole that measures approximately 2⁹⁄₁₆

PARTS LIST

Resistors
- R1, R2—1000 ohms, multiturn potentiometer (A 1K resistor might be needed in series. See text)

Capacitors
- C1, C2—33 µF, aluminum electrolytic (see text)

Semiconductors
- IC1—LM7805 5-V regulator, National Semiconductor or equiv.
- D1–D3—1N4001 rectifier diode
- LED1—light-emitting diode, T-4 Hewlett Packard HLMP-8150 or equiv.
- BR1—1A bridge rectifier, Radio Shack 276-1161 or equiv.
- RY1—SPDT relay, 5-VDC, 90 mA coil, 55-ohm, Radio Shack 275-240 or equiv.

Other components
- S1—SPST switch, push on/push off, Radio Shack 275-1565 or equiv.
- B1—four AA Ni-Cd cells
- J1—coaxial power jack, Radio Shack 274-1565 or equiv.
- PL1—AC line cord
- PL2—coaxial power plug, Radio shack 274-1578 or equiv.
- T1—120/12.6 VAC, 300 mA, transformer, Radio Shack 273-1385 or equiv.

Miscellaneous: two project cases (seetext); perforated construction board; holder for four AA cells; adhesive pads, double-sided ashesive tape, screws and nuts; hookup wire; solder

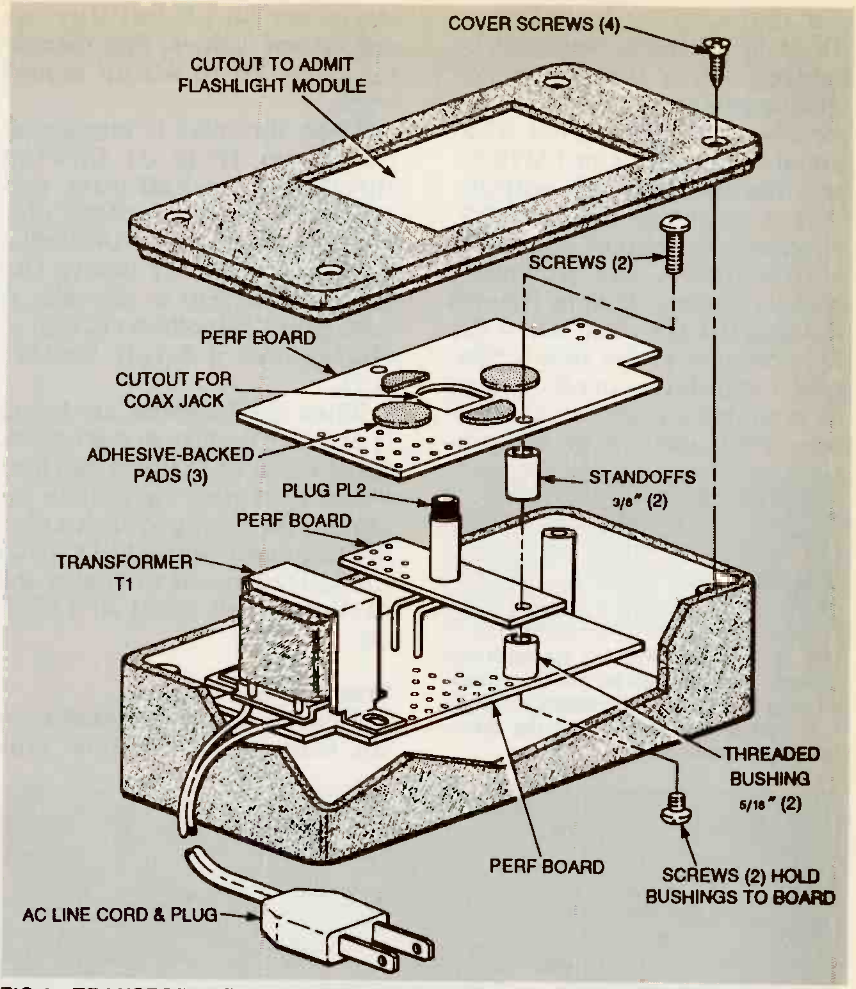
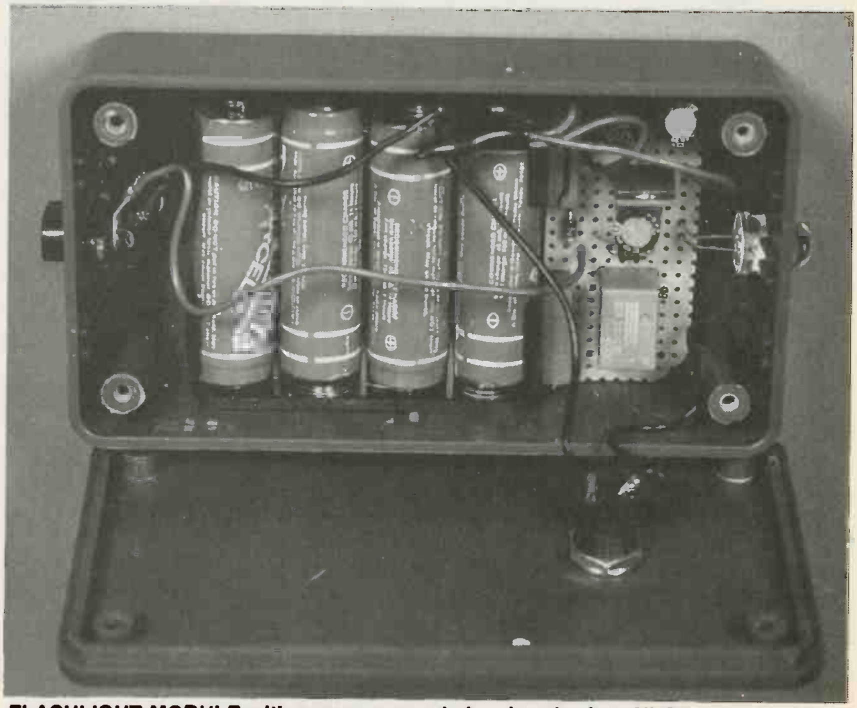


FIG 4—TRANSFORMER MODULE ASSEMBLY. A cutout in the cover admits the flashlight module. The upper board supports the flashlight when jack J1 is plugged into plug PL2 on the middle board. Transformer T1 is on the bottom board.



FLASHLIGHT MODULE with cover removed showing the four Ni-Cd cells, LED, and circuit components.

WHAT IS A CANDELA?

The amount of light produced by a light source is called *luminous intensity*. The standard for measuring luminous intensity is the *candela* (cd). It was formerly the *candle* based on the luminous intensity of a single wax candle. By comparison, a 40-watt light bulb has a luminous intensity of about 3000 candela.

The candela is the amount of light that shines out through a hole with an area of 1/60th of a square centimeter in one side of a ceramic box that has been heated to the temperature of molten platinum (1772°C). It is the basis for both the calculation of the *lumen* (lm) and the *footcandle*(fc).

A 1-cd light source produces a 1-lm light beam that provides 1 fc of illumination on a 1 ft^2 area located on a radius of 1 foot from the source (1 fc = lm/ft^2). The intensity of light falling on a surface varies inversely with the square of the distance between the source and the surface.

× 1⁹⁄₁₆ inches in the cover of the case so that it will admit the end of the flashlight module. Scribe the outline of the end dimensions of the case on the top of the cover with a sharp cutting tool, leaving a pronounced rectangular mark. Drill holes in the four corners and saw an "X" diagonally across the scribed marks with a fine coping saw. Snap off each of the four triangular-shaped pieces along the scored lines.

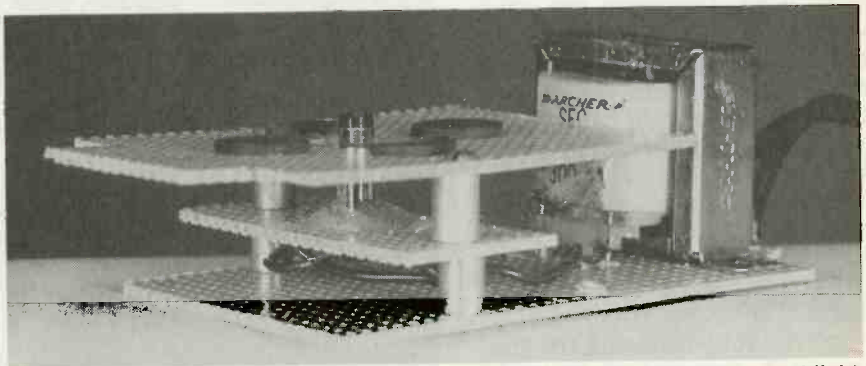
There are three perforated circuit boards in this module. The largest is positioned at the bottom of the case to support transformer T1, the middle one supports the plug PL2, and the upper one acts as a shelf and support for "docking" the flashlight module. These three boards will be fastened together to form a three-deck assembly with threaded bushings, standoffs, and screws.

Cut the large base board from perforated board 3½ × 2¼ inches. Notch out two corners of the board so it can be positioned against one end wall of the case without interfering with the internal posts.

Cut the small board from perforated board 2¼ × 1 inch to form the plug support. Drill a central ¼-inch hole to admit plug PL2 when the flashlight module is "docked."

Cut the upper deck from perforated board 2¼ × 3 inches. Notch out two corners at one end so it does not interfere with the posts at the other end of the case. Cut a ½-inch diameter hole in the center of the board to admit the outer shell of jack J1 when the flashlight module is "docked."

Stack the three boards as shown in Fig.4, and drill holes on each side through all three boards to admit screws so the boards can be fastened in a three-deck stack.



THREE-DECK ASSEMBLY in transformer module permits "docking" the flashlight module.

Fasten the power plug (PL1) in a vertical position in the middle of the board with hot-melt glue. Mount transformer T1 on the lower board near one end, as shown in Fig. 4.

Trim the ends of the wires in the line cord to expose about ⅛ inch of bare copper wire, and insert the cord through the hole in the case. Solder the leads to the primary terminals of T1. Cut two 5-inch lengths of insulated, stranded, hookup wire, and solder them to the secondary terminals of T1 and the terminals on plug PL2.

Assemble the three boards together to form the three-deck assembly. Fasten the lower threaded bushings to the top of the base board with screws from the underside of the board. Then assemble the second board on the bushings and place the top board in position with screws through the two standoffs.

When the assembly is complete, fasten it in the bottom of the case with double-sided adhesive tape. It can also be fastened with sheet metal screws through holes from the bottom of the case. Place adhesive-backed plastic pads around the central hole on the upper board to cushion the "docking" procedure.

Current adjustments

Adjust potentiometer R1 first. (Potentiometer R2 can't be adjusted accurately until the battery is fully charged.) Before you insert the batteries in the holder, set R2 so that its maximum resistance value is in series with the LED.

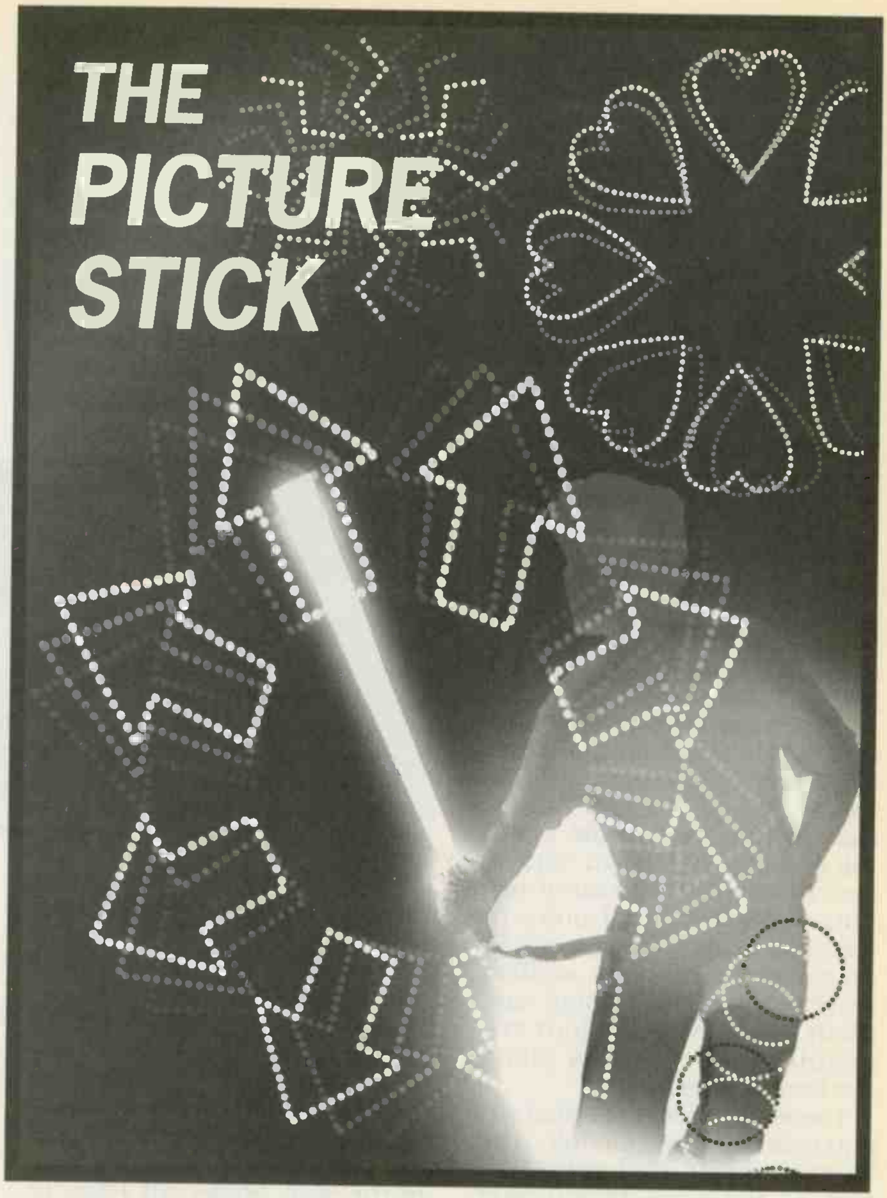
Charge the Ni-Cd cells slowly at a 45-milliampere rate for 45 hours, or fast charge them at 150 milliamperes for four hours.

Once the battery is fully charged, set R1 for a trickle charge of about 10 milliamperes by temporarily inserting an ammeter in series with R1. If the current can't be set low enough, insert a fixed 1-kilohm resistor in series with R1—or use a potentiometer with a higher resistance value. Once R1 is set, solder it permanently.

Adjust R2. The forward current through the LED should not exceed 30 milliamperes. Set the maximum forward current to 300 milliamperes and adjust R2 as was done with R1. If the current can't be reduced low enough, add a 1-kilohm fixed resistor in series with R2. Then solder R2 permanently.

Plug the charger into an outlet, and set S1 in its ON position. LED1 should light when the flashlight module is removed from the charging module and go off when it is in the charger module. You now have a nifty emergency light/flashlight. Ω

THE PICTURE STICK



SCOTT EDWARDS

ON A MILD SUMMER EVENING, YOU walk to the top of a small rise overlooking the park. In your left hand you carry a small circuit board and a battery pack and in your right hand you carry a wooden yardstick studded with LEDs. The two parts are connected by a short length of cable.

You connect the batteries to the circuit and the yardstick begins to glow with a flickering green light. People in the park below notice you now, and turn to watch. You wave the stick over your head and the flickering magically changes into images: stars, circles, diamonds. You watch the faces of the people below register amazement, delight, and curiosity. They come closer, smile and ask the question "How did you do that?"

You did it by building the Picture Stick, a project whose parts cost $35. It combines ICs and 16 LEDs, a yardstick, batteries, wire, and duct tape into a unique demonstrator of the visual principles underlying movies, television, and computer displays. Components preprogrammed with 15 images are available, but if you're creative, you can program your own images with a personal computer and free software.

Build the Picture Stick and light up the night with computer-generated graphics.

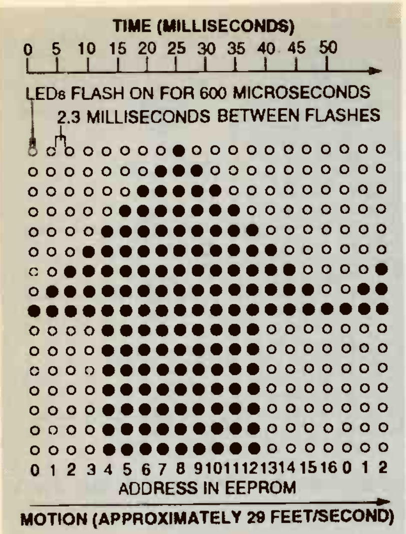
How it works

The Picture Stick consists of two major components: the control electronics and the "wand." The wand is just a wooden yardstick with 16 green LEDs spaced at 1-inch intervals near one end. The LEDs are wired to a ribbon cable that connects them to the controller. The controller turns on the LEDs at 2.3-millisecond intervals, in accordance with one of a series of patterns stored in memory. It leaves the LED pattern on for 600 microseconds, turns the LEDs off, waits another 2.3 milliseconds, loads the next pattern, and repeats the process.

As Fig. 1 shows, the individual LED patterns are pieces of a larger picture. Since the human eye briefly retains the images it sees because of an effect known as persistence of vision, the viewer's eye assembles the sequence of LED patterns into a composite image. Persistence of vision makes it possible for us to see movies and television as seamless, lifelike moving pictures. It also lets electronic circuit designers use fewer components to drive an LED display—only one digit of the display is on at any given instant, but the digits are scanned so rapidly that the eye sees them as a single, stable image. The Picture Stick takes that one step further, eliminating the additional displays in favor of a single moving column of LEDs.

Hardware

The controller, shown schematically in Fig. 2, has two



EEPROM PATTERN MEMORY

ADDRESS	DATA (16-BIT WORDS)
0	0000000010000000
1	0000000110000000
2	0000001110000000
3	0000011110000000
4	0000111111111111
5	0001111111111111
6	0011111111111111
7	0111111111111111
8	1111111111111111
9	0111111111111111
10	0011111111111111
11	0001111111111111
12	0000111111111111
13	0000011110000000
14	0000001110000000
15	0000000110000000
16	0000000010000000

FIG. 1—INDIVIDUAL LED PATTERNS are pieces of a larger picture.

modes: display and download. Assume that there is a series of images stored in IC1 as the display function is described here.

The PIC16C55 microcontroller (IC2) is a self-contained computer with onboard read-only memory (ROM) for permanent program storage and random-access memory (RAM) for storing temporary variables. The chip also includes logic for addition, subtraction, and decision operations. Program control operators allow the programmer to create and call subroutines, or change the order of program execution. The microcontroller in the wand controller has ROM for 512 instruction steps, 24 bytes of general-purpose RAM, and 20 input/output pins.

The wand program is written in assembly language, and is available from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) as part of the file WAND.ZIP. A programmer for PIC16C5X devices was described in the January 1994 issue of *Electronics Now*. Commercial programmers are also available.

The PIC has three sets of input/output pins: ports RA, RB, and RC. Through RA, the PIC retrieves pattern data from storage in EEPROM IC1 in 16-bit words. The PIC writes these patterns to ports RB and RC. Each of those output ports is connected to a ULN2803 Darlington inverter/driver (IC3 and IC4).

When a pin of port RB or RC outputs a logic 1 (+5 volts) to the connected driver, the driver grounds the cathode (negative end) of the corresponding LED. Since all of the LED anodes are wired to the positive supply, this lights the LED. Resistors R6 through R21 limit the maximum current through the LEDs to about 64 milliamperes. The LED current is calculated by the supply voltage, minus the LED's forward voltage drop, plus the driver's voltage drop, divided by the series resistance calculated as: $(6-(2+1))/47 = 63.8$ milliamperes.

The PIC lights the LEDs

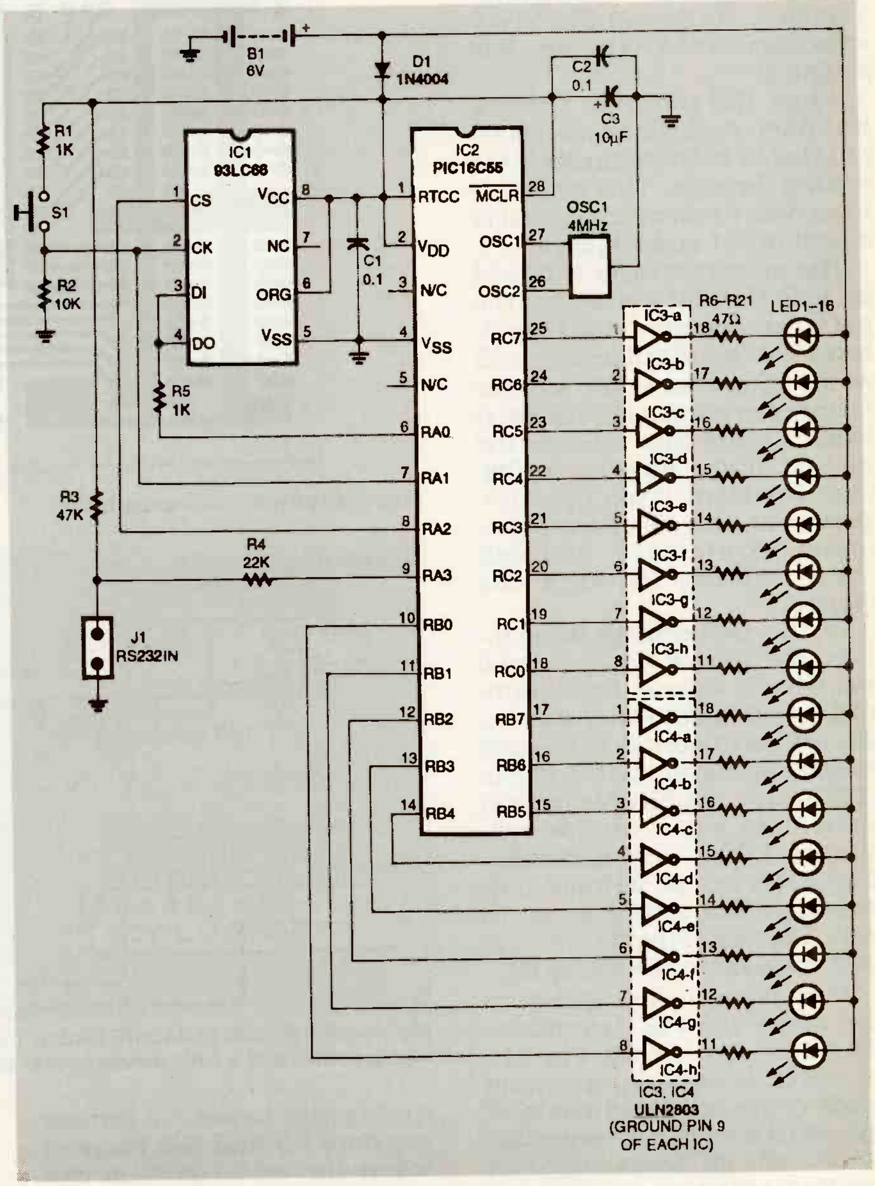


FIG. 2—THE CONTROLLER HAS TWO MODES: display and download.

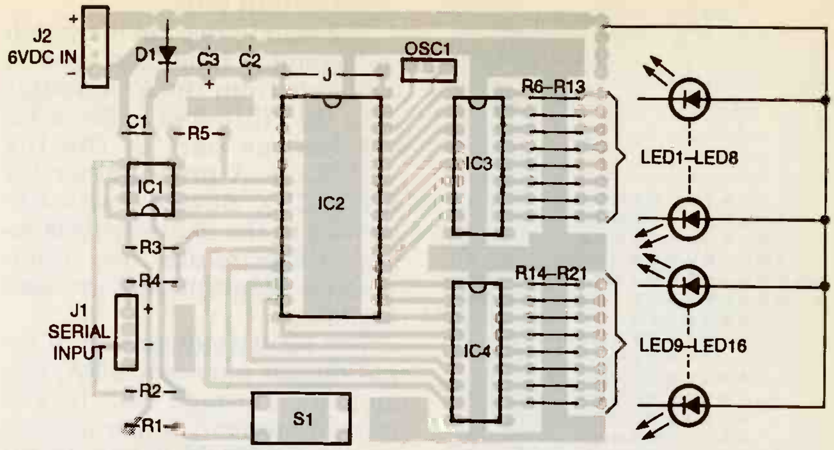
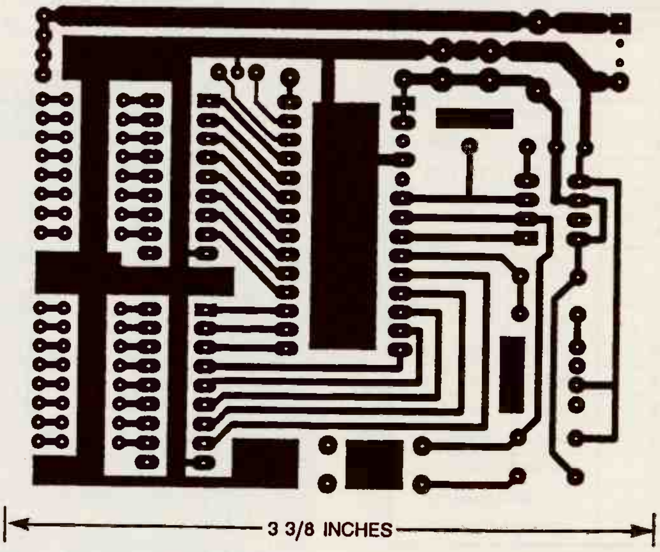


FIG. 3—PARTS-PLACEMENT DIAGRAM. Install sockets for IC1 and IC2, but don't insert the ICs into the sockets until tests are complete.



FOIL PATTERN for the Picture Stick.

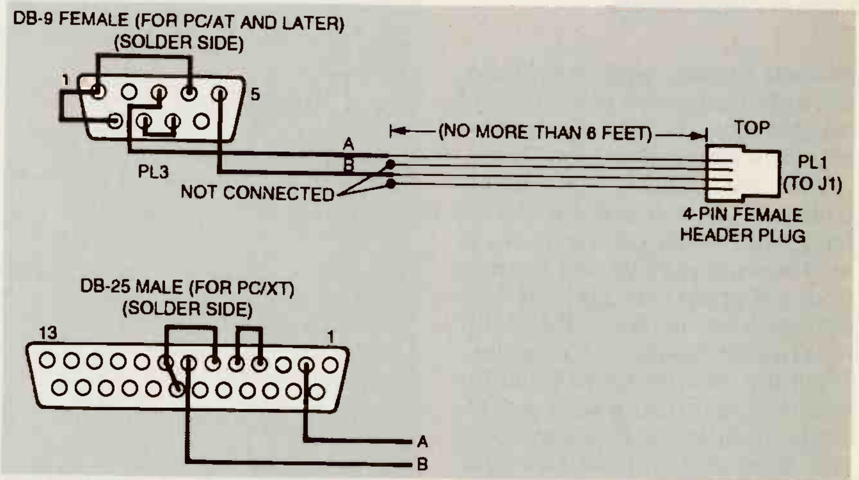


FIG. 4—SERIAL DOWNLOADING CABLE. Install a DB-25 male connector on one end of this assembly and a 4-pin female header plug on the other end.

based on the 16 bits of data it retrieves from IC1, then turns all LEDs off 600 microseconds later. It then waits 2.3 milliseconds, loads another 16 bits, and flashes the LEDs again. It repeats this process—cycling through 17 addresses of 16 bits each—to create the basic 16-row by 17-column image.

Periodically the PIC checks pin RA1, which is connected to pushbutton switch S1. When S1 is open, RA1 sees a logic 0 because resistor R2 pulls it to ground. When S1 is closed, RA1 sees the voltage divider formed by R1 and R2. Assuming that the positive supply is 5 volts, the voltage drop across R1 becomes 5(R1/(R1 + R2)) = 5(1000/11,000) = 0.45 volts. Therefore, RA1 sees 4.55 volts (5 volts minus 0.45 volts, which is a logic 1).

When the program detects this high (the logic 1), it adds an offset of 17 to the addresses it is cycling through. This causes it to retrieve the next image that is stored in IC1 and display it.

The microcontroller can hold up to 256 16-bit words, but the patterns occupy only 15 pictures × 17 words/picture = 255 words of memory. The leftover memory location isn't wasted; it holds a value that controls the highest frame number to display. Therefore, if you have programmed only 5 of the maximum 15 pictures, you can avoid cycling through the blanks.

In the preceeding description, the role of IC1, the serial electrically erasable/programmable ROM (EEPROM) was neglected. As in normal ROMs and erasable/programmable ROMs (EPROMs), EEPROMs retain their data when unpowered. Unlike ROMs and EPROMs, EEPROMs can be written to or erased while in an operating circuit. Therefore, the PIC can update the data in the EEPROM.

When power is first applied to the wand, the PIC determines whether the wand should switch to its standard operating mode or its download mode. If the serial port is not connected to a PC, the PIC sees a logic 1 on pin RA3, which is connected to the positive power rail through resistors R3 and R4. However, when the serial port is connected, its resting voltage of −10 volts is impressed on the junction of R3 and R4. Pin RA3 sees that voltage as a logic 0. So, upon startup, the PIC executes

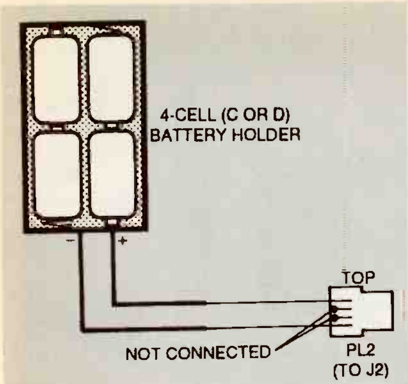


FIG. 5—BATTERY HOLDER WIRING. DC power is connected to the PC board at J2.

the display program if RA3 is 1, and the download program if RA3 is 0.

Once in the download mode, the PIC handles two types of serial communication: synchronous and asynchronous. Communication with the EEPROM takes place over a synchronous or "clocked" serial connection, while the PC serial port is an asynchronous or "unclocked" connection. The basic difference between the two is that synchronous communication requires at least two signals, data and clock, while asynchronous communication requires only a data signal.

Synchronous connections operate on a simple principle: A data bit is valid only at an instant in time defined by some feature of the clock signal. The rest of the time, the receiver can ignore the data signal. In the case of the EEPROM, the data line is valid only on the rising edge of the clock signal; that is, when the clock line is changing from a logic 0 to a 1. (The EEPROM also has a chip select (CS) line. When this line is 0, the EEPROM effectively disconnects itself from the circuit. (This is a standard feature of devices that are intended to share a bus, not a part of synchronous communication.)

Synchronous communication has three virtues: First, it can be implemented with simple edge-triggered flip-flops. Second, it is independent of time. Bits can arrive at intervals of a microsecond or a week; only the state of the clock line determines when a bit is valid. Third,

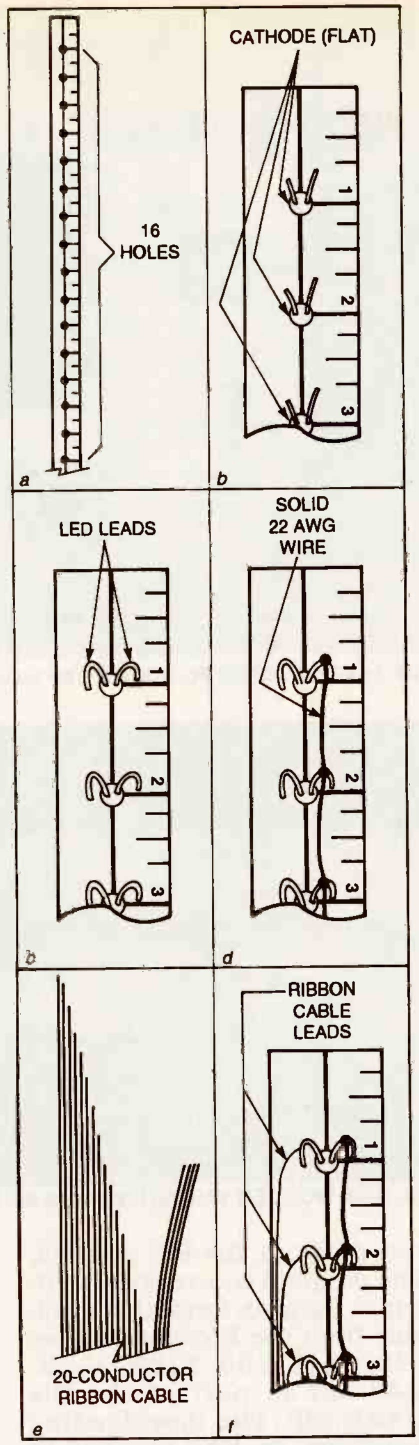


FIG. 6— HOW TO MAKE THE WAND. Drill 16 holes for the LEDs down the center of a wooden yardstick starting at the 1-inch mark (see text).

it does not require the additional start and stop bits associated with asynchronous communication (described below).

The primary disadvantage of synchronous communication is the need for a clock signal. In many cases, such as in this EEPROM, it just means one extra connection on the circuit board. But imagine a synchronous version of the standard telephone modem. It would require two phone lines, one for data and one for the clock signal.

Asynchronous connections work on a more complex principle: After receiving a start bit, the receiver expects a fixed number of data bits at fixed intervals of time, followed by a stop bit that is opposite in polarity to the start bit. The use of start and stop bits makes an asynchronous link less prone to timing errors. Look at it this way: at 1200 bits per second, a bit occupies an 833-microsecond slice of time. With start and stop bits, the sender and receiver can have a combined error of ± 416 microseconds (half a bit) over the time required for 10 bits (8.33 milliseconds). That's a total permissible timing error of 5%; 2.5% for the sender and 2.5% for the receiver. An alarm clock with that accuracy could be off by almost an hour a day!

Without start and stop bits, timing would become increasingly critical with increases in message length. Ultimately, even the most precise timing devices known would be unable to maintain synchronization.

Now that you know how these two forms of communication work, understanding the download process is easy. The PIC is programmed to receive data at 1200 bits per second (bps). At startup, if the PIC detects a serial port connection, it waits for a start bit. When one arrives, the PIC waits 1½ bit times (1.5(1/1200) = 1.25 milliseconds) to receive the first data bit. By waiting until the middle of the first data bit, it gains a little extra safeguard against timing errors. After the first bit, it receives the remaining seven data bits at 1-bit-time intervals (833 microseconds).

During the stop bit that follows each byte, the PIC stores the received data in its own RAM. Every second byte, it synchronously writes a 16-bit word consisting of the last two received bytes to the EEPROM. Because the synchronous connection with the EEPROM is very fast, the PIC can send all 16 bits (plus 3 bits of instruction code and an 8-bit address) in less than the time required for the stop bit. As a visual check of the progress of a download, the PIC also writes the 16 bits of data to ports RB and RC, causing the LEDs to flash in the patterns of the incoming data.

When the PIC has received 512 bytes of data from the PC and stored them as 256 16-bit words in the EEPROM, it stops "listening" to the serial port and switches to the display mode.

The operation of the major components of the wand have been explained, but what about the "bit players?" Diode D1 has a small but important role: its forward voltage drop of approximately 0.7 volts reduces the 6 volts from the battery pack to around 5.3 volts to supply the PIC and EEPROM. Since these devices will operate from voltages ranging from 4.5 to 5.5 volts, a well-regulated supply isn't required.

The rapid switching of the LEDs and the lack of voltage regulation subject the ICs to noise on the power-supply rails. Capacitors C1, C2, and C3 filter this noise.

Finally, OSC1, a ceramic resonator, sets IC2's internal clock to 4 MHz. Since IC2 executes an instruction every fourth clock cycle, in this circuit it executes 1 million instructions per second. Ceramic resonators are similar to crystal resonators, but they are generally cheaper, less fragile, and less accurate. The unit specified here is accurate to better than 1%, which is good enough to receive 1200-bps serial data reliably.

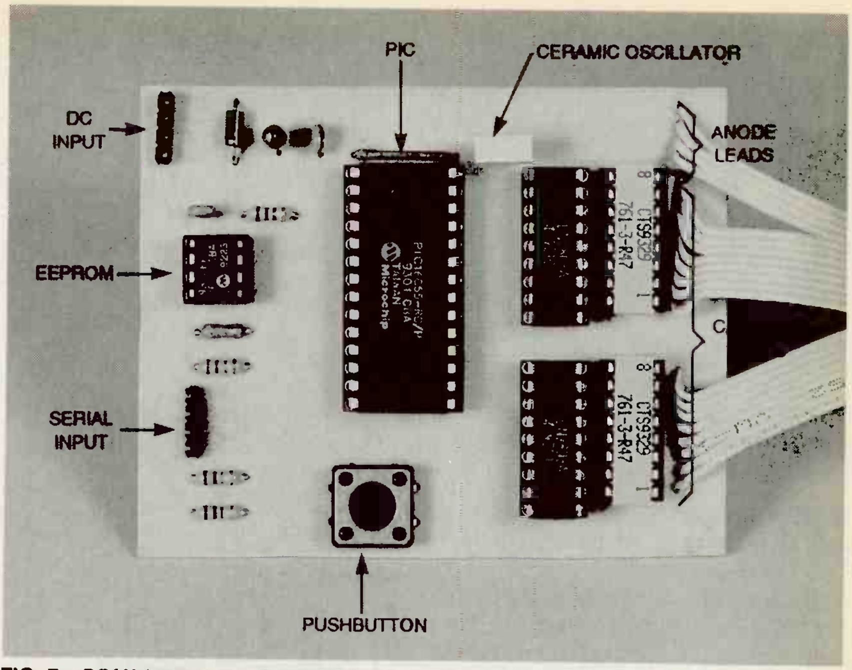


FIG. 7—COMPLETED PC BOARD. The board can be installed in a case of left as-is.

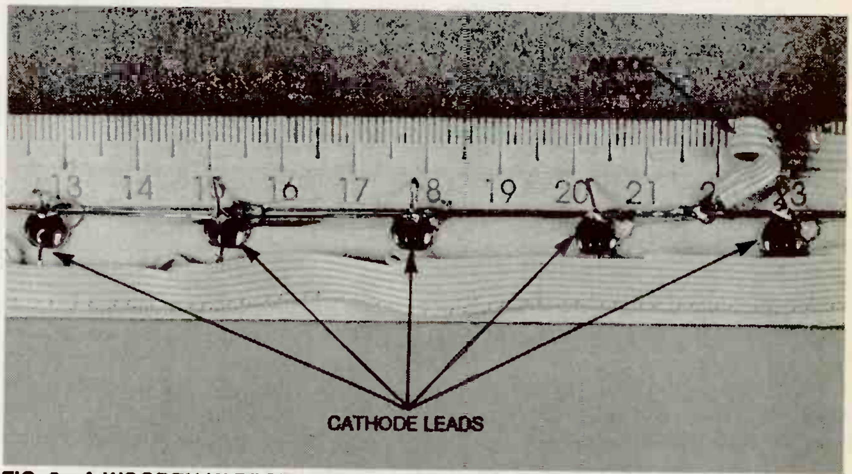


FIG. 8—A WOODEN YARDSTICK forms the body of the wand.

Construction

Begin by obtaining the components in the Parts List. Be sure that IC1 is a 93LC66 manufactured by Microchip Inc. There are subtle differences in other manufacturers' parts with the same part number that make them unusable in this circuit. If you have the necessary programming hardware, you can program the PIC yourself. The program source code (written in Parallax format) is available from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) as part of the file WAND.ZIP. The downloading programs, as .EXE files and in QBASIC format, are also part of the ZIP file.

You can substitute practically any standard, inexpensive LEDs for the green ones used in the prototype. Since LEDs are commodity items these days, you should briefly connect a sample LED to 6 volts DC through a 47-ohm resistor. If it is initially bright, then seems to fade, it is probably overheating. Disconnect the power immediately, and either substitute a higher value resistor (found by experimentation) or a different LED.

After you have obtained the parts, you can either make a printed circuit board from the foil pattern provided, purchase one from the source given in the Parts List, or point-to-point wire the circuit on perforated construction board. The LEDs on the wand section must be hand-wired, so hand wiring the rest of the circuitry shouldn't be a problem.

If you use a PC board, mount the components as shown in Fig. 3. The order of installation isn't critical. Use sockets for IC1 and IC2. Don't forget to install the single jumper wire near the top end of IC2. Leave IC1 and IC2 out of their sockets on the controller board for the time being. Install them during the checkout and final assembly steps given below.

Figure 4 shows how to assemble the serial downloading cable. This allows you to transfer new light patterns to the Picture Stick from your PC. A DB-25 male connector is attached to one end of this assembly, and a 4-pin female header plug is attached to the other end (two pins of this plug are not used). The plug connects to the 4-pin header (J1) on the circuit board. Instructions for wiring the battery holder are given in Fig. 5.

Figure 6 shows how to make the wand. Start by drilling 16 13/64- or 1/4-inch holes down the center of a wooden yardstick, starting at the 1-inch mark, and ending at the 16-inch mark (Fig. 6-*a*). Push each LED into each hole with its cathode (the flat side of the reflector) facing one side of the stick (*b*). Trim the leads to a length of approximately 3/8-inch and bend them into a "U" shape, and push the ends into the wood (*c*). Connect all of the anodes together by soldering them to a piece of solid 22 AWG wire (*d*). Next, starting at the colored stripe, separate the first 16 conductors of a piece of 20-conductor ribbon cable to a length of about 2 feet (*e*). (The last four conductors remain attached, and the stripped ends are twisted together at the yardstick end to form one heavier gage wire for the return current.)

Leave the colored wire full-length, and trim each successive lead 1 inch shorter than the previous one. Trim about 8 inches off the four wires that remain connected together. Strip and tin the ends of all 20 wires. Solder the staggered ends of the ribbon cable to the cathodes of each LED. The colored wire goes to the LED at the end of the yardstick (LED16 at the 1-inch mark), and each successively shorter lead goes to the cathode of the next LED. Solder all four of the remaining wires to the middle of the wire that connects the anodes of the LEDs. Secure the ribbon cable to the yardstick with duct tape, nylon wire ties, or other suitable fasteners.

Now solder the stripped wires at the other end of the ribbon cable to the PC board. Start by soldering the colored wire (it goes to LED16) to the pad that connects to R21 (it's the pad on the lower-right side of the board). Solder the remaining wires to the pads in order, working toward the top of the board. Four pads are provided for the four wires that are to be soldered together at the wand end. Figure 7 shows the completed PC board, and Fig. 8 shows a section of the wand.

PARTS LIST

All resistors are 1/4-watt, 5%, unless otherwise indicated.

R1, R5—1000 ohms
R2—10,000 ohms
R3—47,000 ohms
R4—22,000 ohms
R6–R21—47 ohms (alternately, you can use two 16-pin, 47-ohm DIP resistor networks)

Capacitors

C1, C2—0.1 µF, 50 volts, ceramic disk or monolithic
C3—10 µF, 16 volts, electrolytic

Semiconductors

IC1—93LC66 512-byte serial EEPROM (Microchip—do not use the same part from a different manufacturer)
IC2—PIC16C55 microcontroller, programmed with wand firmware (Microchip)
IC3, IC4—ULN2803A Darlington inverter/driver
OSC1—PX400 4-MHz ceramic resonator with integral capacitors (Panasonic)
D1—1N4004 diode
LED1–LED16—T 1 3/4 LEDs (the color choice is yours)

Other components

S1—Momentary-contact pushbutton switch (Digi-Key P8034S mounts directly to circuit board)
J1, J2—4-pin single-row male header
PL1, PL2—4-contact IDC female header plug
PL3—Female DB-9 connector (PC/ATs and later) or male DB-25 (PC-XTs)

Miscellaneous: Battery holder (4 C- or D-cells), PC board, one 8-pin IC socket, one 28-pin IC socket, 9 feet of 20-conductor ribbon cable, solder, hookup wire, inexpensive wooden yardstick, duct tape.

Note: The following items are available from Scott Edwards, 964 Cactus Wren Lane, Sierra Vista, AZ 85635:

- **Pre-programmed PIC16C55 microcontroller (IC2) and ceramic oscillator (OSC1)—$20**
- **93LC66 EEPROM with preloaded images (IC1)—$7**
- **3 1/2-inch PC compatible disk with the downloading software (5 1/4-inch disks not available)—$7**
- **A kit consisting of IC1–IC4, OSC1, the disk, and a PC board—$42**

All prices are postpaid; check or money order only.

- **Tools for programming PIC microcontrollers are available from Parallax Inc, 3805 Atherton Road, Rocklin, CA, 916-624-8333.**

Checkout

With both IC1 and IC2 out of their sockets, connect the batteries to the power input. Strip both ends of a short length of solid hookup wire, and insert one end into pin 1 of IC2's 28-pin socket. Touch the other end of the wire to pin 10 of the same socket to determine if LED16 (the one at the end of the wand) lights. Move the pin-10 end of the wire to pins 11 through 25. The LEDs should light up in sequence. If any of the LEDs fails to light, recheck your work and correct any errors.

After you have confirmed that all LEDs work, disconnect the power from the circuit and install IC2 (the 28-pin PIC). Leave IC1 out of its socket for now. Reapply power to the circuit. The LEDs should light up. Dim the lights and wave the wand around carefully. The LEDs should appear as a ribbon of dots. If the LEDs don't light, or if there are breaks in the dot pattern, bridge pins 8 and 4 of IC1's socket and try again. If this doesn't correct the problem, remove the power from the circuit and recheck your wiring. Once you have the test pattern working properly, bridge pins 4 and 5 of IC1's socket. Now the LEDs should all be off.

Disconnect power and install IC1 in its socket. If IC1 is purchased pre-programmed (from the source in the Parts List), you can power up the wand and check out the preprogrammed images. If not, you must download some images, as described further on.

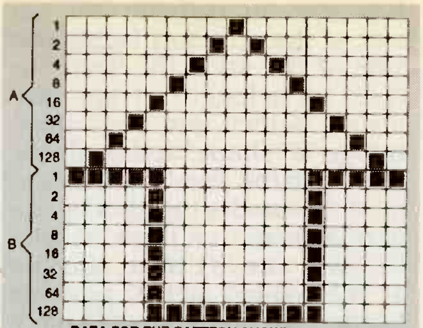
To observe the pre-programmed images, take the wand, controller, and batteries to a place you can dim the lights and swing the wand around without danger of damaging property or hurting anyone. Apply power to the controller and swing the wand back-and-forth. If the image appears compressed horizontally, swing the wand a little faster. To change images, press and release S1. To switch rapidly, hold S1 down. If you are demonstrating the wand to someone else, you will find that you can monitor the images from the back of the wand (some light from the LEDs can be seen from the back).

The batteries and controller are kept separate to keep the wand as lightweight as possible for safety reasons. Use common sense; carelessly swinging the wand around in the dark could hurt someone. Supervise children using the wand. (No sword fights! No running!)

Downloading images

To download images to the controller, you'll need the software from the source given in the Parts List or from the *Electronics Now BBS*. The program comes in two flavors: One is graphical and allows you to edit, save, and download pictures simply and easily. The other is a bare-bones downloading program that requires that you calculate the data manually and enter it into a text file. The graphical version requires a VGA monitor; the manual version works in a pure text mode, and it has no special requirements.

Downloading is simple, but it requires a specific sequence. Remove power from the controller. Connect the download cable to the COM1 port on your computer with the computer off. Then turn the computer on. Connect PL1 to the J1 header on the controller board.



DATA FOR THE PATTERN SHOWN:

0,1,128,1,64,1,32,1,16,255,8,128,4,128,2,128,1,128,2,128,4,128,8,128,16,255,32,1,64,1,128,1,0,1

PROCEDURE:

1. MARK THE SQUARES THAT MAKE UP YOUR PATTERN.
2. FOR THE FIRST COLUMN, ADD UP THE "A" ROW NUMBERS CORRESPONDING TO THE MARKED SQUARES. RECORD THIS NUMBER. DO THE SAME FOR THE "B" ROWS. VALID NUMBERS WILL BE BETWEEN 0 AND 255.
3. REPEAT THIS PROCEDURE FOR EACH OF 17 COLUMNS. WHEN YOU'RE DONE WITH A PATTERN, YOU SHOULD HAVE 34 NUMBERS.
4. REPEAT THIS PROCESS FOR AS MANY PATTERNS AS YOU DESIGN.
5. USING A TEXT EDITOR (LIKE EDIT THAT COMES WITH DOS5 AND LATER) OR WORD PROCESSOR CAPABLE OF SAVING A PLAIN TEXT FILE, TYPE IN THE NUMBERS SEPARATED BY COMMAS. EXAMPLE: 193,255,0,17,111... YOU MAY BREAK THE DATA INTO MULTIPLE LINES, BUT DON'T END A LINE WITH A COMMA.
6. IF YOU HAVE ENTERED FEWER THAN 510 NUMBERS (15 PATTERNS), PAD THE FILE WITH ZEROS (0,0,0,0,0...) UNTIL YOU HAVE 510 NUMBERS OR MORE. (THE DOWNLOADER IGNORES EXTRA ENTRIES.)
7. SAVE THE FILE.
8. RUN THE PROGRAM WAND_NO AND FOLLOW THE PROMPTS TO DOWNLOAD YOUR PATTERNS TO THE WAND. IF YOU HAVE BLANK PATTERNS, BE SURE TO ENTER THE HIGHEST FILLED-IN PATTERN (FRAME) NUMBER WHEN THE PROGRAM PROMPTS YOU TO. FRAMES ARE NUMBERED 0 TO 15.

FIG. 9—TO PREPARE DATA for the manual downloader, work out your patterns on graph paper, calculate the corresponding numeric values, and enter them into a text file.

Boot the downloading software (WAND for those with VGA monitors; WAND—NO for those without) and load the included image file SAMPLE.WND. Now apply power to the controller. The LEDs should remain dark. Follow the on-screen instructions to perform a download. The LEDs will flash brightly; they are displaying each incoming pair of data bytes. Downloading takes a little more than 4 seconds; after that, the wand will be active in its normal display mode. Remove power from the wand and remove the downloading connector. The images are now programmed into non-volatile EEPROM storage. Whenever you power up the wand from now on, you'll see the downloaded images.

When the controller is working properly, finish the assembly for a neat appearance. The wand can be encapsulated in clear acrylic plastic or covered with a large-diameter length of clear heat-shrink tubing. You can also leave everything as-is.

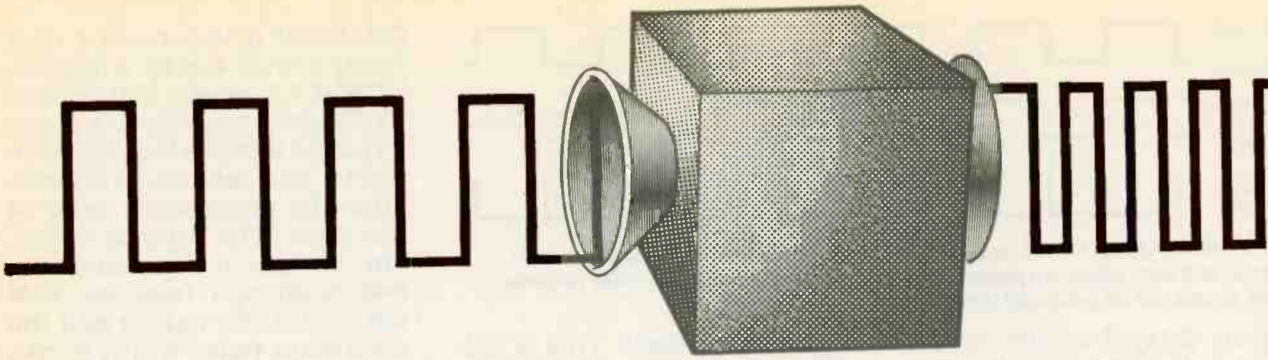
Designing your own images is fun and creatively satisfying. It's a great project for kids. If you have a VGA monitor, make use of the graphical editor (WAND). Move a cursor around a grid of dots with the keypad arrow keys, and toggle individual dots on and off with the spacebar.

Preparing data for the manual downloader (WAND—NO) is more complicated, but educational. Work out your patterns on graph paper, calculate the numeric values, and enter them into a text file. The process is shown in Fig. 9.

You may have noticed that all of the sample images are symmetrical left to right; stars, circles, arrows, etc. That allows you to swing the wand left-to-right and right-to-left and get the same image.

If you choose to create asymmetrical pictures, you must use a different technique to display them. Swing the wand rapidly in one direction, then slowly return it to the starting point. This will prevent viewers from seeing a reversed afterimage of your picture. Remember, you are the mechanical part of the display. If you find this inconvenient, you could modify the wand as follows: Wire a normally closed pushbutton between the controller and the LED anodes. Be sure the switch you select can handle current pulses of nearly 1½ amperes. With this switch in line, you can swing the wand to display your images, and press the button to blank the display while you prepare for another swing.

Another possible modification would be to make a continuous display of the wand's images by mounting the LEDs on a large rotating wheel, or by building a pendulum. Ω



FREQUENCY DOUBLER

Double the frequency of any CMOS or TTL clock signal with this easy-to-build doubler circuit.

JOHN J. YACONO

A UNIVERSAL FREQUENCY-DOUBLING circuit will come in handy in your home shop or on the job. The subject of this article is the construction of a simple circuit that will double the frequency of a digital clock input and be independent of input frequency.

The entire circuit is based on a quad EXCLUSIVE-OR (XOR) gate whose output is 1 (logic high) if any but not more than one of its inputs is 1. The output is 0 if more than one input is 1 or if all inputs are 0. You can make a doubler circuit based on either the CMOS CD4070B or the TTL 74386 because these quad XOR devices are pin-for-pin compatible. A 14-pin socket will permit the devices to be interchanged.

Before discussing construction, some background information on a practical application for the frequency doubler should be helpful, and its theory of operation will be explained.

Consider this situation: You are troubleshooting a digital circuit with a digital logic analyzer and you see that the logic analyzer latches data on the same edge of the clock pulse each time a clock pulse arrives. If you set the analyzer to latch data on the rising edge of a clock pulse, the plot of the clock data will show a constant high. However, if you set the analyzer to latch data on falling transitions, the clock data will appear continuously low. Unfortunately, after you select the desired edge for triggering, you can view only half of the circuit activity and none of the clock transitions.

It is easy to see that under certain circumstances the logic analyzer would be useless. This situation could occur when troubleshooting a microprocessor or microcontroller circuit whose data is latched on one clock transition, processed, and then transmitted on the opposite clock transition.

If you were to view only data collected as it is presented for input or output, it would be impossible to determine if a malfunction were caused by signal-path propagation delays, device propagation delays, settling time, or incorrect processing. Of course, you must distinguish between those three causes to correct them. A digital frequency-doubler that can provide clock pulses for either rising or falling clock pulses (and still remain in-step) would be invaluable.

Operational theory

Propagation delay, a key characteristic of logic gates, is significant in any logic application. It is the time required for a change of logic at the input of a gate to affect the logic at its output. The longer the propagation delays of transistors in a signal path, the longer it takes to produce a usable result. It follows that integrated circuit designers are always trying to minimize propagation delays.

Ironically, a delayed clock signal can be useful in this frequency-doubler circuit. The output of an XOR gate is low when its inputs are equal, and high when its inputs are unequal. Consider what would happen if both a clock pulse and a

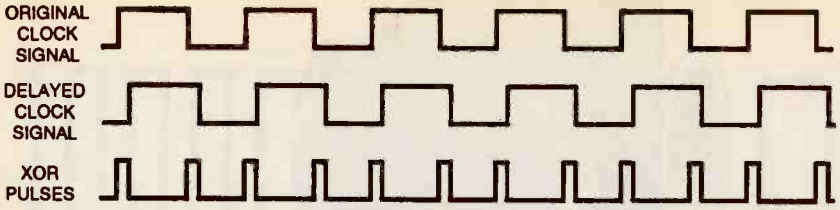


FIG. 1.—IF A PULSE TRAIN (top) is delayed to produce a second pulse train (middle) and both trains are passed into an XOR gate, a pulse train with variable-width pulses will be produced (bottom).

slightly delayed version of the same pulse are applied to the inputs of an XOR gate. The plot of pulses in Fig. 1 shows the original clock pules at the top and a delayed pulse below it.

The output of the XOR gate will appear like the lower waveform in Fig. 1. Thus, the XOR gate generates one pulse for each clock transition. As a result, the gate produces output pulses at twice the clock frequency, but they remain synchronized with the clock, as shown in the upper waveform.

The lower XOR waveform illustrates another important characteristic: the width of the XOR pulses equals the delay introduced to the clock signal or the difference between the rise times of the pules in the top and middle waveforms.

The XOR pulse width will respond to the delay time regardless of frequency with one condition: the delay introduced to the clock signal (the middle waveform) must be shorter than both the high and low times of the clock. Thus, the clock should be delayed by less than 180 electrical degrees if the doubler is to work properly.

This sets the criteria for a circuit that will double clock pulses, but the circuit requires a delayed clock pulse. Because an XOR gate can be configured as a buffer by grounding one of its inputs, and it has an inherent phase delay, the gate will function as delay line to stall clock pulses before they reach a second XOR gate.

The circuit

The frequency doubler circuit is shown in Fig. 2. It is powered by the DUT. This eliminates the need for additional circuitry and also "configures" the doubler to operate at appropriate logic-voltage levels. This is necessary for testing CMOS logic because of the wide range of operating voltages and logic levels.

In Fig. 2, IC1-a is the pulse-producing gate, and IC1-b, IC-c, and IC1-d form a variable-delay network. Each gate in the network adds its phase delay to the signal it receives. Thus, IC1-b delays the clock by one phase delay period, IC1-c delays it for an equal period, and IC1-d adds yet another delay.

The gates are arranged so that both the phase delay and the width of the output pulses can be selected by making wire changes on a header that carries the delayed signal to IC1-a. That feature has two functions: 1) it extends the duration of the output pulses for slower test equipment, and 2) decreases the pulse width for testing very fast circuits.

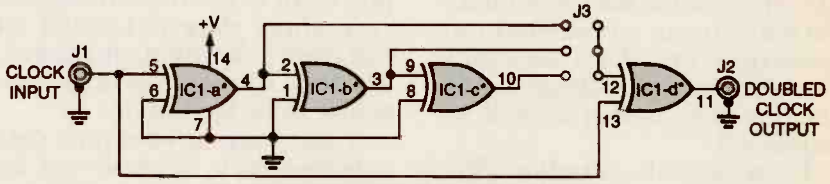
As stated earlier, you have a choice of quad XOR IC: a CMOS CD4070B or equivalent in a faster CMOS family (HC/HCT, HCS/HCTS, or ACL (FACT)) or a 74386 or its equivalent in faster TTL logic families (AS, LS, ALS, FAST). Your selection will determine the propagation delay of the gates. The delay is important because it determines the maximum input frequency that the circuit can handle and the maximum pulse width it can generate.

Maximum input frequency will limit the circuitry with which the doubler will be effective. Maximum pulse width will permit the circuit to work with the slowest test equipment. (Additional gates can be added to the delay network to increase the output pulse width for the slowest equipment.) To maximize the doubler's versatility, select a quad XOR with the highest maximum frequency that is compatible with your test equipment.

Table 1 provides information to help you select the optimum TTL family for your needs. The propagation delays are typical values obtained from data books, but devices from different manufacturers might have different typical values. The maximum output pulse widths given in the table were obtained by multiplying the

TABLE 1—TTL PROPATATION DELAYS VS. DOUBLER FREQUENCY LIMITS

TTL Family	Typical Delay (ns)	Maxcimum Input Frequency (Hz)	Longest Output Pulse (ns)
Advanced Schottky	1.5	166,667	4.5
Fast Schottky	2	125,000	6
Schottky	3	83,333	9
Advanced Low-power TTL	6	41,667	18
Low-Power Schottky	9	27,778	27
Standard TTL	10	25,000	30
Low-Power TTL	33	7,576	99



*IC1 SHOULD BE A 4070 FOR CMOS OPERATION OR A 74386 FOR TTL OPERATION

FIG. 2.—THE ACTIVE COMPONENT OF THE FREQUENCY DOUBLER is a quad exclusive-or (XOR) gate.

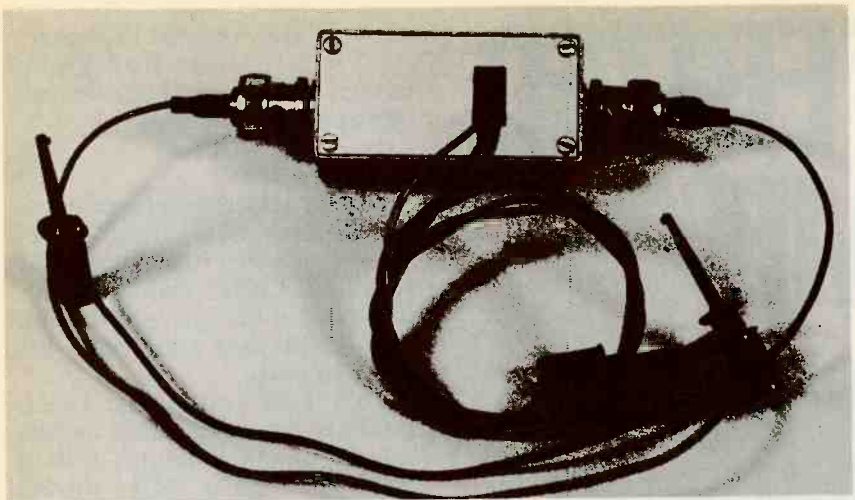
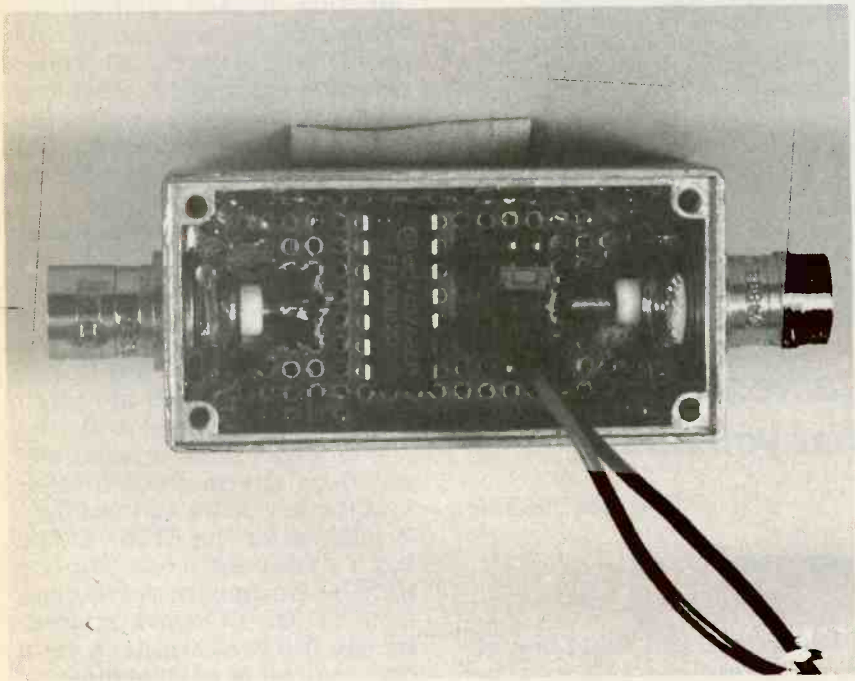


FIG. 3—COMPLETED FREQUENCY DOUBLER. The power leads are fitted with microclips and attached to two extra pins on the jumper block.



A JUMPER BLOCK was substituted for a triple-throw switch to conserve space.

propagation delay by a factor of 3 (the number of delay gates in the delay network).

PARTS LIST

Semiconductor

IC1—quad XOR-gate, CMOS or TTL (see text)

Other components

J1, J2—BNC jacks, wall mount

J3 (S1)—four-pin header, PCB mount (or triple-throw switch, see text)

Miscellaneous: Project case (metal, see text), two BNC plugs, two microclips, 14-pin IC socket (see text), perforated construction board, heat-shrink tubing, insulated hookup wire, solder.

Deciding on a CMOS IC is easier because even the fastest CMOS ICs are slower than the response times in most test equipment. A device from the high-speed HCT CMOS family is suitable for testing CMOS circuits that are powered by 5 volts, but a standard 4000B series IC will be suitable for testing all other CMOS circuits.

Doubler construction

The doubler circuit's 14-pin IC is mounted in a 14-pin DIP socket on a rectangular piece of perforated construction board. (Regardless of assembly method—wire wrapping or point-to-point wiring—keep all wires as short as possible.) If you design your own PC board, design in a ground plane on the reverse side.

Select a metal project case with a metal cover that will provide good shielding. The prototype is housed in an aluminum case measuring 5¼ × 3 × 2⅛inches. Holes are drilled in both ends of the metal case for BNC jacks J1 and J2. Another hole is cut in the case cover to allow the power and ground wires to exit.

In order to fit the circuit in such a small case, a 4 × 2 shorting header was used in place of a triple-throw switch for S1. The S1 connections are then made by moving a jumper. The two extra pins on the shorting jumper have leads attached to them for obtaining power and ground from the DUT. (You can prevent shorting between the closely-spaced power and ground jumper header pins with heat-shrinkable tubing, if necessary.) If you can find a small triple-throw switch you can use that, or use the header instead (as we did) or use a larger switch and bigger case.

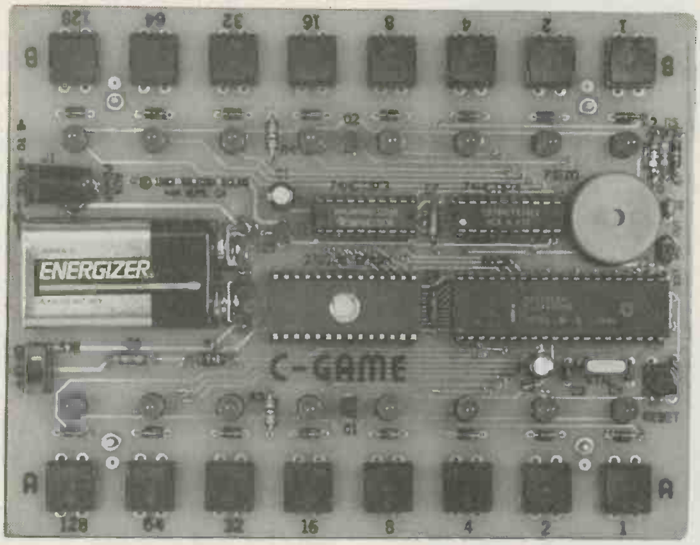
Position the completed circuit board in the bottom of the case and fasten it in place with double-sided tape or RTV silicone. Pass the power leads through the hole in the cover and terminate them with microclips. Figure 3 shows the assembled frequency doubler ready to be put to work.

Testing the doubler

To test out the frequency doubler, feed in a signal of known frequency from a crystal-based reference or function generator and measure the output frequency with a frequency counter or oscilloscope. The doubler will double the input frequency if it is functioning correctly.

The details will not be described in this article, but you can increase the versatility of the frequency doubler by fitting it with an analog front end. An operational amplifier configured as a Schmitt trigger will perform this function. Ω

COMPUTERIZED GAME



Learn how electronic games work; then have fun playing one that you built.

DAN RETZINGER

ALTHOUGH PLAYING COMPUTER games can be a lot of fun, operating them teaches you very little about how they work. A good way to learn how electronic games work is to build your own. This article shows you how to build the C-Game, a two-player game with a dozen different game modes. In addition to the 12 games, there are four other modes that let you generate sound effects and light-pattern displays.

The C-Game has 16 pushbuttons for player input, and it has 16 LEDs for display output. Eight LEDs and pushbuttons are arranged along each side of the device, making it convenient for two players to sit opposite each other while playing a game. The pushbuttons are installed with the same spacing as found on a standard computer keyboard, which makes them comfortable to use. A piezoelectric buzzer provides game sound effects.

Features

The games and functions of the C-Game are selected by pressing one of the 16 pushbuttons after the device is reset. A new game can be selected at any time by pressing the reset switch followed by another pushbutton. Once a game is selected, the operation of all pushbuttons and LEDs are specific to that game.

Of the twelve games, three are reaction-time (who's quickest) competitions. Four games involve skill and thought, and two others are simple memory challenges. The C-Game also has two binary arithmetic contests in which you must add, subtract, divide, and multiply two binary numbers. (It's not as difficult as it sounds!) Another game performs logic functions such as and, or, and exclusive-or. Finally, four non-game modes create sound effects and light-pattern displays.

Circuitry

Figure 1 is the schematic of the C-Game. The circuit is designed around IC3, an 80C31 ROMless, CMOS version of Intel's 8051 8-bit microcontroller. The 80C31 has four 8-bit I/O ports (0 to 3).

Port 1 is connected to 16 pushbuttons, organized as two banks of eight (Bank-A and Bank-B). The 16 1N914 diodes (D1–D16) isolate each bank from the other. Each bank has one side of each pushbutton connected in common to one pin of Port 3 of the 80C31. These two pins (12 and 13, P3-2 and P3-3, respectively) enable the switch banks separately so that they can be periodically read under software control.

Port 0 of the microcontroller communicates with the 27C256 EPROM (IC1), where C-Game's software is stored. The address and data buses of the microcontroller are multiplexed. A 74HCT573 8-bit latch (IC2) is first strobed with the ALE (address latch enable) signal from the microcontroller, and the low-order address data is latched for the EPROM. The high-order address for the EPROM is output by port 2, pins 21 to 27. The EPROM is enabled by the microcontroller's PSEN (program store enable) line.

Port 0 also connects to IC4, a 74HCT574 8 bit D-type flip-flop that drives two banks of eight LEDs. Port 3 (P3-0 and P3-1) enables each bank separately through Q1 and Q2. Each bank is multiplexed under software control and is turned on approximately 50% of the time.

Port 3 bit-4 (pin 14) connects to a transducer. Components R5, R6, and C8 provide a signal through output jack J2 for connection to the line-level input of an external amplifier to produce a louder sound output.

At power up, C2 and R1 initialize the microcontroller. Reset switch S17 will reset the circuit to power-up conditions at any time. An oscillator is

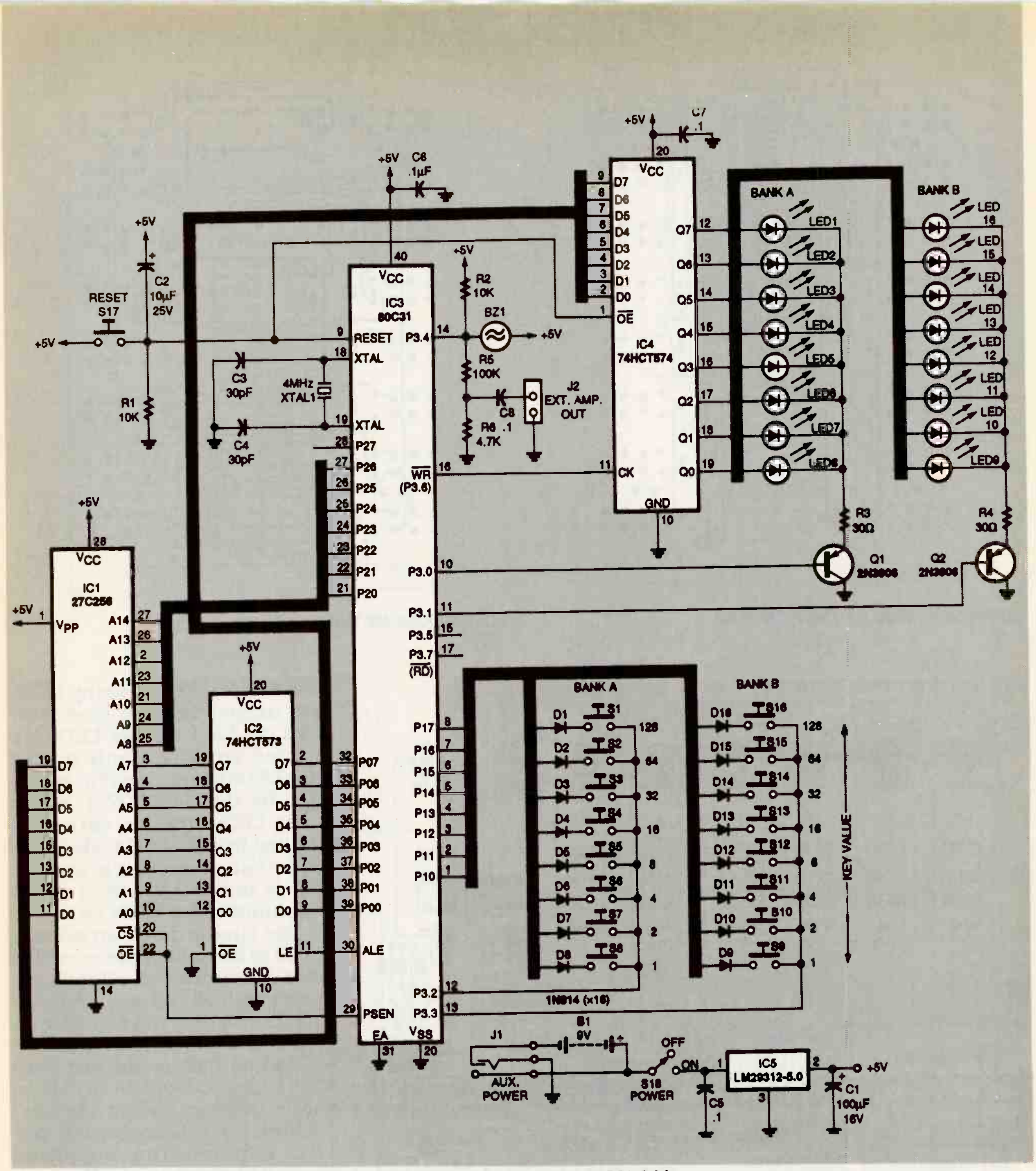


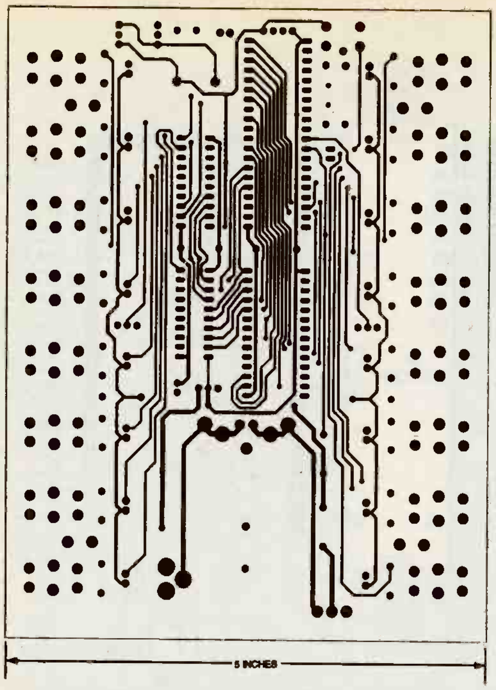
FIG. 1—C-GAME SCHEMATIC. The circuit is designed around an Intel 80C31 8-bit microcontroller.

made up of a 4-MHz crystal (XTAL1) and two 30 pF capacitors (C3 and C4). An LM2931Z-5.0 low-dropout 5-volt regulator IC5 will tolerate a reversed battery voltage of 15 volts without damage. The circuit is normally powered from a 9-volt battery, but power-input jack J1 can provide auxiliary power to the C-Game with any power adapter capable of supplying 6 to 9 volts DC at 100 milliamperes or greater.

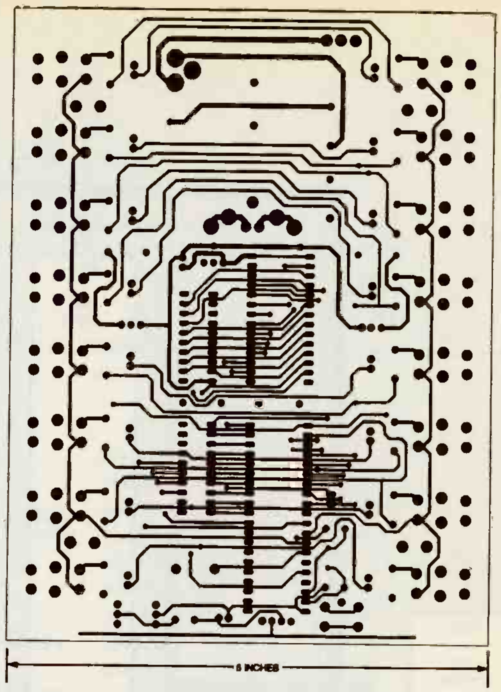
Designing a battery-powered circuit with this many LEDs and components requires some special considerations. All ICs (except the regulator) are CMOS to conserve battery power—a non-CMOS 74LS574 would require approximately 27 milliamperes more current than the CMOS version, and the non-CMOS version of the 8031 microcontroller would need almost 100 milliamperes extra.

Second, the 80C31 is clocked by a 4-MHz crystal. Although most 80C31 controllers can operate at speeds up to 12-MHz, the lower speed keeps power consumption to a minimum. Current drain is directly related to the clock speed in this CMOS microcontroller.

Third, all LEDs in each bank share one common-cathode resistor (R3 for Bank-A and R4 for Bank-B), instead of one resistor per LED. That results in less



COMPONENT SIDE OF THE PC BOARD.



SOLDER SIDE OF THE PC BOARD.

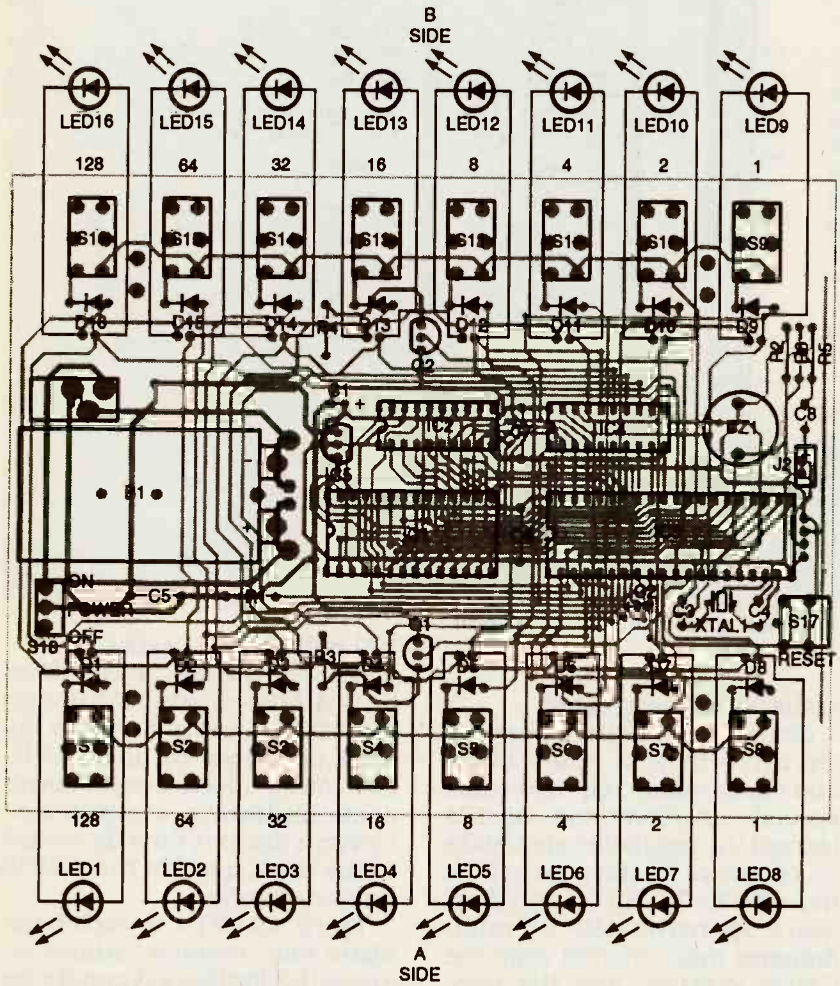


FIG. 2—PARTS-PLACEMENT DIAGRAM. Solder the 1N914 diodes first, then the resistors and capacitors.

current per LED if many LEDs are turned on, and more current per LED if fewer LEDs are turned on. When only one or two LEDs are on, current is limited by the 74HCT574. When more LEDs turn on, current is limited by R3 and R4. However, the change in brightness is barely noticeable with a differing numbers of LEDs on.

The circuit draws an average of 20 to 30 milliamperes, with a maximum drain of 65 milliamperes with all LEDs on. A 9-volt alkaline battery will last an average of 8 to 10 hours and a nickel-cadmium battery will last from 5 to 8 hours. Avoid 9-volt carbon batteries; even a fresh one can't deliver the C-Game's peak current requirements. Supplying power through jack J1 eliminates the need for a battery. This is recommended if the game is played often.

Construction

All of the necessary components including the PC board are available from the source given in the Parts List. Foil patterns are provided if you want to make your own PC board. Preprogrammed EPROMs are available from the source given in the Parts List, and the hex code is posted on the *Electronics*

TABLE 1—GAME INSTRUCTIONS

Activation Key	2 Player Game	1 Player Game	Game Title		Score Displayed & End
A1	X		Who's Quickest #1	First player to press the key next to his lit LED gets a Point. Most points out of 20 wins.	X
A2	X		Road Kill	Most 'hits' (press key while LED on) out of 20 wins.	X
A4	X		Tennis	Press a key to send a ball (LED) to your opponent. Fewest misses (press key before time-out) out of 40 wins.	X
A8		X	Reaction Timer	Test your reflex time. Press a key to shut off the LED. Gives an average time for 10 hits.	X
A16	X		Race Around	"A" player sends LED counterclockwise, "B" player clockwise. If LED slips past you, other player gets a point.	X
A32		X	Binary Math	Use "A128" to enter your answer for add/sub/divide/multiply on two 14 bit binary numbers. "B" LED's show progress.	
A64		X	Binary Logic	Use key "A128" to enter your answer for and/or/xor/modulus on two 4 bit binary numbers. "B" LED's show progress.	
A128		X	Count to 64	Use key "A128" to repeatedly add original number shown until you've counted to 64 or greater. "B" side keeps your time.	X
B1	X		Who's Quickest #2	First player to press all lit keys gets a point. Best out of 20.	X
B2		X	Memory #1	A number will be shown. Use key "A128" to enter each number in the "sequence" correctly. 10 total in sequence.	
B4	X		Memory #2	Alternate play. Two players build and copy a sequence. 10 total.	
B8	X		Last Player Wins	Move lit LED (press a key) toward A1, then toward B128 any number of "jumps". Alternate play. Last player able to move wins. Score is accumulative game to game.	X
B16	Special Effects			Press any key or key combinations to generate steady tones.	
B32	" "			"A" key control pitch range, "B" keys control speed range of randomly appearing LED's and tones.	
B64	" "			Sixteen different sound effects, one per key.	
B128	" "			Sixteen different sound and LED patterns, one per key.	

NOTE 1: Press RESET, then any key (left side of chart) to start a game.
NOTE 2: After a game terminates, pressing the key (other than RESET) will restart same game.

PARTS LIST FOR THE C-GAME

All resistors are ¼-watt, 5%.
R1, R2—10,000 ohms
R3, R4—30 ohms
R5—100,000 ohms
R6—4700 ohms
Capacitors
C1—100 μF, 16 volts, radial electrolytic
C2—10 μF, 25 volts, radial electrolytic
C3, C4—30 pF, 25 volts, ceramic disc, 20%
C5-C7—0.1 μF, 50 volts, ceramic, axial, 20%
C8—0.1 μF, 50 volts, ceramic, radial, 20%
Semiconductors
IC1—27C256 CMOS EPROM
IC2—74HCT573 octal D-type CMOS latch
IC3—80C31 CMOS microcontroller
IC4—74HCT574 octal D-type CMOS flip-flop
IC5—LM2931Z-5.0 low-dropout 5-volt regulator
D1–D16—1N914 diode
LED1–LED16—green light-emitting diode
Q1, Q2—2N3906, PNP transistor
Other components
S1–S17—PC-mount pushbutton switch
S18—SPST PC-mount slide switch
J1—DC power jack, PC mount, 2.0mm pin
J2—2-pin molex header, 0.1-inch spacing
XTAL1—4-MHz crystal, HC-18 metal case
B1—9-volt alkaline battery
BZ1—piezo-alarm (murata-erie No. PKM22EPP-40)
Miscellaneous: PC board, 9 volt battery connectors (1 each, Keystone No. 593 and No. 594), six stick-on rubber feet, two 20-pin IC sockets, one 28-pin socket, and one 40-pin socket
Note: The following items are available from Silicon Sound, PO Box 1694, Reseda, CA 91337-1694 (818) 996-5073:
- **Double-sided, silk screened PC board—$35.00**
- **Programmed 27C256 EPROM—$15.00**
- **Complete C-Game kit including all parts—$79.00**
- **Assembled and tested C-Game—$99.00**

Please add $3.50 for shipping and handling. California residents add 8.25% sales tax.

Now BBS (516-293-2283, V.32. V.42bis) as a file called CGAME.HEX.

Using Fig. 2 as a guide, solder the components in place beginning with the 1N914 diodes, resistors, and capacitors. Next, install the sixteen LEDs flush with the PC board. Follow with the IC sockets, but do not install the ICs into their sockets until all other parts are installed.

To install the two battery connectors, align them by first snapping them onto a 9-volt

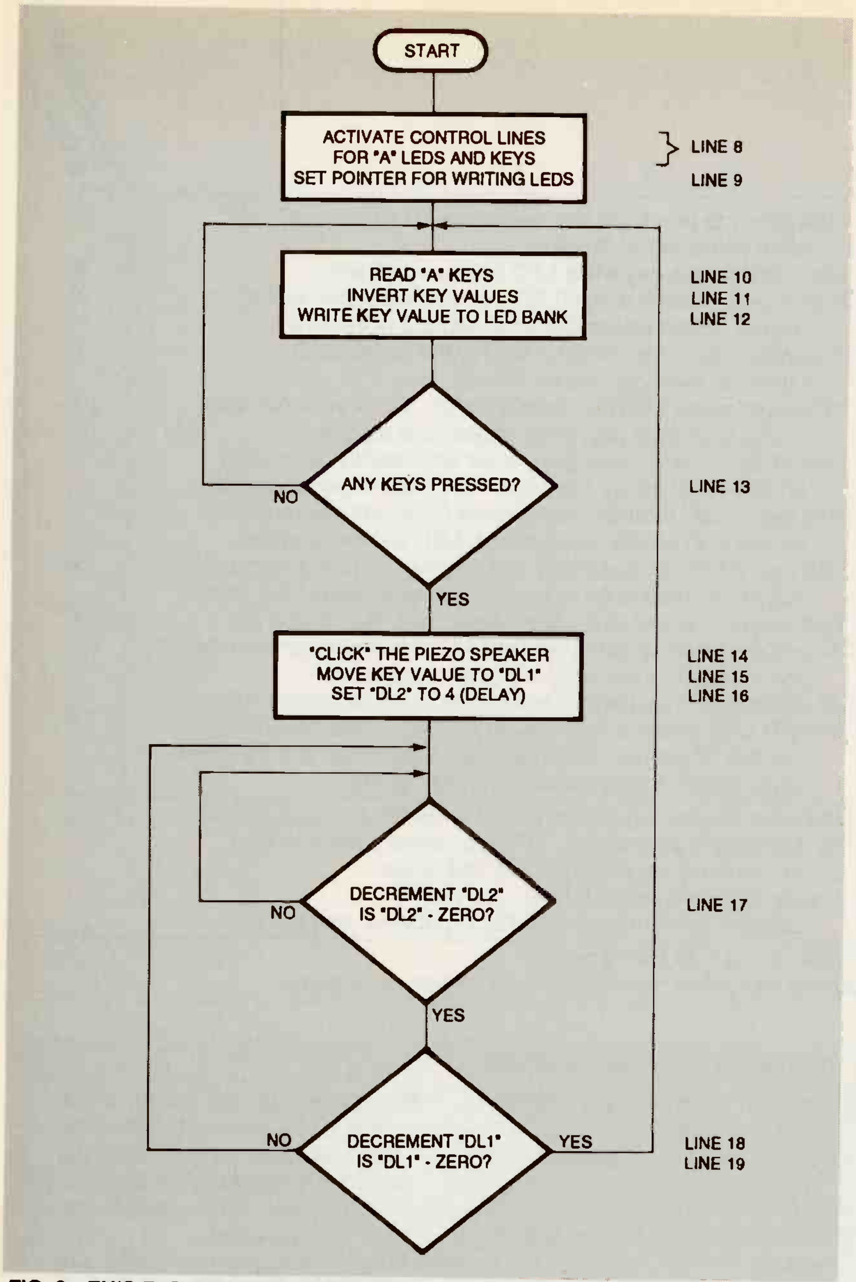


FIG. 3—THIS FLOWCHART details the operations performed in Listing 1.

battery. Be sure the battery polarity is correct. While holding the battery flush with the PC board, solder the battery connectors in place. Remove the battery after the clips are in place. Next, solder in the 16 pushbuttons, the power switch and jack, transducer, crystal, and audio output jack.

Next install six rubber feet on the bottom of the printed circuit board. These will keep the cut leads of the components from damaging your table top while you play the game. Optionally, you might want to mount a sheet of plastic to the PC board's bottom side to keep the leads from scratching your fingers. Cut it to the same size as the PC board and fasten it with machine screws and spacers. One-sixteenth inch thick styrene or black ABS plastic works well. Finish up by installing the four ICs. The completed game is shown on page. 88.

Checkout

Connect a 9-volt battery and turn on the power switch. You should first hear a short beep, then see the 16 LEDs light one at a time in a repeating counterclockwise pattern. If nothing happens when power is applied, check to see that +5 volts is present at the output of IC5. Also check for +5 volts on each IC's power pin, and make sure each ground pin is at zero volts. Verify that none of the address or data lines are shorted.

Check to see that each of the 16 pushbuttons work. To do this, you need to press the reset switch before pressing each pushbutton. At this point, don't try to play each game; just see that every pushbutton causes a distinct change in the game's behavior. (Note that you will hear a similar start-tone sequence after each game is selected, so wait long enough for a few LEDs to turn on.)

The games

Table 1 shows a complete list of the 16 game functions. Notice the designations A1, A2, A4, etc., on the left side of the chart, which correspond to the key designations shown in Fig. 2. As an example of how a particular game is selected, if after pressing reset you press the "4" key on the "A" side, you will start the tennis game.

The second column from the left in Table 1 shows the games that require two players. Typical play is with both players sitting opposite each other, each with both hands on the keys. Games checked in the third column can be played by one player, or alternately by two or more. Game titles are shown in the fourth column, and how-to-play instructions are shown in the middle of the chart.

Be aware that the numbers in the key designation (1, 2, 4, 8, 16, 32, 64, 128) also correspond to the bit values of an 8-bit binary number. It is important to know this when playing games A32, A64, and A128. Also, after many games terminate, the score will be displayed in binary on both sides of the board. For example, if after a game ends, LEDs A8 and A4 are lit, the score is 12 for the A side.

Four of the single-player games (A32, A64, A128, and B2) require that you "enter" an answer. During those games,

(Continued on page 108)

Circuit Grab Bag

CHARLES D. RAKES

We're going to reach into the circuit grab bag and bring forth a number of simple, but, we hope, useful circuits that might fill a present or future need. In any case sit back, make yourself comfortable, and we'll spend some time together looking over this circuit mix.

TURN-SIGNAL MONITOR

Our first circuit (see Fig. 1) really makes a statement for simplicity when only three parts are used in a turn-signal monitor. I'm sure you have had the experience of traveling down the highway, watching the driver ahead going for miles with his or her left or right

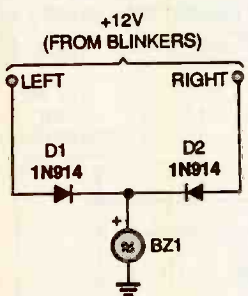


Fig. 1. With just three components, this turn-signal monitor could not be simpler.

blinker flashing without a care in the world, or a clue to his or her next move. This simple turn-signal monitor can help keep you from becoming just such a highway flasher.

A 1N914 signal diode is connected from each of the (left/right) directional blinkers to supply power to the piezo buzzer when either turn signal is activated. The piezo buzzer will sing out as long as either turn signal is operating. When selecting the piezo buzzer, go for the one that has the loudest and most irritating sound.

PARTS LIST FOR THE TURN-SIGNAL MONITOR (Fig. 1)

D1, D2—1N914 silicon diode
BZ1—Piezo buzzer
Wire, solder, etc.

DELAYED TURN-SIGNAL MONITOR

If you don't want to hear the piezo buzzer's irritating sound each time you use the turn signals, take a look at the time-delayed monitor circuit in Fig. 2. A simple RC time-delay circuit made up of R1 and C1 keeps the sounder from going off until the turn signal has been on for a number of flashes. Varying potentiometer R1 varies the number of flashes before the sounder is activated.

Here's how the delay circuit operates. The DC voltage from the 12-volt flasher goes through R1 and either D1 or D2 to charge C1. When the voltage across C1 reaches the gate turn-on voltage of Q1, that IRF511 FET switches the negative side of the piezo buzzer to circuit ground, operating the sounder. If you would like a longer time period before the sounder goes off, increase the value of C1. To decrease the time period, just reduce the capacitor's value.

BIKE ALARM

Our next item, shown in Fig. 3, is a low-cost, no-frills motorcycle- or bicycle-alarm circuit. The sensor is a mercury switch that's mounted to the cycle in a manner that places it in the open-circuit condition when the cycle is resting on its kick stand. When the cycle is moved to the upright position, the mercury moves over the two switch contacts, completing the circuit supplying gate current to the SCR (SCR1) and turning it on. The voltage at the cathode of the SCR goes positive, turning on the FET (Q2) and sounding the horn. The horn will sound until S2 is opened or the battery goes dead. The IRF511 FET is rated for about 4 amps, which should be good for a small, loud horn, but if you opt for a higher current, super-loud horn

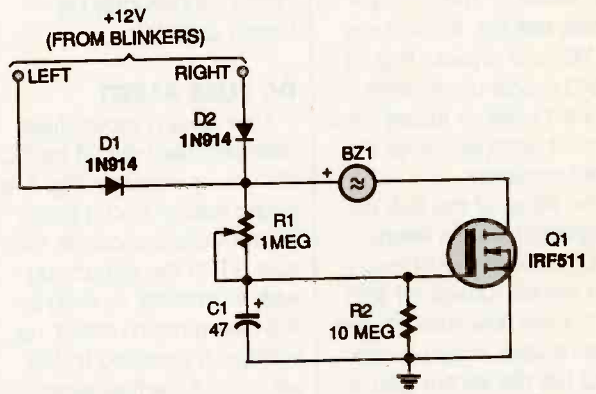


Fig. 2. To minimize driver irritation, a time delay can be added to the turn-signal monitor.

PARTS LIST FOR THE IMPROVED TURN-SIGNAL MONITOR (Fig. 2)

D1, D2—1N914 silicon diode
Q1—IRF511 FET transistor
R1—1-megohm, potentiometer
R2—10-megohm, ¼-watt, 5% resistor
C1—47-muF, 16-WVDC, electrolytic capacitor
BZ1—Piezo buzzer
Wire, solder, etc.

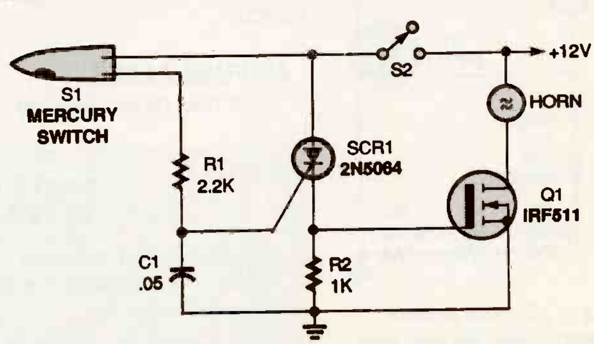


Fig. 3. Protect your bike with this simple alarm circuit.

PARTS LIST FOR THE SIMPLE ALARM (Fig. 3)

Q1—IRF511 FET transistor
SCR1—2N5064 or similar SCR
R1—2200-ohm, ¼-watt, 5%, resistor
R2—1000-ohm, ¼-watt, 5%, resistor
C1—0.05-µF, Mylar or ceramic-disc capacitor
S1—Mercury switch
S2—SPST switch, toggle or key switch
Horn, wire, solder, etc.

you should substitute a IRF530 for Q2. That unit is rated to handle up to 14 amps.

RAIN DETECTOR

If you like to leave your windows open and breath the fresh air, our next entry might be just what you need to warn you when the rain blows in. The rain detector, see Fig. 4, also uses an FET and a piezo buzzer. A grid made up of close-spaced wires or traces on a circuit board serves as the moisture sensor.

The string of the five 22-megohm resistors keeps Q1's gate voltage at zero and hence turned off with no current flow through the piezo buzzer. When a rain drop hits the sensor grid, a small current flows between the grid contacts, raising the voltage at the gate of the FET sufficiently to turn it on and operate the sounder. When you hear the sounder, it is time to close the windows.

A standard 9-volt transistor battery should operate the circuit for about the shelf life of the battery. Of course, you'll need a monitor circuit for each window that's open. Always remove the grid from the wet area and clean it thoroughly between uses.

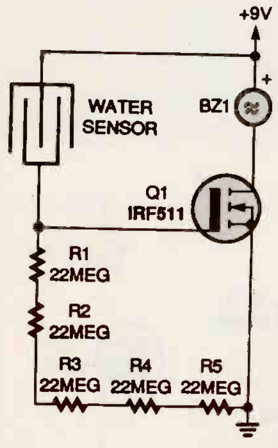


Fig. 4. You can prevent damage from the rain with this water-detector circuit.

DC FUSE ALERT

Next up is a blown-fuse detector/alert circuit for DC circuits. As shown in Fig. 5, a single resistor and a piezo buzzer connect across the fuse (F1) in the circuit you wish to monitor. As long as the fuse remains intact, no voltage is supplied to the sounder. If the fuse goes, the piezo buzzer receives current through R1 and the monitored circuit to alert you of a problem.

The circuit can be used to monitor fuses operating at higher DC voltages by increasing the value of R1. The resistor should be selected to allow the piezo buzzer's rated voltage to appear across it when the fuse is removed from the circuit.

AC FUSE ALERT

Our next blown-fuse detector, shown in Fig. 6, is designed to operate in conjunction with 110-volt AC circuits. A bridge-rectifier circuit, in series with a fixed resistor, is connected across the circuit's fuse, with the bridge's DC output feeding the piezo buzzer. A 12-volt Zener diode limits the maximum voltage feeding the sounder and a filter capacitor takes off the rough edges. Resistor R1 should be selected, with the fuse out of the circuit and the equipment on, to just produce 12 volts across the sounder circuit.

PARTS LIST FOR THE WATER ALERT (Fig. 4)

Q1—IRF511 FET transistor
R1–R5—22-megohm, ¼-watt, 5%, resistor
BZ1—Piezo buzzer
Water sensor (see text), wire, solder, etc.

PARTS LIST FOR THE DC FUSE MONITOR (Fig. 5)

R1—1000-ohm, ¼-watt, 5%, resistor
BZ1—Piezo sounder
F1—Fuse, see text
Wire, solder, etc.

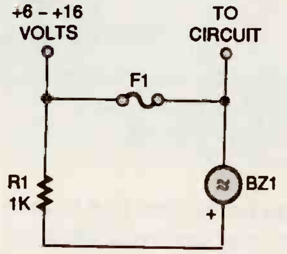


Fig. 5. You'll know immediately when a fuse has blown in a DC circuit when you use this fuse monitor.

SIMPLE FM TRANSMITTER

Our last entry this visit (see Fig. 7) is an FM home- or office-monitoring transmitter circuit. By placing the transmitter inside your home or office, you can monitor what's going on inside on your car or portable radio before entering. That way, this simple circuit just might keep you out of harm's way.

A 12-volt DC plug-in supply powers the circuitry, and (Continued on page 102)

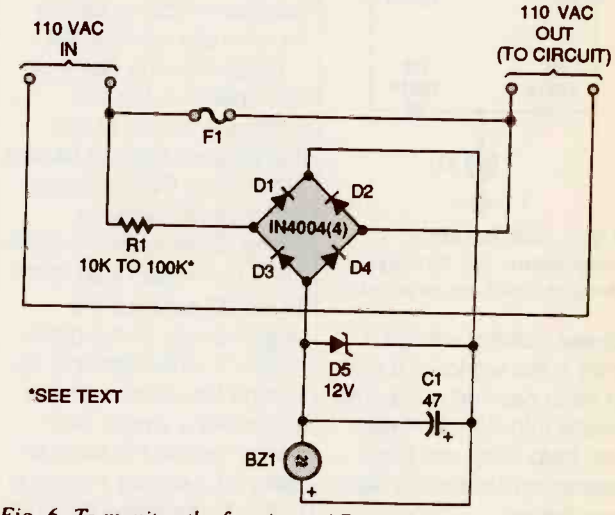


Fig. 6. To monitor the fuse in an AC circuit, you will have to use this AC version.

TOD T. TEMPLIN

BUILD THE RETRO-REMOTE

Add remote-control capability to anything that doesn't have it already with the Retro-Remote.

ONE MAJOR FEATURE THAT SEPArates most consumer electronics from home-built gear is remote-control capability. Even some of the most inexpensive commercially manufactured electronics is equipped with a wireless remote control. Hobbyists have been unable to include remote controls in their projects simply because there is no "off the shelf" circuitry available to do the job. That's not true any longer!

The Retro-Remote Control presented in this article is designed for maximum interfacing flexibility. The versatile circuit can be configured to remotely control the operation of home and automotive entertainment systems, home and auto security alarms, robotics, and almost any other project that might benefit from the addition of wireless remote control. So, whether you want to add remote-control capability to an older device that lacks it, or have shelved an idea for a great stereo project because it wouldn't be as convenient to operate as a store-bought unit, then the Retro-Remote is the perfect solution.

Description

The remote-control system consists of two separate circuit boards. One board contains an infrared receiver/decoder. It is added to the device that you want to operate remotely. The second board is an infrared "training transmitter." Its purpose is to train a commercially available universal "learning" remote control transmitter. The universal remote can then operate your equipment.

The universal remote control that you purchase will undoubtedly be smaller and more attractive than anything you could build easily. Learning remote controls have the added advantage of being able to learn the commands of multiple devices, thereby consolidating the functions of many separate remotes into one. You might already own a learning remote, as they are included with many brands of TVs, VCRs, and stereo receivers. If you don't own a learning remote, one can be purchased from a consumer-electronics store for as little as $20. The author used a Radio Shack Model 150 learning remote that can store codes for controlling up to four devices (TV, VCR, AUX 1, and AUX 2).

The training transmitter ensures that you can select unique codes for controlling "retro" devices that never had remote-control capability. You must be sure that the newly assigned codes will not interfere with those in use by your existing remote-controlled devices.

The training transmitter circuit is battery operated for portability and convenience. It is built on a small PC board that contains a pair of DIP switches to select the address (1 of 256) and command codes (0 through 15). It also contains the encoder IC, a modulator circuit, and the infrared transmitter diode. In practice, the training transmitter is placed next to the learning remote in an "eye to eye" fashion. An address and data command code are selected with the DIP switches, and then the learning remote is "taught" up to 16 commands. If more than 16 commands are required, a second receiver board set to a different address can be built for those commands.

The receiver/decoder board contains a pre-built and aligned infrared receiver module. It also has address and data decoding circuits that match those of the training transmitter, and interfacing circuits to connect it to the device that you want to control. The module can be self-powered or power can be provided by the device it serves.

The board can decode 16 command codes at any one of 256 possible addresses, for a total of 4096 available codes. Commands 0 through 11 are user-definable. That is, they decode to simple TTL-level signals which are selected by the user to

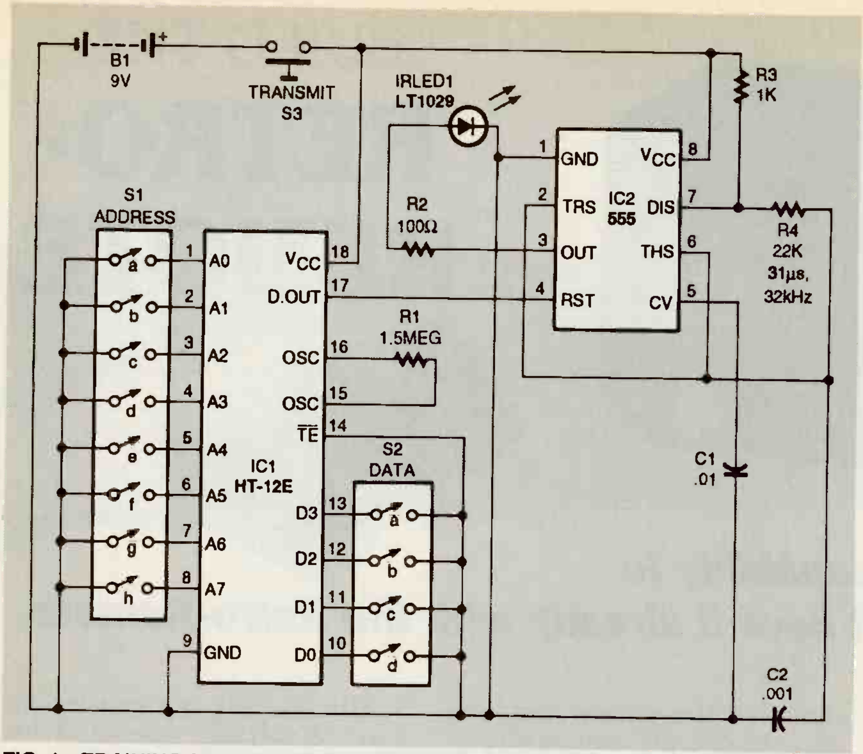


FIG. 1—TRAINING TRANSMITTER SCHEMATIC. The heart of the circuit is an HT-12E remote control encoder manufactured by Holtek Microelectronics.

be either latched or momentary, and high or low, as needed. The 12 decoded commands are brought out to a header for connection to external circuits. The four remaining commands (12, 13, 14, and 15) are hard wired on the decoder board to relays that operate a motorized potentiometer for volume-up and volume-down controls and for power on/off and mute on/off controls.

Transmitter circuitry

Figure 1 is the schematic for the training transmitter. The heart of the circuit is an HT-12E remote control encoder (IC1) manufactured by Holtek Microelectronics. The HT-12E encodes 12 bits of information into a serial stream of data. Eight bits select the system address while the remaining four bits select the data code. Both the address and data are binary-coded decimal (BCD). The encoded serialized data stream appears at pin 17 of IC1 whenever pin 14 (TE, or TRANSMIT ENABLE) is held low. Note that TE is grounded at all times, and transmit switch S13 enables the entire circuit. Resistor R1 sets IC1's internal oscillator frequency to about 3 kilohertz.

A 555 timer (IC2) modulates the encoded data onto a carrier wave and also drives the infrared LED transmitter diode (IRLED1). An infrared modulation frequency of 32 kilohertz was chosen to be compatible with the receiver module. Data from pin 17 of IC1 is routed directly to pin 4 (RESET) of IC2, which is configured as an astable multivibrator with a free-running frequency of about 32 kilohertz. This is determined by R3, R4, and C2. Data going into pin 4 of IC2 effectively turns it on and off in-step with its high or low value, thereby presenting a series of 32-kilohertz pulses that match the data stream to the infrared LED. Resistor R2 limits the current provided by IC2 to a safe value for the LED.

Receiver circuitry

Figure 2 is the schematic of the receiver circuit. The circuit consists of the IR receiver module (MOD1), the HT-12D decoder (IC1), a BCD-to-decimal decoder (IC2), and various driver ICs and relay circuits that interface the Retro-Remote to the outside world. With its clean and stable output, the IR receiver module, whose block diagram is shown in Fig. 3, greatly simplifies the construction and reliability of this part of the circuit. The IR module contains an infrared-sensitive photodiode, followed by a high-gain preamplifier, a limiter circuit, a 32-kilohertz bandpass filter, a demodulator, an integrator, and a Schmitt trigger.

The 12-bit serial signal that is sent from MOD1 when it receives transmitted pulses is buffered and inverted by Q1 and applied to the input of the HT-12D decoder IC, which interprets the first eight bits of the word as address and the last four bits as data. The HT-12D checks three consecutive samples of the received 16-bit word against the address selected by DIP-switch S1. If all three samples match, the VALID TRANSMISSION (VT) output goes high and the four-bit data word is latched onto its output pins. Resistor R8 sets the internal clock frequency of the HT-12D to about 150 kilohertz. Note that the oscillator in the decoder IC must run approximately 50 times faster than the oscillator in the encoder IC.

Although the data on the output pins of IC1 remains valid until a new word is decoded, the VT signal stays high only as long as the actual decoding is being performed. Thus, VT acts like a momentary-contact signal because it is active only as long as a button is pressed on the remote transmitter. The VT output is applied to Q2 which drives relay RY1. The relay provides a connection to ground to light the VT RECEIVED indicator (LED1), and also provides the ground return for the motorized volume-control circuit through RY2 and RY3 (volume up and volume down, respectively). The momentary ground closure is also brought out to the output header pins (HEADER1) for custom user applications that might require it. Note that VT is also routed to IC6, a 7473 dual JK flip-flop, and used as a clock signal.

The latched four-bit BCD data from decoder IC1 is presented to the four-bit input of IC2, a 74154 BCD-to-decimal decoder

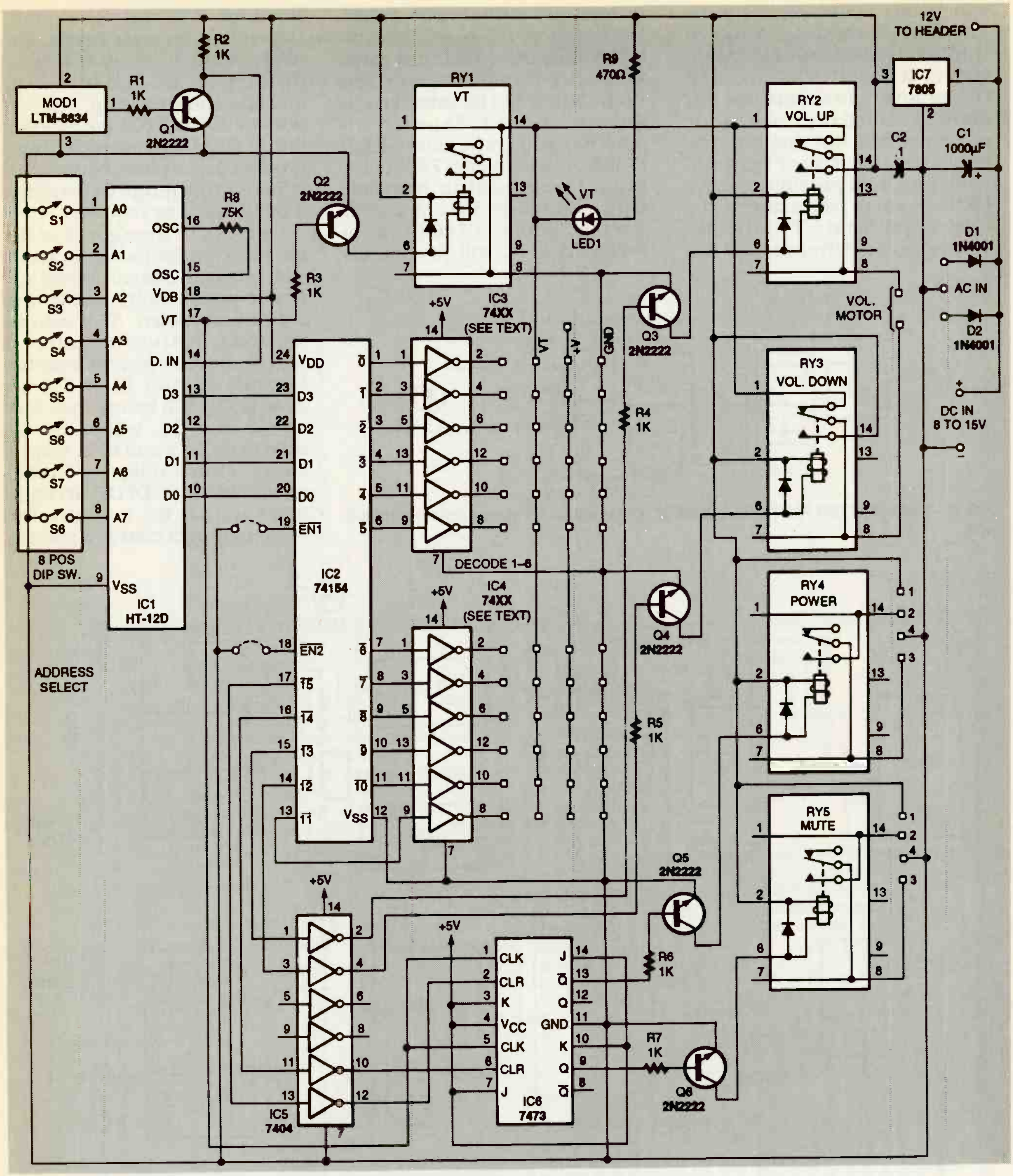


FIG. 2—RECEIVER/DECODER SCHEMATIC. The circuit consists of the IR receiver module (MOD1), an HT-12D decoder, a BCD-to-decimal decoder (IC2), and various driver ICs and relay circuits.

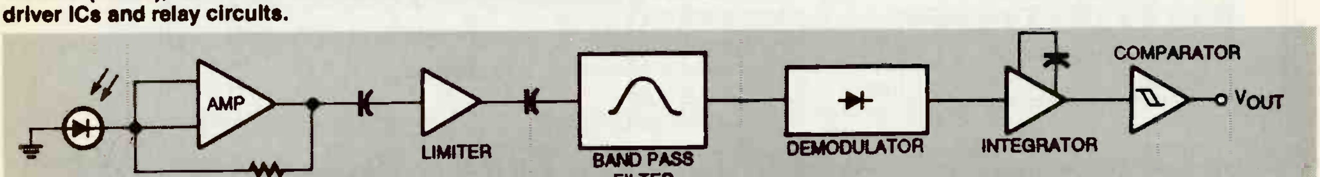


FIG. 3—THE IR MODULE (MOD1) simplifies the construction and improves the reliability of the circuit.

which has active-low outputs. The first 12 outputs of IC2 (0 through 11) are connected to inverters IC3 and IC4. The particular inverters selected for IC3 and IC4 should depend on your requirements, but they must be either hex inverters or hex buffer drivers. It is possible to drive LEDs or small relays directly by selecting either the 7406 hex inverting buffer driver or the 7407 hex non-inverting buffer driver. Both of those ICs have open-collector outputs which are rated for about 40 milliamperes and up to 30 volts. The inverter you select should depend on whether you want active-high (7406) or active-low (7407) outputs. If you want to interface with additional TTL or CMOS circuits, obtain a 7404 hex inverter. That IC will provide active-high TTL output signals. Depending on your needs, you might want IC3 and IC4 to be different ICs—one inverting and one non-inverting. The outputs of IC3 and IC4 are brought out to HEADER1 along with VT, ground, and a power-supply bus which can be jumpered to either 5 or 12 volts, as required.

Outputs 12 through 15 of IC2 are reserved for four circuits on the receiver board. These are power on/off, mute on/off, and volume up/down. The volume up/down feature requires a motor-driven potentiometer. Outputs 12 and 13 of IC2 are inverted by IC5 before they turn on Q3 and Q4, which are the drivers for RY2 and RY3, respectively. Those relays are cross connected in a DPDT arrangement so that the output taken at their wipers changes polarity

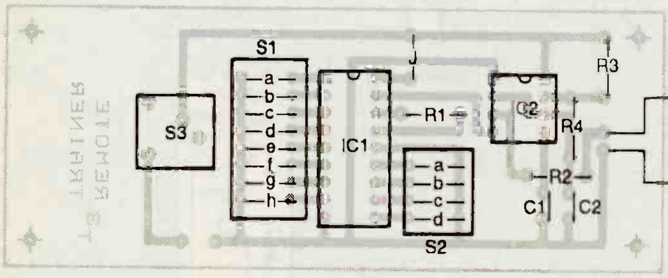


FIG. 4—TRANSMITTER PARTS-PLACEMENT. The small board makes a nice handheld unit.

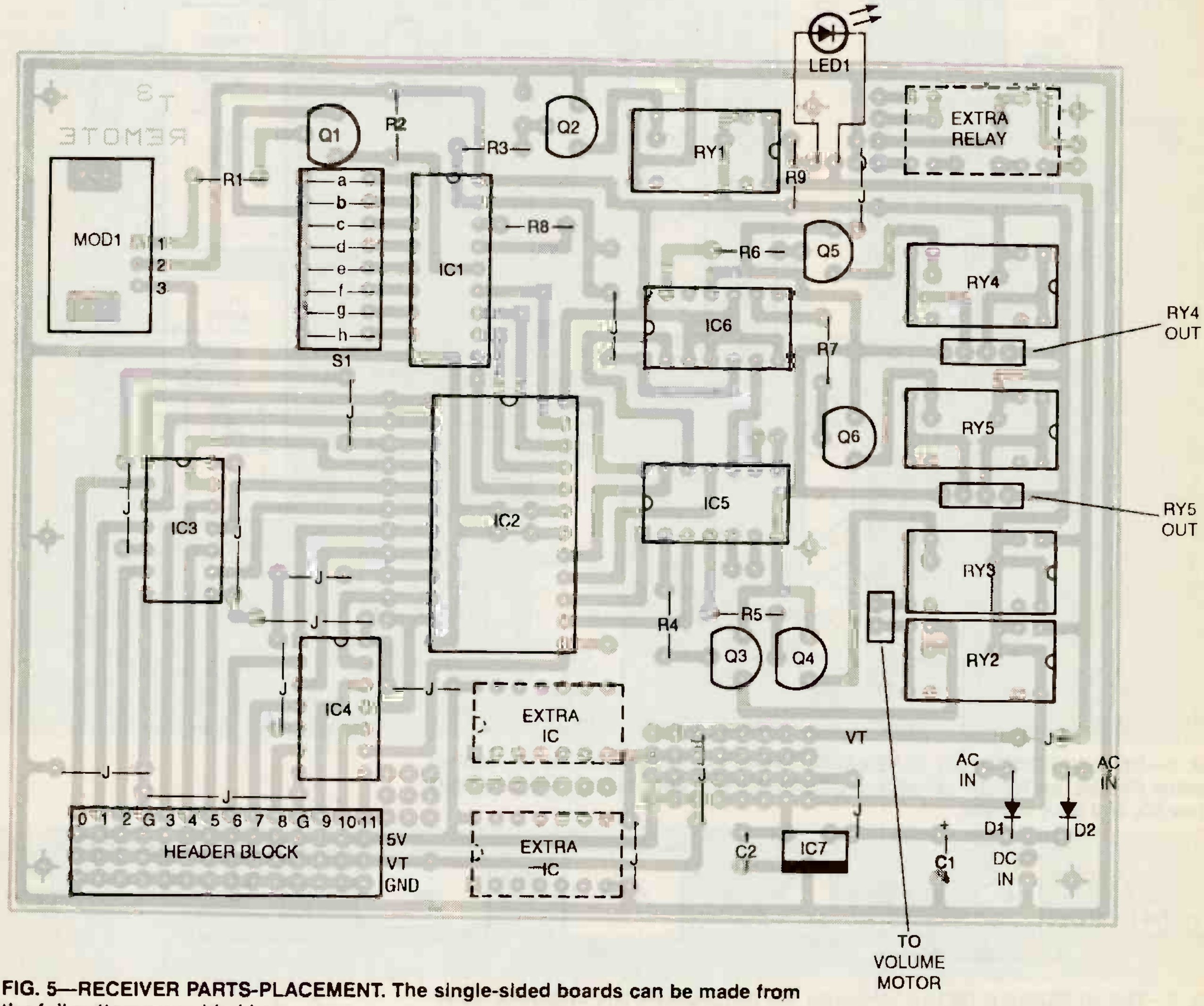


FIG. 5—RECEIVER PARTS-PLACEMENT. The single-sided boards can be made from the foil patterns provided here.

PARTS LIST—TRANSMITTER

All resistors are ¼-watt, 5%

R1—1.5 megohms
R2—100 ohms
R3—1000 ohms
R4—22,000 ohms
Capacitors
C1—0.01 µF, polyester
C2—0.001 µF, polyester
Semiconductors
IRLED1—LT1029 infrared LED
IC1—HT-12E remote control encoder (Digi-Key part No. HT-12E-ND)
IC2—555 timer
Other components
S1—8-position DIP switch
S2—4-position DIP switch
S3—normally-open push button
Miscellaneous: 18-pin IC socket, 8 pin IC socket, 9-volt battery and connector, PC board

PARTS LIST—RECEIVER

All resistors are ½-watt, 5%

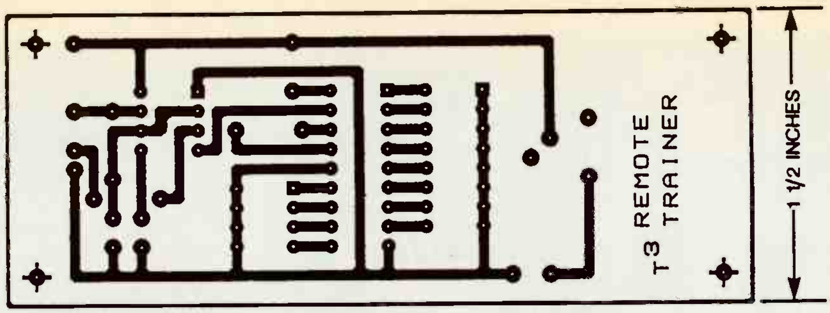
R1–R7—1000 ohms
R8—75,000 ohms
R9—470 ohms
Capacitors
C1—1000 µF, 25 volts, radial electrolytic
C2—0.1 µF, Mylar
Semiconductors
D1, D2—1N4001 diode
LED1—red generic light-emitting diode
IC1—HT-12D remote control decoder (Digi-Key part No. HT-12D-ND)
IC2—74154 4- to 16-line decoder
IC3, IC4—7404 or similar hex inverter (see text)
IC5—7404 hex inverter
IC6—7473 dual J-K flip-flop
IC7—7805 5-volt regulator
Q1—Q6—PN2222 NPN transistor
Other components
RY1, RY4, RY5—HE721A0510 SPST DIP relay, N.O. (Hamlin 5-volt 700 series, see text)
RY2, RY3—HE721C0510 SPDT DIP relay, N.O. (Hamlin 5-volt 700 series, see text)
S1—8-position DIP switch
MOD1—32-kHz infrared remote-control receiver module (Digi-Key part No. LT1033-ND or equivalent)
Miscellaneous: 11 × 4 header-pin block; 2-, 3-, 4-, and 6-pin headers; 24-pin IC socket; 18-pin IC socket; 16-pin IC socket; three 14-pin IC sockets; PC board; solder

ORDERING INFORMATION

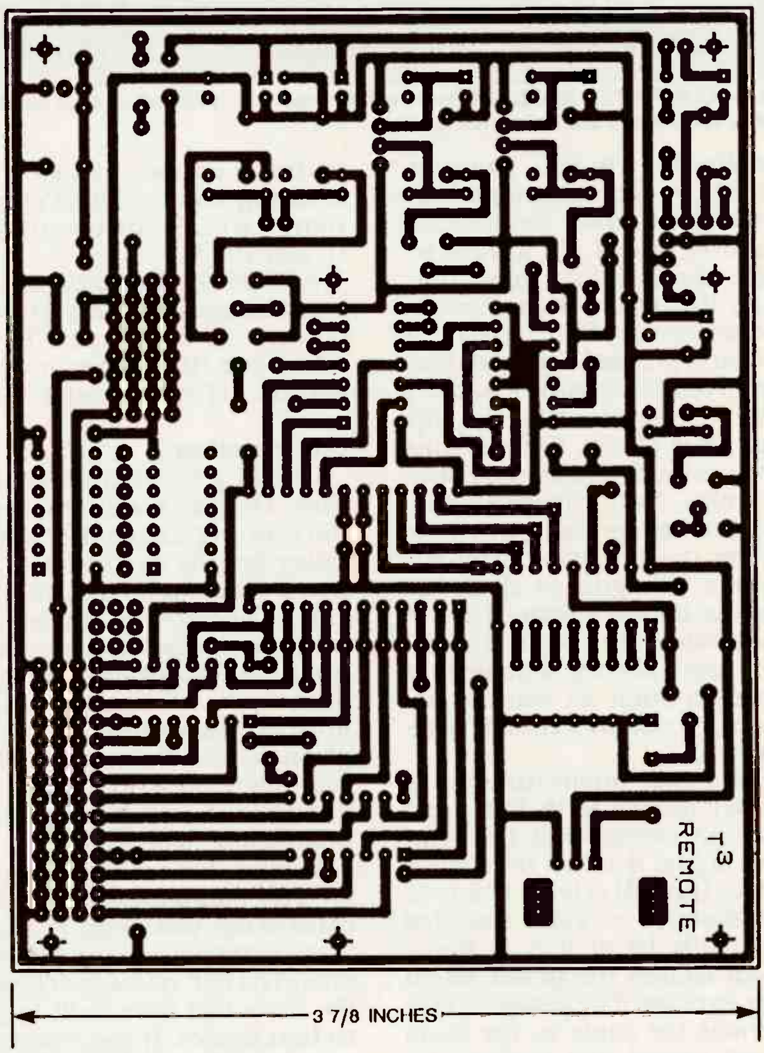
Note: The following items are available from T3 Research, Inc., 5329 N. Navajo Ave., Glendale, WI. 53217-5036:

- **Training Transmitter PC board—$6.00**
- **Receiver/decoder PC board—$12.00**
- **Training Transmitter electronic Part Kit—$8.00**
- **Receiver/Decoder electronic Part Kit—$29.50**
- **Motor driven pots (specify 50K or 100K)—$11.25 each.**

Add $2.00 S&H to any order. Wisconsin residents must add 5½% sales tax. Visa and MasterCard accepted.



RETRO TRANSMITTER FOIL PATTERN.



RETRO RECEIVER FOIL PATTERN.

depending on which relay closes. The potentiometer motor will rotate clockwise with one polarity and counterclockwise with the opposite polarity. The ground return of the volume-control circuit must be routed through the VT relay so that the motor will run only during the reception of a valid command. Otherwise, the latched data of IC1 would cause the motor to run continuously until it decoded a new command.

Output 14 (pin 16) of IC2—the speaker mute function—is inverted by IC5 and connected to one half of IC6, a dual J-K flip-flop. The flip-flop is wired as an alternating latch that is clocked by the VT signal. The first time IC2 decodes decimal 14 (when the mute button is pressed on the remote control), pin 16 goes to a logic low, presenting a logic high at the clear input (CLR) of

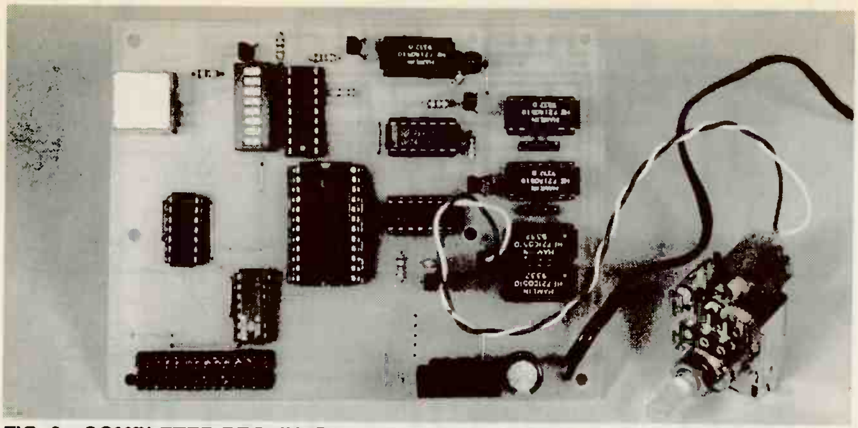


FIG. 6—COMPLETED RECEIVER board can be mounted in its own case or inside the device you want to control remotely.

the flip-flop via IC5. Simultaneously, VT presents a logic high to the clock input. Because the J and K inputs are always set high, the Q output goes high. That, in turn, switches on Q6 and closes relay RY5. If the mute button is pressed a second time, pin 16 of IC2 remains low, but a new VT is received by the flip-flop. That clocks IC6, causing the Q output to go low and open the relay. Note, however, that once latched, pressing any valid key on the remote control will cause a VT signal to clock IC6 into the opposite state. The circuit is wired that way so that an "unmute" occurs whenever a function such as volume up/down or a channel change is requested.

The power on/off function is almost identical to the mute function except that the relay drive signal is taken from the $\bar{Q}$ output (pin 13) of latch IC6-b. In the absence of valid decoded data, pin 13 of IC6 is high, which causes the power on/off relay to close. The power circuit operates the same as the mute circuit except that the first received and decoded power-on command turns the power off. That might seem backwards only until you have cycled the power circuit once. After that it will appear to function normally. The advantage of doing it this way is that pressing any valid key on the remote will switch the power on, but pressing the power key is the only way to switch the circuit off. Builders can wire the flip-flop differently, select a different style flip flop IC latch, or do away with IC6 entirely by using self-latching relays. Select components which suit your particular needs.

A 7805 5-volt regulator, IC7, provides the necessary 5 volts to power the standard TTL devices, the IR receiver module, and the HT-12D decoder IC.

Construction

Building the Retro-Remote is easy. The parts are installed in the training transmitter and receiver boards as shown in the parts-placement diagrams of Figs. 4 and 5. The single-sided boards are easy to make yourself from the foil patterns provided here, or you can purchase finished boards from the source given in the Parts List. Work carefully with a fine-tipped soldering iron and watch out for inadvertent solder bridges.

To allow for customizing, the receiver board has space for an extra relay, two extra ICs, and many extra pads in the interface area. The DIP relays specified in the Parts List have built-in protection diodes. If the relays you use don't have these diodes, there are pads on the PC board at each relay location where you can add them, but they will have to be mounted on the solder side of the board. Not all DIP relays have the same pinouts. Be sure to use relays with pinouts that match those shown.

Any power source with an output between 8 and 15 volts that can supply a least 250 milliamperes is suitable for the receiver. Diodes D1 and D2 are necessary only if your power source is AC. A clip-on heatsink for IC7 is recommended if your power source is 12 volts or more. Figures 6 and 7 show the completed boards.

It is not necessary to mount the IR module on the receiver/decoder PC board. If you prefer, cut an appropriate length of shielded, balanced microphone cable and attach a pair of three-pin female header sockets to make a jumper cable. Then mount the IR module in a suitable location, and mount the decoder board wherever it's convenient or out of the way. The IR module need not be in the same room as the decoder PC board—the author installed a Retro-Remote receiver board in the trunk of his car to operate stereo equipment. The IR module is discretely hidden behind an air conditioning vent grill on the dashboard. To be sure that the Retro-Remote is receiving properly, mount the valid transmission-received LED away from the circuit board in a visible location.

Interfacing

The small DIP relays specified for this project are not intended to switch either high voltage or high currents. If you want to switch 120-volts AC power for a TV set or any other AC load, use the DIP relay on the Retro-Remote to actuate a relay with a higher power rating capable of handling the load.

If you are working with TTL or CMOS circuits, as might be found in robotic and security systems, then it is only necessary to select appropriate buffer/driver ICs for IC3 and IC4 to get the proper logic. If you need to use relays in your project, as will most often be the case, then use a pair of 7404 hex inverter ICs for IC3 and IC4 followed by a 1K resistor and a general-purpose NPN transistor to drive a relay. Wire the relay as RY2 is wired in Fig. 2.

Programming notes

Begin programming by selecting an address on the training transmitter. If you have only one Retro-Remote system, select address 256 by leaving all eight ad-

(Continued on page 110)

MOTORCYCLE

Continued from page 73

ever feel threatened.

The IRF511 N-channel FET (Q1) will handle currents up to 4 amps. If you need a higher-current device, an IRF530, which is rated at 14 amps, can be substituted.

TWO-WAY INTERCOM

A simple "passenger-to-pilot" intercom circuit is shown in Fig. 5. Two LM386 IC's are connected in a low-gain amplifier circuit with the headphone output of one paired to the microphone input of the other. The microphones are electret elements and the earphones can be of the in-ear type.

Both amplifiers in the circuit operate at a minimum gain of 20 dB. That helps to keep the wind and road noise to a minimum. However, that also means that the microphone must be located close to the mouth.

TURN-SIGNAL SYSTEM

Our final motorcycle gadget (see Fig. 6) is a complete turn-signal system. It can be added to an older bike or used as a replacement for a non-working existing system.

Two sections of a 4049 inverting hex buffer, U1, are connected in a very-low-frequency oscillator circuit. The output at pin 2 of the inverter U1-b drives the remaining inverter stages; the output of inverter U1-c drives the gate of the FET transistor, which in turn operates the turn-signal lamps. Also, the oscillator's output at pin 2 drives the three remaining inverters, which flash the turn-signal indicator LED.

The directional switch, S1, is a center-off switch; when the switch is in the center position, no power reaches the circuitry. When S1 is switched to either the left or right position, power for the oscillator circuit passes through either D1 or D2, and the power for the turn-signal lamps flows through the switch contacts.

The flashing rate of the lamps is set by R3. Again, the IRF511 FET (Q1) can only handle up to 4 amps. For more current, use an IRF530. ■

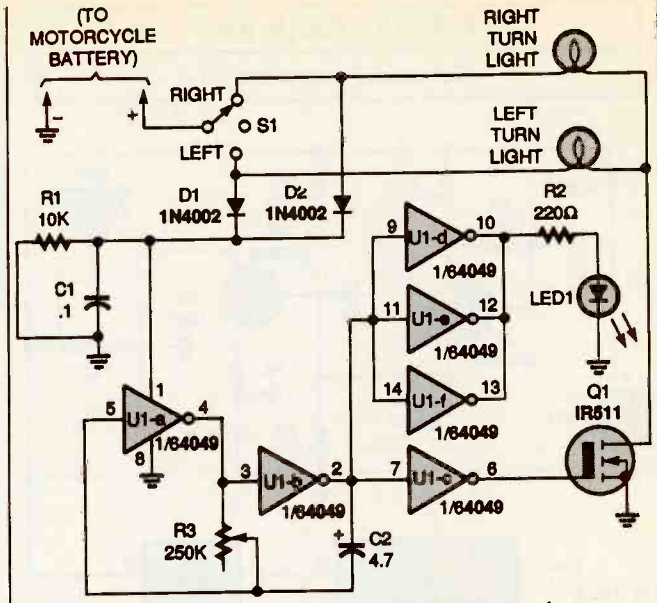


Fig. 6. Tired of making hand signals? Build this simple turn-signal system and keep your hands on the handlebars.

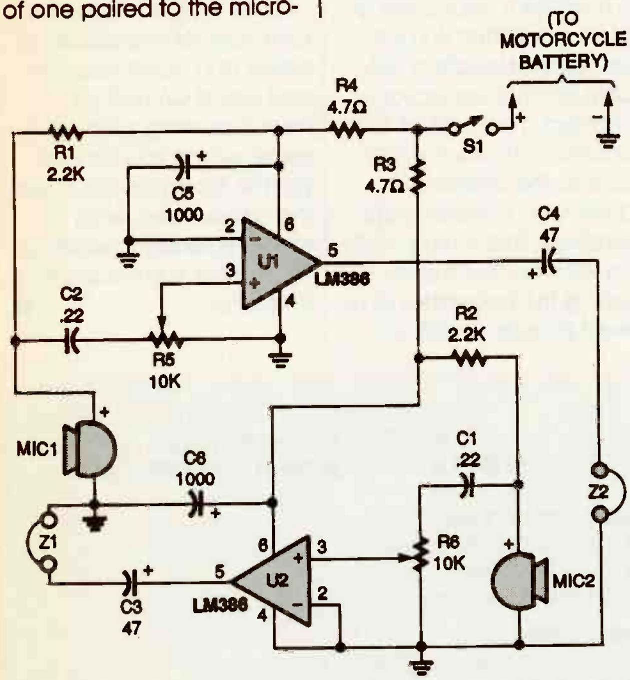


Fig. 5. Why yell at your passenger when you can talk? Use this two-way intercom to make communicating a lot easier.

PARTS LIST FOR TWO-WAY INTERCOM (Fig. 5)

RESISTORS

(All fixed resistors are ¼-watt, 5% units, unless otherwise noted.)
R1, R2—2200-ohm
R3, R4—4.7-ohm, ½-watt
R5, R6—10,000-ohm, potentiometer

CAPACITORS

C1, C2—0.22-µF, Mylar
C3, C4—47-µF, 25-WVDC, electrolytic
C5, C6—1000-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

U1, U2—LM386, power audio amplifier, integrated circuit
MIC1, MIC2—Electret microphone element
Z1, Z2—Stereo or mono headphones
Wire, solder, knobs, etc.

PARTS LIST FOR TURN-SIGNAL SYSTEM (Fig. 6)

SEMICONDUCTORS

U1—4049 hex inverting buffer, integrated circuit
D1, D2—1N4002 silicon diode
Q1—IRF511 FET transistor
LED1—Light-emitting diode

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—10,000-ohm
R2—220-ohm
R3—250,000-ohm, potentiometer

CAPACITORS

C1—0.1-µF, ceramic-disc
C2—4.7-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

S1—SPDT, center-off switch (see text)
Wire, solder, IC socket, etc.

CIRCUIT GRAB BAG

Continued from page 94

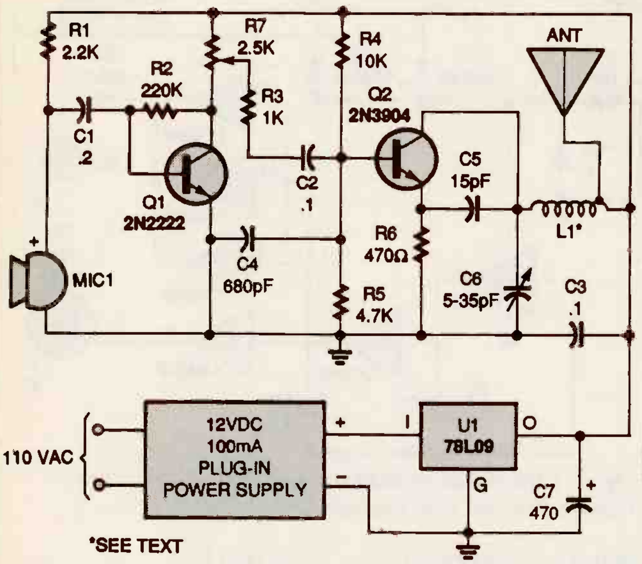


Fig. 7. This simple FM transmitter makes a great monitor circuit that can keep you out of harm's way.

a 78L09 9-volt regulator IC helps to keep the transmitter's frequency stable. Transistor Q1 amplifies the audio signal from the electret mike and feeds it to the base of the oscillator transistor, Q2. The audio at the base of Q2 frequency-modulates the oscillator's frequency. R7 determines FM modulation level.

Coil L1 is homemade. It consists of about 6 inches of number-20 enamel-covered copper wire wound around a ¼-inch diameter plastic form. The tap is one turn up from the cold end of the coil (that's the end that connects to the positive power source).

The trimmer capacitor, C6, may be any value with a maximum capacitance of no more than 40 pF. If you cannot locate a suitable trimmer capacitor, connect a fixed 33-pF capacitor in its place and tune to the desired frequency by spreading L1's windings. That tuning method will work, but makes setting the transmitter to an exact frequency difficult.

Keep the circuitry wiring neat and compact. Make all of the component leads connecting to Q1 as short and stable as possible. The antenna should be kept short to cover a small range.

To set up the transmitter, tune your FM-broadcast receiver to a quiet frequency and adjust C6 until you hear a quieting sound. If, for some reason you can not get the transmitter to cover the desired frequency range, spread L1's windings to increase the transmitter's frequency. ■

PARTS LIST FOR THE AC FUSE MONITOR (Fig. 6)

D1–D4—1N4004 silicon diode
D5—12-volt, 1-watt, Zener diode
R1—10,000- to 100,000-ohm, ½-watt, 5% resistor, see text
C1—47-µF, 16-WVDC, electrolytic capacitor
BZ1—Piezo buzzer
F1—Fuse, see text
Wire, solder, etc.

PARTS LIST FOR THE SIMPLE FM TRANSMITTER (Fig. 7)

SEMICONDUCTORS
Q1—2N2222 NPN transistor
Q2—2N3904 NPN transistor
U1—78L09 9-volt regulator, integrated circuit

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1—2200-ohm
R2—220,000-ohm
R3—1000-ohm
R4—10,000-ohm
R5—4700-ohm
R6—470-ohm
R7—2500-ohm, potentiometer

CAPACITORS
C1—0.2-µF, Mylar
C2, C3—0.1-µF, ceramic-disc
C4—680-pF, ceramic-disc
C5—15-pF, ceramic-disc
C6—5- to 35-pF, trimmer
C7—470-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
MIC1—Electret microphone
L1—See text
12-volt 100-mA plug-in power supply, coil form, magnet wire, wire, solder, etc.

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MICRO-LIGHTS

Continued from page 31

and direction of spin will depend on the sounds in the room.

Cycle through the routines by pressing the select pushbutton and check to see that sound, and the absence of sound, affects each of the eight Micro-Lights routines. Perform the checkout in a quiet room.

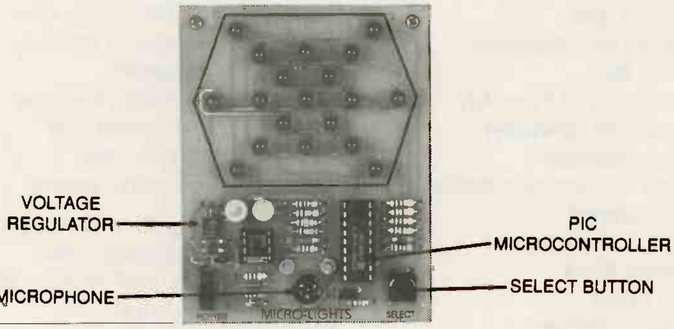

FIG. 8—THE COMPLETED MICRO-LIGHTS BOARD. The board is designed so that it does not need a case.

If nothing happens when power is applied, use a voltmeter to check for +5-volts DC at the output of the regulator, on pin 8 of the op-amp, and pins 4 and 14 of the PIC16C71. Verify that ground is present where it should be on both ICs. If you have an oscilloscope, check for an audio waveform (in the presence of sound) at the op-amp's output at pin 1. The voltage should swing from ground to about 3.6 volts.

To verify the circuit's overall current consumption, connect a multimeter (set on the 200-milliampere DC scale) in series with the 9-volt battery. A reading of 5 to 35 milliamperes, depending on how many LEDs are lit, is a normal measurement.

Operation

Operate Micro-lights in a dimly lit room to obtain the most striking effects. A desk top, coffee table, or bookcase is a good location. If the battery cable is lengthened by several inches, the circuit board can be worn. Tuck the battery in your shirt or coat pocket and wear the board on your lapel.

Applying power to Micro-Lights always causes routine 1 to start. Pressing the select pushbutton always advances the operating routine to the next one. However, if power is applied and the select pushbutton is not pressed, Micro-Lights will automatically increment through all the routines, spending about 5½ minutes on each. The whole cycle repeats after approximately 45 minutes.

Although the circuit draws fairly low current, consider an AC-to-DC adapter for powering Micro-Lights, especially if you want it to operate continuously. The circuit draws an average of 15 milliamperes—about that of a small transistor radio. Expect 15 to 20 hours of operation from a fresh alkaline battery.

The circuit has no sensitivity control. The author believed the addition of one would detract from the simplicity and elegance of this project. A little experimentation with placement will resolve any problems related to noisy environments. In locations where there is consistently loud noise, a small piece of tape placed over the microphone will reduce the circuit's sensitivity. Check out the effect of music as well as voice on the sound routines.

Micro-Lights might not be as spectacular as the Northern Lights, or a fourth of July fireworks show, but it will provide you with your own miniature light show—and an understanding of microcontrollers. Ω

CREATING CHAOS

Continued from page 71

with wood screws, making sure the assembly is securely fastened and rigid.

Mount the solenoid on the post with the two screws provided. Fasten the circuit board to the shelf of the post with two flathead wood screws. If the wire connections between the solenoid and circuit board are too long, this is the time to unsolder, trim, and resolder them.

Assemble the ball-spring and solenoid shaft adapter block (Details A and B of Fig. 5) by inserting the coiled end of the wire in the drilled holes of the block and threading it through the holes. Snap the completed assembly over the shaft of the solenoid. The Bonker is now ready to give you hours of relief from those monotonous routines of life. Ω

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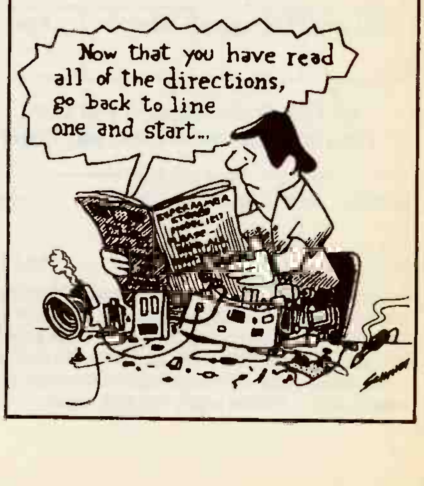

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The head operates over a temperature range of 32°F to 100°F, and it measures relative humidity from 10 % to 100 %.

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COMPUTERIZED GAME

Continued from page 92

pushbutton A128 acts as an enter key. First hold down a combination of A keys for your answer, then enter that answer by pressing key A128.

In two games, A32 and A64, two numbers will be shown in binary. The first number will be displayed with a corresponding "low" beep, followed by the second with a corresponding "higher" beep, then a pause. The numbers keep repeating. Those are the two numbers you need to work on in those games. The object of game A32 (Binary Math), for example, is to correctly add, subtract, divide, and multiply (in any order) the two 4-bit numbers shown. Each time you enter a correct answer (enter with key A128), two B side LEDs light up. After all eight B-side LEDs are lit, you win and the game ends.

In game B8 (Last Player Wins), the game will prompt the player whose turn it is by momentarily flashing all eight LEDs on that side. You then must move an LED by pressing a key next to a lit LED to move it to an "empty" (non-lit) space. Either player can move any LED (in his turn), as long as it is in the direction of LED A1, and then finally in the direction of LED B128. The game won't let you make illegal moves. Once there are no more unlit spaces toward B128, the game is over. The last player to fill an empty space wins.

A few games are quite simple. They require only that a key be pressed when that side's corresponding LED lights. Games A1, A4, and A8 are three such games. When you are learning the C-Game, it is suggested you start with the games in the order shown in Table 1 (first A1, then A2, A3, etc.) as they are organized by order of difficulty.

The four "special effects" selections are included just for fun. When selected, C-Game produces random and pre-programmed LED displays and sound effects. In selection B16,

LISTING 1

```
1                    ;EXAMPLE SOFTWARE LISTING FOR 80C31 C-GAME
2
3   0030                DL1      EQU   30H            ;VARIABLE, INNER DELAY
4   0031                DL2      EQU   31H            ;VARIABLE, OUTER LOOP
5
6   0000                         ORG   0000H          ;SET ORIGIN OF PROGRAM
7
8   0000 75B0CA  START   MOV   P3,#0CAH       ;ENABLE "A" KEY & LED BANKS
9   0003 900000          MOV   DPTR,#0        ;SET ADDRESS FOR LEDS
10  0006 E590    START2  MOV   A,P1           ;READ PUSHBUTTON KEYS
11  0008 F4              CPL   A              ;MAKE LOWS TO HIGHS
12  0009 F0              MOVX  @DPTR,A        ;WRITE TO LED'S
13  000A 60FA            JZ    START2         ;GO BACK IF NO KEYS DOWN
14  000C B2B4            CPL   P3.4           ;TOGGLE PIEZO (ONE "CLICK")
15  000E F530            MOV   DL1,A          ;MOVE A TO DL1 VARIABLE
16  0010 753104  DELAY   MOV   DL2,#04        ;SET INNER LOOP TO 4
17  0013 D531FD  DELAY2  DJNZ  DL2,DELAY2     ;INNER LOOP
18  0016 D530F7          DJNZ  DL1,DELAY      ;OUTER LOOP (KEY VALUE)
19  0019 80EB            JMP   START2         ;START OVER
20  001B                 END

    Errors:  None
```

the A-side keys and B-side keys each produce a separate tone; the frequencies are dependent on the keys held down. Selection B32 lights LEDs in a random pattern, with the A-side keys controlling the range of the tones, and the B-side keys controlling the overall cycling speed.

Refer back to Table 1 for more details about operating all of the games and functions. Don't be afraid to experiment and press the keys in any order you wish—you can't harm anything.

Going further

For readers who want to program their own custom applications or games, a short assembly software listing is given in Listing 1. This program continuously reads the A-side keys and correspondingly lights the A-side LEDs while producing a tone from the transducer. The frequency of the square wave is directly dependent on the binary value of the keys that are pressed.

The flow chart, Fig. 3, details the operations performed in Listing 1. The line numbers in the flow chart correspond to the line numbers in the assembly listing.

Notice line 16 in the listing. The square wave's frequency is determined by the value placed in the "inner loop" (refer to the flowchart and also lines 16 and 17). By changing the value from 4 to some larger value, for example, the loop would require more time to decrement to zero, causing the overall range of frequencies of the square waves to be lower. Ω

Telephone Titters

"That's the radio . . . this is the phone!"

"Sorry, I can't play now, Larry . . . I've got to stay in and show my Dad how to use our new computer."

"Herb and I couldn't possibly correct the overheating problem 'till after lunch!"

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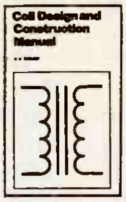

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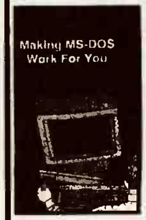

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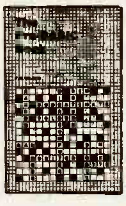

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PHONE-CALL RESTRICTOR

Continued from page 48

prototype unit. Run the wires through the slots and assemble the two halves of the case.

Operation

Locate a suitable phone jack in your home or business and plug in the phone cord of the Telephone Call Restrictor. Put it in a location that is not accessible to those whose phone access you wish to control, and plug the wall adapter into an AC outlet.

Refer to Table 1 for the set of programming commands that can be entered from your Touch-Tone phone. Initially, before programming, set the call restrictor to the "Allow Group" mode. Because there have not been any numbers entered into the EEPROM, all numbers that someone attempts to dial will be blocked. Pick up the phone and try to dial any number. You should hear a tone after pressing the first digit, and a busy signal will be placed on the line to prevent you from completing the call. If that does not occur, the call restrictor is not operating properly.

Make a list in advance of the telephone numbers that you want to either block or allow. If you want to add or remove numbers, that list will come in handy. When programming the unit, LED1 will light immediately prior to the input of telephone numbers and/or password, indicating thatthe circuit is in the programming mode and that a valid password has been entered (if applicable). Until you decide on a password and have entered it into the EEPROM, omit this number wherever it appears in the programming sequence in Table 1. Be careful not to enter a password and then forget the number. If that occurs, you will have to replace the EEPROM with a blank chip.

The EEPROM has enough memory to hold 248 characters including the # sign which separates the telephone numbers.

You can enter full 7- or 11-digit numbers, or you can enter partial numbers such as 786, and all numbers beginning with that prefix will be considered part of the list. A prefix can be any length; entering 1-900 will add all 900 numbers to the list, while entering 1-9 will add all numbers beginning with 1-9 (1-900, 1-976, 1-905, etc.).

At any time you can bypass the call restrictor from any phone on the line simply by pressing #, your password, and then hanging up. The unit is then disabled until the next call is made, and is re-enabled upon completion of that call. With the Telephone Call Restrictor you can finally gain complete control of your phone, and your bill, whether at home or at work. Ω

RETRO REMOTE

Continued from page 100

dress DIP switches open, address zero with all eight switches closed, or anything in between. Regardless of the address you select, be sure to set the same address on the receiver/decoder board.

Apply power to the receiver and connect a 9-volt battery to the transmitter. Test the training transmitter and receiver by aiming the transmitter at the receiver and pressing the transmit switch. If the circuit is working correctly, the valid transmission LED on the receiver will light up as long as you hold down the transmit switch. The VT LED should light regardless of the settings of the DATA DIP switches (S2 a–d). If the LED does not light, find and repair the mistake.

Follow the manufacturer's instructions for programming the learning remote. Operate the training transmitter as you would any other remote control. As discussed earlier, the power-on command is decoded by the receiver as decimal 15. But, because the training transmitter understands only BCD, set all four data DIP switches at logic high (1111).

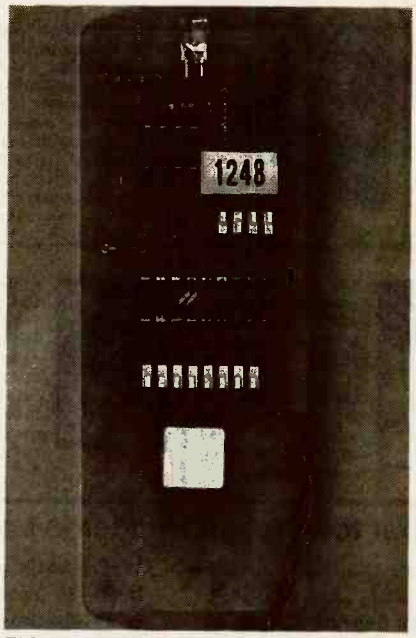
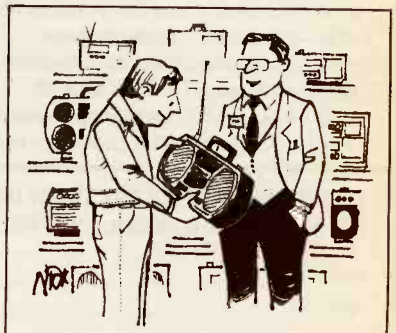


FIG. 7—COMPLETED TRANSMITTER BOARD. This board allows unique coding that won't interfere with nearby remote-controlled equipment.

Now activate the learning remote's learning mode, press the on button, and press the transmit button on the training transmitter until the learning remote indicates that it has received the command. Next set the mute function as decimal 14 (1110), volume-up as decimal 13 (1101), and volume-down as 12 (1100).

How you program the remaining 12 receiver command codes is your choice. You might want to map 0 through 9 to buttons 0 through 9 on the remote. That still allows for two additional commands. Don't forget to program all your other remote controls into the learning remote too. Ω



"It's made here. The manual is poorly written as any Japanese product."

NEW LITERATURE

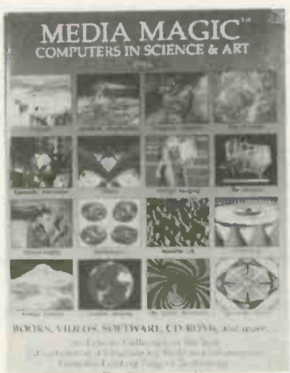
Continued from page 11

your house or apartment for the installation of a home theater system.

He tells you how to install acoustic insulation in that room to minimize or eliminate unwanted noise to improve viewing and listening pleasure.

A 16-page, full color insert in the book illustrates actual home-theater installations, and pricing information is included for many of the components shown.

Computers in Science & Art Catalog. Media Magic, P.O. Box 598-PR, Nicasio, CA 94946; Phone: 415-662-2426; 132 pages; free.



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This mail-order catalog lists more than 1000 products that provide information on the leading-edge of art, science, and technology. It is a valuable resource for determining what material is available for classroom and self-education in those fields.

The catalog covers such varied topics as artificial life, astronomy, chaos theory, computer animation, computer networking, fractals, mathematics, medical imaging, multimedia, robotics, satellite imaging, three-dimensional art, scientific visualization, and the world of virtual reality (VR).

These subjects are presented in such diverse media as books, MAC and IBM-PC compatible (DOS) software, video tapes, and CD-ROMs.

The Microcontroller Idea Book; by Jan Axelson. Lakeview Research, 2209 Winnebago Street, Madison, WI 53704; Phone: 608-241-5824; $31.95 +$3.00 S&H; 277 pages.

This is a book of circuits and programs for applying the popular Intel 8052-BASIC microcontroller (MCU). The MCU, otherwise known as the single-chip computer, contains all the CPU functions of the microprocessor (MPU) as well as memory and I/O functions not found on the MPU chip.

CIRCLE 59 ON FREE INFORMATION CARD

Axelson's book contains complete circuit diagrams, parts lists, design theory, and construction tips for working with the 8052-BASIC. Its on-chip BASIC-52 programming language simplifies the task of writing applications software. Special commands store programs in EPROM or other non-volatile memory.

In addition to its coverage of the basic circuits needed to complete any project, this book explains how to add keypads, switches, and other input/output interfaces. Ω

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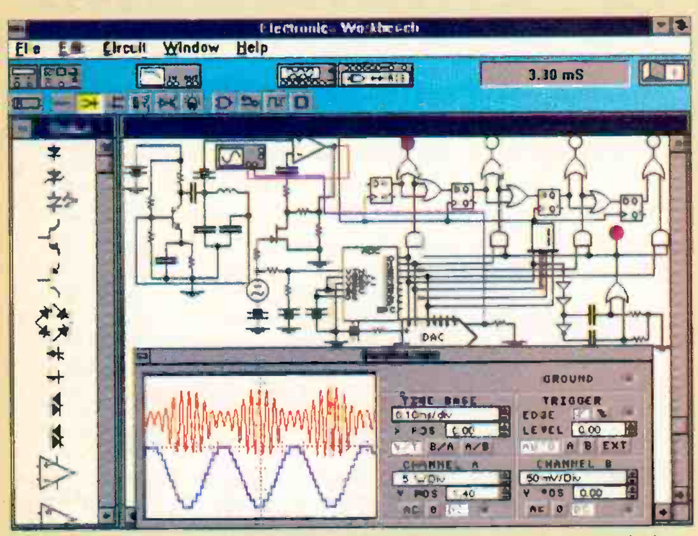

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CIRCLE 18 ON FREE INFORMATION CARD

With convenient wireless installation, two lighting systems offer the brightest solar light ever available!

Alpan's industrially-proven solar technology harvests the power of the sun to protect your home and family.

by Bob S. Garrard

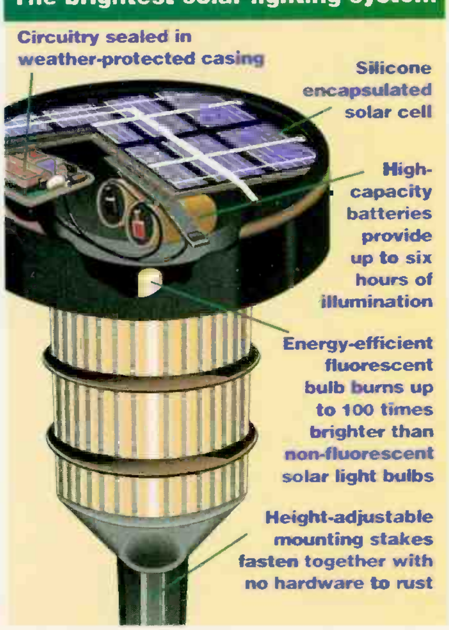
How many nights have you had to negotiate a dark walkway to the door hoping you wouldn't trip on something? Or how often have you stood in the dark fumbling with keys? If you're like me, you leave the porch light on all day, but you still have to find the porch in the dark!

Now there's a better way to come home to the warmth and safety of a well-lit home. Alpan, in colaboration with Siemens, has developed two new lighting systems—the Solar Pathway Light and Solar Sensor Light.

The fluorescent advantage. Built with a fluorescent bulb, the new Solar Pathway Light provides the maximum amount of illumination while using a minimum amount of energy. In fact, the unique fluorescent tube is up to 100 times brighter than non-fluorescent solar-powered lights.

Industrial technology. Alpan has put the *single crystal cell*, the same powerful cell found in industrial power modules, to work for you in the Solar Pathway Light. Using the energy collected by the cell during the day, the power source is charged. At night, the built-in photo sensor detects darkness and automatically turns the light on to provide up to six hours of illumination.

The brightest solar lighting system



No bills, no wires. The Solar Pathway Light can be installed in minutes. Simply twist the two parts together and put the light in the ground. All of the connections are internal, so there are no wires. And because these lights store and use energy from the sun, you'll never pay for outdoor lighting.

Ensured safety. Outdoor lighting is not just convenient. It makes your home safer. Well-lit walkways and yards discourage burglars and vandals. And they can keep you from tripping over unexpected objects in the path—like toys or ice and snow.

Factory-direct offer. This advanced solar lighting technology would retail for hundreds in stores. But through this special factory-direct offer, you can get the Solar Pathway Light for just $59. Order extras, and receive them for just $49. The Solar Sensor Light is available for only $79 with additional lights costing only $69 each. Take advantage of this special offer to add beauty and safety to your home and yard.

Solar Sensor Light for extra security. *Equipped with the same powerful technology as the Solar Pathway Light, the Solar Sensor Light offers you and your family extra protection for your home and outbuildings. This powerful floodlight uses solar power to light your yard with a powerful quartz-halogen bulb. And it has a built-in heat and motion sensor. With no timers or switches to set, this light automatically switches on when triggered and stays on after you leave for 30 to 60 secconds. The adjustable 30 to 60 second delay ensures that you'll never be left in the dark. With no wiring, it's easy to install. The solar panel mounts directly on your roof. The light mounts anywhere. The 14-foot plug-in cord simply connects the two. The solar storage system is so powerful it will switch on as many as 120 times with just a single full charge. And it's able to run for up to two weeks—even if there's no sun.*

Economical and dependable, the Solar Sensor Light has a built-in heat and motion sensor.

Try them both risk-free. Both systems are backed by a "No Questions Asked" 30-day risk-free home trial and a one-year manufacturer's limited waranty. If you're not satisfied, return them within 30 days for a full "No Questions Asked" refund. Most orders are processed in 72 hours and shipped UPS.

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