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Vol. 65 No. 8

CONTENTS

AUGUST 1994

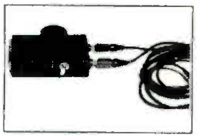
ON THE COVER

VCRs have forever changed the way we watch TV, allowing us to time-shift our favorite programs to watch at our convenience. Unfortunately, when we record broadcast-television programming, we also record the commercials. What should be relaxing playback at our leisure is interrupted either by the commercials themselves, or by trying to fast-forward through them and return to play mode without missing any of the program! Now,

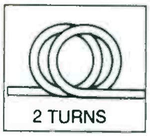
however, you don't have to record the commercials. The ComEd 1000 interrupts recording at the commercial breaks. The powerful, flexible microprocessor-based controller can be set to mute the sound, eliminate the picture, switch to another TV channel or to a radio station, or pause the VCR when a commercial break occurs. When the program comes back on, normal recording is resumed.

— *Russell Hurst*

BUILD THIS



This handy device lets you test for continuity more accurately than you can with a DMM. — *Dan Kennedy*



It's time to build our affordable two-way TV station, and properly align it for base and mobile operation. — *William Sheets and Rudolf F. Graf*

COMPUTERS

Put the I/O Breadboard —presented in the June and July issues—to work as an EPROM programmer. It's easy to build and it teaches volumes! — *Dave Dage*

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WHAT'S NEWS

A review of the latest happenings in electronics.

U.S. retakes lead in semiconductor industry

The United States has regained its leadership position in the international sale of semiconductors, according to the Semiconductor Industry Association. The U.S. is reported to have garnered a 43% share of the world market in sales, making it the first time since 1985 that the U.S. rather than Japan has held the top position.

The announcement was made at a White House press conference attended by Vice President Al Gore, White House Science and Technology Adviser John Gibbons, Commerce Secretary Ron Brown, and Energy Secretary Hazel O'Leary.

Mr. Gore announced an expanded government/industry partnership to strengthen America's leadership in the electronics industry. Closer cooperation is expected to preserve high-wage jobs and provide increased business opportunities for American industry.

The Clinton Administration outlined a number of elements to the partnership:

- The Department of Commerce will establish a National Semiconductor Metrology Program.
- The Department of Defense is sponsoring research and development under its Technology Reinvestment Program.
- The Department of Energy will establish a center for the simulation and modeling of semiconductor materials, manufacturing processes, and chip design. (It will share costs with industry).
- The National Science Foundation will continue its investments in long-term research.

To implement its technology policy, the Administration has created the National Science and Technology Council. It is also establishing the Semiconductor Technology Council to coordinate government, industry, and academic efforts to expand the nation's role in high-technology into the 21st century.

VICE PRESIDENT AL GORE, speaking at a White House news conference, announced an expanded partnership between government and private industry to promote America's worldwide leadership in semiconductors.

Low-Power IC Trend

Power conservation was an important topic during the International Solid State Circuits Conference (ISSCC) held last February in San Francisco. Papers were presented on integrated circuits that operate at far lower than normal voltages without sacrificing performance. The trend is driven by rising consumer demand for lower power-consuming, battery-portable electronics in the face of rising circuit complexity.

Eric Vittoz, a vice president of the Swiss Center for Electronics and Microtechnology in Neuchâtel, said there are limits to how much power can be reduced for both analog and digital circuits. In analog circuits, he said, power reduction is limited by the desired signal-to-noise ratio that must be maintained. Reducing the ratio to the minimum value required by the design can cut power.

In reducing digital IC power, the Swiss engineer said, the lower limit is set by cycle time, operating voltage, and circuit capacitance. In addition to installing a smaller supply voltage, he said, more radical approaches include minimizing the number of device transitions needed to perform a given function, local suppression of clocks, and reduction of clock frequencies. Moreover, he said, clock systems might be replaced by self-timed modules. Parallelism can restore the performance lost by slower clocks.

Mr. Vittoz warned that if power savings cannot be achieved by trading off performance, the price will be longer design time, larger chip area, and the higher costs of scaled-down processes for power reduction instead of speed increase.

An example of the trend was a six-chip IC set for portable multimedia products developed at the University of California at Berkeley. The set reportedly operates at only 1.1 volts to interface a high-speed digital radio modem with a speech coder-

Continued on page 75

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VIDEO NEWS

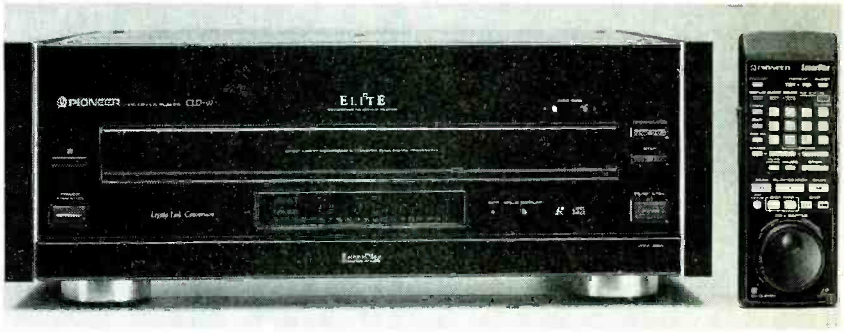
What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• **New laserdisc standards.** The Laser Disc Association is now considering proposals to modify standards for laserdiscs for the era of the digital home theater. One of the key proposals is the addition of Dolby AC-3 audio. AC-3, the encoding system chosen for high-definition TV by the alliance of companies developing HDTV standards, is capable of being operated at various bit rates and reconfigured in several different channel arrangements. Spearheading the drive for AC-3 is Pioneer, the leading laserdisc system manufacturer. The same proposal is being considered by the Laserdisc Association of the Pacific, the Japanese trade association that is dominated by Pioneer. Several other new digital audio systems are also being considered, including Musicam, backed by Philips, and Digital Theater Systems, being pushed by Universal Pictures, which is owned by Matsushita, parent of Panasonic.

• **Video CD here.** Panasonic has been the first to introduce a Video CD player in the United States, under its Technics label. The first product is a $1200 mini component system, scheduled for delivery early this fall. The Video CD system can play up to 74 minutes of full-motion video compressed using the MPEG-1 algorithm. Technics says it is fielding the system as an audio accessory and not as a substitute for prerecorded videocassettes. "Every place we have an audio CD, we want to see Video CD," said an official of Technics. The company said its research showed that consumers want to take video with them, and a portable is scheduled to be among the three of four new models scheduled for introduction next year.

A sketch of one possible configuration showed it resembling a laptop or notebook PC, with the CD player where the keyboard would be and a color LCD display in the cover. One of the other models planned is a five-disc changer, capable of playing full-length movies without interruption, thanks to built-in memory that will eliminate the pause between discs.



PIONEER ELECTRONICS, which makes the CLD-97 laserdisc player shown here, is spearheading the drive to incorporate Dolby AC-3 audio in future laserdiscs.

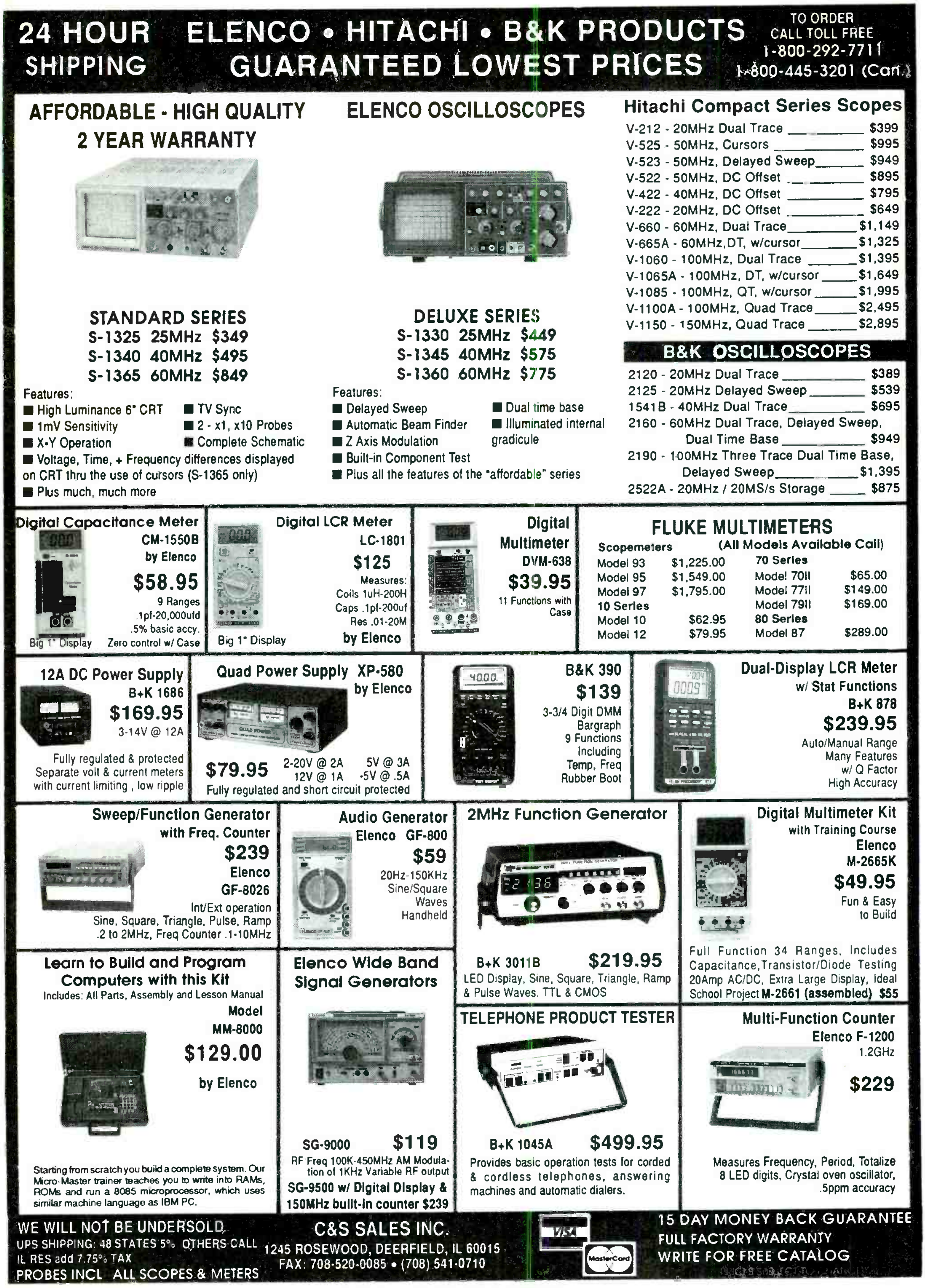
• **Cable interface.** The FCC has issued strict rules in an attempt to solve consumer complaints about the incompatibility of cable systems with such consumer-electronics features as picture-in-picture, on-screen tuning systems, and video recording of one program while viewing another.

Most of the solutions are relatively long-term. For the nearer future, the Commission is banning scrambling of basic tier programs and requiring cable systems to use standard channels as designated by the Electronic Industry Association. The FCC developed a series of specifications that a receiver must have to be advertised or sold as "cable ready" or "cable compatible." Those include the ability to tune all standard cable channels up to 804 MHz and meet new standards on adjacent-channel, image-channel, and direct-pickup interference; tuner overload; cable input conducted emissions; and radiated emissions. In addition, all cable-ready sets must contain a standard back-of-set decoder interface, designed to replace the set-top box and permit the TV's features to be used with scrambled signals by separating scrambling functions from program functions.

A committee of engineers from the cable and consumer-electronics industries has been working to develop standards for this interface but has been unable to agree on some aspects of the system. The FCC warned that if the committee didn't develop a final interface system within 90 days after the effective date of its rules (May 2), it would impose its own specifications on them.

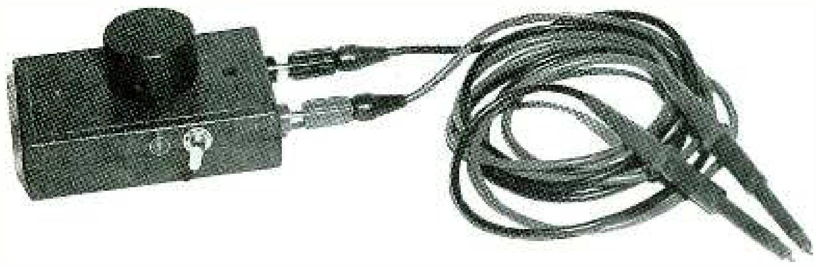
Members of the engineering committee as of this writing indicated that there still were basic differences on the subject, but said they were confident that agreement could be reached. Both sides fear the "or else" implications of the FCC's order.

• **Clock-setting by TV.** It's a small step, but it has major implications for the future. Sony has introduced the first VCRs whose clocks are set automatically by TV. The recorders use the TV signal's vertical blanking interval (VBI), specifically field 2 of line 21, which is the closed-caption line. PBS stations currently are transmitting the clock-setting signal. When The VCR is turned off, it automatically searches through the channels until it finds one that is transmitting the clock signal. Ω



CIRCLE 109 ON FREE INFORMATION CARD

ADJUSTABLE CONTINUITY TESTER



Test for continuity easily and more accurately than you can with a DMM.

DAN KENNEDY

THE CONTINUITY TEST PROVIDED BY most digital multimeters indicates a closed circuit whenever the resistance across the test leads is less than 100 ohms. The tester described in this article lets you set the continuity-test resistance level anywhere from the resistance of only the test leads to 49 ohms. The instrument is especially useful for finding poor connections in multiconductor cables where all the leads are the same length and gauge.

The circuit

Figure 1 is the schematic for the continuity tester. The voltage at the junction of R4 and R5 (about 0.09 volt) is applied to the non-inverting input of op-amp IC1-a. When the test leads are connected to an external resistance, that resistance is placed in parallel with R5, and therefore reduces the voltage at the non-inverting input of IC1-a. The op-amp is configured as a non-inverting amplifier with a gain of 100. Its output is fed to the inverting input of IC1-b, which is configured as a comparator. The non-inverting input of IC1-b sees the voltage selected by R3. When the voltage at its non-inverting input is greater than the voltage at its inverting input, the output of IC1-b goes high. That turns on Q1 and the buzzer sounds. By adjusting R3, you can set the upper resistance level at which the buzzer sounds. The buzzer will sound only when the resistance between the test leads is less than that of the set point.

The set point is adjusted by placing the test leads across a resistor of known value. (Be sure the test leads have sharp points to penetrate any surface dirt or oxide.) To test multi-conductor cables, the set point

PARTS LIST

All resistors are ¼ watt, 5%.
R1, R4—1000 ohms
R2—100,000 ohms
R3—100,000 ohms, potentiometer
R5—10 ohms
R6—100 ohms
R7—10,000 ohms
Semiconductors
IC1—LM1458 dual op-amp
Q1—2N3904 NPN transistor
LED1—light-emitting diode
Other components
S1—SPST switch
BZ1—Piezo electric buzzer
B1—9-volt battery
Miscellaneous: Nylon binding posts, project case, prototype board, 9-volt battery connector, 8-pin IC socket, control knob, LED holder

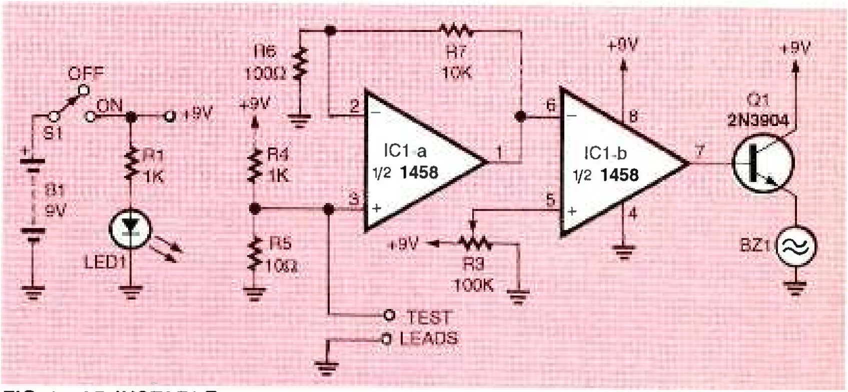


FIG. 1—ADJUSTABLE CONTINUITY TESTER. The buzzer trip point can be adjusted to indicate from less than an ohm to about 50 ohms.

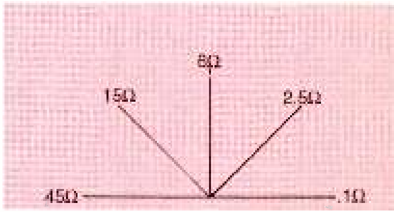


FIG. 2—DIAL CALIBRATION. You can calibrate the dial to give an approximate indication of the resistance that you are measuring.

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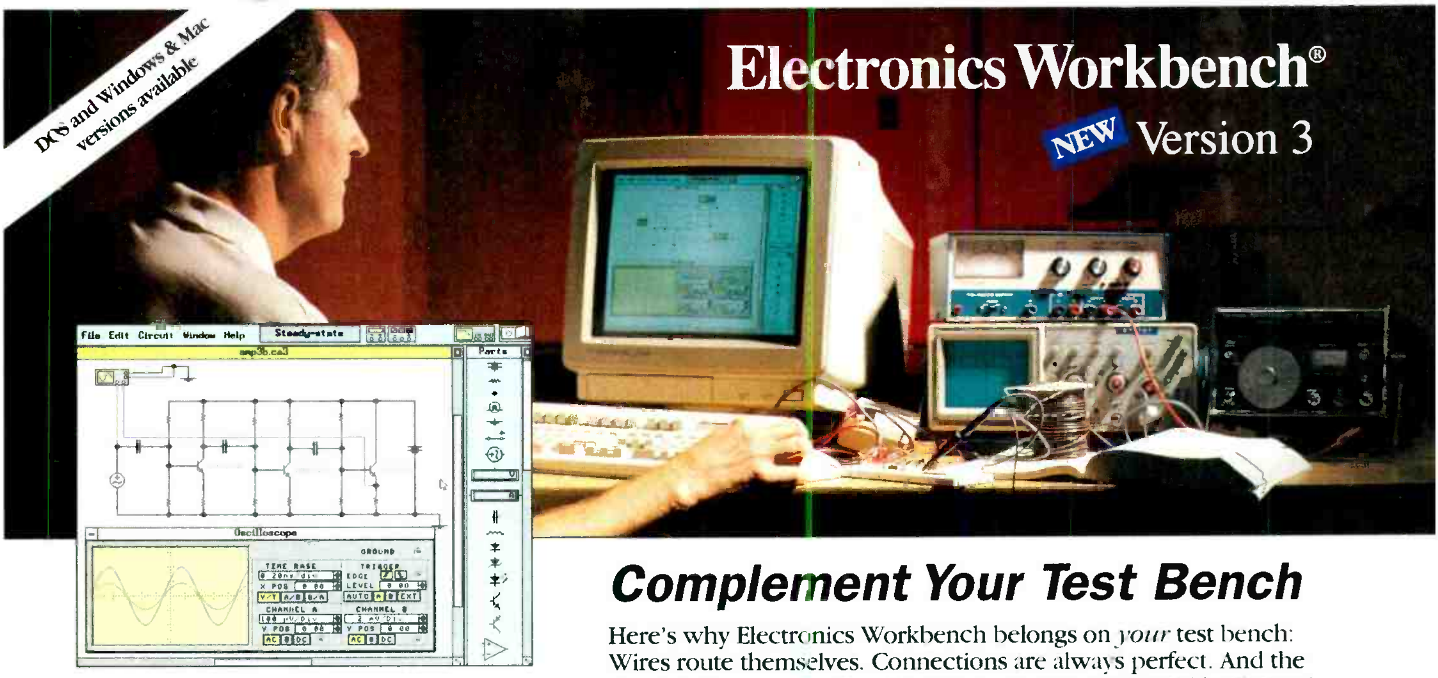

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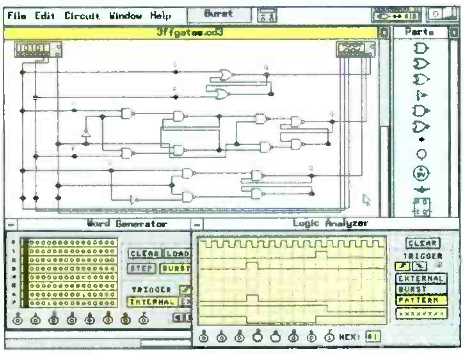

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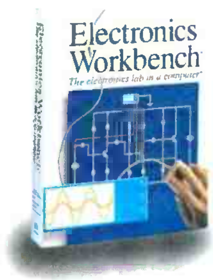

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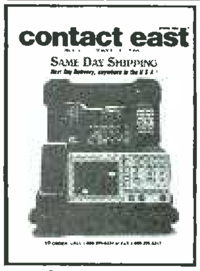

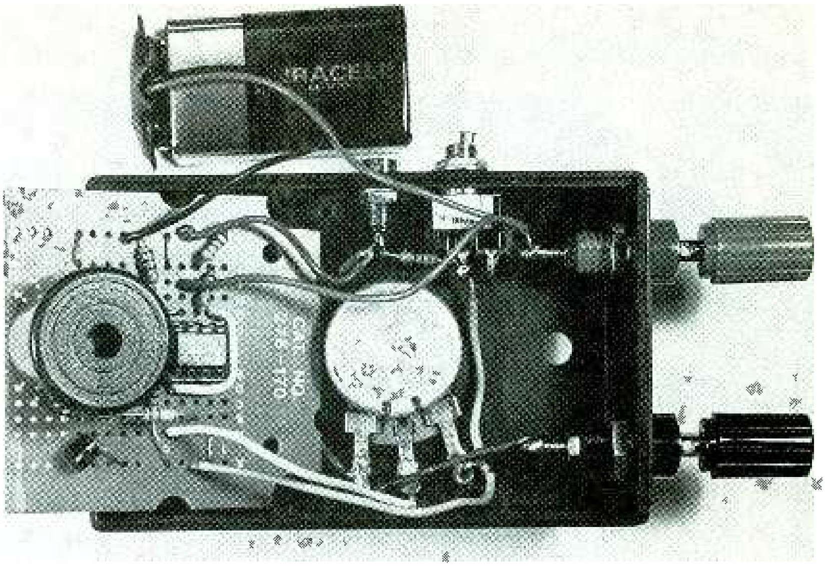

FIG. 3—EVERYTHING FITS in a relatively small project case.

should be set with the test leads across a connection known to be good. Then the other conductors in the cable should be checked for continuity.

The current through any circuit under test must not exceed 9 milliamperes since the current from the 9-volt supply must first pass through 1000-ohm resistor (R4). Linear-taper potentiometer R3 can be calibrated roughly as shown in Fig. 2 to give an approximate indication of the resistance being measured. Figure 3 shows the inside of the completed unit.

The continuity tester is most sensitive in the lower range. If you need a more accurate instrument, R3 should be replaced with a 10-turn precision potentiometer, and the other resistors should be replaced with metal-film resistors that have a low temperature coefficient. When calibrating the dial, be sure to consider the resistance of the test leads, and be sure to use the same set of calibrated leads when you make your measurements. When calibrated, the instrument can be a precise low-level ohmmeter or it can measure the length of a coil of wire based on its resistance. Ω

Cybermations SCK-2000 Stepper-Motor Controller Kit

Developing a new product these days can be a scary proposition. Any new product—especially one that's packed with high technology—can cost thousands, and sometimes millions of dollars to bring to market. There's no guarantee that the investment will ever be recovered.

Most products consist of many individual subsystems. Often, each subsystem is designed by a separate person or team. One way to speed product-development time and save the development costs of "re-inventing the wheel" is to buy one or more subsystems from a third party as an off-the-shelf item. If the prototype built with the off-the-shelf subsystem suggests that it will be a profitable product, the off-the-shelf subsystem can be integrated into the final design.

When a project subsystem requires precise mechanical movement, stepper motors are the engine of choice. Stepper motors have output shafts whose rotations can be controlled precisely, and whose positions can be returned to repeatedly. Stepper motors are often used in automotive, aerospace, computer peripheral, industrial, medical, and robotics applications, just to name a few. The only "problem" with stepper motors is that they can't simply be connected to a DC voltage and be expected to work. Instead, they must be connected to a stepper-motor controller circuit.

Why reinvent the wheel—or a stepper-motor controller—when you don't have to?

CIRCLE 15 ON FREE INFORMATION CARD

The SCK-2000

The *SCK-2000* stepper-motor controller kit from Cybermations (1943 Sunny Crest Drive, Suite 288, Fullerton, CA 92635, 714-992-2266) is best described as a subsystem. It's not a kit in that you don't have to build anything, but it is in that you have to connect together the various parts. It is a subsystem, though, because you can get it working by itself, but it's not very productive to simply watch stepper motors stepping—it's far more useful to have the motors perform a job of some kind.

The SCK-2000 is supplied with two 48-step Astrosyn stepper motors, a controller card, and an AC transformer with a line cord. Also included are an instruction manual, and IBM-compatible software written in QBASIC and GWBASIC on a 5¼-inch disk. The price of the kit is $249.95. The minimum requirements for running the software is an IBM XT-compatible computer with 512K RAM, DOS 2.1 or higher, a low-density 5¼-inch disk drive, a parallel port, and a hard drive. GWBASIC or QBASIC is required to control the SCK-2000.

Although the kit includes the two Astrosyn stepper motors, the controller is also compatible with any of Airpac's 4-phase stepper motors. The 12-volt AC transformer is capable of powering up to four separate controller cards. The controller card is a standard 4½- × 6-inch circuit board with a 22-pin double-sided edge connector.

The controller card address can be set by a DIP-switch to any address from 0 to 15. Therefore, up to 16 cards can be controlled from a single parallel port. Because each controller card can control two stepper motors, up to 32 separate motors can be controlled from the same port. The controller card's 22-pin edge connector fits in the stand-alone adapter included in the kit as well as in standard 4½ × 6 × 19-inch card racks to allow for expansion. The card has a built-in Centronics connector so a standard printer cable can to connect the card to a PC.

Software

Software installation requires that everything on the included floppy disk be copied into a separate subdirectory on your hard drive. GWBASIC or QBASIC and their related files must be copied into the same subdirectory. Then either GWSTEP or QSTEP is run.

Once the software is running, you are prompted to select a parallel port (LPT1–LPT3), a board address (0–15), the number of steps for Motor 1, a direction for Motor 1 (clockwise or counterclockwise), the number of steps for Motor 2, the direction for Motor 2, and the speed, which must be the same for both motors. The speed setting, is sensitive to the clock speed of the computer that is controlling the motors.

The test software makes it easy to "manually" control stepper-motor-driven projects from a computer. And because the software is written in basic, it's easy to include stepper-motor control in more advanced, custom software. It's even possible to implement custom stepper-motor control software in firmware, eliminating the need for a PC, but that's far beyond the scope of this kit.

Although the SCK-2000 is a quality kit, it suffers from poor, sloppy documentation. Despite the documentation, the controller is basically simple to operate. More important, it can greatly speed the development time for projects that require stepper-motor control. Ω

LETTERS

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

HDTV AUDIO

I read Jeff Holtzman's comments on HDTV audio in the "Computer Connections" column in the March 1994 issue of *Electronics Now* and I am writing to correct an error in it.

The U.S. HDTV system does not "include a special form of Dolby noise reduction," as he stated. It includes Dolby AC-3, a low bit-rate transform coding system that codes 5.1 channels of audio (five full-range channels plus a subwoofer channel, the 0.1 portion) into a 384 kps data stream. This is the same coding system that is in the Dolby Stereo Digital film system and its upcoming digital satellite cable and DBS services.

WILLIAM BARNES
Dolby Laboratories
Licensing Corporation
San Francisco, CA

MICROPHONE BALANCING

In the April 1994 issue of *Electronics Now*, M. Bith asked a question in "Q&A" about using low-impedance microphones with high-impedance inputs. The circuit shown would give enough gain, but its input is unbalanced. Most low-impedance microphones have two-wire shielded cables and three-pin XLR connectors, and they are designed for balanced inputs.

They can be used with unbalanced inputs (connect one of the wires to the shield), but balanced inputs are less susceptible to interference from hum and electrical noise.

I solved a similar problem—electrical interference with an unbalanced input. The use of a balanced input almost completely eliminated the interference. The circuit I designed to solve the problem (Fig. 1) is a simplified version of a circuit that appeared in "Build the EM Phantom-Power Microphone Preamp," by Jules Ryckebusch, in *Electronic Musician*, April 1993.

If R6 and R13 are 10,000 ohms, the gain will be about the same as with a low-impedance to high-impedance matching transformer (such as Radio Shack's No. 274-016). Because I needed more gain, I used 47 kilohms; It gives enough gain for most "line-level" inputs. If variable gain is desired, 100-kilohm potentiometers could be substituted.

If R6 and R13 are fixed resistors, R5 and R12 should have the same value to keep the inputs balanced. If R6 and R13 are variable, R5 and R12 can be an intermediate value such as 10 or 22 kilohms. To keep the input balanced with variable gain, R5 and R6 as well as R12 and R13 could be replaced with a dual 100 kilohm control (such as Radio Shack's No. 271-1732).

If only one channel is needed, the NE5534 single op-amp version of the NE5532, and the 741 single op-amp version of the 1458 can be used. The NE5534 and NE5532 are examples of low-noise op-amps widely specified for audio equipment, while the 741 and 1458 are older devices which might produce more noise.

BILL STILES, CET
Hillsboro, MO

RADIO LICENSE RENEWAL SEMINARS

Electronics Now readers might be interested to know that the National Association of Broadcasters (NAB) has added three dates and locations in its series of one-day regional seminars to prepare radio broadcasters for the 1995–98 round of license renewals.

The newly announced seminars will by held July 14 at the Holiday Inn/Woodlawn in Charlotte, North Carolina for North and South Carolina broadcasters; September 22 at the Radisson Hotel/Airport in Or-

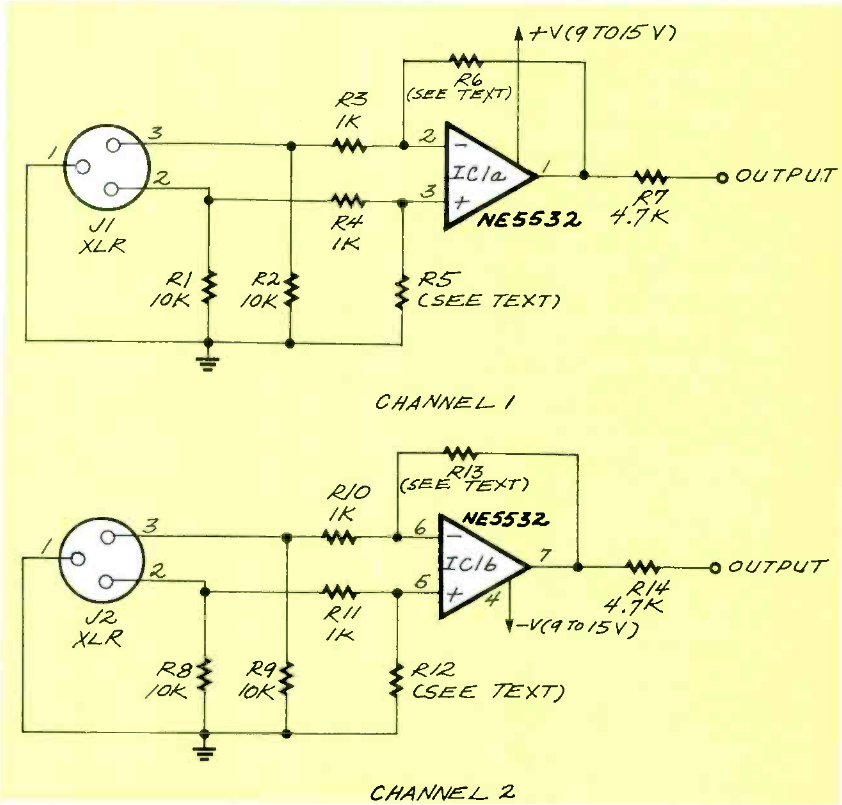

FIG. 1—A BALANCED INPUT solves interference problems.

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

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4401 Connecticut Avenue, NW
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lando, Florida for broadcasters in Florida, Puerto Rico, and the Virgin Islands; and November 17 at the Holiday Inn/Airport in Columbus, Georgia for Georgia and Alabama broadcasters.

The seminars are scheduled to take place about 13 months before the renewal deadline in each region of the country, and will coordinate with state broadcaster associations. Each seminar will focus on the needs of small and medium-market stations, but executives from stations in markets of all sizes are welcome to attend. Speakers will include NAB attorneys, NAB EEO specialists, and outside experts. Each seminar will run from 9 AM to 4 PM, with lunch included.

The first person from each NAB member station will be admitted free. The fees for the second and third attendees from each member station are $35 and $50, respectively. The fee for non-members is $300. Pre-registration is mandatory. To register for a seminar, or for more information, call Christina Griffin at NAB Radio, 202-775-3511.

NATIONAL ASSOCIATION OF BROADCASTERS
Washington, DC

SURFACE-MOUNT ADVOCATE

I would like to give a thumbs-up to your "Equipment Reports" (*Electronics Now*, April 1994) review of the Elenco Electronics SM-220K decision maker. I am glad to see a magazine finally acknowledge that surface-mount devices exist in the real world of electronics. I was particularly pleased with the way the author suggested that the reader try this simple project to get his feet wet working with surface-mount components and that, with patience, it's not that difficult.

Having worked with SMCs for more than seven years, I have found that it is actually easier to rework circuit boards with SMCs than those with leaded through-hole components. I recommend that *Electronics Now* print future articles on surface-mount devices to help the average reader understand that surface-mount technology is the wave of the future.

DOUGLAS HURKMANS
Milwaukee, WI

TRAFFIC-LIGHT SEQUENCING CORRECTION

I am an engineering student at Texas Tech University, and I am writing about the "Traffic-Light Sequencing" letter that appeared in the May 1994 issue of *Electronics Now*.

The circuit shown is a convenient and easy way to create a realistic traffic-light sequence. There is, however, one mistake in the circuit design. The emitters of the 2N2222 transistors (Q1, Q2, Q3) should be grounded and the collectors should be connected to diodes D9, D11, and D13, respectively.

I have already found an application for the circuit, and it works great!

SCOTT A. SMITH
Lubbock, TX

PLD PROGRAMMER CORRECTIONS

The schematics accompanying my article "Build This PLD Programmer" (*Electronics Now*, May 1994) contain several errors.

Figure 1 all related to IC7: pin 16 should go to pin 4 of S1; pin 14 should go to pin 6 of S1; pin 12 should go to ground; pin 9 should go to pin 7; pin 7 should go to pin 5 and; pin 5 should go to pin 3.

Figure 2, related to IC3: label PS14 should be at pin 2, *not* pin 18; label PS15 should be at pin 3, *not* pin 19.

Figure 2, IC1: pin 2 should connect to the junction of R7 and R9, *not* the junction of R6 and R7. The collector of Q4 should connect to pin 2 of the ZIF socket, *not* pin 4, and the collector of Q6 should connect to pin 4 of the ZIF socket, *not* pin 2.

In the symbol for SIP resistors R23 and R24, pin 1 should directly connect to the common point of all other resistors in the SIP.

Break the connection between pin 10 of R23 and pin 1 of the ZIF socket.

ROBERT G. BROWN
East Northport, NY

TELEPHONE RING AMPLIFIER

The circuit in the letter from D.A. Butch, "Telephone Ring Amplifier" (*Letters, Electronics Now*, February

Continued on page 26

COMPUTER CONNECTIONS

A vision of the future.

JEFF HOLTZMAN

IBM is up to something that could change the computer industry as we know it. Early this past spring, IBM called in about 750 of its closest advisors for talks given by Lou Gerstner (IBM's CEO) and his top managers. The close advisors are highly influential in IBM's Consultant Support Program. They included representatives from such financial and management firms as Arthur Anderson, Merrill Lynch, and Coopers and Lybrand, as well as many independent consultants. No reporters, no hardware developers, and no software developers were invited. Why consultants? Because IBM believes that they are the people with the knowledge, influence, judgment, and independence to help IBM—or help to bury it.

The talks were intended to outline IBM's new strategy for breaking the industry dominance of Intel and Microsoft. Armed with the knowledge they gained, the consultants were expected to go back to their constituencies and preach the IBM gospel.

IBM's gospel runs something like this: Don't forget the past—but scratch everything and start over. Maybe that's not how IBM would put it, but that's the substance. What does it mean? Look at IBM's product line: mainframes, minicomputers, workstations, personal computers, and personal digital assistants (PDAs). That's five classes of hardware and five classes of software. They require five development efforts, five manufacturing operations, five support operations, and they are five architectures for the rest of the industry to support.

Suppose that there was a way to consolidate those five, widely divergent architectures into one. Would doing so make any difference to IBM, to the industry, and to the end user?

RISC or bust

You've probably read here in the past about IBM's POWER (Performance Optimization With Enhanced RISC) architecture, but here's a quick recap. Recall that there are two basic microprocessor architectures: CISC (Complex Instruction Set Computing) and RISC (Reduced Instruction Set Computing). Until Apple's recent introduction of the Power Macintosh, all personal computers were based on the CISC concept. That includes, of course, the established base of almost 150 million Intel processor-based PCs worldwide.

On the other hand, most engineering workstations were built around RISC processors. The exceptions were early Sun Microsystems and all NeXT machines, which were based on the Motorola 68000 family of CISC processors. However, those exceptions are all now obsolete. RISC processors rule supreme in workstations. The question now is not even whether, but when, RISC processors will make their presence felt in the mainstream PC market.

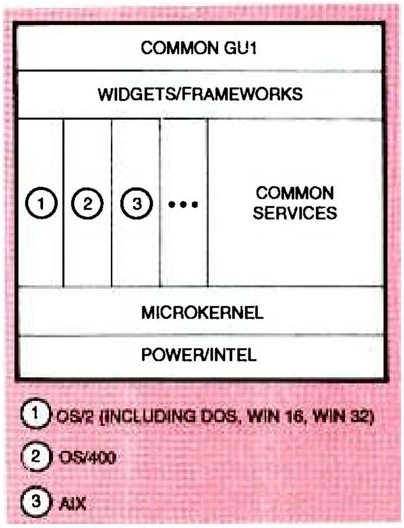

FIG. 1—IBM'S NEW CPU-INDEPENDENT computer architecture is applicable to all computers from PDAs to mainframes.

RISC processors are simpler to design and cheaper to build than CISC processors. They do fewer things than CISC CPUs, but they do them extremely well. And what they can't do in silicon, they can do in software. Ironically, RISC was invented at IBM.

CISC, by contrast, represents an "everything-but-the-kitchen-sink—and-maybe-that-as-well" design philosophy. If you can think of a machine-language instruction or addressing mode, no matter how arcane, there's a good chance that your favorite CISC chip implements it—or will in its next generation. As a result, CISC processors will continue to be comparatively complex and expensive, both to develop and to manufacture.

RISC processors are faster and cheaper, but are they better? IBM, Apple, and all workstation vendors have bet their futures on RISC. It's RISC or bust.

Technical architecture

Figure 1 shows the architecture of IBM's new, unified set of product lines. It will allow IBM to build everything from PDA's to mainframes using similar hardware and software technologies.

The processors common to all these computers will be based on POWER. They will include both the single-chip PowerPC processor, intended for the mass market (in such machines as Power Macintoshes and Power PCs), and multichip modules for the workstation market. With the new architecture, IBM is extending POWER's range. Inexpensive, power-conserving versions for PDAs, mass-produceable versions for the mainstream desktop PC market (currently dominated by Intel and Microsoft), and higher-power, multiprocessor versions to cover workstations, minicomputers, and mainframes.

The next level up from the processor is the *microkernel*, which forms the core of a computer operating system. Microkernel technology, developed at Carnegie Mellon University, permits an operating system to be built with a modular approach. To understand this, first take a look at what it is not. MS-DOS is the antithesis of microkernel. Everything about MS-DOS is hardware-dependent. A computer will be compatible with MS-DOS only if video buffers, serial port addresses, amd hard-disk controllers exist at specified locations and function in specified ways.

The microkernel approach abstracts and isolates hardware. If you want to change to a whole new video system, or a whole new hard-disk control mechanism, you're free to do so. The microkernel allows even more radical changes. It takes the processor itself out of the equation. Therefore, most of the microkernel—and all levels above it—is processor-independent.

With processor independence, application development becomes a totally different kind of endeavor, one that is less concerned with computer architecture, and more concerned with application functionality, that is, meeting user needs.

Microkernel is not some new, untried, pie-in-the-sky technology. It has been in operating systems such as NextStep (now OpenStep), for years. The same concept is used by Microsoft in its Hardware Abstraction Layer, which is at the core of its 32-bit operating system architecture, as discussed here in the July 1992 *Electronics Now*.

Now consider layer three of the model, particularly the vertical slices. Those are "personality modules" that plug into the microkernel and provide high-level services that developers can use when building applications. The personality models roughly correspond to the application programming interfaces (APIs) that are essentialy today's operating systems—OS/2, Unix, and Windows. These slices permit applications written to any of those APIs such as Windows16, Windows32, OS/2, and Unix—to run on the new architecture.

Layer 4 presents high-level "widgets" that combine and encapsulate groups of low-level services. These widgets have different names, and the way they're used varies by development environment, but the concepts are the same.

For example, Windows C++ programmers use the Microsoft Foundation Class or Borland's Object Windows Library (OWL). These are object-oriented "class libraries" that allow programmers to reuse standard chunks of code. Visual Basic programmers use VBXs, which are drag-and-drop controls for adding user-interface and internal functionality to Visual Basic programs. If you have ever written a macro in Lotus or some other package, you can view the widget layer as a kind of macro capability for software developers.

In IBM's model, the widgets in this layer are the result of the development effort of Taligent, another of IBM's strategic joint ventures with Apple (and more recently, Hewlett-Packard), also discussed here in the July 1992 issue. At one point, many believed that Taligent would produce an entirely new next-generation object-oriented operating system. Now it appears that Taligent's objective is to produce widgets, or what it calls frameworks.

Level five is the user level, where widgets are combined, customized, and packaged into real applications. This is where application programmers do their work. This is the layer

Continued on page 25

POWER-QUALITY ANALYSIS METER. The Wavetek CPM Series of clamp-on, hand-held power meters are intended for power measurement when installing, maintaining, and monitoring electrical systems.

The CPM2000 (for AC measurements) and the CPM2100 (AC and DC) function as wattmeters, volt-ampere meters, power-factor meters, and autoranging digital multimeters with data hold, continuity, and diode test.

Measurements are displayed on a four-digit, 4000-count display with a bargraph. Both meters have a low-pass, 100-Hz filter for detecting potentially destructive harmonics. True-RMS values are measured on all waveforms. Hall-effect sensors and the clamp-on jaw allow measurements to be taken without circuit interruption.

Peak mode measures the instantaneous maximum of the waveform. Surge mode detects and holds the maximum RMS current measurement, and average-sensing mode measures in non-true RMS. Pressing the data hold button stores a measurement on the display.

The CPM2100 also has an analog output for viewing waveforms on an oscilloscope or a chart recorder. Each meter can be connected to a computer through an RS-232 interface. The computer can act as a data logger. Measurements can be recorded with data logging software.

The CPM2000 is priced at $795 and the CPM2100 is priced at $995 with test probes, battery, and carrying case.

Wavetek Corporation
9145 Balboa Avenue
San Diego, CA 92123
Phone: 619-279-2200

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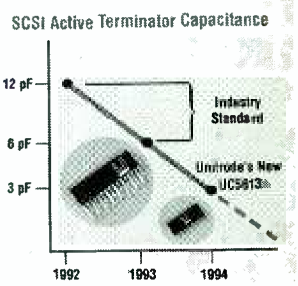
NINE-LINE SCSI ACTIVE TERMINATOR. Unitrode Integrated Circuits has introduced the UC5613 that provides nine lines of active transmission for SCSI (Small Computer Systems Interface) parallel bus. It complies with the SCSI recommendation of an active termination at both ends of the cable segment.

The UC5613 provides a disconnect feature which, when opened or driven high, disconnects all terminating resistors. This disables the regulator which reduces standby power. The output channels retain their high impedance characteristic.



CIRCLE 22 ON FREE INFORMATION CARD

When disconnected, the device goes into a "sleep mode," drawing less than 10 nanoamperes with all output channels remaining in a high-impedance state. A low channel capacitance of 3 picofarads allows units at interim points of the bus to have minimal effect on signal integrity.

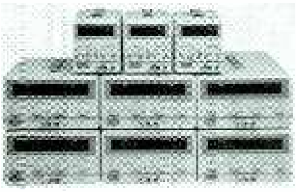
The UC5613 is pin-for-pin compatible with its predecessor, the UC5603 nine-line terminator. It features a 400 mA sink/source regulator which eliminates problems asso-

DC POWER SUPPLIES. Leader Instruments has added nine more models to its 700 Series bench DC power supplies. These single-output supplies have maximum output voltages of 18 to 110 volts DC, and maximum currents from 3 to 20 amperes.

All models offer constant voltage or constant current output. Voltage and load current are displayed on a 3½-digit LED readout. Reverse polarity protection with fast overload recovery are standard.

Th Model 700 Series power supplies are priced from $354 to $1150.

Leader Instruments Corp.
380 Oser Avenue
Hauppauge, NY 11788
Phone: 516-231-6900 in NY, or 800-645-5104

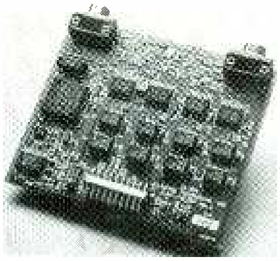


CIRCLE 21 ON FREE INFORMATION CARD

ciated with active negation drivers. It has a low dropout regulator of 0.7 volts, thermal shutdown, and current limiting.

The *UC5613* active terminator is priced at $2.18 in thousand-piece purchase quantities.

Unitrode Integrated Circuits Corporation
7 Continental Blvd.
Merrimack, NH 03054-0399
Phone: 603-424-2410
Fax: 603-424-3460



CIRCLE 23 ON FREE INFORMATION CARD

ANTI-ALIASING FILTER. Alligator Technologies has introduced its AAF-HE8P low-pass, RS-232C-programmable, anti-aliasing filter. It is recommended for installation in front of any analog-to-digital converter in data-acquisition systems under extreme environmental conditions.

The eight-channel board has a 1-Hz to 50-kHz software-selectable cutoff frequency range, DC accuracy, 0.5° phase matching between channels, and a five-pole Butterworth filter with a maximally flat passband and low phase lag.

Built to withstand high vibrations and extreme temperatures, the filter is said to be suitable for airborne instrumentation and control, ground vehicle engine testing, shock and vibration measurement, sonar and acoustical analysis, and robotics.

The filter allows valid input signals to pass while removing undesired signals with frequency components above one-half the sampling rate of the A/D converter. Aliasing in A/D converters can cause higher frequency noise components to "fold over" into the lower frequency spectrum and appear as gross errors that cannot be corrected once the signal is digitized. An anti-aliasing filter with sharp attenuation eliminates the need to oversample the input signal.

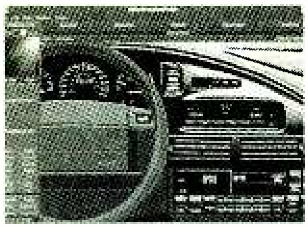
The filter has a menu-driven interface for IBM PC XT or compatible computers that allows the user to control the cutoff frequency of up to 16 filter units with a single RS-232 link.

The AAF-HE8P anti-aliasing filter with eight filtered channels, is priced at $3950.

Alligator Technologies
2900 Bristol Street,
Suite E-101
Costa Mesa, CA 92626-7906
Phone: 714-850-9984

HUMAN INTERFACE DESIGN SOFTWARE. Altia Design 1.3 for Windows 3.1 is software that allows users to create full custom, dynamic user interfaces for the accurate simulation of their physical counterparts and the display of real-time data. The program is intended for designing products such as automobile dashboards, airplane cockpits, electronic test instruments, and communications equipment.

A graphical editor allows the user to assemble "pre-built" graphic components, such as buttons, meters, and dials, as well as allowing the user to create custom components. Interactive animation features simplify the creation of dynamic components such as



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LCD displays. Designers have full control over input signals, with interactive definition of input areas, triggers, and actions.

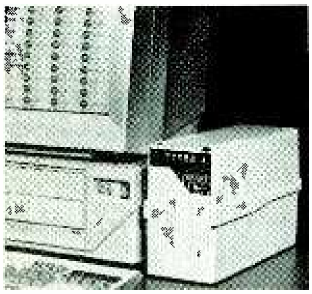
Users can manipulate graphics with a mouse, a touch screen, or trackball. A code-connection feature allows designers to link external software for data feeds and modeling instrument behavior. Record and playback capabilities can capture user interaction and gather human factors data.

Altia Design for Windows 3.1 is priced at $4900. It is available for 386/486 processor-based computers.

Altia, Inc.
5030 Corporate Plaza Drive #200
Colorado Springs, CO 80919
Phone: 719-598-4299
Fax: 719-598-4392

INTERACTIVE UPS SYSTEMS. The Smart Series interactive uninterruptible power supply (UPS) systems from Tripp Lite are available in seven sizes, ranging from 250 to 1250 volt-amperes.

Microprocessor control



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gives them a wide range of operating modes and network management and communication functions. With the company's PowerAlert PLUS software loaded, network power operations can be tracked and logged with a menu.

Incoming voltage, frequency, percent of remaining battery power, UPS temperature, and UPS load can be displayed. The UPS systems also provide continuous voltage regulation from 87 to 140 volts, and complete spike and surge protection.

The UPS system prices start at $295.

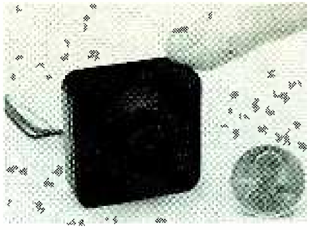
Tripp Lite
500 North Orleans
Chicago, IL 60610-4188
Phone: 312-329-1777
Fax 312-644-6505

IC CAMERA. Marshall Electronics has introduced its watch-sized Model V-007 video camera said to be the world's first on a single silicon chip. It is intended for such applications as unobtrusive security cameras, robotics, machine vision, computer video, and videoteleconferencing.

The camera is integrated into a single 32-pin CMOS VLSI chip. It has a ½-inch format, 312 × 287-pixel image sensor array and the circuits necessary to drive and sense the array. Pixel size is 19.6 × 16.0 microns.

Automatic exposure range is 40,000:1, and automatic gain control is adjustable up to 10 dB. Light sensitivity is 2 lux. The camera is more sensitive to infrared than standard CCD cameras, so it can sense heat sources that cannot be seen.

Evaluation samples of the V-007 camera module are available with a wide-angle lens in a small aluminum housing that can plug



CIRCLE 26 ON FREE INFORMATION CARD

directly into any TV monitor or VCR. It operates from a 7 to 12-volt DC battery.

A V-007 in an enclosure is priced at $249.

Marshall Electronics Inc.
P. O. Box 2027
Culver City, CA 90230
Phone: 310-390-6608
Fax: 310-391-8926

NON-CFC CONTACT CLEANER. Micro Care has introduced Precision Cleaner II for cleaning high-density, complex electronic and mechanical assemblies. It will remove oil, grease and general contaminants, and is said to be the only commercially available non-chlorofluorocarbon (CFC)-based contact cleaner that is a true replacement for

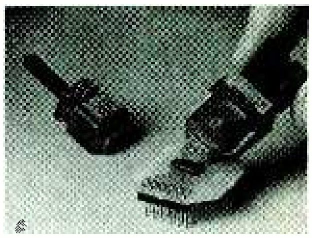
CIRCLE 27 ON FREE INFORMATION CARD

CFC-113. The manufacturer reports that the non-flammable, non-toxic, non-conductive solution will not attack plastics. Precision Cleaner II consists of a solvent derived from the perflourocarbon family, HFC propellants and some inert additives.

Precision Cleaner II is priced $18.80 for a 16-ounce canister in volume purchases.

Micro Care Corporation
34 Ronzo Road
Bristol, CT 06010
Phone: 203-585-7912
Fax: 203-585-7378

LOCK-ON IC TEST CLIPS. Three locking test clips from ITT Pomona are intended to make firm connection to large-scale integrated circuit packages. These clips have a slightly larger footprint than earlier models to provide greater holding power for positive connections in either horizontal or vertical positions.



CIRCLE 28 ON FREE INFORMATION CARD

Model 5962A mates with a 20- and 24-pin QSOP packages, with pins on 0.025-inch centers and a 0.150-inch-wide body. Models 5969A (20-pin) and 5972A (24-pin) connect to SSOP devices with pin centers at 0.65 mm and a 5.3 mm-wide body. The clips have spring-loaded locking-jaws for positive connection and wiping contact with each device lead. After positioning the clip over a device, the jaws can be released, with the lip of the jaws gripping the unleaded ends of the IC. Pins that are 0.018 inch square provide access on each side of the test clip for grabbers, or high-density cable connectors.

Model 5969A is priced at $150, and Models 5962A and 5972A are priced at $165.

ITT Pomona Electronics
1500 East Ninth Street
Pomona, CA 91766-3835
Phone: 909-469-2900
Fax: 909-629-3317

DATA-ACQUISITION MODULE. National Instruments is offering the DAQPad-1200, a compact external data acquisition (DAQ) module. It communicates through the parallel port on an IBM PC or compatible personal computer. The module includes a 12-bit A/D converter with eight analog inputs configurable as eight single-ended or four differential inputs.

It also contains two 12-bit DACs with voltage outputs, 24 lines of TTL-compatible digital I/O, and three 16-bit counter/timer chanels for timing I/O. It is software configurable and self-calibrated. It can digitize signals from eight single-ended or four differential inputs at rates up to 100 kS/s.

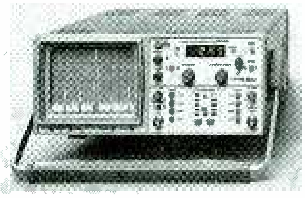
CIRCLE 29 ON FREE INFORMATION CARD

The unit includes an AC adaptor, but an optional battery pack with charger is available. It is packaged in a case that measures 5.75 × 8.375 × 1.5 inches and weighs 1.7 pounds. A second parallel port allows it to be connected to both a PC and a printer.

The DAQPad-1200 data-acquisition box is priced at $995; the battery pack is an additional $295.

National Instruments
6504 Bridge Point Parkway
Austin, TX 78730-5039
Phone: 512-794-0100 or 800-433-3488
Fax: 512-794-8411

SPECTRUM ANALYZER/ TRACKING GENERATOR. The HM5006 spectrum analyzer/tracking generator from Hameg Instruments analyzes signals in the 0.5- to 500-MHz frequency range. Its scan width selector allows the frequency display width to be adjusted from 50 kHz to 50 MHz per division for analysis of low amplitude, narrow-band signals.



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The analyzer is rated to measure low amplitude signals and has a measurement range of over 110 dB. In its zero-scan mode, selective amplitude level measurements can be performed while it is tuned to a fixed frequency. The four-digit LED readout displays either the center or marker frequency. A needle-like cursor can to set the desired point on the display.

The output level of −50 dBm to +1 dBm is adjustable in four 10-dB steps.

The HM5006 spectrum analyzer/tracking generator is priced at $1398.

Hameg Instruments
1939 Plaza Real
Oceanside, CA 92056
Phone: 800-247-1241 Ω

NEW LITERATURE

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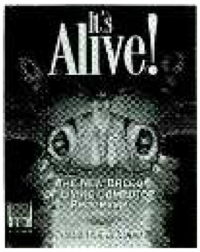
It's Alive! The New Breed of Living Computer Programs; by Frederick B. Cohen. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012; Phone: 1-800-CALL-WILEY; $39.95, including diskette.

This book is a collection of thoughtful essays that examine the intriguing questions about new generations of computer software that appear to grow, learn from experience, modify their behavior, reproduce, age, and die. It explores both the practical issues of concern to professional programmers and the philosophical questions that often come up about the creation of artificial life.



CIRCLE 337 ON FREE INFORMATION CARD

Mr. Cohen's book discusses good and bad viruses, practical applications and concerns for "living" programs in business and entertainment computing. Other topics covered in the bok are artificial life, genetic algorithms, and the development of intelligent software.

A 3½-inch Macintosh-compatible disk, included in the book, gives the reader examples of practical and entertaining "living" programs, including several fun-to-play games.

1994 General Catalog. Contact East, 335 Willow Street South, North Andover, MA 01845-5995; Phone: 508-682-2000; Fax: 508-688-7829; free.

Contact East's 244-page 1994 catalog includes pictures and data on the company's products for assembling, testing, and repairing electronic equipment.

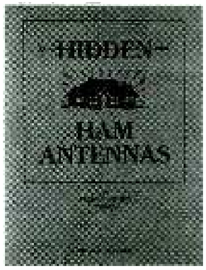
CIRCLE 338 ON FREE INFORMATION CARD

Among the many products covered are inspection equipment, soldering and desoldering tools, communications test equipment, and ESD-protective containers and tools.

New products in this edition include custom tool kits, power supplies, portable and benchtop digital storage oscilloscopes, hand tools, prototyping boards, reference books, and EPROM programmers.

HIDDEN HAM ANTENNAS; by Frank P. Hughes, VE3DQB. Tiare Publications, P. O. Box 493, Lake Geneva, WI 53147; Phone: 800-420-0579 (8 AM to 6 PM Central Standard Time); $12.95 plus $2 shipping and handling ($3 foreign).

Any radio amateur who must overcome local laws or landlord restrictions banning conspicuous out-



CIRCLE 339 ON FREE INFORMATION CARD

door antennas on home rooftops or apartment buildings and in yards will welcome this book about disguising antennas. It discusses building or buying antennas that will get around these restrictions because they look like more familiar, innocuous objects.

Mr. Hughes tells you how to make antennas look like fences, flagpoles, and garden gazebos. The book discusses indoor, outdoor, high-frequency, and VHF-UHF antennas with their attached tuners, ground systems, and counterpoises. More than 40 diagrams illustrate the author's ideas presented in the text.

FCC TEST MANUALS; by Martin Schwartz. Ameco Corporation, 224 East Second Street, Mineola, NY 11501; Phone: 516-741-5030; Fax: 516-741-5031; $5.95 each.

The revised editions of these popular Federal Communications Commission license manuals include all the latest changes in the FCC's amateur-radio

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test preparation requirements. There are three manuals: Novice Class FCC Test Manual (No. 27-01), Technician Class FCC Test Manual (No.28-01), and No-Code Technician Class FCC Test Manual (No.78-01).

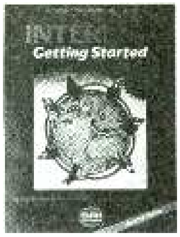
They include all the present FCC examination questions for their classes with corresponding multiple-choice answers. The clear explanation provided for each correct answer will help the reader to understand the theoretical basis of each question. Both questions and answers are arranged to minimize the need to flip pages.

INTERNET: GETTING STARTED; by April Marine, Susan Kirkpatrick, Vivian Neou, and Carol Ward. Prentice Hall, 113 Sylvan Avenue, Route 9W, Englewood Cliffs, NJ 07632; Phone: 515-284-6751; Fax: 515-284-2607; $28.

This book is an effective introduction to Internet. It covers a wide range of topics of interest to entry-level and intermediate Internet users. The book's authors are Internet specialists at SRI International, a non-profit research and consulting organization.

The book discusses the available options in Internet access and services, states costs, and gives step-by-step guidelines for gaining access. The latest Internet registration information available has been included.

This book answers the most frequently asked questions to give the entry-



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level subscribers enough confidence to get started. It also explains Internet applications such as electronic mail and file transfer, and it lists Internet resources and its many organizations.

THE CONCISE ILLUSTRATED DICTIONARY OF SCIENCE AND TECHNOLOGY; by Stan Gibilisco. Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Phone: 800-233-1128; $24.95.

This is a reference book containing definitions of widely used terms in the disciplines of astronomy, chemistry, medicine, earth science, engineering, life science, mathematics, physics, and social science. It defines more than 5500 scientific and technical terms.

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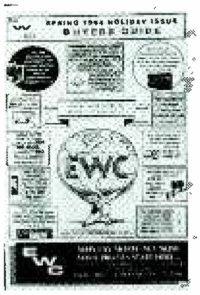
Gibilisco's book is intended for high school and college student seeking a one-volume reference on scientific and technical terminology. The entries are arranged in alphabetical order, cross referenced with related topics, and accompanied by more than 450 illustrations.

EWC BUYERS GUIDE. Electronics Warehouse Corp. (EWC), 1910 Coney Island Avenue, Brooklyn, NY 11230; Phone: 718-375-2700 or 800-221-0424; Fax: 718-375-2796.

This is the latest issue of EWC's quarterly catalog. It contains 188 pages detailing more than 20,000 electronic components and replacement parts for consumer electronics.



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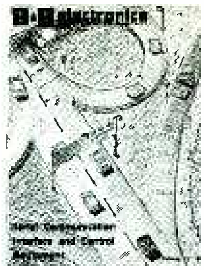
The products offered include replacement VCR parts, Nintendo and Sega/Genesis video game parts, instructional videotapes, tools, and test equipment. The company also carries a comprehensive selection of semiconductors.

SERIAL COMMUNICATION INTERFACE AND CONTROL EQUIPMENT CATALOG #17. B&B Electronics Manufacturing Company, 4000 Baker Road, P. O. Box 1040, Ottawa, IL 61350; Phone: 815-434-0846; Fax: 815-434-7094; BBS: 815-434-2927.

B&B's latest 23-page catalog offers affordable solutions to your electronic connectivity needs. It includes information on the latest developments in RS-232 serial communication interface and control equipment.

The new products described in the catalog include a current-loop serial card, an eight-port expan-



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dable "smart" switch, and a keyboard-powered current-loop. Other products include an international power supply, hardware and software for personal computer analysis, and various port-powered, two-channel, and optically isolated RS-485 and RS-422 converters.

THE COMPREHENSIVE GUIDE TO MILITARY MONITORING; by Steve A. Douglass. Universal Electronics, Inc., 4555 Groves Road, Suite 13, Columbus, OH 43232; Phone: 614-866-4605; Fax: 615-866-1201; $19.95 plus $4 shipping.

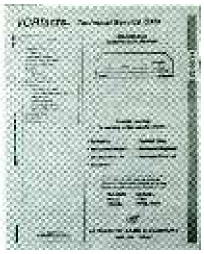
If you enjoy listening in on the communications of the world's military services, this is the book for you. It tells you all you need to know about monitoring military messages. But you must have a suitable scanner and patience.

CIRCLE 345 ON FREE INFORMATION CARD

This guide explains how to get started in this hobby. It contains pictures, specifications, and brief descriptions of several popular scanners. Included is a list of military frequencies, and maps showing the locations of originating military bases, a source guide, and a listing of the U.S. Navy's FLTSATCOM channels. The author, a self-confessed "stealth freak", put in an illustrated chapter on the world's stealth aircraft.

VCRfacts Technical Service Data. Howard W. Sams & Company, 2647 Waterfront Parkway, East Drive, Suite 300, Indianapolis, IN 46214; Phone: 800-428-7267; Fax: 317-298-5604; $24.95 each for single issues, $19.95 each by subscription.

VCRfacts are filled with information on the electronic and mechanical servicing of VCRs arranged in the publisher's standardized format. Each issue covers several different makes and models of VCRs.



CIRCLE 346 ON FREE INFORMATION CARD

Included in the publications are data on mechanical alignment, exploded views from several perspectives, mechanical parts lists, sample waveform diagrams, voltage tables, descriptions of IC functions, and various schematic diagrams.

A new concept in diagramming interconnect wiring illustrates wiring design, the signal and voltage path between the boards, plug numbers of a board, and a reference to the schematic page showing the related connector. Ω

COMPUTER CONNECTIONS

continued from page 17

in which such programs as WordPerfect and Excel are written. Level five will combine user-interface elements of today's leading graphical user interefaces (GUIs): IBM's WorkPlace Shell; HP's NewWave; Motif (the Unix version the Windows GUI).

Now look at the model as whole. By way of contrast, a traditional computer architecture starts with a specific microprocessor (80X86), builds a hardware-dependent operating system around it (DOS), and extends it into the GUI realm (Windows). It then builds applications that are either 1) Closely tied to that architecture, hence hard to transport, or 2) Burdened by the necessity of building (and rebuilding for each new application) application-specific abstraction models.

Aldus claims that 80% of PageMaker's code is common to both the Mac and PC versions. Aldus apparently took the time and trouble to understand the commonalities and differences between the two computer platforms, and built a model that accommodates those commonalities. With the architecture being described here, Aldus would not have to build its own model, because it's already a built-in feature.

Highlights

The model as presented so far doesn't differ much from other "open system" models, some of which have been described here in the past. IBM differentiates it by a deep commitment to the POWER architecture and by OS/2 support. However, if my industry contacts are correct, OS/2 is no longer of strategic importance to IBM. OS/2, they say, might be valuable in the short term, say for about five years, as a way to maintain IBM's presence in the mainstream market. But in the model, OS/2 is just one of the compatibility slices. It is not the major API of the operating system.

Another way that IBM's model differs from previous architectures is in its scalability. This architecture is *the* model for all future IBM computers, from PDA to mainframe. It is also microprocessor independent and compatible with every "legacy" (preexisting) application ever written for an IBM computer. In other words, a computer built on this new architecture will run DOS, Windows, AS/400, and MVS programs. In my opinion, IBM is the only company that could even attempt such an ambitious undertaking. A good deal of the technology already exists. While I don't doubt IBM's technological capability, I do have several reservations.

I question whether IBM has the clout to "sell" the concept to the industry. Right now, in terms of both earnings and "mind share," Microsoft and Intel "own" the market. It is theirs to lose. For IBM to gain, it must offer significant incentive.

As Apple has found from its recent introduction of the PowerPC-based Macintoshes, users will not switch computer platforms to gain incremental performance improvements, even if it's less expensive than prevailing prices. Even with the ability to emulate 80X86 processors (albeit without complete success), the consumer reaction has been "interesting, but no thanks." Apple is having trouble convincing DOS/Windows users to switch, yet IBM hopes to convert *everyone*.

Another consideration is timing. Microsoft is expected to release Chicago, the next major version of Windows, by the end of 1994. Chicago will dispense with DOS; it is a bootable 32-bit operating system with multitasking capability like OS/2, and a user interface like that of the Macintosh. Microsoft owns the Win32 API that is the basis of Chicago. IBM has no rights to it (as it does to today's Windows code).

Which way will the market go? Will it go to the next version of its favorite operating system, along with a high likelihood of backward compatibility? Or will it go to a new hardware and software architecture? Has the clock slipped back to April 1987? Is this PS/2 and OS/2 all over again? Or has IBM figured out how to focus its massive technical, manufacturing, and marketing operation on a single goal and is it willing to go after it?. Ω

LETTERS

continued from page 15

1994), can be improved several ways for indoor applications, as shown in Fig. 2.

Buzzer BZ1 should be a piezoelectric transducer because it gives a loud piercing noise, is readily available at low cost, and is easy to apply. Diode D2 and capacitor C3 in the Butch circuit have been omitted.

Diode D2 is in the wrong place. It would only be needed if the load were inductive (e.g., an electric horn) and then it should be across the load, not across Q2.

My circuit will work without a battery by replacing the 9-to 12-volt source in the Butch circuit with capacitor C4 whose value should be between 2200 to 4700 μF with a working voltage of 63 volts. It will be necessary to add diodes D3 and D4 and resistors R4 and R5.

With that modification, the circuit can take its power (at a low rate) from the telephone line. Resistors R1 and R4 should be connected to the positive side of the telephone line, and resistors R2 and R5 should be connected to the negative side.

By adding D5 and C5 and changing R3 from 10 kilohms to 1 megohm, transistor Q1 will be protected Q1 and the circuit will be triggered more reliably.

RUNE SODERMAN
Jandrain, Belgium

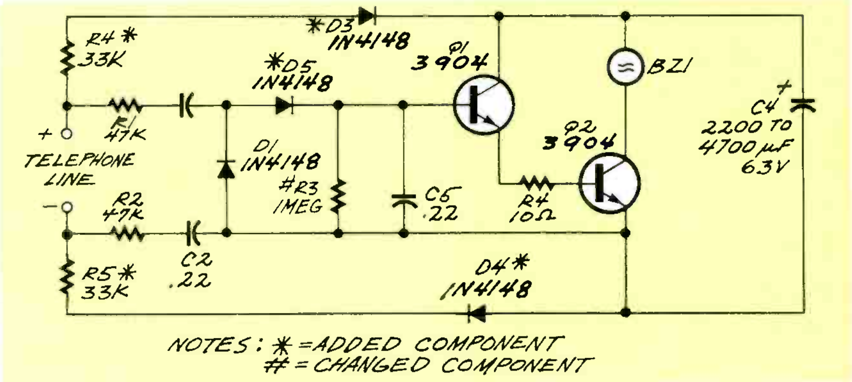


FIG. 2—AN IMPROVED telephone ring amplifier.

IC INVENTORS

Dr. Jack St. Clair Kilby deserves a large share of credit for the invention of the integrated circuit ("What's News, *Electronics Now*, March 1994). However, credit for the invention of the *monolithic* integrated circuit is now generally given to both Dr. Kilby and Dr. Robert Noyce of Fairchild Semiconductor, working independently.

My comments are intended to clarify this subject and are in no way intended to denigrate Dr. Kilby's immense contributions to science.

Jack St. Clair Kilby of Texas Instruments produced the first integrated circuit in 1958, but fine wires were used to interconnect the components. The device was not monolithic, and it has been referred to as a "miniature electronic circuit."

Robert Noyce built the first monolithic IC in 1959 at Fairchild with the planar process. This meant that device connections were integrated into the circuit. Dr. Noyce later went on to become a founder and executive of Intel Corporation.

Both men made contributions that were essential steps toward mass-producing integrated circuits.

T. LAMAR MOORE
Alexandria, VA

Ω

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

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TV COMMERCIAL EDITOR

Never watch or record annoying broadcast-television commercials again. Eliminate them automatically with the micro-processor-based ComEd 1000.

RUSSELL HURST

EVERYONE HAS BEEN IRRITATED at one time or another by the all-too-frequent commercials on broadcast television. Usually a commercial comes just in time to ruin the most suspenseful part of a movie. Recording a show on your VCR doesn't solve the problem. Fast-forwarding through all the commercial breaks is almost as annoying as watching them in the first place!

This article presents The ComEd 1000, a device that intercepts commercial breaks. It can automatically mute the sound, eliminate the picture, switch to a radio station or another TV channel, or pause your VCR when a commercial break occurs. The ComEd 1000, a powerful and flexible microprocessor-based controller, automatically restores normal operation when the commercial break is over. It can work with most VCRs.

Theory of operation

As a rule, there are several attributes that are common to commercial breaks. Commercials are generally less than two minutes long and, in most cases, are preceded and followed by a frame of black video and no audio. This "blank" period can be detected easily with some basic circuitry. By logging the time of day that a commercial set begins and its duration, a "behavior" pattern can be stored for reference. Most TV shows have commercial breaks at the same time every week, so the ComEd 1000 can examine its log when it de-

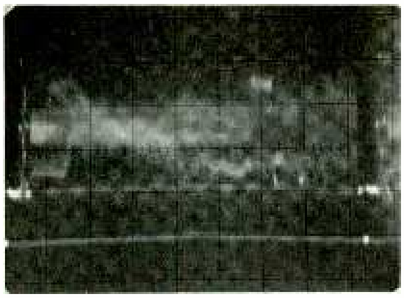


FIG. 1—TYPICAL VIDEO SIGNAL. In the portion of the video signal where the picture resides, the brighter the picture the higher the voltage.

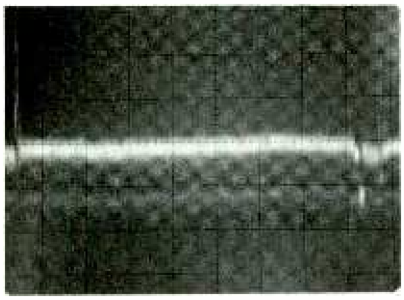


FIG. 2—WHEN A BLACKOUT or blank period is received, the video signal looks something like this.

tects blank video frames to determine that a commercial break is beginning.

An "average" commercial log is included in the unit's EPROM for use until a customized log is stored. Since most television programming follows the same pattern, chances are you will see results in the first week.

There are 525 lines in one complete frame of video, but only half of the lines (262.5) are "drawn" between each vertical interval. To minimize flicker, the lines are *interlaced*; the odd lines are drawn first, and then the even lines.

A typical frame of video, as viewed on an oscilloscope, is shown in Fig. 1. An oscilloscope trace of a frame of black video is shown in Fig. 2. A frame of black video accompanied by no audio signal characterizes the beginning or the end of a commercial break.

The ComEd 1000 has two major sections: 1) The detection and user-interface circuit and 2) the microprocessor-based controller. The detector and controller are built on separate circuit boards. Figure 3 shows a block diagram of the system.

Circuitry

The schematic for the detection and user-interface circuit appears in Fig. 4. Line-level video and audio signals from a VCR or tuner are monitored by the LM319, high-impedance, dual-voltage comparator IC4. A VCR's line-level signals are capacitively coupled to its output jacks. Therefore, the output video signals drift around zero volts depending on the height (brightness) of the video. Normally for threshold detection, the video signal would be clamped so that the blanking portion would be zero volts. To simplify and limit the expense of this project, a voltage comparator is used for threshold detection instead of clamping.

The threshold voltages for the comparator are set by R4 for the audio and R5 for the video. If a signal exceeds the threshold voltage, the output of the comparator will be pulled high. The comparator outputs are combined with a 74LS02 OR gate (IC3) and fed to the RESET or CLEAR input of a 74LS161 asynchronous 4-bit counter (IC2). The counter is clocked with 16 pulses for each frame of video. Therefore, as long as audio and/or video signals are present, the counter is reset by IC3-a before completing the count. During a blank period, there is no reset and the counter's terminal count output is asserted.

The ripple-carry output of counter IC2 is conditioned by retriggerable multivibrator IC1-a (a 74LS123). The output of IC1-a is asserted as long as there is no audio and the video is black. The output of IC1-b is asserted if there are audio or video signals present. Those two signals permit the blank period to be measured.

The controller section of the ComEd 1000 determines whether the blank occurred at the beginning, middle, or end of

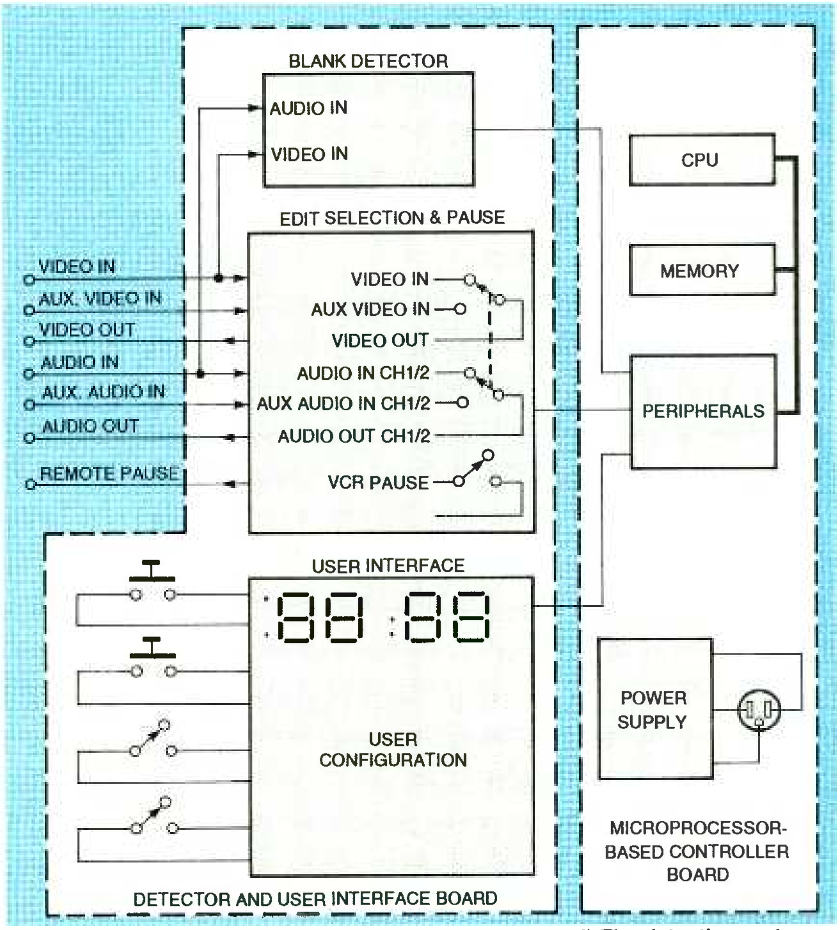


FIG. 3—BLOCK DIAGRAM. There are two major sections: 1) the detection and user-interface circuit and 2) the microprocessor-based controller.

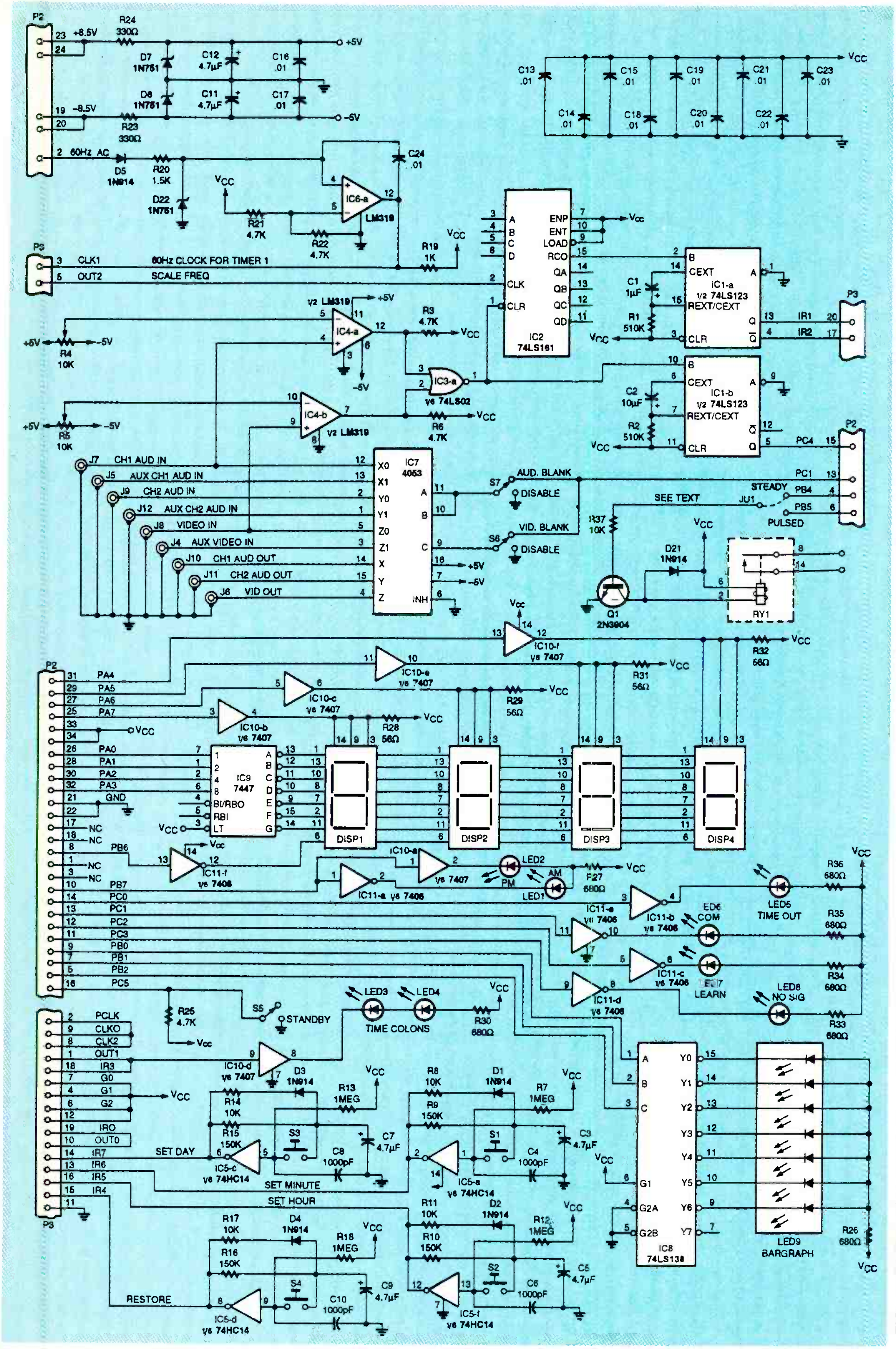


FIG. 4—DETECTION AND USER-INTERFACE CIRCUIT. Line-level video and audio signals from a VCR or tuner are monitored by the LM319 high-impedance dual voltage comparator IC4.

a commercial set. It then either begins the edit, maintains it, or ends the edit respectively. The video and/or audio outputs of the commercial editor are switched to auxiliary inputs during an edit by a 4053 solid-state switch (IC7). Switches S6 and S7 select the signals to be switched.

Relay RY1 is also activated during an edit and can be used to pause a VCR. The relay operates in one of two modes: steady pause or pulsed pause. The mode is selected by the relay mode jumper JU1. If remote pausing is featured on your VCR, it probably has a rear-panel jack labeled "camera pause." To use the relay for wired remote control in this configuration, the relay-mode jumper should be in the lower position when viewing the board with JU1 in the lower left corner (see Fig. 5-*a*).

If your VCR does not have a remote pause jack, then it can be made to pause with a dedi-

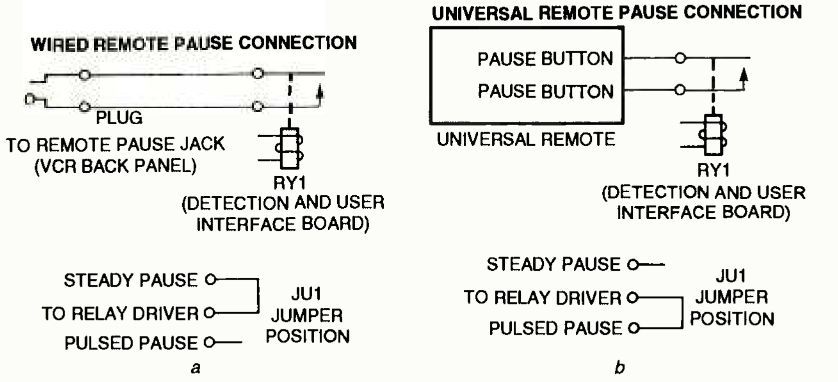


FIG. 5—IF YOUR VCR HAS A REMOTE PAUSE JACK, wire the relay as shown in *a*; if not, you'll have to wire the pause button on a dedicated "universal" remote control directly to the relay (*b*).

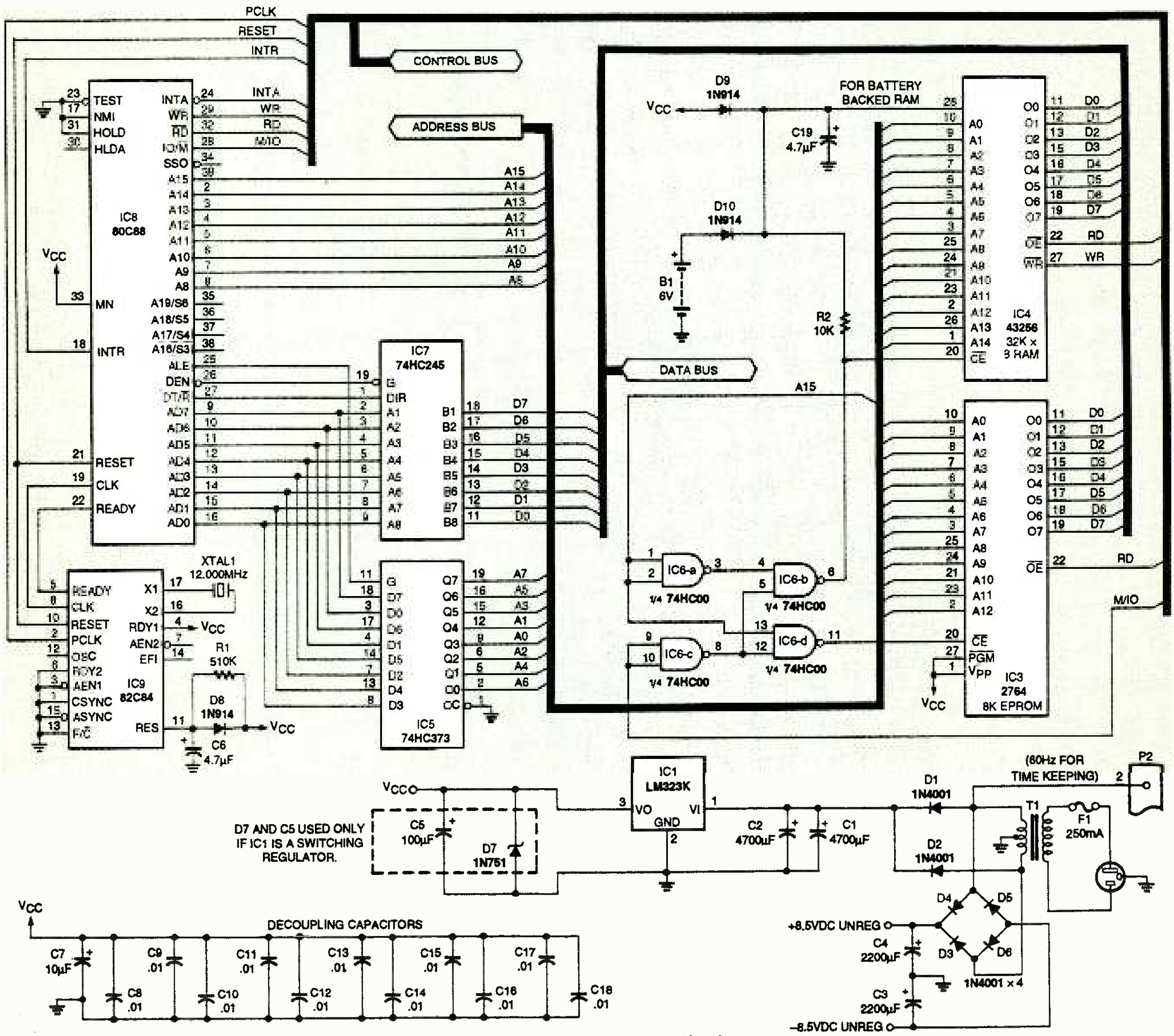


FIG. 6—CONTROLLER CIRCUIT. All that is required to program the controller is an assembler or compiler for the Intel 8088 and an EPROM programmer.

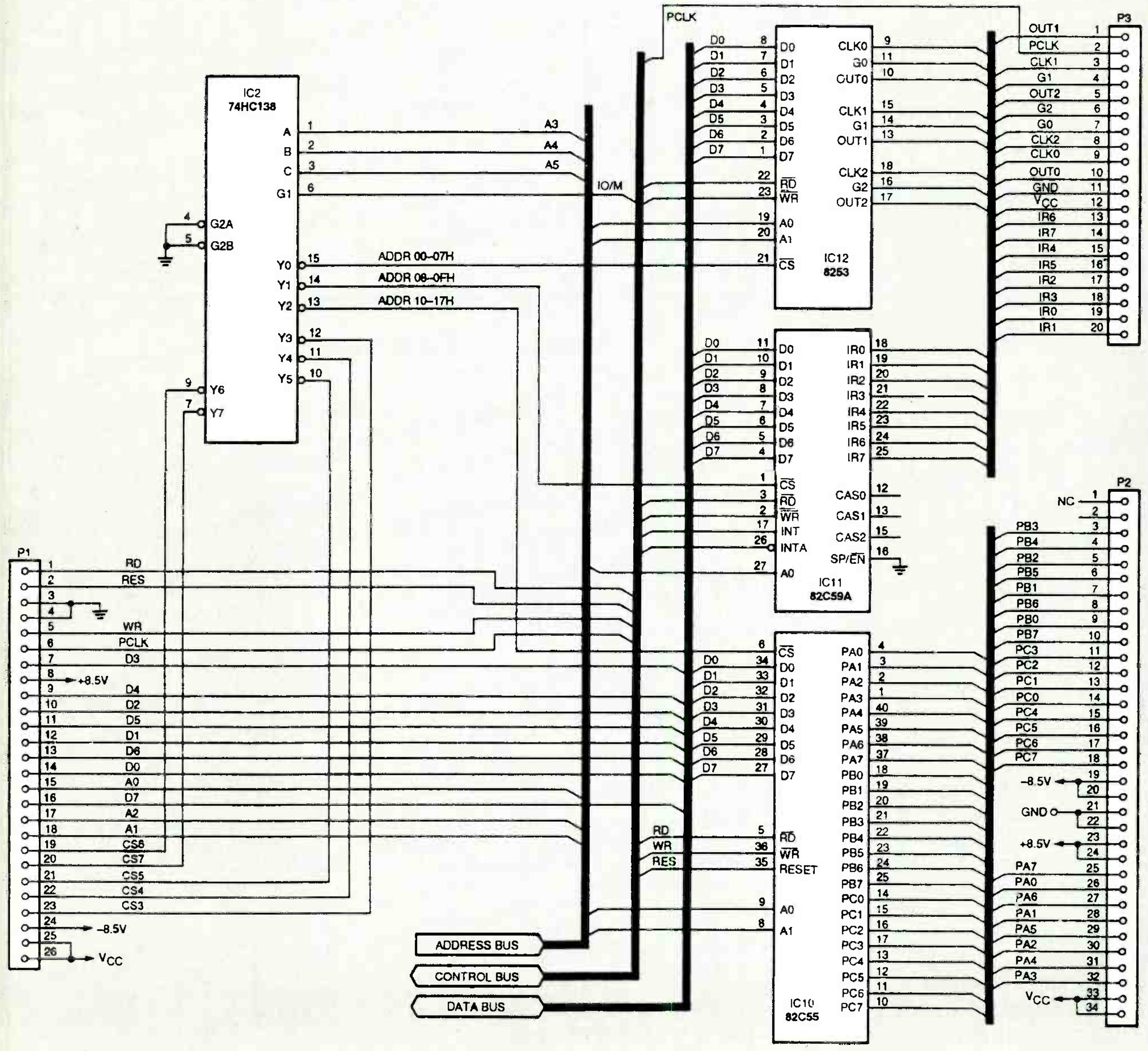
cated "universal" remote control. This is done by wiring the pause button of the remote control directly to relay RY1. If the relay is used in this configuration, the relay mode jumper should be installed in the upper position when viewing the board with JU1 in the lower left corner (see Fig. 5-*b*). With the jumper in this position, the relay is pulsed once to enter the pause mode and once to end the pause.

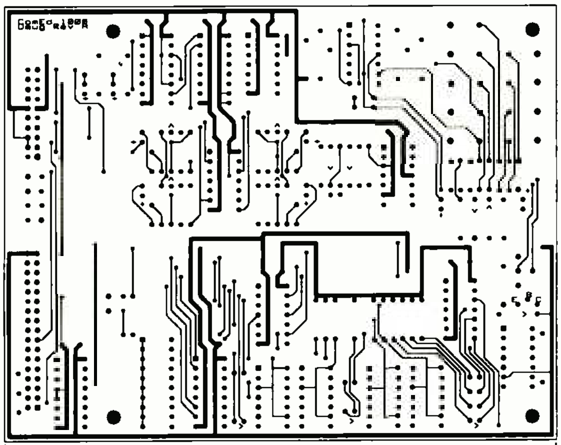
To minimize tape and video head wear, the pause is released for one second every minute. This allows the tape to advance slightly and prevents the video head from wearing out the magnetic coating on the tape. Be aware that although most VCRs allow the user to pause in the record mode, some do not permit pausing when the VCR is in its timer record mode. To get around that problem, you might consider purchasing a remote control with a built-in VCR programming timer.

The user-interface portion of the commercial editor consists of a time-of-day and day-of-week display, status indicators, time-setting switches, and a standby/edit switch. The time-display digits DISP1–DISP4 are multiplexed by the controller circuit and decoded by IC9 (a 7447) and IC10 (a 7407). Colon indicators LED3 and LED4, AM/PM indicators LED1 and LED2, status indicators LED5–LED8, and the decimal points of the 7-segment displays are driven by IC10 and IC11. The decimal points light when a blank is detected and are used during calibration.

Switches S1–S4 and their associated circuitry, and IC5 (a 74HC14) provide de-bounce and auto-repeat pulses which are used to trigger interrupts for setting the time-of-day and day-of-week, and to restore normal operation should you choose to abort an edit.

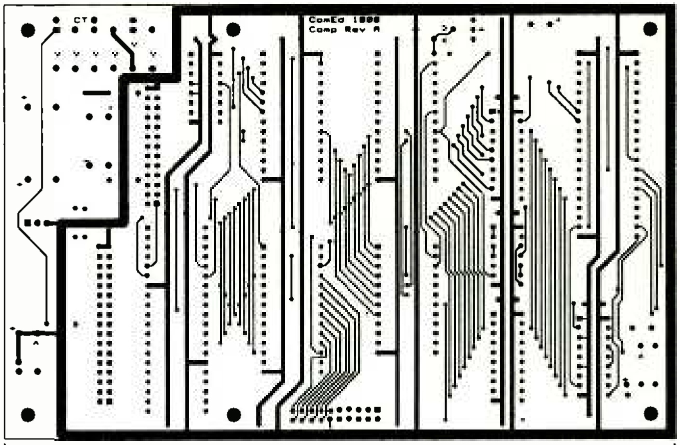
The basis for overall timekeeping is derived from the 60-hertz frequency present at the secondary of T1 (a 120- to 12.6-volt center-tapped transformer). The 60-hertz signal is rectified by D5 and then shaped by IC6 (an LM319), D22 (a 1N751),





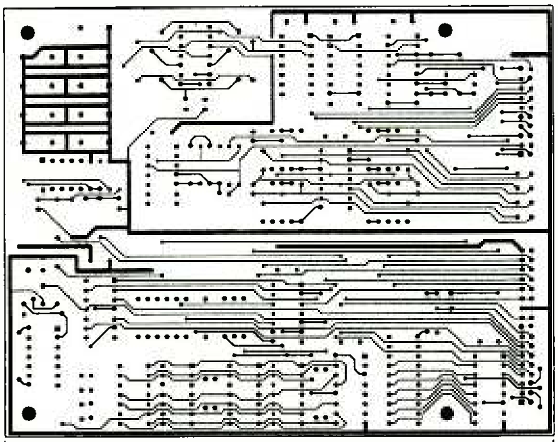
5 3/4 INCHES

INTERFACE BOARD component side.



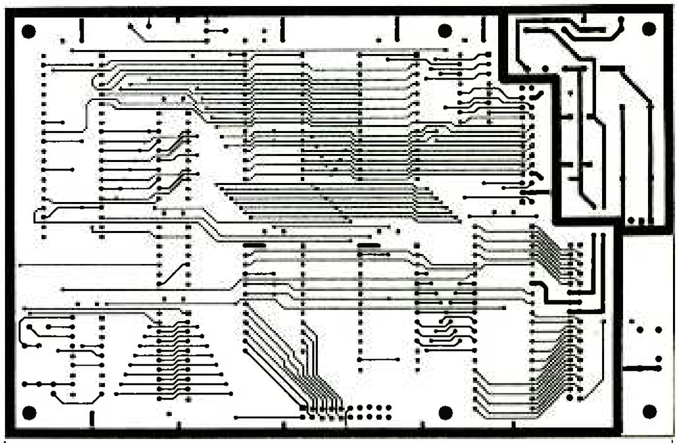
7 INCHES

CONTROLLER BOARD component side.



5 3/4 INCHES

INTERFACE BOARD solder side.



7 INCHES

CONTROLLER BOARD solder side.

R20, and C24. The output of comparator IC6 is fed to the controller's counter circuit for division down to 1-second intervals which provide interrupts on level 3.

The controller

Figure 6 is the schematic for the controller circuit. The heart of the circuit is an Intel 8088 microprocessor. All that is required to program the controller is an assembler or compiler for the Intel 8088 and an EPROM programmer.

The clock and reset signals for the microprocessor (IC8) are supplied by IC9 and its related components XTAL1, D8, R1, and C6. Bus demultiplexing and buffering are performed by IC5 and IC7. The peripherals include IC12 (an 8253 programmable timer/counter), IC11 (an 82C59 interrupt controller),

PARTS LIST—INTERFACE BOARD

All resistors are ¼-watt, 5%, unless noted.
R1, R2—510,000 ohms
R3, R6, R21, R22, R25—4700 ohms
R4, R5—10,000 ohms, 20-turn horizontal potentiometer
R7, R12, R13, R18—1 megohm
R8, R11, R14, R17, R37—10,000 ohms
R9, R10, R15, R16—150,000 ohms
R19—1000 ohms
R20—1500 ohms
R23, R24—330 ohms
R26, R27, R30, R33–R36—680 ohms
R28, R29, R31, R32—56 ohms
Capacitors
C1—1 µF, 16 volts, radial electrolytic
C2—10 µF, 16 volts, radial electrolytic
C3, C5, C7, C9, C11, C12—4.7 µF, 16 volts, radial electrolytic
C4, C6, C8, C10—1000 pF, ceramic
C13–C24—0.01 µF, monolithic
Semiconductors
D1–D5, D21—1N914 diode
D6, D7, D22—1N751 diode
LED1–LED8—miniature light-emitting diode
LED9—Bargraph or 7 discrete LEDs
DISP1–DISP4—common-anode 7-segment LED display
Q1—2N3904 NPN transistor
IC1—74LS123 dual retrigerrable monostable
IC2—74LS161 synchronous 4-bit binary counter
IC3—74LS02 quad 2-input NOR gate
IC4, IC6—LM319 voltage regulator
IC5—74HC14 hex schmitt trigger inverter
IC7—4053 triple 2-channel analog multiplexer
IC8—74LS138 3 to 8 line decoder/demultiplexer
IC9—7447 BCD to 7-segment decoder/driver
IC10—7407 hex buffer
IC11—7406 hex inverting buffer
Other components
RY1—SPST 14-pin DIP relay
J1–J12—RCA jack
S1–S4—normally open pushbutton switch
S5–S7—SPST switch
P2—2 × 17 ribbon-cable connector
P3—2 × 10 ribbon-cable connector
Miscellaneous: PC board, five 14-pin right-angle sockets, PC jumper, wire, solder.

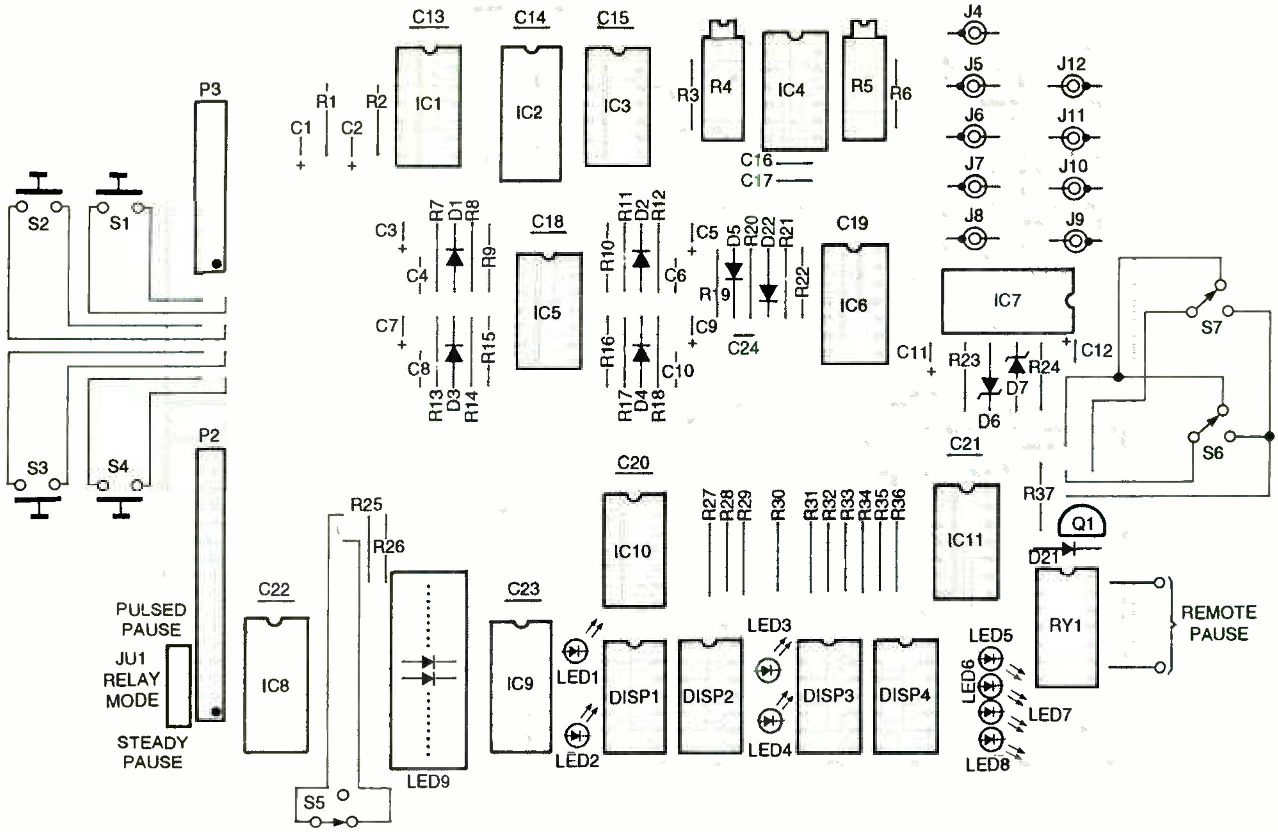
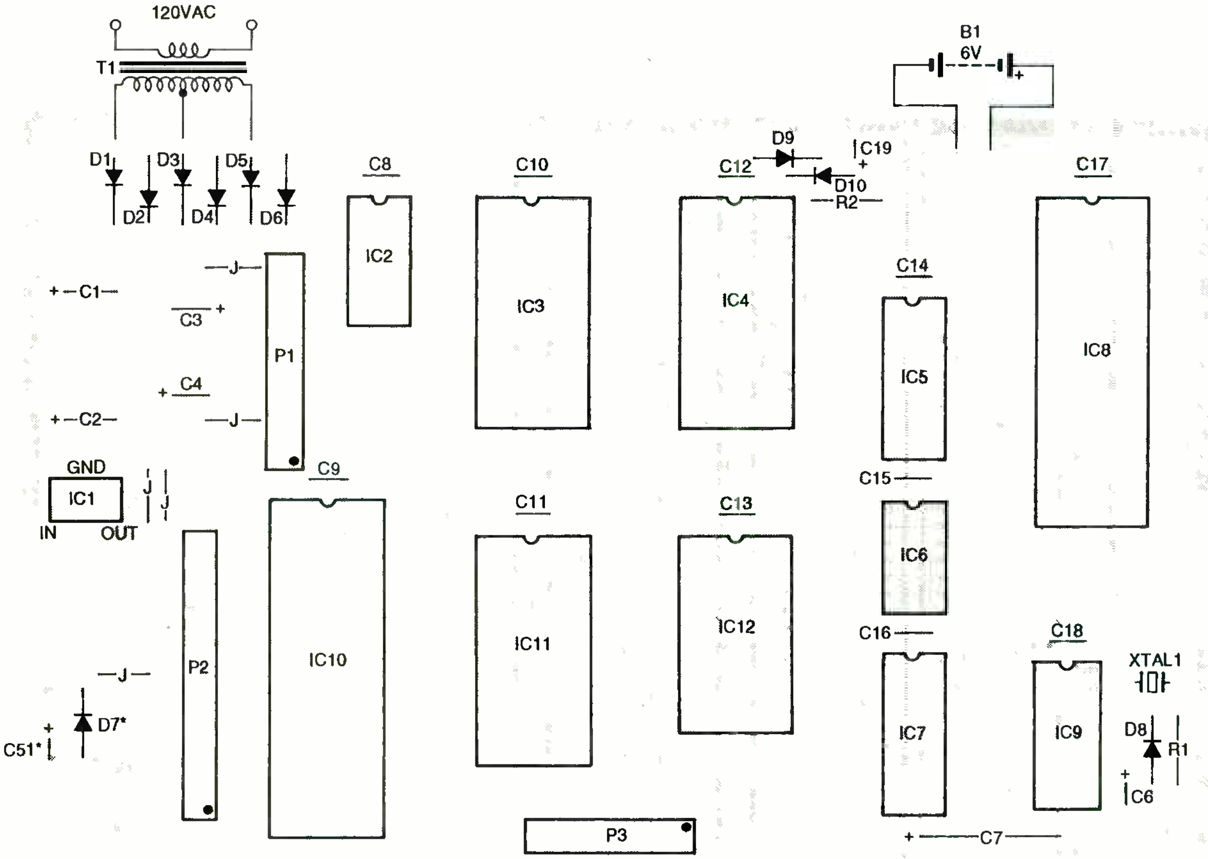


FIG. 7—INTERFACE BOARD PARTS PLACEMENT. The display components must be set at a right angle from the board if they are to be seen while the board is laying flat.



*REQUIRED IF IC1 IS A SWITCHING REGULATOR

FIG. 8—CONTROLLER BOARD PARTS PLACEMENT. The two boards are interconnected by two ribbon cables on P2 and P3.

PARTS LIST—CONTROLLER BOARD

All resistors are ¼-watt, 5%, unless noted.
R1—510,000 ohms
R2—10,000 ohms
Capacitors
C1, C2—4700 µF, 25 volts, radial electrolytic
C3, C4—2200 µF, 16 volts, radial electrolytic
C5—100 µF, 16 volts, radial electrolytic (for switching regulator only)
C6, C19—4.7 µF, 16 volts, radial electrolytic
C7—10 µF, 16 volts, axial electrolytic
C8–C18—0.01 µF, monolithic
Semiconductors
D1–D6—1N4001 diode
D7—1N751 diode (for switching regulator only)
D8–D10—1N914 diode
IC1—LM323K voltage regulator (or switching regulator)
IC2—74HC138 3 to 8 line decoder/demultiplexer
IC3—2764 EPROM
IC4—43256 static RAM
IC5—74HC373 octal D-type latch
IC6—74HC00 quad 2-input NAND gate
IC7—74HC245 octal non-inverting bus transceiver
IC8—80C88 microprocessor
IC9—82C84 clock generator
IC10—82C55 parallel interface
IC11—82C59A interrupt controller
IC12—8253 programmable timer
Other components
B1—6-volt battery backup (4 AA cells)
F1—250 milliamp fuse
T1—120- to 12.6-volt AC centertapped transformer (6.3-6.3VAC output)
P2—2 × 17 ribbon-cable connector
P3—2 × 10 ribbon-cable connector
XTAL1—12-MHz crystal
Miscellaneous: PC board, PC jumpers, wire, solder

ORDERING INFORMATION

Note: The following items are available from Specific Controls, 1539 N. China Lake Blvd, Ste. 200, Ridgecrest, CA 93555-2606 (800) 889-4429:
- **Programmed EPROM—$35**
- **Controller PC board—$40**
- **Interface PC board—$38**
- **Both PC boards and programmed EPROM—$76**
- **Complete kit (includes PC boards, programmed EPROM, and all parts except enclosure, IC sockets, battery holder, and transformer)—$159**
- **Deluxe kit (all above items plus the enclosure, a measured drawing, hardware, IC sockets, battery holder, and transformer)—$188**

Include $6.50 shipping and handling. Visa, Mastercard, check, and money order accepted. California residents add 7.25 percent sales tax (before shipping charges). Allow 4 to 6 weeks for delivery.

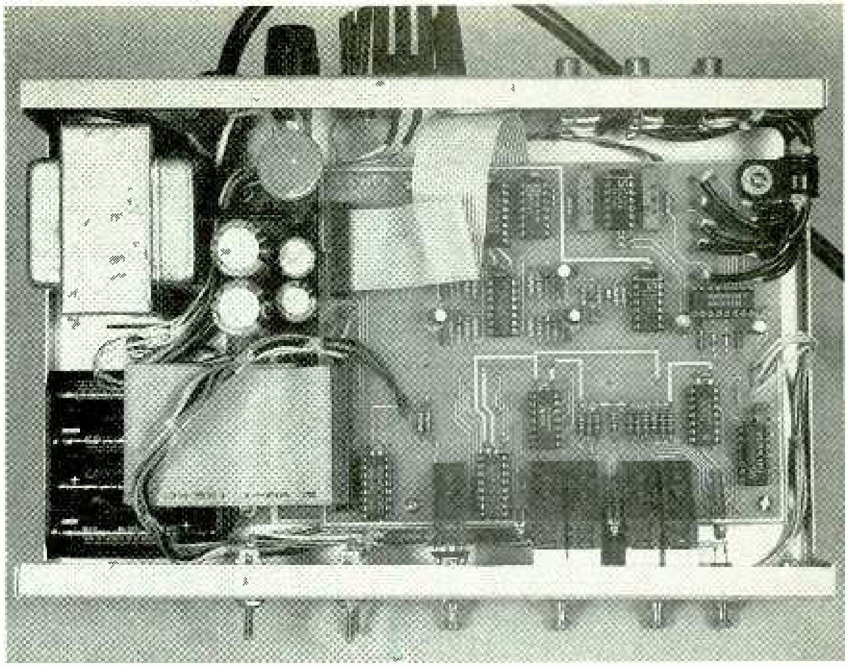


FIG. 9—THE AUTHOR'S PROTOTYPE. You can house the circuitry in an identical case or one of your own.

ENCLOSURE PARTS

Metal enclosure (9.9- × 2- × 6.3-inches)
TO3 heatsink and mounting hardware (for IC1)
Fuse holder (through-chassis type)
Grounded power cord and strain-relief
Battery holder (4-AA cell)
Six ¼-inch 4-40 threaded hex spacers
Four 0.65-inch threaded nylon spacers
Eight 4-40 hex nuts
Two 6-32 hex nuts
14 #4 lock washers
Two #6 lock washers
16 ¼-inch 4-40 round-head screws
Two ¼-inch 6-32 round-head screws
Jack-mounting board (fiberglass, 1⅞- × 3$\frac{5}{16}$-inches)
Red plastic display filter
20-conductor ribbon cable (9 inches)
34-conductor ribbon cable (5 inches)
Small-diameter 75-ohm coaxial cable (5 feet)
Wire clamp and washer

and IC10 (an 82C55 parallel interface). The I/O chip-select decoding is performed by IC2, a 74HC138 3 to 8 line decoder.

Timer IC12 has 3 channels which are used mainly for programmable clock division. Channel 0 divides the system clock to generate interrupts on level 0 (IR0) for the multiplexed display. Channel 1 divides the 60-hertz line frequency used for timekeeping and produces one interrupt per second on interrupt level 3 (IR3). Channel 2 divides the system clock to produce the scaling frequency for the video watchdog timer on the display and user-interface circuit.

The 82C55 parallel interface (IC10) has three 8-bit ports and is used for display output, switch input, and signal monitoring. Port A outputs the multiplexed time of day. Bits 0–2 of port B outputs the day-of-week. Bits 4 and 5 control the VCR pause relay. Bit 6 controls the illumination of the decimal points on the time display which are used for calibration. Bit 7 drives the AM/PM indicators. Bits 0–3 of port C output status information and control the analog switch during editing. Bit 4 monitors the signal present at the multivibrator and makes that information available to the software. Bit 5 reads the position of the Edit/Standby switch.

The interrupt controller IC11 (82C59) alerts the microprocessor of any condition that needs immediate attention. Interrupt 0 (IR0) is for display multiplexing. Each time interrupt 0 is asserted from the timer (200 times per second), a time-display digit is output. Interrupt 1 (IR1) alerts the controller that a video and audio blank has begun. Interrupt 2 (IR2) is

Continued on page 87

Build this Amateur TV Station

Build and align the amateur television transmitters described in the July issue.

WILLIAM SHEETS and RUDOLF F. GRAF

IN PART 1 OF THIS ARTICLE ON AMAteur television transmitters (ATV) the operating theory behind the equipment was described. Four different ATV models were described: a 5-watt transceiver (transmit, receive, and downconvert), a 5-watt transmitter, a ¾-watt transmitter with audio capability, and a ¾-watt video-only transmitter. This month's article explains how to build these circuits.

Constructing the transceiver

The 5-watt transceiver is constructed on two circuit boards. The main board contains all of the circuitry except the power amplifier. The power amplifier is built on a separate board. It is mounted vertically along one edge of the main board on a heatsink made from a 4- × 1- × ½-inch extruded aluminum "U" channel. (The channel can be purchased from most hardware or building-supply stores.) The circuit boards must be made from G-10 0.062-inch thick fiberglass-epoxy (FGE), with a dielectric constant of 4.5 to 4.8. Foil patterns are provided in this article for those who want to make their own boards.

An important point to remember when building any UHF equipment is that lead lengths must be kept as short as possible. Straighten the leads of components with pre-formed leads so that they can be made as short as possible.

Excess lead lengths can degrade circuit operation or prevent its operation. A ¼-inch length of No. 22 AWG copper wire has an inductance of about 0.0037 microhenries. That represents a reactance of nearly 9.3 ohms at 440 MHz. In some circuits that reactance would be negligible, but RF power transistors typically have less than 2 ohms of input impedance at 440 MHz. An RF current of 100 milliamperes will cause a drop of nearly 1 volt across a ¼-inch length of No. 22 AWG wire. Because the 5-watt transmitter's load current is about 316 milliamperes, the extra ¼-inch lead length will cause a drop of about 3 volts.

All components should be mounted as close to the circuit board as possible. Where practical, all grounded leads passing through the PC board should be soldered on both sides to avoid detuning the coils. Ground all coaxial lead shields at both ends. Space all horizontally mounted inductors a distance at least half the coil diameter above the PC board.

5-watt unit

Components are installed on both sides of the transceiver board. Figure 1 is the parts-placement diagram for the component side of the transceiver board, and Fig. 2 is the parts-placement diagram for the solder side. Notice that there are separate sections for the transmitter and downconverter. If you intend to build only the transmitter section, ignore the downconverter section.

Install transistor Q10 temporarily at first. Use just enough solder to make the electrical connections. Solder all component leads that pass *through* the ground plane foil on both sides of the board. As stated in the Parts List, certain coils must be hand-wound; Fig. 3 gives the instructions for doing that winding.

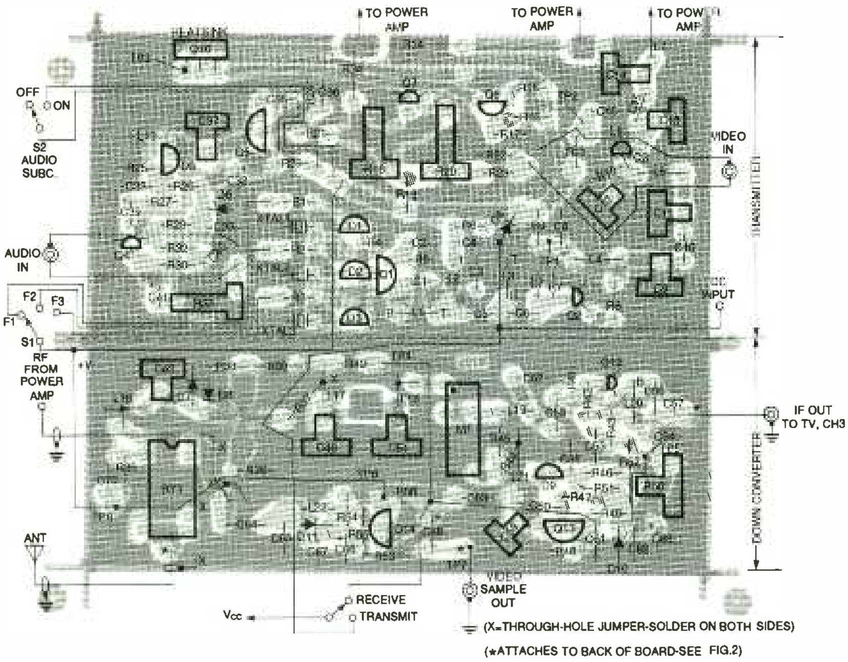
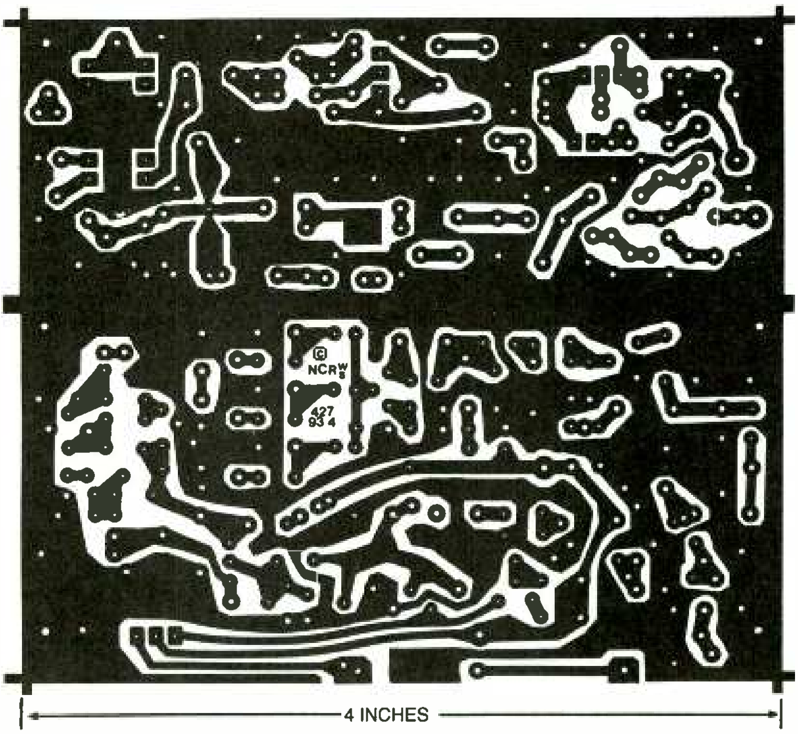


FIG. 1—PARTS-PLACEMENT DIAGRAM for the component side of the transceiver (transmitter/downconverter) board. Solder Q10 temporarily with just enough solder to make the electrical connections.



COMPONENT SIDE of the 5-watt transmitter and downconverter.

Solder component leads as you work, because it will be difficult to reach some components with a soldering pencil after a cluster of neighboring parts is installed. Solder chip capacitors to the bottom surface of the board after all other components are installed. Figure 4 shows how to solder chip capacitors. Teflon insulation is specified for the coaxial cable. Teflon will not melt when its shield is soldered.

Assemble the RF power amplifier as shown in Fig. 5. Form one lead of R13 into a coil (L15). First solder the grounded end of R13 on both sides of the board. Then coil the free end of R13 into L15 following the instructions given in Fig. 3. Then solder the end of the coiled lead in place. Next, install all other components except Q9. Mount the power-amplifier board to the heatsink with five No. 2 × ¼-inch machine screws and nuts (see Fig. 6). Be sure to install a No. 4 lockwasher between the board and the heatsink at all five screw locations to provide the correct spacing to minimize the strain on Q9.

Identify all of Q9's leads (the collector has a notch cut on the end), and then trim them all down to about 3/16-inch in length. Mount Q9 on the heatsink with one No. 8 nut and a lockwasher positioned between the nut and the heatsink. Be sure Q9 is seated flush against the heatsink with no upward strain on its leads. Strain can break off the transistor's ceramic top, destroying the device (see Fig. 6). Be careful when handling the mounting stud of Q9 because it can be easily broken off. Hand-tighten Q9's mounting nut carefully with a small nutdriver held by only two fingers. Solder Q9's leads in place after double checking that it is positioned properly. After the power amplifier module has been completed, set it aside; do not attach it to the main board at this time.

¾-watt transmitter

There are two different ¾-watt versions of the ATV. One has audio (the Mini ATV) and

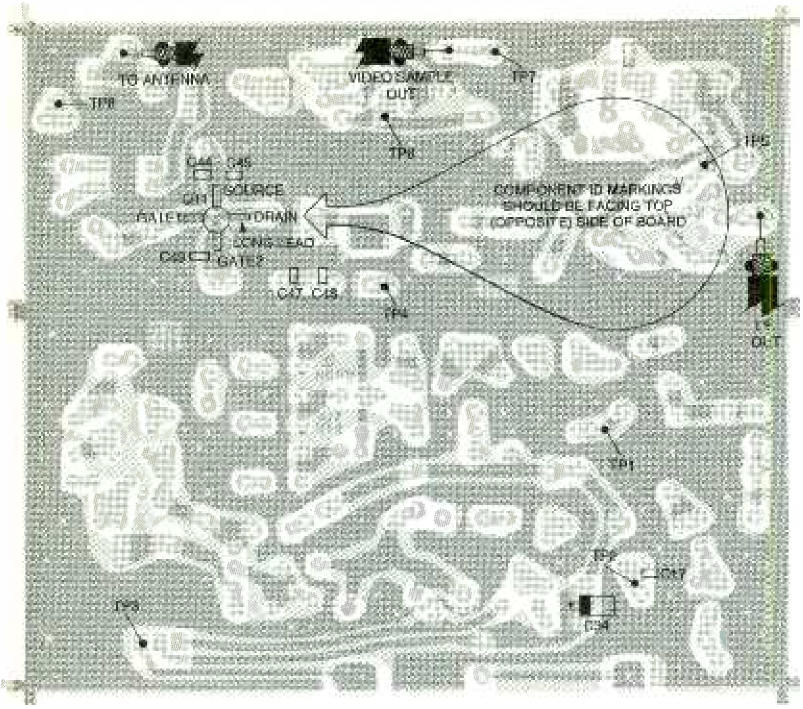
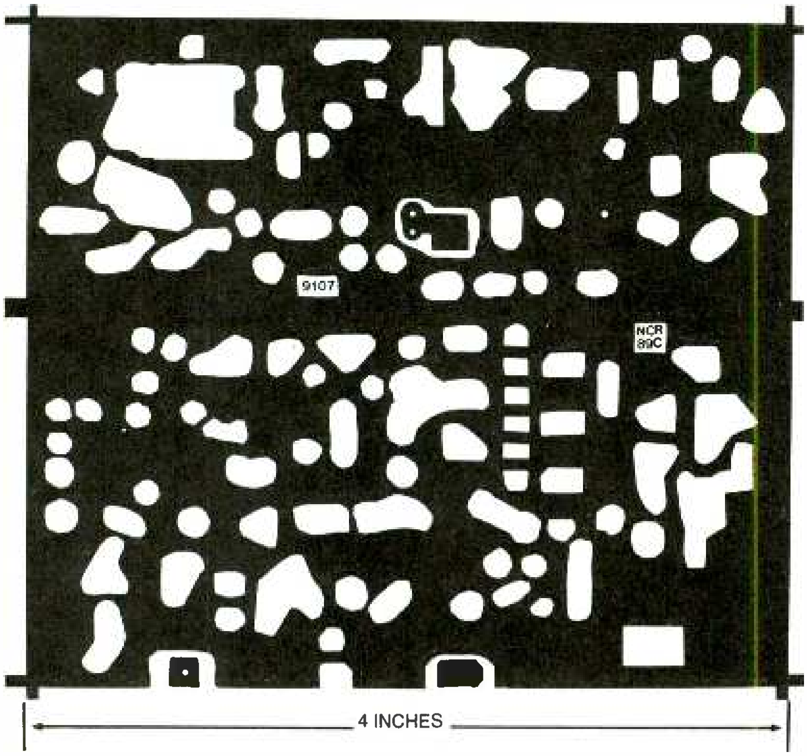


FIG. 2—PARTS ARE INSTALLED on both sides of the transceiver board. Install these parts on the solder side of the board.



SOLDER SIDE of the 5-watt transmitter and downconverter.

one does not (the ATV jr.). The ATV jr. circuit board is not very densely populated, but the Mini-ATV's board is more densely populated because it includes the audio circuitry. Heatsinking is not required on either of the ¾-watt units. Figures 7 and 8 are parts-placement diagrams for the component and solder side of the Mini ATV, and Figs. 9 and 10 are comparable diagrams for the ATV jr. Figure 11 gives coil-winding instructions for both boards.

A metal enclosure is recommended for all transmitters. If weight is a problem, you can install the circuit boards in a plastic case lined with metallic foil, or build a case from G-10 PC board material. A metal case confines the RF energy and can eliminate radio-frequency interference (RFI) problems.

Test the boards after they are fully assembled. The RF power amplifier is difficult to test unless you have a suitable signal source and RF power meter. In any case, make ohmmeter checks for short circuits to ground, continuity, and correct connections. Check for solder bridges and faulty solder joints with a high-powered magnifier.

Make sure that the RF power amplifier module in the 5-watt versions operates correctly because access to it is difficult after it has been mounted to the edge of the main board. On 5-watt versions, do not install the power-amplifier assembly to the main board before completing all tests.

During testing, remember that 5 watts of power at 440 MHz is potentially dangerous to humans and can damage radio equipment. Make sure that the antenna is at least 10 feet away from any other video or audio equipment, people, and pets.

Testing procedures

The minimum test instruments required for testing the ATV units are:

- Volt-ohm-milliammeter (VOM) or DVM
- 50-ohm dummy load rated at 5-watts or better and to 500 MHz, with a built-in power meter
- Well-regulated DC power source capable of 13.8-volts, preferably variable with a current-limiting feature
- Video and audio source (such as a VCR)
- TV receiver or monitor

The following test equipment will be helpful:

- Frequency counter rated to 500 MHz
- Oscilloscope with at least a 20-MHz bandwidth
- Spectrum analyzer

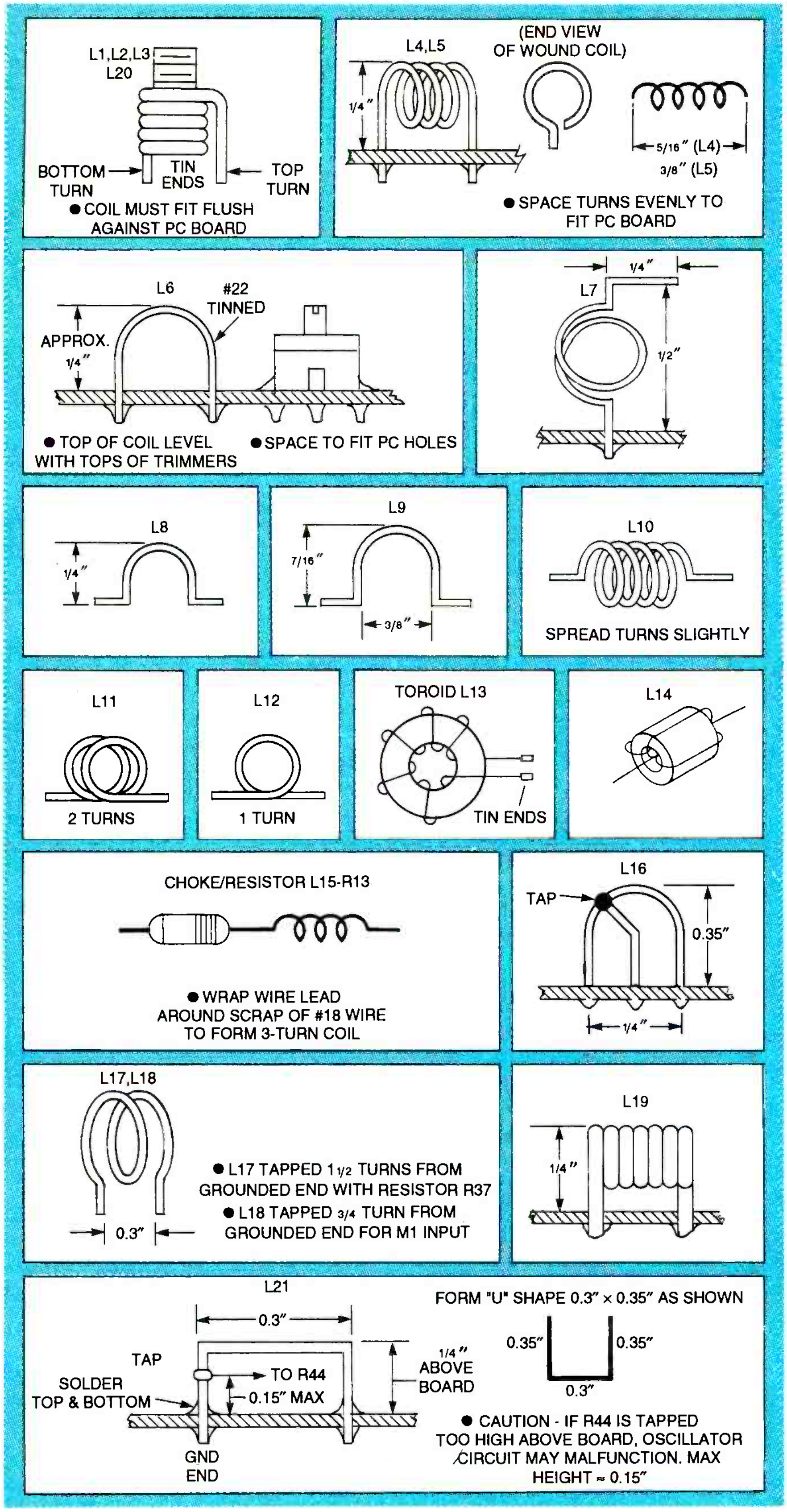


FIG. 3—COILS for the 5-watt units must be made by hand as shown here.

- Grid-dip meter
- Radio-frequency milliwatt meter

Re-check the board for poor or missing solder joints, missing or incorrectly installed components, and long leads. Make the checks with an ohmmeter and magnifier.

A stable, well-regulated 13.8-volt DC power source is required for best operation, although the transmitter will operate with a 12-volt power supply. However, if the transmitter is set up for 13.8 volts and then powered from a 12-volt supply, the video waveform sync tips might be clipped unless the video drive is reduced or the linearity control (R18 or R14) is readjusted. Set the transmitter video linearity and gain controls for the lowest expected supply voltage.

Preset all trimmer capacitors and potentiometers in accordance with Table 1. (Check the main board of the 5-watt units first.) Apply +10 volts to the power input lead. This point is the free end of D4 on the 5-watt unit, or the junction of D1 and C20 on ¾-watt units. Recheck the circuit board for errors if significantly more than 100 milliamperes is drawn from the power supply.

Apply 13.8 volts to the power input. Connect the positive test lead of a voltmeter to the emitter of Q10 and the negative lead to ground. A voltage of 2 to 12 volts should be present. Set R20 (video gain) at midpoint. Vary R18; the emitter voltage of Q10 should swing between about 2 and 12 volts. If it does not, reset R20. If the voltage appears to be "stuck," check the modulator circuit (Q6, Q7, and Q10). Leave R18 set for maximum voltage after completing this test.

For ¾-watt units, apply 13.8 volts and connect the positive test lead to the emitter of Q7 and the negative lead to ground. Set R18 to its midpoint. R14 should vary Q7's emitter voltage from about 2 to 11 volts. Leave R14 set for maximum voltage.

In 5-watt units, connect a test lead between R1's free end and +13.8 volts. Then connect a meter's negative lead to TP1 and the positive lead to the power supply. (This applies to all units.) The reading should be 1 volt or less.

Adjust the slug in L1 for a sudden rise in the meter reading of

PARTS LIST—5-WATT TRANSMITTER

All resistors are ⅛-watt, 5%, unless otherwise specified.
R1–R3, R7—2200 ohms
R14—10 ohms, ¼-watt
R4, R17—1000 ohms
R5, R23—330 ohms
R6, R9, R12, R16—100 ohms
R8, R13—10 ohms
R10—470 ohms
R11—33 ohms
R15—15 ohms
R18, R20—1000 ohms, trimmer potentiometer
R19, R27—10,000 ohms
R21—not used
R22—82 ohms
R25—470,000 ohms
R26—220,000 ohms
R28, R34—4700 ohms
R29—680 ohms
R30, R32—33,000 ohms
R31—100,000 ohms
R33—100,000 trimmer potentiometer
R34 (alternate value)—2200 or 3300 ohms

Capacitors
C1—39 pF, NPO
C2, C7—56 pF, NPO
C3—18 pF, NPO
C4, C33—0.01 µF, disc GMV
C5, C42—2.2 pF, NPO (C42 alternates 1 or 3.3 pF)
C6—33 pF, NPO
C8, C16—470 pF, 20% disc
C9, C11, C13, C14, C19, C26—2–10 pF, trimmer (yellow body)
C10, C15—1 pF, NPO
C12—2–18 pF, trimmer (green body)
C17, C18, C24, C25, C31—100 pF, chip 60 × 120
C20–C23—33 pF, chip 60 × 120
C27—6.8 pF, NPO
C28, C30—4.7 pF, NPO
C29—10 pF, NPO
C32—10 µF, 16 volts, aluminum electrolytic
C34—10 µF, 16 volts, tantalum chip
C35—68 pF, NPO or SM
C36—120 pF, NPO or SM
C37—3–40 pF, trimmer (gray body)
C38—0.0022 µF, 50 volts, Polyester
C39–C41—1 µF, 35 or 50 volts, aluminum electrolytic

Semiconductors
D1–D3—Motorola MPN 3404 PIN diode (alternate MPN 3700)
D4—1N4007 diode
D5—Motorola MV2112 varactor diode
D6—1N757 diode
Q1—2N3563 transistor
Q2, Q3—Motorola MPS3866 transistor
Q4—2N3565 transistor
Q5—Motorola MPF102 FET
Q6—2N4355 transistor
Q7—2N3569 transistor
Q8—Motorola MRF559 transistor (alternate MRF627)
Q9—Motorola MRF652 transistor
Q10—Motorola MJE200 transistor

Inductors (all coils wound on a No. 8-32 mandrel unless otherwise noted—inductances below 50 nH are approximate and might vary ±10nH)
L1—125 to 300 nH (7½ turns No. 22 enameled with Cambion Blue 8-32 × ¼ slug)
L2, L3—50 to 100 nH (3½ turns No. 22 enameled with Cambion Blue 8-32 × ¼ slug)
L4—30 nH (4 turns No. 22 tinned)
L5—39 nH (5 turns No. 22 tinned)
L6, L8—5 nH (½ turn No. 22 tinned)
L7—10 nH (1½ turns No. 22 tinned)
L9—7 nH (½ turn No. 20 tinned, 0.375" dia.)
L10—40 nH (5 turns No. 22 tinned)
L11—20 nH (2 turns No. 20 tinned)
L12—12 nH (1 turn No. 29 tinned)
L13—11 µH (12 turns No. 22 enameled on 0.375" toroid core)
L14—Bead choke, 43 matl
L15—part of R13

Other components
XTAL1—54.90625 MHz crystal
XTAL2—54.25000 MHz crystal
XTAL3—53.28125 MHz crystal
S1—SP3T switch and hardware
S2—SPST toggle switch

Miscellaneous: two RCA jacks, one female BNC, one power connector, one LED, one 1000-ohm ¼-watt resistor, No. 22 AWG enameled wire, No. 20 AWG tinned wire, No. 22 AWG tinned wire, No. 32 AWG enamelled wire, aluminum heatsink material, one TO-220 mica insulator, five No. 2 × ¼" machine screws, five No. 2 nuts, six No. 4 lock washers, one No. 4 × ½" machine screws, one No. 4 nut, one No. 8 nut, one No. 8 lock washer, one No. 8 × 1" machine screw (for use as coil form), transmitter PC board, power-amp PC board

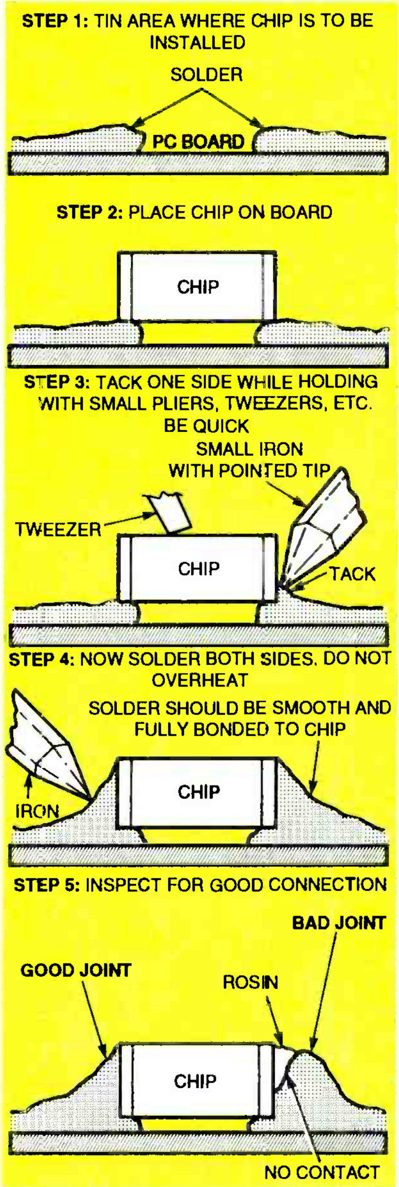


FIG. 4—CHIP-CAPACITOR mountings.

0.5 volt or more. Back the slug of L1 out about ¼ turn past this point. Next, adjust L2 and L3 for a maximum reading. A reading of 2 to 5 volts should be obtained. Readjust L1 as required. In 5-watt units, check to see if all three crystals produce this voltage reading. Readjust L1, L2, and L3 as required.

Next, move the negative lead of the voltmeter to TP2 (leave the positive lead connected to the power supply's positive terminal). When first connected, there might not be a voltage reading. Adjust C9, C11, and C12 for a maximum reading from 1 to 2.5 volts (this applies to both units).

Readjust L1, L2, L3, C9, C11, and C12 as needed. (In 5-watt units, all three crystals should produce a reading.) If less than a 1-volt drop is obtained, set C13 and C14 to half their capacitance values and repeat this step. If you have one, connect an RF milliwatt meter to the free end of L7 and ground. In 5-watt units only, use as short a length as possible of 50-ohm coaxial cable. About 50 to 75 milliwatts of RF energy should be obtained by tuning C13 and C14. In this test, all three crystals should produce a similar reading. This test verifies the performance of the exciter section.

If you are testing a ¾-watt transmitter, connect a 50-ohm load between C9 and ground with a short length of coaxial cable. A relative reading of output power is acceptable if no test instrument capable of true measurement is available. The 50-ohm load should preferably have an indicator.

Set R14 for maximum voltage on the emitter of Q7. Now adjust C13 and C14 for maximum RF output from Q4. This should be at least 750 milliwatts, and with a 13.8-volt supply, many units will produce over 1 watt. You can squeeze or spread the turns of coils L8 and L9 to optimize this. Repeak C13 and C14 as needed. Transistor Q4 will be warm to the touch. If 9-volt operation is desired, repeak C13 and C14 with the supply voltage at 9 volts. This completes the transmitter tune-up for the ¾-watt units. (Video and audio adjustments must still be made.)

For 5-watt units, assemble the RF power amplifier. Trim excess ground foil away from certain areas to avoid short circuits. Hold the power amplifier at right angles to the main board, and tack-solder the ground planes of the two boards together in two or three places. Next, solder the R34 pad on the main board to the L10 pad on the amplifier board. Also apply solder between the L14 pad on the amplifier board and the adjacent R14 pad to the main board. Now solder a continuous bond between all mating ground planes of both boards. When soldering is complete, carefully check the assembly to make sure there are no short circuits between those two "hot" connections and ground. Now solder the free end of L7 (which is mounted on the main board) to the base of Q8 and R12 on the amplifier board.

Remove Q10 from the main board. Form Q10's leads as shown in Fig. 12 and install it on the heatsink. Install a mica or Teflon insulator between Q10 and the heatsink. Tighten screws only until they are snug. Check for short circuits between the collector of Q10 and the heatsink.

With the power amplifier installed, check both sides of R14 for short circuits to ground with an ohmmeter. If 10 ohms or less is noted, there is definitely a short somewhere. Find it and fix it before proceeding. If you are building the transceiver, next check the antenna relay for correct operation (with an ohmmeter check both energized and deenergized states). Connect the power-amplifier cable to the relay, and connect the relay's common pole to the antenna jack with 50-ohm coaxial cable. Check for continuity and inadvertant short circuits. Temporarily connect a jumper wire between either side of D4 and TP8 to make sure the relay is energized at all times when the

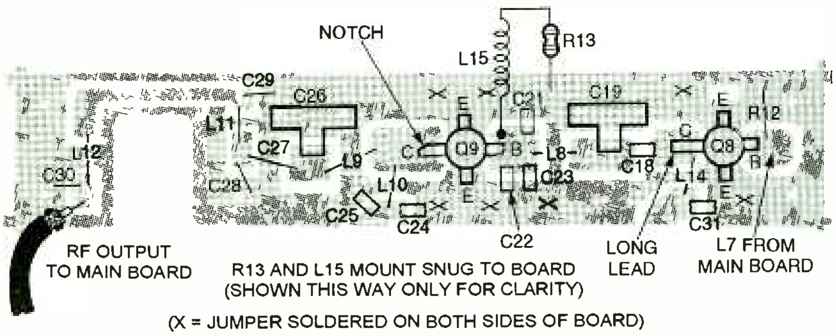
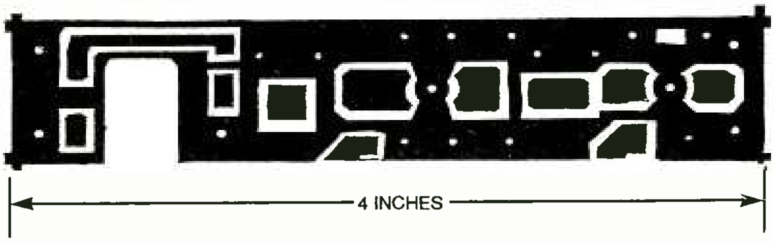


FIG. 5—RF POWER AMPLIFIER parts-placement diagram. Install all parts except Q9.



RF POWER AMPLIFIER foil pattern.

PARTS LIST—5-WATT TRANSCEIVER

All resistors are ⅛-watt, 5%, unless specified

R1–R3, R7, R49—2200 ohms
R14—10 ohms, ¼-watt
R4, R17, R53, R55—1000 ohms
R5, R23, R45, R47, R56—330 ohms
R6, R9, R12, R16, R35, R36—100 ohms
R8, R13—10 ohms
R10, R41—470 ohms
R11—33 ohms
R15, R44—15 ohms
R18, R20—1000 ohms, horizontal-mount potentiometer
R19, R27, R46—10,000 ohms
R21—not used
R22—82 ohms
R25, R39—470,000 ohms
R26—220,000 ohms
R28, R34, R42—4700 ohms (7× gain R34 = 3300 ohms, 5X gain R34 = 2200 ohms)
R30, R32—33,000 ohms
R31, R38, R51—100,000 ohms
R33—100,000 ohms, horizontal-mount potentiometer
R29, R43—680 ohms
R37—47 ohms
R40—220 ohms
R48—6800 ohms
R50—1000 ohms, thumbwheel trimmer potentiometer
R52—470 ohms, ¼-watt
R54—3300 to 4700 ohms (see text)

Capacitors

C1, C53—39 pF, ceramic NPO
C2, C7—56 pF, ceramic NPO
C3, C52—18 pF, ceramic NPO
C4, C33, C53–C55, C62, C67, C69, C70—0.01 µF ceramic disc GMV
C5, C42—2.2 pF, ceramic NPO (alternate C42—1 or 3.3 pF)
C6, C56—33 pF, ceramic NPO
C8, C16—470 pF, 20% ceramic disc
C9, C11, C13, C14, C19, C26, C43, C46, C57, C59—2–10 pF trimmer (yellow body)
C10, C15, C60, C64—1 pF, ceramic NPO
C12—2–18 pF trimmer (green body)
C17, C18, C24, C25, C44, C45, C47–C49—100 pF, chip
C20–C23—33 pF, 60 × 120 chip
C27—6.8 pF, ceramic NPO
C28, C30—4.7 pF, ceramic NPO
C29, C65—10 pF, ceramic NPO
C32, C63, C66—10 µF, 16 volts, aluminum electrolytic
C34—10 µF, 16 volts, tantalum chip
C35—68 pF, ceramic NPO or SM
C36—120 pF, ceramic NPO or SM
C37—3-40 pF, trimmer (gray body)
C38—0.0022 µF, 50 volts, mylar
C39, C40, C41—1 µF, 35 or 50 volts, electrolytic
C50—0.6 pF (part of PC board)
C57—6.8 pF, ceramic NPO
C58—5.6 pF, ceramic NPO
C61—100 pF, ceramic NPO
C68—470 µF, 16 volts, electrolytic

Inductors (all coils wound on No. 8-32 mandrel unless noted—inductances below 50 nH are approximate and might vary ±10 nH)

L1—125 to 300 nH (7½ turns No. 22 AWG enameled with Cambion Blue 8-32 × ¼ slug)
L2, L3—50 to 100 nH (3½ turns No. 22 AWG enameled with Cambion Blue 8-32 × ¼ slug)
L4—30 nH (4 turns No. 22 AWG tinned)
L5—39 nH (5 turns No. 22 AWG tinned)
L6, L8—5 nH (½ turn No. 22 AWG tinned)
L7—10 nH (1½ turns No. 22 AWG tinned)
L9—7 nH (½ turn No. 20 AWG tinned, 0.375" dia.)
L10—40 nH (5 turns No. 22 AWG tinned)
L11—20 nH (2 turns No. 20 AWG tinned)
L12—12 nH (1 turn No. 29 AWG tinned)
L13—11 µH (12 turns No. 22 AWG enameled on 0.375" toroid core)
L14—Bead choke, 43 matl
L15—part of R13
L16—7 nH (½ turn No. 20 tinned)
L17, L18—20 nH (2 turns No. 20 tinned)
L19—75 nH (5 turns No. 22 enameled)
L20—200 to 550 nH (11½ turns No. 22 AWG enameled with Cambion Blue, 8-32 × ¼ slug)
L21—8 nH (½ turn No. 20 square loop)
L22—18 µH RF choke

Semiconductors

D1–D3—Motorola MPN 3404 PIN diode (alternate MPN 3700)
D4—1N4007 diode
D5—Motorola MV2112 varactor diode
D6, D10—1N757 diode
D7, D8, D11—8200-2835 diode
D9—Motorola MV2103 varactor diode
Q1, Q12—2N3563 transistor
Q2, Q3—Motorola MPS3866 transistor
Q4—2N3565 transistor
Q5—Motorola MPF102 FET
Q6—2N4355 transistor
Q7—2N3569 transistor
Q8—Motorola MRF559 transistor (alternate MRF627)
Q9—Motorola MRF652 transistor
Q10—Motorola MJE200 transistor
Q11—NEC 25137 or NEC 25139 FET
Q13—Motorola MPSH81 transistor
Q14—2N3904 transistor

Other components

XTAL1—54.90625 MHz
XTAL2—54.25000 Mhz
XTAL3—53.28125 MHz
S1—2P3T switch
S2—SPST toggle switch
RY1—12-volt DIP relay
M1—SBL-1 mixer

Miscellaneous: two RCA jacks, one female BNC, one power connector, one LED, one 1000-ohm ¼-watt resistor, No. 22 enameled wire, No. 20 tinned wire, No. 32 enameled wire, aluminum heatsink material, one TO220 mica insulator, five No. 2 × ¼" machine screws, five No. two nuts, one 12" teflon cable, one 2" potentiometer shaft, six No. 4 lock washers, one No. 4 × ½" machine screws, one No. 4 nut, one No. 8 nut, one No. 8 lock washer, one 8 × 1" machine screw (for use as coil form), transceiver PC Board, power-amp PC board

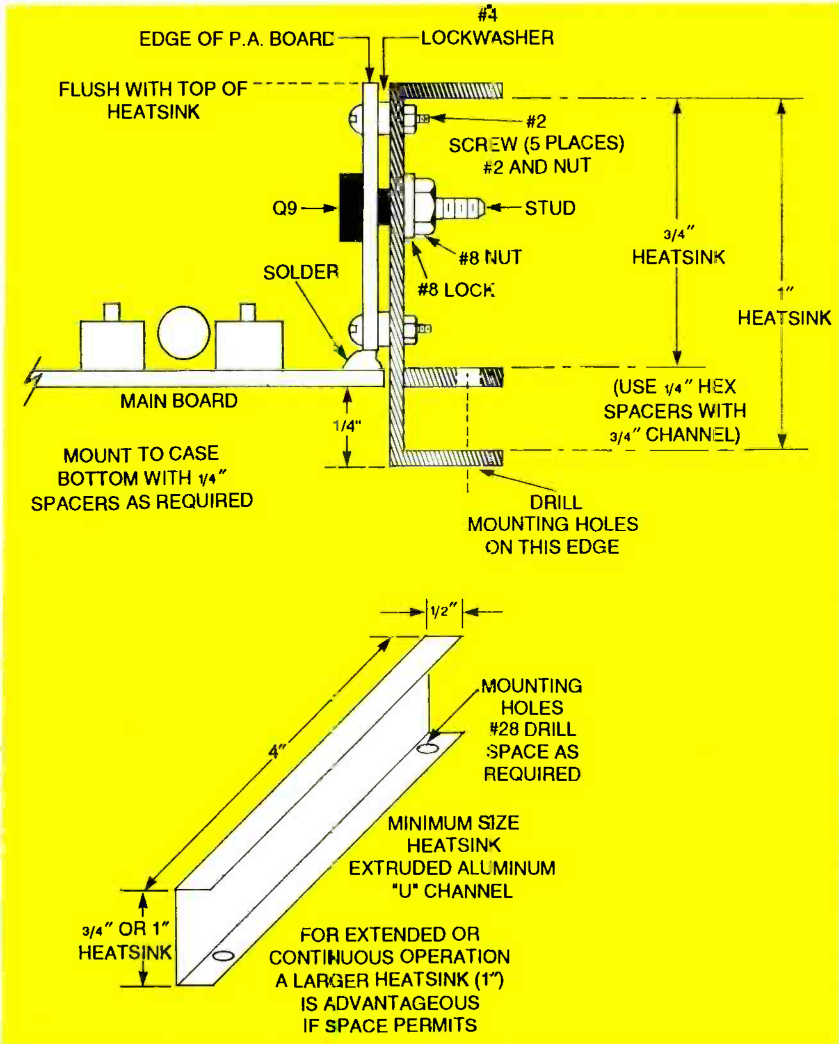


FIG. 6—AFTER MOUNTING THE power-amplifier board to the heatsink, install Q9 as shown here.

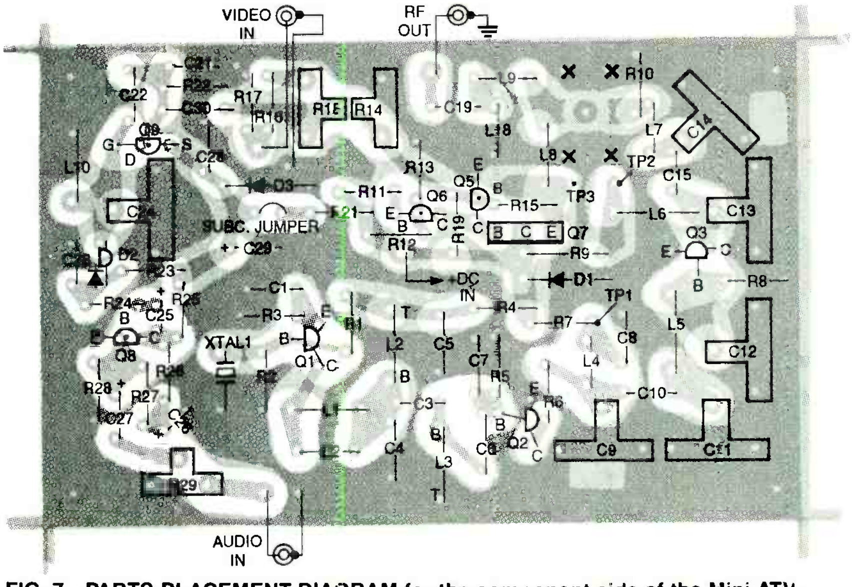


FIG. 7—PARTS-PLACEMENT DIAGRAM for the component side of the Mini ATV.

transmitter is operating.

Verify that R18 is set so that the power amplifier has full voltage (at least 12 volts). Check that on the emitter of Q10 or the junction of R14, C24, and C25.

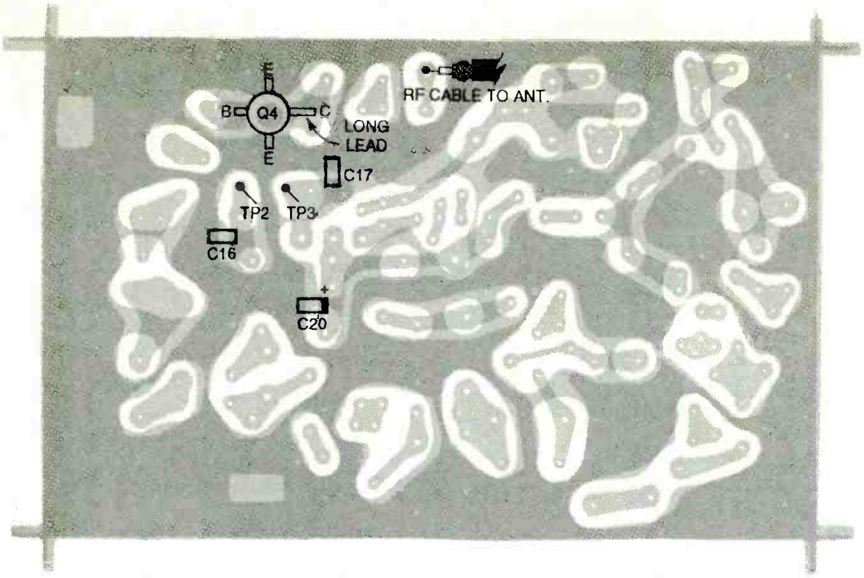


FIG. 8—**PARTS-PLACEMENT DIAGRAM** for the solder and solder side of the Mini ATV.

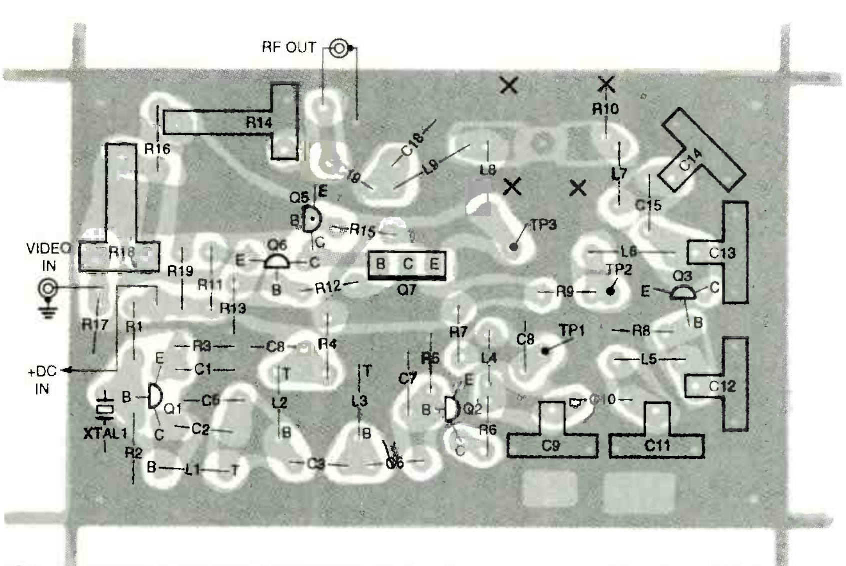


FIG. 9—**PARTS-PLACEMENT DIAGRAM** for the component side of the ATV jr.

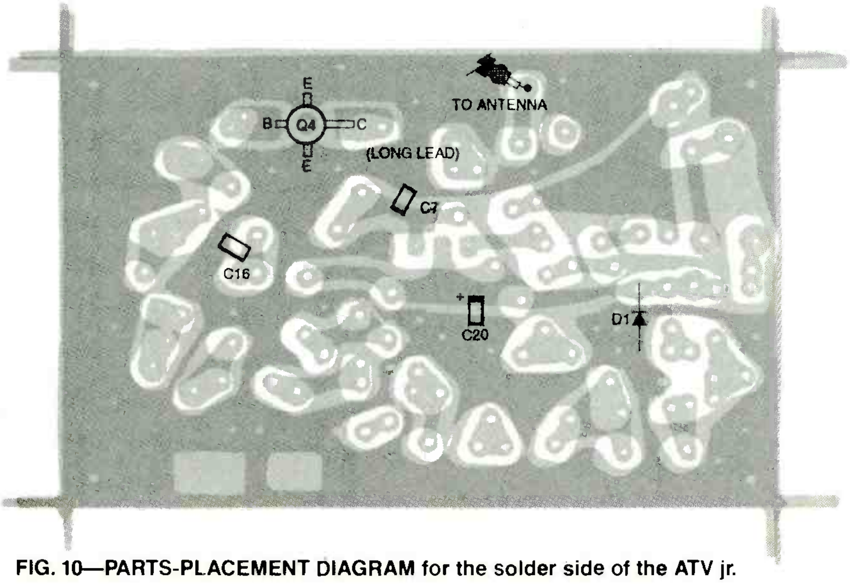


FIG. 10—**PARTS-PLACEMENT DIAGRAM** for the solder side of the ATV jr.

PARTS LIST—ATV JR.

All resistors are ⅛-watt unless specified
R1—33,000 ohms
R2, R19—10,000 ohms
R3, R12, R16—330 ohms
R4, R7,—R10—100 ohms
R5—2200 ohms
R6—10 ohms
R8—470 ohms
R9, R11—33 ohms
R13—3300 ohms
R14, R18—1000 ohms, horizontal-mount potentiometer
R15—3300 ohms (alternate 2200 to 4700 ohms)
R17—82 ohms
Capacitors
C1, C7—56 pF, ceramic NPO
C2—39 pF, ceramic NPO
C3—2.2 pF, ceramic NPO
C4—18 pF, ceramic NPO
C5—0.01 µF, ceramic disc GMV
C6—33 pF, ceramic NPO
C8—470 pF, ceramic disc GMV
C9, C11, C13, C14 2–10 pF trimmer (yellow body)
C10, C15, C18—1 pF, ceramic NPO
C12—2–18 pF trimmer (green body)
C16, C17—100 pF, chip
C19—10 pF, ceramic NPO
C20—10 µF, 16 volts, chip
Semiconductors
D1—1N4007 diode
Q1—2N3563 transistor
Q2, Q3—Motorola MPS3866 transistor
Q4—Motorola MRF559 transistor
Q5—2N3904 transistor
Q6—2N3906 transistor
Q7—Motorola MJE180 transistor
Inductors (all coils wound on 8-32 × ¼" form unless noted—inductances below 50 nH are approximate and may vary ±10 nH)
L1—125 to 300 nH (7½ turns No. 22 AWG enameled with 8-32 × ¼" Cambion Blue slug)
L2, L3—50 to 100 nH (3½ turns No. 22 AWG enameled with 8-32 × ¼" Cambion Blue slug)
L4—30 nH (4 turns No. 22 AWG tinned)
L5, L8—39 nH (5 turns No. 22 AWG tinned)
L6—5 nH (½ turn No. 22 AWG tinned 0.375" dia.)
L7—10 nH (1½ turns No. 22 AWG tinned)
L9—25 nH (2½ turns No. 22 AWG tinned)
Other components
XTAL1—54.90625 MHz crystal
Miscellaneous: ATV Jr. PC board, 8-32 screw for coil winding

Next, connect a 50-watt dummy load or wattmeter capable of dissipating 10 watts to the RF output terminals (the antenna jack or between C30 and ground). For the 5-watt transceiver, use the line sampler circuitry.

Apply +13.8 volts across C69 and ground. Connect a DC volt-

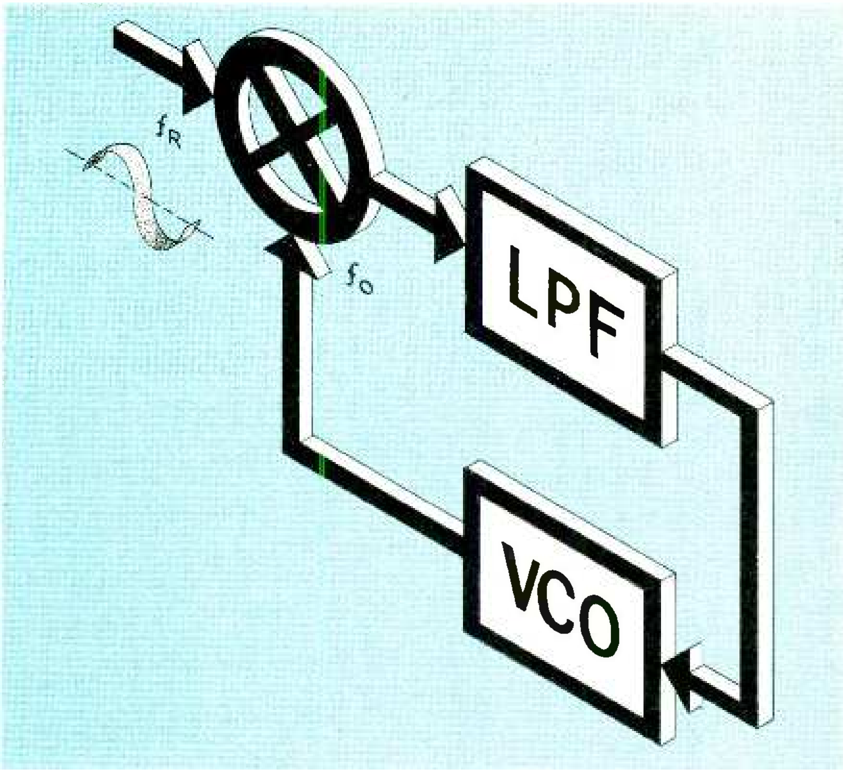
Continued on page 52

RAY MARSTON

THE PHASE-LOCKED LOOP (PLL) CIRCUIT "locks" the frequency and phase of a variable-frequency oscillator to that of an input reference. An electronic servo loop, it provides frequency-selective tuning and filtering without the need for coils or inductors, a desirable feature in miniature, solid-state circuits.

This article examines the theory and basic operating principles of phase-locked loop circuits. It then shows many practical applications for the voltage-controlled oscillator integrated within a monolithic PLL circuit. Subsequent articles in this series will examine communications and control circuits that make use of complete PLL ICs.

Figure 1 is the block diagram of a basic PLL circuit. It consists of blocks representing the phase comparator (sometimes called the phase-detector), low-pass filter (LPF), and a linear, voltage-controlled oscillator (VCO). Prominent applications for PLL ICs include FM demodulators, frequency synthesis, and tone decoding.



PHASE-LOCKED LOOPS

Learn about phase-locked loops (PLL), and design communications and control circuits with them.

PLL principles

The phase comparator receives and compares the phase and frequency of the circuit's output frequency (f_O) with an external input reference frequency (f_R), and generates a corresponding variable output error voltage.

After the error voltage is filtered by the LPF, it is fed to the control input of the VCO so that any frequency or phase differences between f_O and f_R are progressively reduced to zero. When that occurs, the loop is said to be *locked*.

If the VCO's frequency is initially below that of the input reference, the phase comparator's output swings positive. Its filtered voltage output then commands the VCO's frequency to increase until both its frequency and phase precisely match those of the input reference.

Similarly, if the VCO's frequency increases above that of the internal reference, the reverse response takes place. The phase comparator's output decreases, again directing the VCO's frequency to lock to the same frequency as the input reference.

The low-pass filter is the essential part of the PLL circuit that converts the output of the phase detector into a smooth DC control voltage. Because it has a finite time constant, PLL locking is not instantaneous, and the output frequency locks to the *mean* value of f_R, rather than to its instantaneous value. This characteristic is valued for producing clean output frequencies from a noisy input reference frequencies.

Frequency multiplication

In the basic PLL block diagram in Fig. 1, the output signal frequency locks to the mean value of the input frequency so that the input and output frequencies are identical. Figure 2 shows a variation of that circuit in which the output frequency is precisely ten times greater than the input frequency. As a result, the circuit acts like a frequency multiplier.

In the block diagram of Fig. 2, a divide-by-ten counter is inserted in the feedback loop between the VCO output and the input of the phase comparator. Consequently, the phase comparator locks to the output fre-

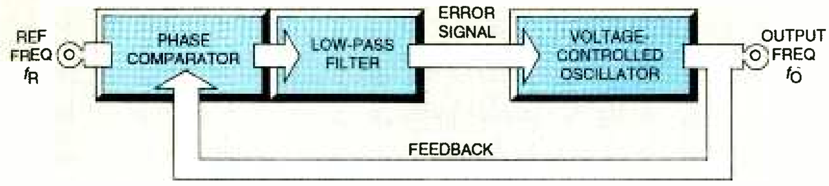


FIG. 1—PHASE-LOCKED LOOP (PLL) circuit.

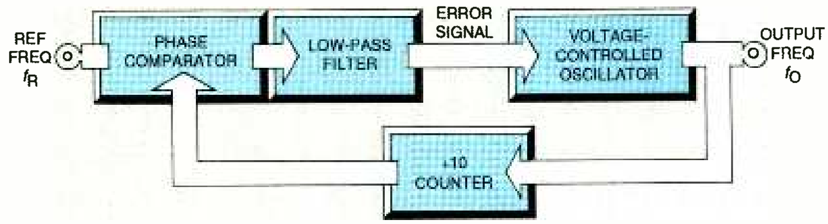


FIG. 2—FREQUENCY MULTIPLIER circuit based on the PLL.

quency of the divide-by-ten counter instead of the output frequency of the VCO.

Therefore, at the lock condition, the VCO's frequency (f_O) is ten times greater than the input reference signal (f_R), and the circuit acts as a 10× frequency multiplier. This circuit can multiply by any number other than ten if it has a counter with an appropriate division ratio in its feedback loop.

Frequency synthesis.

The PLL circuit can also function as a precise programmable frequency synthesizer (see Fig. 3). The reference input frequency of the phase comparator is a fixed precision 1-kHz signal derived from a 1-MHz crystal oscillator through a divide-by-1000 counter.

As in the frequency multiplier circuit, there is a counter in the feedback loop between the VCO's output and the phase comparator's input. However, this circuit is externally programmable, so it can provide any whole-number division ratio between 100× and 1000×.

This feature permits the circuit to generate or synthesize accurate, stable frequencies between 100 kHz and 1 MHz in 1-kHz steps. The VCO circuit in Fig. 3 must have a frequency span range of at least 10 to 1 to cover the required range. Moreover, the frequency step value corresponds to the 1-kHz external input frequency.

High-frequency synthesis

The programmable counter is an essential function of all frequency synthesizers. Practical counters typically respond to maximum input frequencies of only a few megahertz. As a result, the Fig. 3 circuit cannot directly synthesize frequencies higher than a few megahertz. Figures 4 to 6 show three alternative versions of high-frequency PLL synthesizer circuits.

The circuit in Fig. 4 depends on a prescaling technique. An additional *divide-by-X*, fixed-value, high-frequency counter stage (the prescaler) is located between the VCO output and the input of the programmable counter.

This configuration permits the VCO to operate at a frequency X-times higher than the programmable counter stage. In the example shown, the prescaler has a divide-by value of 20×, giving the synthesizer the ability to cover 2 to 20 MHz in 900 discrete steps. A disadvantage is that it causes the step value of the synthesizer to increase by a ratio equal to the prescaler value (i.e., to 20×f_R)—20 kHz in this circuit.

In the Fig. 5 circuit, a mixer technique synthesizes frequencies between 100 and 101 MHz in 1000 discrete steps of 1 kHz. The VCO's output is mixed with a crystal-derived 99.9-MHz frequency before being sent through a low-pass filter to produce a 100-KHz to 1.1-MHz *difference* frequency. That difference frequency then enters the PLL and passes through the programmable counter stages. This scheme permits the VCO frequency to be varied in steps equal to the f_R value, but it limits the VCO's useful span to a few megahertz.

Figure 6 shows how the mixer and prescaler circuits in Fig. 5 can be combined to make a wide-range, high-frequency synthesizer that can generate frequencies between 100 and 120 MHz in 1000 discrete 20-Hz steps. The VCO's output frequency is mixed with a crystal-derived 98-MHz frequency and put through a low-pass filter to produce an output from 2 to 22 MHz.

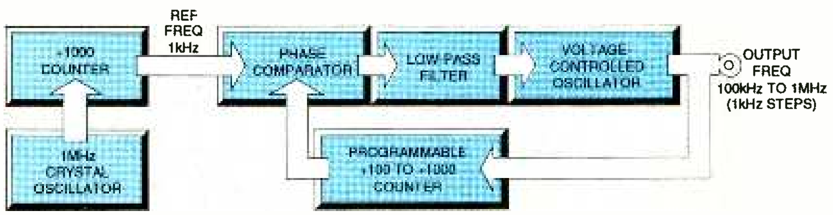


FIG. 3—FREQUENCY SYNTHESIZER based on the PLL.

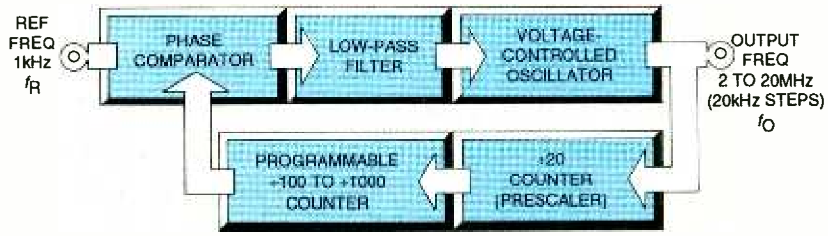


FIG. 4—FREQUENCY SYNTHESIZER with prescaler based on the PLL.

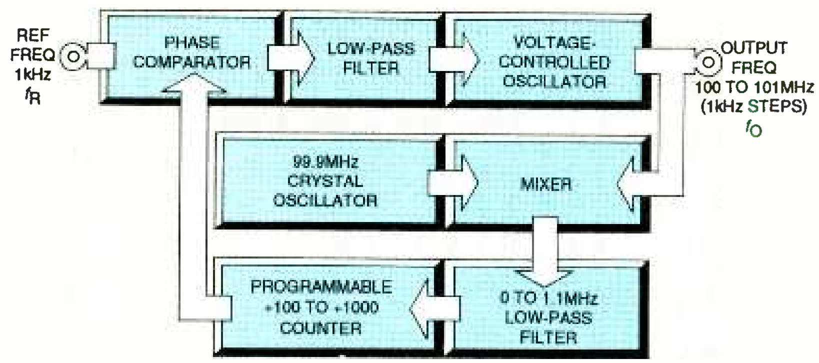


FIG. 5—HIGH-FREQUENCY, MIXER-TYPE synthesizer based on the PLL.

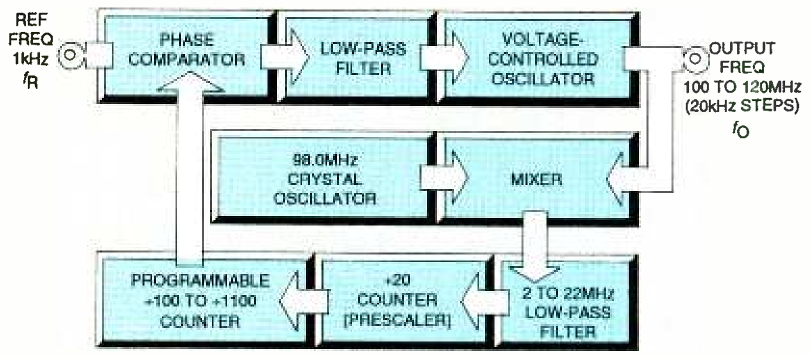


FIG. 6—WIDE-RANGE, HIGH-FREQUENCY synthesizer based on the PLL.

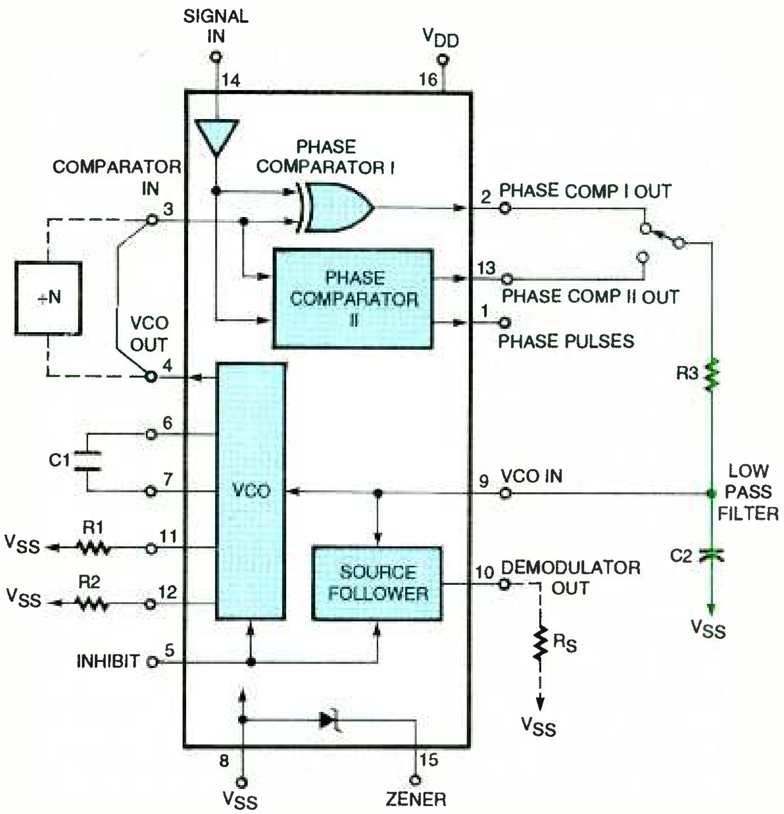


FIG. 7—BLOCK DIAGRAM for the CD4046B PLL IC showing its external components and connections.

That output is then reduced to the 100-kHz to 1.1-MHz range by a divide-by-20 prescaler stage before it is fed back into the PLL through the programmable counter. This synthesizer circuit gives excellent results.

VCO operation.

The voltage-controlled oscillator in high-frequency PLL synthesizers typically must cover a very limited span range. This function is typically performed by a variable capacitor-controlled transistor oscillator with a buffer circuit. By contrast, the VCO in low-frequency synthesizers typically must cover a very wide span range. That circuit is typically a special monolithic CMOS or bipolar IC oscillator.

Some monolithic PLL integrated circuits contain excellent wide-range VCOs that can be used by themselves in practical circuits. An example is the popular Harris CMOS CD4046B, widely alternate-sourced by many other manufacturers including Motorola, National Semiconductor, Philips, and SGS-Thomson. It is also made with HC and HCT CMOS technologies.

The CD4046B PLL IC.

Figure 7 is the block diagram for the CD4046B that includes external components. It consists of a low-power, linear, voltage-controlled oscillator (VCO), a source-follower, a Zener diode, and two phase comparators. The two phase comparators have a common signal input and a common comparator input. The signal input can be directly coupled for a large voltage signal, or capacitively coupled to the self-biasing amplifier for a small voltage signal

Phase comparator I, an exclusive OR gate, provides a digital error signal (PHASE COMP I OUT) and maintains 90° phase shifts at the VCO center frequency. Between signal input and comparator input (both at 50% duty cycle), it can lock onto the signal input frequencies that are close to harmonics of the VCO's center frequency. It offers good noise-rejection performance, but must be driven by square waves on both pins 3 and 14. It has only a narrow capture-frequency range.

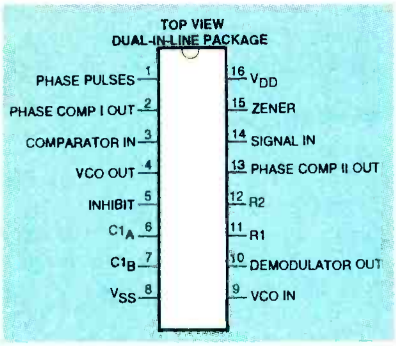


FIG. 8—PINPOUT DIAGRAM for the CD4046B PLL IC in a 16-pin dual-in-line package.

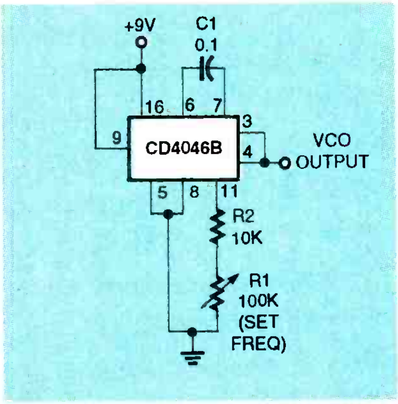


FIG. 9—SQUAREWAVE GENERATOR for 200 Hz to 2 kHz.

Phase comparator II, an edge-triggered digital memory network, provides a digital error signal (PHASE COMP II OUT) and lock-in signal (phase pulses) to indicate a locked condition. It maintains a 0° phase shift between the signal and comparator inputs. It can be driven by crude, non-symmetrical waveforms on pins 3 and 14. Although it has a very wide capture-frequency range, it has poor noise rejection.

The VCO produces an output signal (VCO OUT) whose frequency is determined by the voltage at pin 9 (VCO IN) and the input and the capacitor between pins 6 and 7 ($C1_A$ and $C1_B$, respectively) and resistors R1 and R2 at pins 11 and 12 (R1 and R2, respectively). Resistor R2 permits the minimum operating frequency to be preset. The VCO generates a symmetrical squarewave output that appears on pin 4 (VCO OUT).

The source-follower output of the VCO IN (DEMODULATOR OUT) is used with an external resistor whose value is 10 kilohms or more. When high, the INHIBIT input disables the VCO and source-follower to minimize standby power consumption. The Zener diode between pin 8 (V_{SS}) and 15 (ZENER) has a nominal operating value of 5.6 volts; it can provide supply regulation, if required.

Pin 9 has a nearly infinite input impedance. It can be driven from a high-impedance source. The internal source-follower stage permits the voltage at pin 9 to be externally monitored without loading the source. Pin 5 (INHIBIT) is normally connected to pin 8 to enable both the VCO and the source-follower.

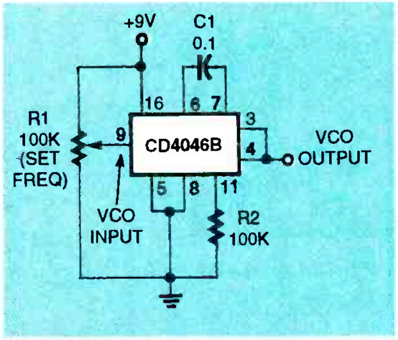


FIG. 10—WIDE-RANGE VCO, variable from near-zero to 1.4 kHz by adjusting the voltage on pin 9.

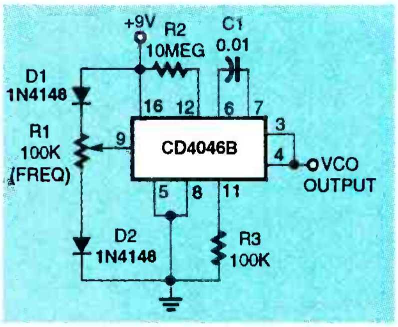


FIG. 11—WIDE-RANGE VCO fully variable down to zero frequency

Figure 8 is the pinout diagram for the CD4046B in a 16-pin dual-in-line package. It will operate over a supply voltage range (V_{DD}) of 3 to 18 volts. Typical power consumption is 70 microwatts, and its VCO frequency is typically 1.3 MHz. The CD4046B has a maximum operating frequency of about 1.6 MHz.

VCO applications

Figures 9 to 17 show various ways to make practical use of the voltage-controlled oscillator section of the CD4046B. In Fig. 9, pin 9 is permanently connected to the supply so that the circuit acts as a basic squarewave oscillator. Its frequency is variable over a 10 to 1 range by adjusting trimmer potentiometer R1.

Pin 4 is tied directly to pin 3 (COMPARATOR IN). If pin 3 is allowed to float, the comparators self-oscillate at about 20 MHz, and superimpose a high-frequency on the VCO output waveform.

Figure 10 shows how to connect the CD4046B as a wide-range VCO. Resistor R2 and capacitor C1 set the maximum frequency that can be obtained, and trimmer potentiometer R1 controls the frequency through the pin 9 voltage. The frequency falls nearly to zero (at a rate of a few cycles per minute) when pin 9 is set at zero volts.

The effective control range of pin 9 varies from about 1 volt above zero to 1 volt below the positive supply value (e.g., po-

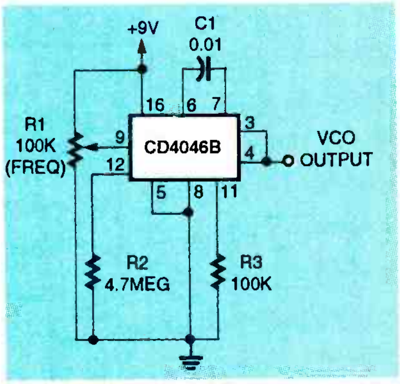


FIG. 12—RESTRICTED-RANGE VCO, variable from 60 Hz to 1.4 kHz with trimmer potentiometer R1.

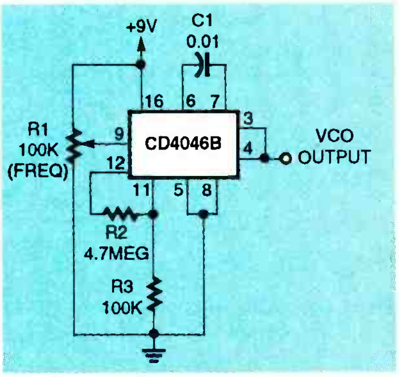


FIG. 13—ALTERNATIVE RESTRICTED-range VCO.

tentiometer R1 has a "dead" control region of several hundred millivolts at either end of its span.)

Figure 11 shows how the "dead" regions of R1 can be eliminated by placing a silicon diode in series with each end of R1 (D1 and D2). The circuit also shows how the minimum operating frequency can be reduced to zero by connecting 10-megohm resistor R2 from pin 12 to pin 16 (V_{DD}). When the frequency is reduced to zero, the VCO output randomly settles to either the logic-0 or logic-1 state.

Figure 12 shows how the resistor at pin 12 can also be connected to pin 8 to set the minimum operating frequency of a restricted-range VCO. The minimum frequency is determined by the combination of R2 and C1, and the maximum frequency is determined by C1 and the parallel value of R2 and R3. Potentiometer R1 can vary the frequency range from 60 Hz to 1.4 kHz.

Figure 13 shows an alternative version of the restricted-range VCO. Its maximum frequency is controlled by R2 and C1, and the minimum frequency is controlled by C1 and R2 and R3. With a suitable choice of values for R2 and R3, the restricted-range VCO can span any range from 1 to 1 to near infinity.

The VCO can be set up to generate a pair of squarewave outputs 180° out-of-phase by connecting the VCO output to the phase comparator input, making pin 14 (SIGNAL IN) high, and taking the 180° out-of-phase output from pin 2, as shown in Figure 14. This circuit takes advantage of the integrated circuit's built-in exclusive OR gate at pin 2.

As shown in Fig. 15, the VCO section of the CD4046B can be disabled by connecting pin 5 high to logic 1. This feature permits the VCO to be gated on and off by external signals. The VCO can be manually gated with pushbutton switch S1 that is connected between pin 5 and ground.

Figure 16 shows how the VCO can be gated electronically by an external inverter stage, one-fourth of a CD4011B, a CMOS NAND gate. Alternatively, if you do not need two-phase ouput capability, Fig. 17 shows how the internal exclusive OR phase detector can control the gate. In this circuit, pin 4 is not connected to pin 3. Ω

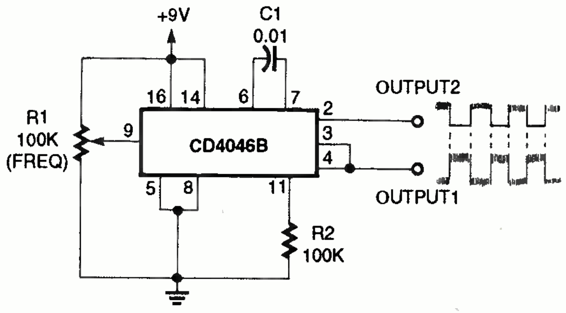


FIG. 14—A TWO-PHASE, WIDE-RANGE VCO.

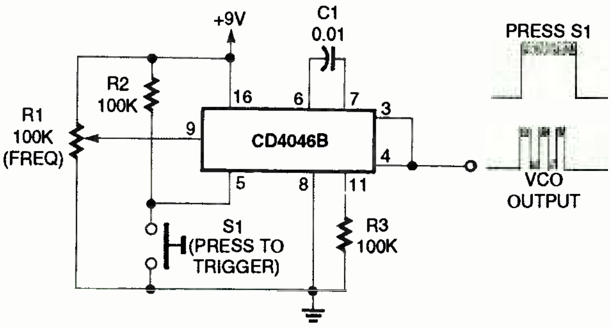


FIG. 15—MANUALLY GATED wide-range VCO.

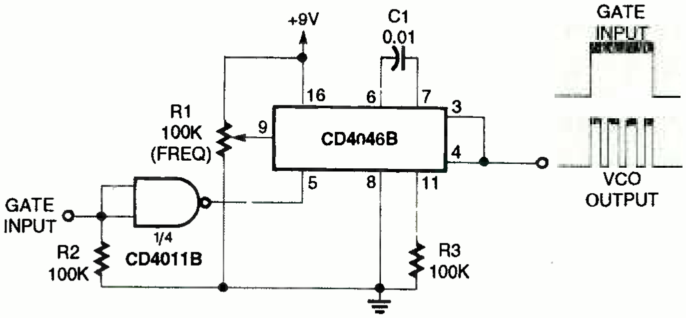


FIG. 16—ELECTRONICALLY GATED, wide-range VCO with an external gate inverter.

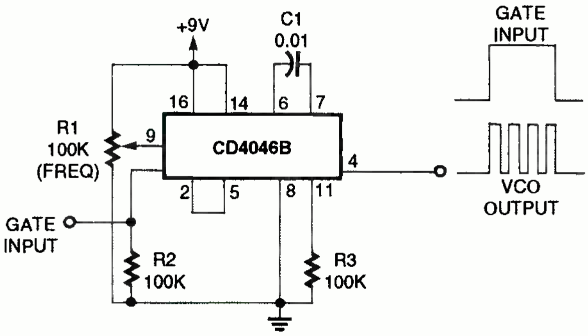


FIG. 17—ELECTRONICALLY GATED, wide-range VCO with an internal exclusive OR phase detector to permit gate inversion.

TABLE 1—CHECKOUT PROCEDURES
Initial voltages & resistance checks for 5-Watt ATV xcvr/xmtr

MAIN BOARD:

Initial current draw: Smoke test		< 100 ma. @ 13.8 VDC (04 xmtr connection only)
Initial current draw:	TP4	< 50 ma.
	TP5	< 50 ma.
	TP6	< 50 ma.
	TP8	< 50 ma.
TP5 @ 13.8 VDC:	Jct.R52, C63, C62, D10	+9.0 V
	Center term R50:	+5.5 V adj. R50 if needed
(xcvr only)	Emitter Q13:	+6 to +7V
	Collector Q12:	+6 to +9V
	Jct. R46, R51, C58, D9	+5.5V should vary +1 to +9V with 50 rotated to limits, reset to +5.5V if tests OK
TP4 @ 13.8 VDC	Source Q11:	+0.6 to +1.4V
	Gate #2 Q11:	+2.0V
(xcvr only)	Drain Q11:	+10.0 to +12.5V
TP6 @ 13.8 VDC:	Jct R53,R54, R55, D11, C66,C67:	+3.0 to +3.5V
(xcvr only)	Emitter Q14:	+2.4 to +3.0V
D4 free end @ 13.8 VDC:	Collector Q1	> +13.5V
	Collector Q2	> +13.5V
	Collector Q3	> +13.5V
Install temp. jumper for subcarrier	Jct R29 & D6	+9.0V
	Collector Q4	+3 to +3.5V
	Jct D5, C38	+5 to +6.5V

PA BOARD RESISTANCE CHECKS BEFORE INSTALLING:

Jct L12, C30 to ground	infinity
Jct L12, C30 to Jct L11, C36, C27	zero
Base to Q8 to ground	100 ohms
Base Q9 to ground	10 ohms
Collector Q8 to point B	< 1 ohm
Collector Q9 to point A	< 0.1 ohm
Jct L9, C26 to point A	< 0.1 ohm
Jct C18, C19, L8 to ground	10 ohms

RELAY CHECKS FOR TRANSCEIVER ONLY BEFORE POWER UP:

Jct L12, C30 to ground	infinity
Antenna terminal and ground	< 1 ohm
Connect +13.8 VDC to TP8 and check:	
Antenna terminal and ground	infinity (>1 megohm OK)
Antenna terminal and jct L12, C30	< 1 ohm

INITIAL VOLTAGE CHECKS FOR 3/4-WATT UNITS

Initial current draw at 13.2 VDC Smoke test	< 100 ma. DC
Initial voltages:	
Collector Q7	+13.2V
Collector Q1	+12.6V
Collector Q2	+13.2V
Drain Q9	+6.8V (Mini ATV only)
Collector Q8	+3.5V (Minit ATV only)
Collector Q4, and Emitter Q7	Varies with setting of R14 and R18, from < +3 to > +11.5V. Verify before tuning up.

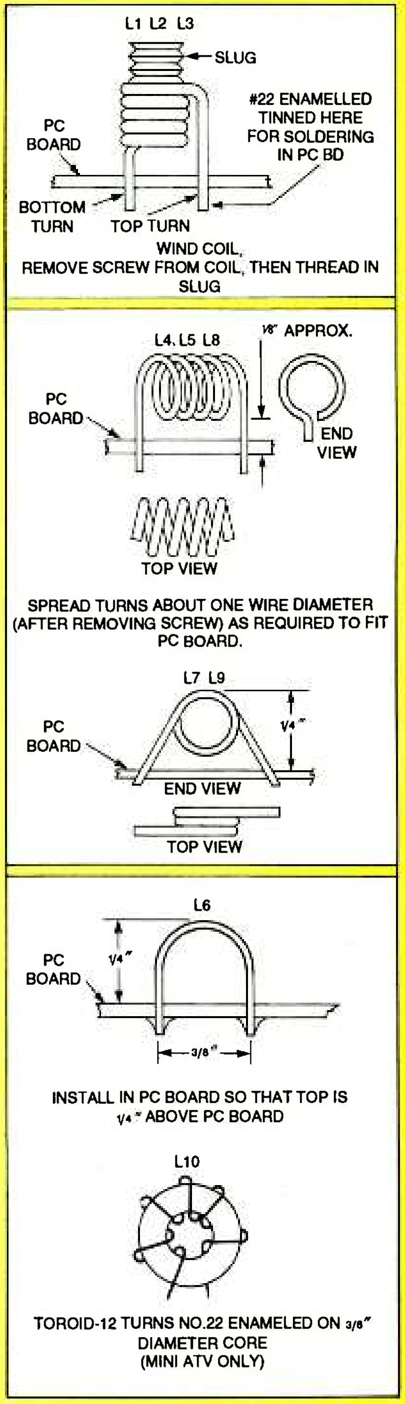


FIG. 11—COIL-WINDING INSTRUCTIONS for the Mini ATV and the ATV jr.

meter across R56 in the down-converter board (positive lead to emitter, negative to ground). The reading should be about + 3 volts with no RF output. This voltage will decrease with increasing RF output. Full output might drive this voltage below + 1 volt. The best results will be obtained with a wattmeter.

Continued on page 68

HANK BRANDLI

THE SCIENCE OF WEATHER FORECASTING has been revolutionized in recent years by weather satellites that transmit cloud pictures and surface temperature data back to earth from space. You can tune to the signals and display their transmitted images in real time on your personal computer's monitor.

It is easy to produce hard copies of the weather satellite pictures that appear on your computer screen. Any PC-compatible printer from dot matrix to inkjet and laser can produce quality images. These images can also be saved as graphic files on disk.

Photography is another alternative: If you have a single-lens reflex camera and are familiar with its lens and stop settings, you can obtain clear photos of the images that appear on your monitor.

Weather telecasts

Cloud pictures taken from satellites are a part of commercial TV weather forecasts. Most are enhanced by combining radar images of precipitation with symbols for high- and low-pressure areas and moving weather fronts. The jet stream might also be plotted.

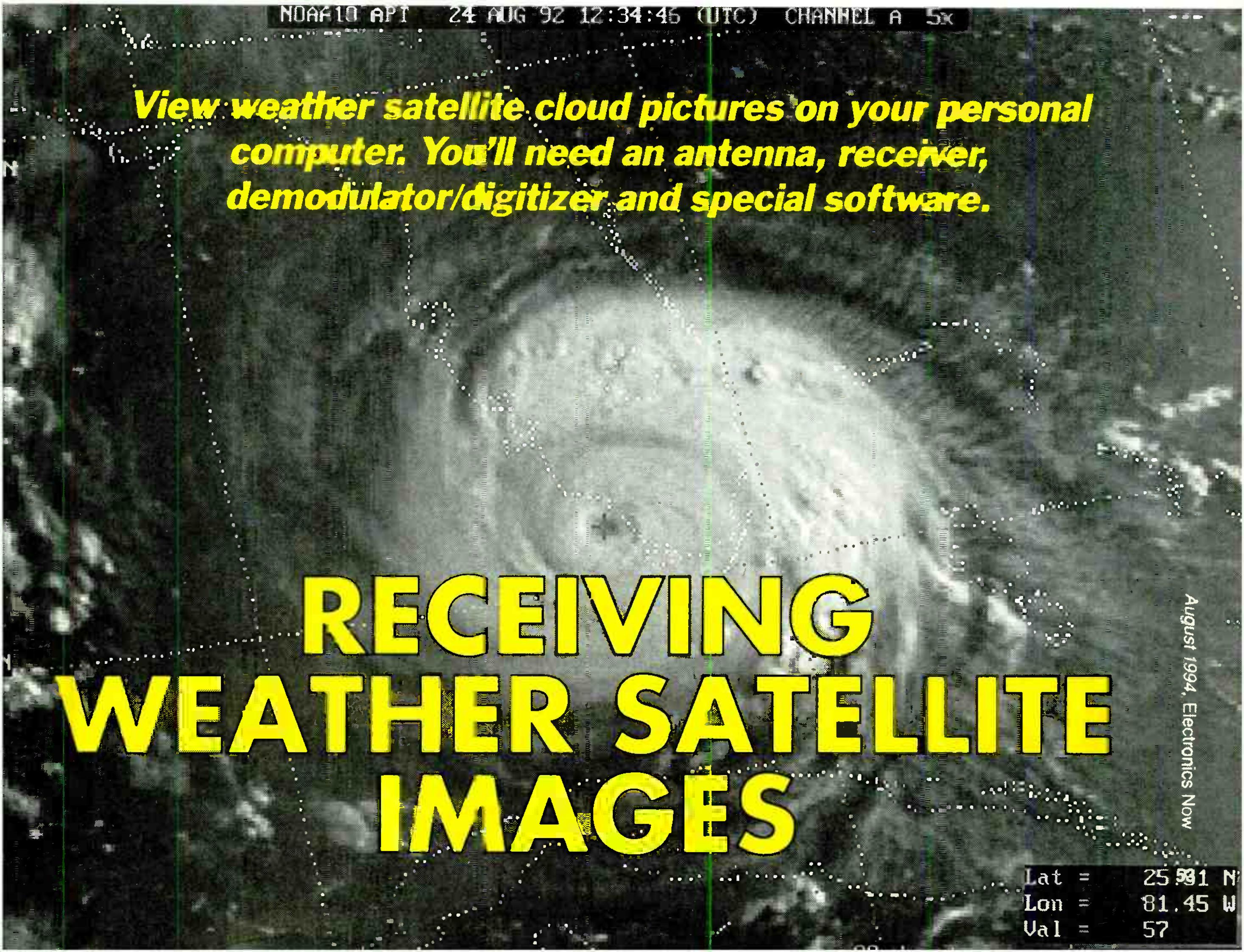
TV stations in the United States usually obtain their weather images from Geostationary Operational Environmental Satellites (GOES) by subscribing to services. Their cloud pictures are displayed in varying shades of gray. They might rerun loops of images stored over a period of hours to provide a display of cloud movements in accelerated time. The radar images imposed on the cloud pictures can show the relative density of precipitation as rain or snow in the clouds.

This enhancement calls for expensive computer and video equipment beyond the means of most amateur forecasters. Moreover, those fancy graphics are not particularly helpful if you are using them to predict weather near your home. The images are too coarse, and they are usually delayed in time.

You could also receive satellite weather pictures from computer on-line services, but they are also delayed by hours, so they probably would not give you the kind of local coverage you really want. And you must pay for this service.

Home weather station

However, you can receive far more detailed satellite pictures on your home computer than



View weather satellite cloud pictures on your personal computer. You'll need an antenna, receiver, demodulator/digitizer and special software.

RECEIVING WEATHER SATELLITE IMAGES

are available from either of those sources in real time—and they will be free! Detailed local weather information will be especially valuable to you if you want to know or are advising others on the weather to be expected at fairs, ball games, picnics, hiking, sailboat races, or other outdoor activities.

As an amateur, you can receive weather pictures directly from GOES satellites on your computer. Those satellites are positioned at an optimal altitude of 22,238 miles above the equator, and their motion is synchronized with the rotation of the earth so that they effectively stand still over the equator. From that vantage point, weather movement over an entire continent can be viewed at one time, as if seen from a fixed tower.

There are usually five geostationary weather satellites in orbit spaced out along a belt above the equator (along with many communications satellites). Two weather satellites belong to the U.S.A., one to Japan, one to India, and two, called Meteostats, belong to a European consortium.

On April 13, NASA launched GOES-8 to replace GOES-6 that failed. After completing its checkout, GOES-8 will be moved to a position of 75° west longitude (over Columbia) to monitor the Atlantic coast. GOES-7 will then be moved back to 135° longitude, the normal position for monitoring the Pacific coast.

Polar-orbiting satellites

GOES satellites provide excellent wide-angle coverage of the lower 48 states of the United States, but their coverage north of about 60° latitude is poor. This includes Alaska, most of Canada, and the northern countries of Europe and Asia.

However, eight low-altitude environmental (LEO) satellites extend weather coverage to the extremities of the earth by orbiting over the poles. They all provide automatic picture transmission (APT) in the visible light and infrared regions, so as a group they are called APT satellites.

APT satellites circle the earth in polar orbits at altitudes from 400 to 600 miles (850 to 1250 kilometers). Thus, they fly at only 1/45th of the altitude of a GOES satellite. The orbits of these LEO satellites are fixed in space so the earth rotates within them. This means that in successive passes, each satellite "flies" over all parts of the earth in about 12 hours, typically completing a revolution in about 105 minutes

As an amateur, it is possible to receive real-time pictures from GOES satellites. However, if you are just getting started in this hobby, it is recommended that you start by receiving pictures from APT rather than GOES satellites. The price of an antenna, receiver and software for your computer to permit you to receive pictures from APT satellites is less than $1000, compared to about $2000 for receiving pictures from GOES satellites.

Although the same plug-in circuit board and receiver can receive signals from both types of satellites, the reception of GOES signals calls for a more expensive antenna, more expensive software, and a downconverter to convert the 1.7 GHz signals to the 137 to 138 MHz APT satellite transmission band.

APT satellite signals are stronger because they fly at a far lower altitude than a GOES satellite, so their stronger, uncoded, radio fax signals need less amplification. Moreover, APT satellites offer more detailed information than GOES satellites because they view narrower "strips" only about 1500 miles rather than continent-wide views.

Table 1 identifies the APT satellites that were operational when this article went to press. The American and Chinese APT satellites return to about the same location above the earth every 12 hours—allowing for some drift due to gravity and magnetic fields.

Because each satellite is orbiting continuously, no earth receiving station can receive one satellite's transmissions 24 hours a day. But, with eight satellites in orbit, one station can receive pictures from all of them twice a day.

The orbits of the Russian Meteor LEO satellites are *retrograde* or *prograde* because the satellites do not appear overhead at the same times each day. They orbit at altitudes of about 600 miles and complete each orbit in about 105 minutes. But a prograde satellite arrives earlier each day by some fixed time increment, and a retrograde satellite arrives later

TABLE 1
POLAR ORBITING WEATHER SATELLITES

Country Origin	Satellite Name	Image (VL)	Image (IR)	Transmission Frequency (MHz)	Local Passage (East. Std. Time)	
U.S.A.	NOAA-9	X	X	137.62	1000	2200
	NOAA-10	X	X	137.5	0700	1900
	NOAA-11	X	X	137.62	1500	0300
	NOAA-12	X	X	137.5	0900	2100
China	Feng Yun	X	X	137.78	0500	1700
		(Day	Night)			
Russia	Meteor 2-21	X	X	137.30	Prograde or Retrograde Orbits + or – 20 min/day	
	Meteor 3-4	X	X	137.40		
	Meteor 3-5	X	X	137.85		
VL visible	IR infrared					

by a fixed time increment, in both instances that time is about 20 minutes.

The APT satellites are usually lofted into orbits so that they pass over their home countries during the daylight hours, usually once in the morning and once in the afternoon. The signals from LEO spacecraft can be acquired when they are in line-of-sight positions from the receiving station.

In most locations it takes about 15 minutes for the satellite to pass over a fixed earth station. Noise-free reception can be expected for about 10 minutes during each pass. Table 1 gives the arrival times of LEO satellites now in polar orbit over the Eastern part of the United States in Eastern Standard, 24-hour time.

All LEO weather satellites transmit images in the visible light band (0.38 to 0.78 micrometers (μm)), the near infrared band (0.78 to 1.0 μm), and part of the far infrared band (10.5 to 12.5 μm). However, infrared pictures might only be transmitted during local nighttime hours.

The American NOAA APT satellites transmit images of 1,600-mile wide strips. These satellites can resolve cloud areas as small as 4 square miles. However, the Russian Meteors can resolve cloud areas as small as 2 square miles.

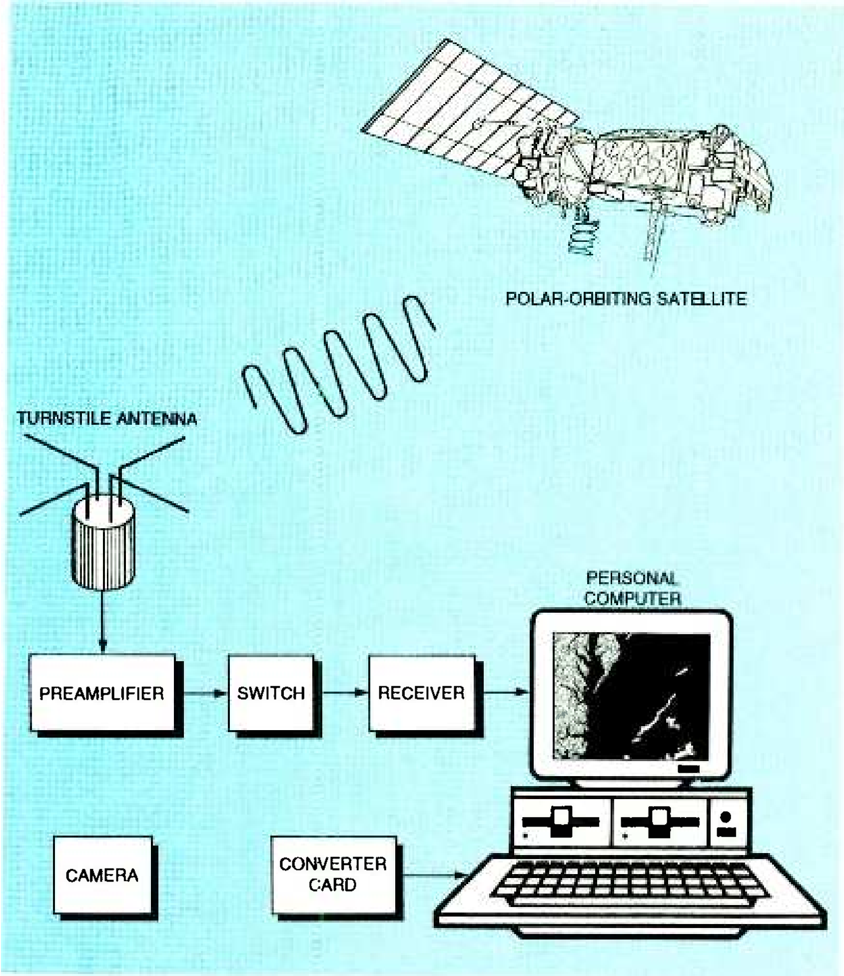


FIG. 1—BLOCK DIAGRAM OF AN APT SATELLITE IMAGE receiving station based on a personal computer. Images that appear on the monitor screen can be saved to disk as a graphic file or Polaroid camera.

Amateur reception

If you already own an IBM PC or compatible computer with an Intel 386, 33-MHz processor or better (more on this later), you can start receiving APT satellite pictures for less than $1000 worth of hardware and software. The APT satellites transmit information back to earth as slow-scan television signals because the bandwidth of those satellites must be limited to 50 kHz to hold the signal-to-noise ratio to acceptable levels.

APT satellites transmit information equivalent to a minimum of 1200 pixels per line. (This compares with a resolution of about 400 pixels per line for commercial TV.) If the signals were fast-scanned, the bandwidth requirement would be 18 MHz, but the entire band allocated to all APT satellites is only 1-MHz wide.

The signals from an APT satellite can be converted for television viewing, but only one-third of the transmitted pixels could be used for picture formation. This is why the weather pictures you see on television are only crude versions of what you can see on your PC screen.

The audio output from the receiver must be converted to digital data for the PC. The circuit for this must convert the 2400-Hz, amplitude-modulated audio signal into pixel samples of eight bits each (256 levels).

System components

A basic system, structured around your computer, must have a suitable antenna (typically with a preamplifier), a satellite receiver, and a demodulator/digitizer circuit plug-in board or external module that converts the analog signal from the receiver to a digital format suitable for display on your PC's screen. Figure 1 is block diagram of a typical system.

Most satellite image capture and display software is written for the MS-DOS disk operating system, so your personal computer should be an IBM PC XT or compatible. As mentioned earlier, your computer can capture APT images (as well as GOES images) effectively if it contains at least an Intel 386, 33-MHz processor and a coprocessor. Additional minimum requirements are 1 Mbyte of random-access memory (RAM), and a 50 Mbyte hard-disk drive.

However, you will get better results with a 486DX processor,

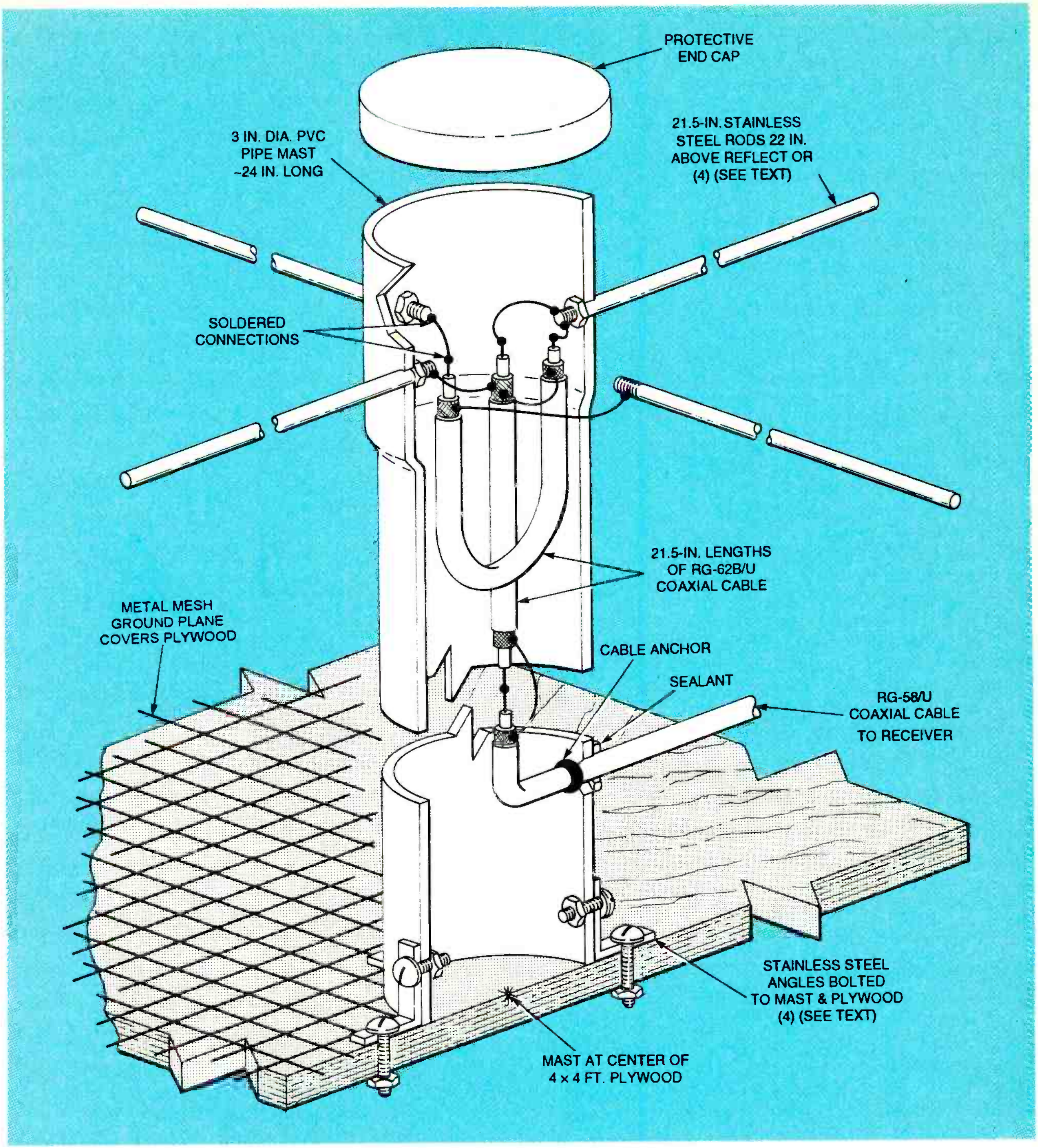


FIG. 2—SATELLITE RECEIVING ANTENNA for APT satellites has a 3-inch OD PVC pipe mast and dipoles made from stainless-steel rods. Coarse metal screening serves as the ground plane/ reflector.

8 Mbytes of RAM, and at least 170 Mbytes of hard disk. It is also recommended that you have a non-interlaced SVGA monitor (.28 dot pitch).

There is some software available for Apple and Macintosh computers, but it is expensive and lacks the sophistication of the DOS-compatible products.

Because the preamplifier, receiver, and demodulator are complex, it is recommended that you purchase factory-built products rather than build your own. Many receiver models are available in a wide price-performance range. Expect to pay between $300 and $450 for a receiver.

Stand-alone preamplifiers are generally priced under $100, but if it is packaged with an antenna, the combination could sell for less than $200. Most demodulator/digitizers are on IBM-compatible add-on boards, but stand-alone modules are available if you don't want to open up your computer or tie up a slot in it. All the necessary hardware and the capture and display software are available from the suppliers listed under Sources. Some offer discounts for package or "turnkey" deals.

If you want some hands-on experience in integrating your own satellite receiving station, you can build your own APT signal receiving antenna.

Building the antenna

Figure 2 contains enough information to permit you to build an APT receiving antenna that can be mounted on your roof, if it has a shallow pitch. However, if your house has a steep roof (or local laws prohibit external antennas), you can mount it on an outdoor deck or place it in your back yard.

The turnstile antenna shown in Fig. 2 was designed to receive circularly-polarized APT satellite signals. When those signals pass through the ionosphere, they can be circularly polarized. Ionospheric electron density, the orientation and strength of the earth's magnetic field, and longitude all determine the degree of polarization.

Rotated signals received with a conventional dipole antenna will be seriously attenuated. At the extreme 90° shift condition no signal will be received. It is unlikely that signal would undergo that much rotation, but even if it did, the turnstile antenna could receive the signal efficiently.

A turnstile antenna consists of two half-wave dipoles arranged at right angles to each other to form a cross. The overall length of each dipole is about 44 inches or one half the wavelength from 137 to 138 MHz.

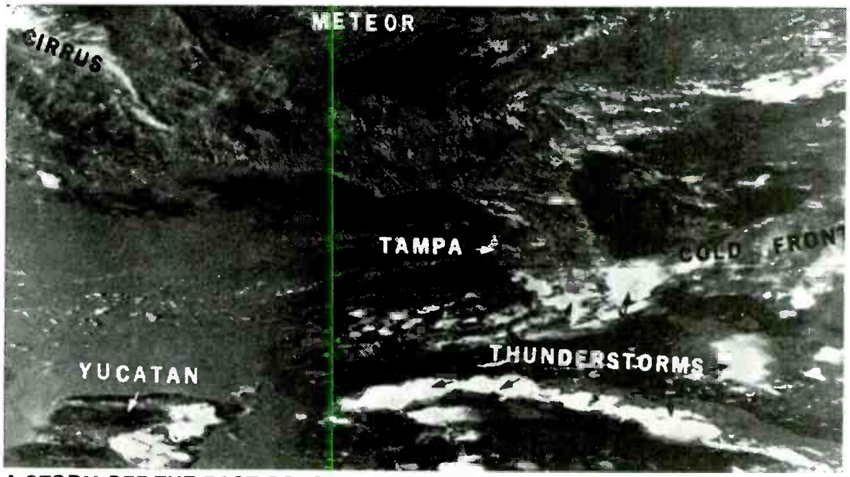
If a transmission line is connected to one of the dipoles, and if the two dipole-center feed points are joined by a quarter-wave line section, there will be a 90° phase delay between the currents in the two dipoles. The antenna's input impedance is nonreactive. As a result, the currents in the two dipoles are equal and in quadrature, and the receiving pattern is essentially omnidirectional.

Refer to Fig. 2. Make the mast from a length of 3-inch outside diameter PVC pipe. Cut the four dipole elements to the correct lengths (one-quarter wavelength) from ⅛-inch diameter stainless-steel rod. Thread the ends of each of the rods so they can be fastened to the PVC mast with nuts and washers.

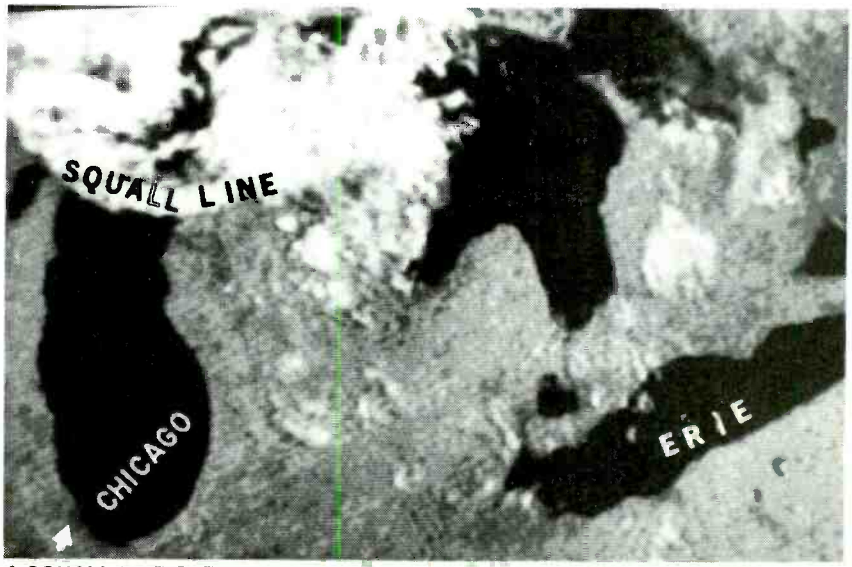
Cut two phasing sections from 93-ohm RG-62B/U coaxial cable 21.5 inches long (quarter wavelength) and strip the jacketing from their ends to expose the braid shielding and center conductors. Bend one length back on itself and connect it to the dipoles, as shown in Fig. 2. Connect one end of the second length of cable to the dipoles and the other end to a length of 50-ohm RG-58/U coaxial cable that should be long enough to reach your receiver.

Mount the antenna on a 4 × 4-foot square of coarse metal screening that serves as a reflector/ground plane. Depending on where or how you mount the antenna, it might need a rigid plywood base. The screening, commonly called *hardware cloth*, can be purchased at most hardware and home supply stores. It is important that the metal mesh and its supporting base be parallel with the dipoles. If you want to perform the extra work, cut both the screen and the base as a 4-foot diameter circle to conserve mounting space.

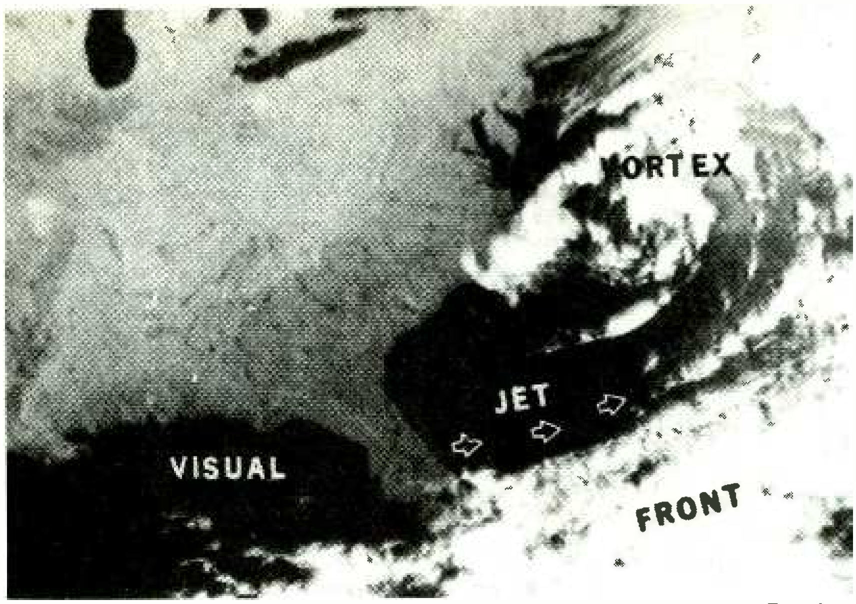
Some suppliers of factory-made satellite receiving antennas offer a ridge pole that can be permanently mounted on the ridge of your roof or to your chimney. The hollow mast of the antenna is then inserted over the mounting pole and fastened



A STORM OFF THE EAST COAST as seen from a NOAA AFT satellite.



A SQUALL LINE OVER LAKE MICHIGAN as seen from a NOAA APT satellite.



A VIEW OF THE WEATHER OVER THE SOUTHEASTERN STATES taken from a Russian Meteor satellite.

permanently to the rod when the antenna is set in its most favorable receiving position. The factory-made antennas typically have a set of metal rods that radiate from the base of the mast to act as the reflector/ground plane in place of wire mesh.

Messages from space

Some adjustment of your antenna (factory or home-built) might be necessary if you want to obtain the strongest signals. Fasten only one leg of the home-built antenna mast loosely to its support (roof or plywood base) with a nut and bolt. Then swivel the antenna around until you find its optimum orientation. You can then drill the holes for the other legs and bolt the antenna securely in position. Provision is made for antenna position adjustment with factory-made antennas.

Camera-viewing hood

If you want to take pictures of your computer's monitor with a still camera, you should mask out the background light interference with a viewing hood. You can sew a tapered sleeve from heavy black cloth or felt with a narrow end that will admit the lens of your camera and a wide end that can be stretched over the outside of your monitor. Position the camera on a tripod.

As an alternative, you can build a hood from thin plywood in the form of a truncated pyramid that is wide enough at the base to pass over the monitor and small enough at the other end to admit your camera lens. Paint the hood flat black inside and outside, and tape the large end over your monitor. The camera should also be positioned on a tripod. Film with an ASA speed of 100 is recommended for this photography.

SUPPLIERS

The following companies provide: Antennas, Receivers, Demodulator/digitizers, Software, and Complete turnkey systems

GTI Electronics
1541 Fritz Valley Road
Lehighton, PA 18235
717-386-4032

Quorum Communications, Inc.
Suite 850
8304 Esters Blvd.
Irving, TX 75063
214-915-0256

Software Systems Consulting
615 S. El Camino Real
San Clemente, CA 92672
714-498-5784

Tri-Space Inc.
P.O. Box 7166
McLean VA 22106
703-442-0666

Vanguard Laboratories.
196-23 Jamaica Avenue
Hollis, NY 11412
718-468-2720

A satellite ephemeris

Before you can receive images efficiently and regularly, you should know when the APT satellites will pass over your ground station. An ephemeris or a table containing the computed times of arrival of each satellite will be helpful in planning your satellite image viewing. You can make your own by leaving your receiver on and waiting for the audible beeping signals that announce each passing satellite and then recording those times.

A better way is to collect ephemeris data that provides computed positions of each satellite. An ephemeris database can be compiled from data available on one of many computer BBSs. The following four BBSs should be of interest: 1) NOAASAT BBS (Maryland), 301-763-8500; 2) Celestial RCP/M (Ohio) 513-253-9767; 3) Datalink RBBS (Texas) 214-394-7438; 4) MAPS-NET BBS (Maryland) 410-239-4247.

Several of the bulletin boards also have satellite prediction programs that will create an accurate satellite prediction schedule for your time zone. It is based on downloaded Keplerian elements. Some of the vendors listed under Sources offer software that will automate the scheduling process.

Pictures from space

Weather satellite photographs

Continued on page 76

References

Exploring The Environment Through Satellite Imagery, Tri-Space Inc., P.O. Box 7166, McLean, VA 22106
(Specially priced for "Electronic Now" readers at $26.50 including S&H)
WeatherSat Ink, Bluebird Greenhouses, 4821 Jessie Drive, Apex NC 27502
Weather Satellite Report, R. Myers Communications, P.O. Box 17108, Fountain Hills, AZ 85269-7108

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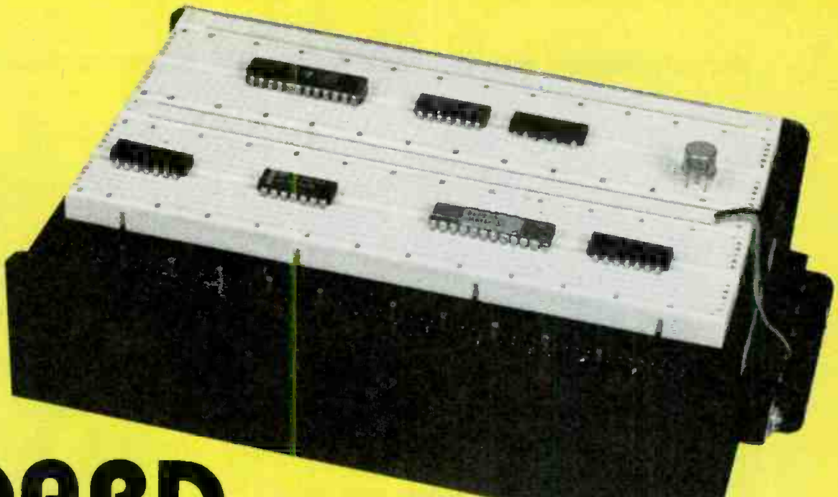
BUILD THIS PC I/O BREADBOARD



DAVE DAGE

GIVE A MAN A FISH AND YOU'LL FEED him for a day; teach a man to fish and you'll feed him for life. That old proverb can be applied to EPROMs, too. Give a man an EPROM programmer and he can program some devices. Teach him how to build a programmer, and he can program any EPROM he will encounter.

You can build a sophisticated EPROM programmer on your PC I/O breadboard with nothing more than a few jumper wires. The PC I/O breadboard was described in the June 1994 issue. An article in the July issue showed how to program it. The breadboard contains ten fully decoded and latched I/O ports, controlled by a simple PC interface card. This third and final installment shows that the breadboard is not just for building "toy" circuits, but can be put to real-world use as well. The EPROM programmer is fully functional, and can read, write, program, copy, and verify EPROMs ranging from a lowly 2716 all the way up to a 27512. The popular 27128 is used here as an example.

With what you'll learn here, adapting the program to new types of EPROMs will be simple. By the way, to make sure there are no misunderstandings, we'll use the expression *burn* to signify programming the EPROM, and *program* to refer to the BASIC software that controls the programmer.

Two notes about the software: 1. It will run under either GW-BASIC (supplied with MS-DOS prior to version 5) or QBASIC (supplied with DOS 5 and later versions). 2. The complete program is too long to print here. However, significant portions of the code will be explained, so that you'll know how it works. You can obtain the complete listing from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis—the program is called EPROMBRN.BAS, and is part the PCIO.ZIP file), or with a kit of parts from the author.

Addressing the EPROM

First set up the hardware. Figure 1 shows the hookup between the ST-1 breadboard and the 27128 28-pin EPROM. The port numbers shown in the figure and in the program listings represent the decimal values of the default base I/O port (260) provided by the breadboard. If the board is not set to the default address, substitute the values in all diagrams and software. (Part 1 of this series detailed base I/O port selection.)

The 27128 has 128K bits of memory, accessible as 16,384 (16K) eight-bit bytes. Addressing 16K of memory requires 14 address lines ($2^{14} = 16,384$). Output port 260 drives the eight low-order address lines (A0–A7), and output port 261 drives the six high-order address lines (A8–A13), leaving the two highest bits of output port 261 unconnected.

Each successive byte in the EPROM can be addressed, starting at 0, as follows: Assume all 14 address lines are low. Increment the value at port 260 until all eight bits are high (i.e., the counter hits 255). Then put a 1 in 261, and a 0 in 260. Again increment through all values at 260, increment 261, and again put a 0 in 260. Continue in this fashion until the counter for 261 reaches 64, at which point you're accessing the highest address in the EPROM (64 × 256 = 16,384). Then reset both counters to 0 and start over.

The way to do this in software is with a pair of nested FOR/NEXT loops, as shown in Listing 1. The inner loop, which addresses port 260, counts from 0 to 255; the outer loop counts from 0 to 63, addressing port 261.

This simple routine can be used for reading, verifying, burning, or copying the EPROM, by placing corresponding functions within the innermost loop (between lines 230 and 400). Note that the number at the head of each line is required only with GW-BASIC; neither compiled BASIC nor QBASIC requires line numbers.

Data flow

Addressing each location in the EPROM is easy. The next question is how to get data into and out of a specified location. A mini data bus is formed by connecting the EPROM's eight data lines to output port 262 and in-

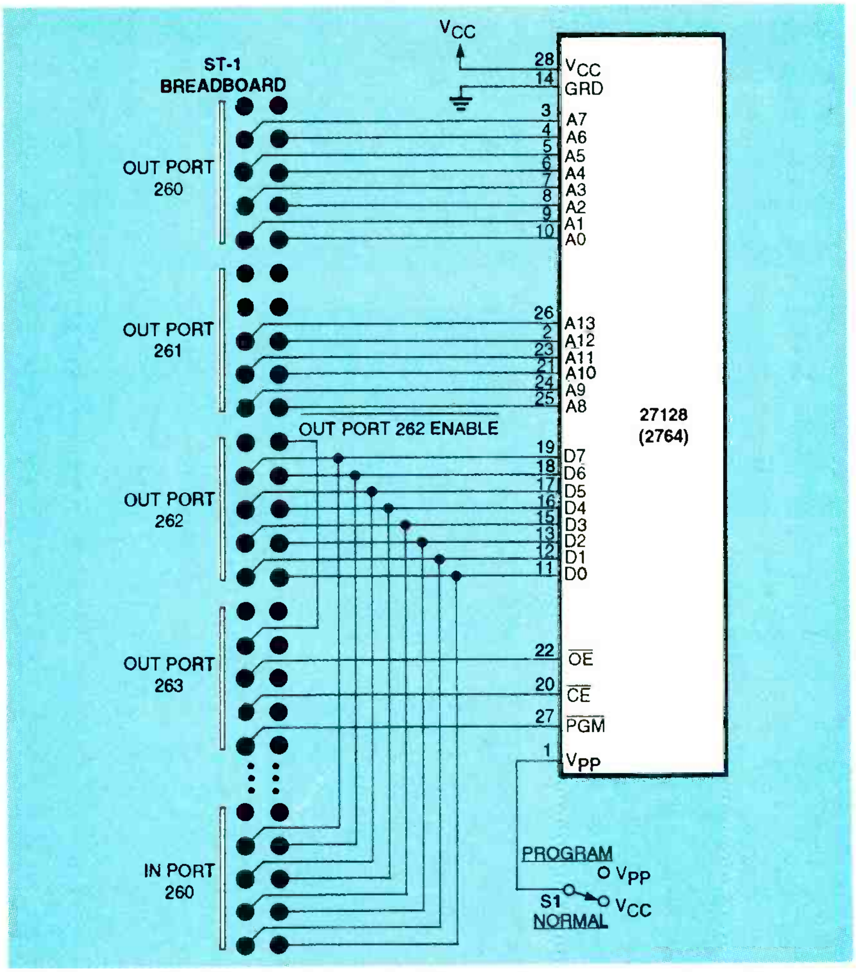


FIG. 1—27128 EPROM HOOKUP to the ST-1 breadboard appears here. The same hookup works for a 2764.

put port 260. The only "trick" is that the EPROM's outputs must never be activated at the same time as those of port 262. Fortunately, data flow can be controlled with just two pins: the EPROM's output-enable ($\overline{\text{OE}}$) line and the breadboard's enable line.

To read data from the EPROM, you must enable its output by bringing pin 22 low, while at the same time disabling port 262 by bringing its control pin high. Then BASIC's input port instruction (INP) can read data from the EPROM into variable V, as follows:

```
300 V = inp(260)
```

Conversely, output variable V to the EPROM like this:

```
310 out 262, V
```

Control lines

Of course, an OUT instruction by itself will not burn any data into an EPROM; the technique for doing so will be described momentarily. For now, note that port 263 drives the EPROM's output enable ($\overline{\text{OE}}$, pin 22), chip enable ($\overline{\text{CE}}$, pin 20), and program pulse ($\overline{\text{PGM}}$, pin 27), as shown in Fig. 1. Port 263 also controls port 262's enable line. The odd-numbered bits of 263 are configured as follows: D1 ($\overline{\text{PGM}}$), D3 ($\overline{\text{CE}}$), D5 ($\overline{\text{OE}}$), and D7 ($\overline{\text{PORT 262 ENABLE}}$). All four signals are active-low. Bits D0, D2, D4, and D6 are not used, so they can be set to any arbitrary value. You might want to make them the complements of D1, D3, D5, and D7. Then, if extra hardware is ever needed, both the active signals and their complements will be available.

In the inactive state, all four control signals must be high. To determine what value to send to port 263, place 1's in bit positions 1, 3, 5, and 7, and 0's in positions 0, 2, 4, and 6. Convert the resulting eight-bit binary number (1010 1010) to decimal (170); that value must be sent to port 263 before the EPROM is installed. In fact, whenever a procedure completes, you should return output 263 to the inactive state, as follows:

```
100 out 263, 170
```

To read a byte from the EPROM, output enable ($\overline{\text{OE}}$) and chip enable ($\overline{\text{CE}}$) must be activated (pulled low). Plugging the two 0's in along with their complements gives 10010110 (150). Thus, to activate read mode:

```
150 out 263, 150
```

To burn a byte into the EPROM, the program prompts the user to apply the programming voltage, and then waits for a response. After receiving the user's response, the program enables port 262 and the EPROM's chip-enable line. Then (and only then) can it apply the 50-millisecond burn pulse.

Activating port 262 and the EPROM's chip-enable line equates to 01100110 (102). To perform the burn, that value

LISTING 1—EPROM ADDRESSING

```
200 for HI = 0 to 63
210  out 261, HI
220  for LO = 0 to 255
230       out 260, LO
...       some useful function
400  next LO
410 next HI
```

LISTING 2—EPROM BURNING

```
340 print "APPLY PROGRAMMING VOLTAGE NOW"
 ... wait for positive response
350 out 262, V rem out value to burn
360 out 263, 102 rem get ready to burn
370 out 263, 101 rem turn on PGM (burn EPROM)
 ... wait for 50 milliseconds
380 out 263, 102 rem shut off PGM
```

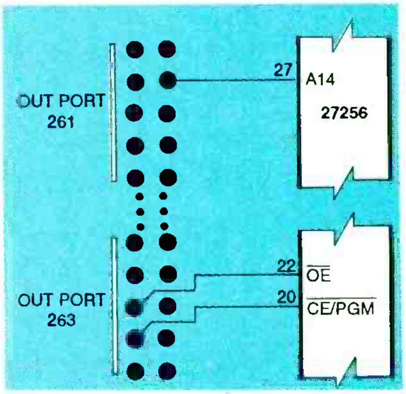


FIG. 2—27256 EPROM HOOKUP: Only the differences between the 27128 and the 27256 are shown.

must be changed to 01100101 (101) for 50 milliseconds, then back to 102. Listing 2 shows the entire sequence, except the 50-millisecond delay, which will be described next. For now, note than V_{PP} can remain on, and the actual value of the currently addressed byte in the EPROM can be read as described previously. If the written value equals the current value, programming was therefore successful, so the next address can be selected.

The 50-millisecond delay

The most difficult part of this whole project is generating an accurate time delay. The problem is how to guarantee the accuracy of the generated timing pulses. The simplest kind of delay is a do-nothing loop that increments a counter to some value. By adjusting the value, the delay can be made longer or shorter. That approach is not the best solution because it is CPU-dependent. That is, it depends on the type of CPU and its clock speed. Thus a program that runs fine on a 4.7-MHz PC might not do so well on a 66-MHz 486.

DOS interrupts are an additional complication. If an interrupt (e.g., for disk access) occurs during the loop, the time would increase unpredictably. The bottom line is that, as good as it is for other things, BASIC is just not suitable for generating accurate time delays. However, BASIC provides a fairly clean way of incorporating short assembly-language programs that can accomplish that type of task.

The assembly-language routine shown in Listing 3 combines line 370, the 50-millisecond pulse, and line 380 from the previous listing. First it turns off all interrupts, then it outputs the burn command (65

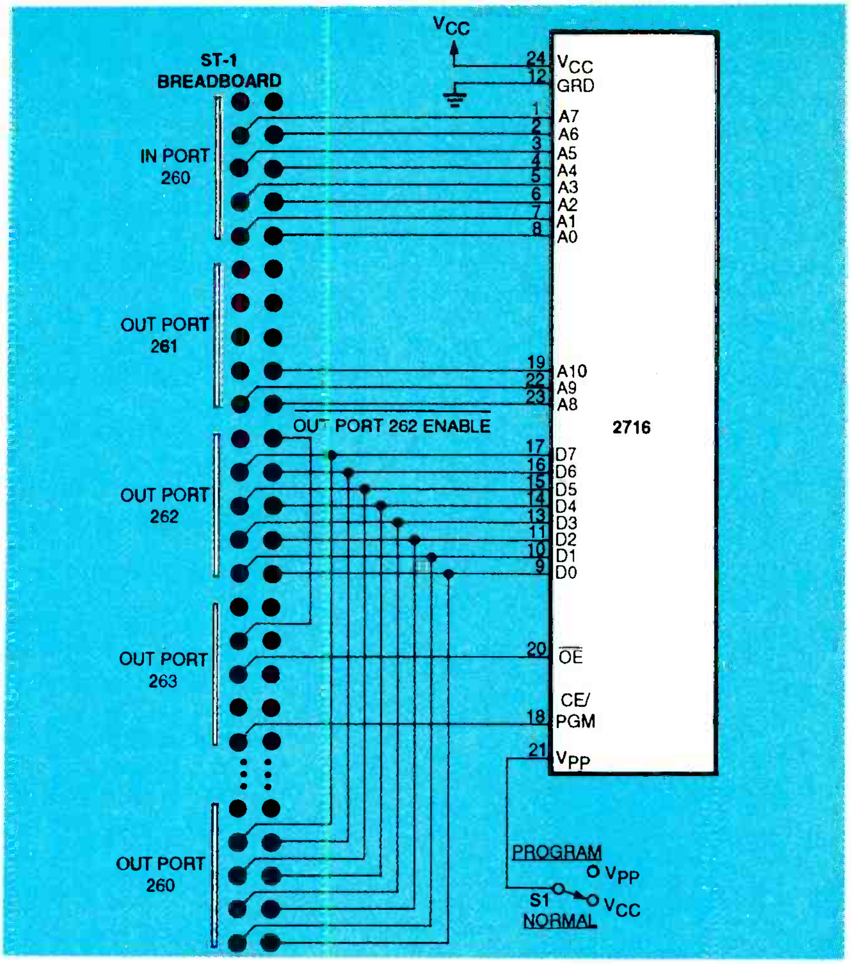


FIG. 4—2716 EPROM HOOKUP: Note that power moves to pin 24, and fewer address lines are needed.

LISTING 3—ASSEMBLY LANGUAGE DELAY ROUTINE

```
FA                        CLI               ; stop interrupts
BA0701                    MOV DX,0107       ; control address in hex
B065                      MOV AL,65         ; load control for pulse
EE                        OUT DX,AL         ; start PGM pulse
B81000                    MOV AX,0010       ; outer loop start value
B90000        OUTLOOP:    MOV CX,0000       ; max value on inner loop
49            INLOOP:     DEC CX            ; start inner loop
75FD                      JNZ INLOOP
48                        DEC AX            ; start outer loop
75F7                      JNZ OUTLOOP
B066                      MOV AL,66         ; load off pulse value
EE                        OUT DX,AL         ; turn off pulse
FB                        STI               ; allow interrupts
CB                        RETF              ; return
```

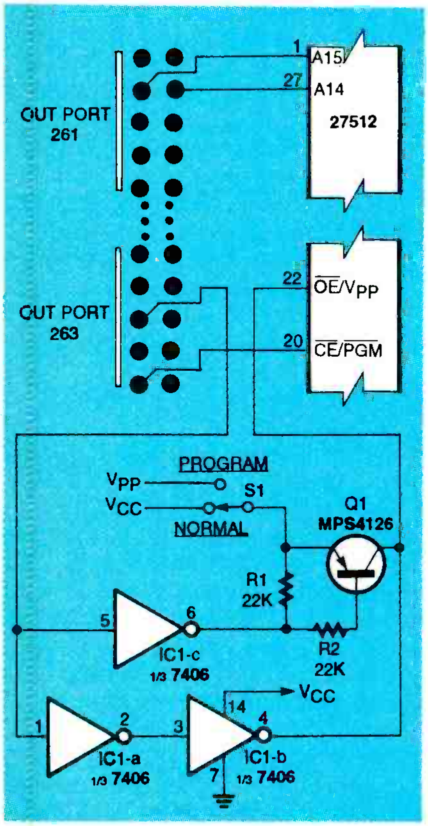


FIG. 3—27512 EPROM HOOKUP: Only the differences between the 27128 and the 27512 are shown.

hex) to port 263 (107 hex). Next it wastes time in two loops, shuts off the burn signal (66 hex), turns interrupts back on, and then returns control to the BASIC program.

So how do you integrate an assembly-language program with a BASIC program? Convert the hexadecimal machine instructions in column 1 of Listing 3 to decimal, and then include them in the BASIC program via DATA statements. Then read the data into a pseudo variable, MC$. Then assign the variable BASE to where MC$ starts in memory. To execute the program, all you need to do is execute a CALL BASE statement. Listing 4 shows how it all works. Note that the loop values are defaults; the BASIC program pokes updated values into the appropriate locations, depending on the desired pulse length.

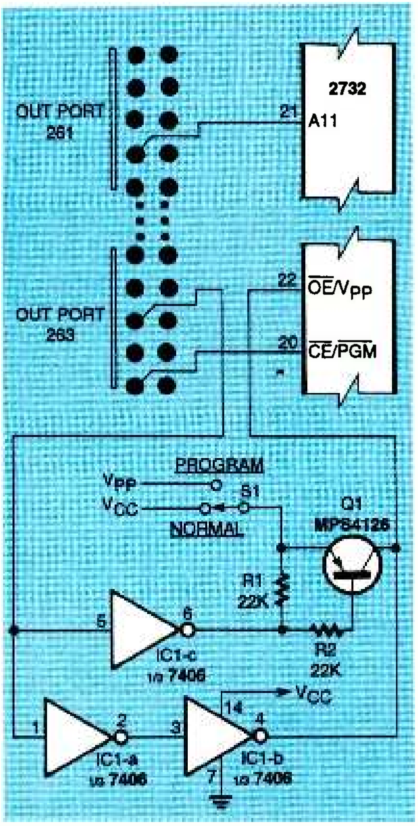


FIG. 5—2732 EPROM HOOKUP: Only the differences between the 2716 and the 2732 are shown.

As the routine stands now, it will generate a delay of 5 to 6 seconds on an 8088, and much shorter delays on faster machines. The program calculates how many loops per second it takes to produce a five- to ten-second time delay on any specific machine. Then from that value, the program calculates constant LM (loops/millisecond). Do not alter your "turbo" switch after the program has calculated that value. The actual pulse length (in milliseconds) is stored in constant PL, and defaults to a value of 50. However, by altering that value, it is possible to generate any time delay of about 0.1 milliseconds or longer.

The only down side to that delay method is that your computer is almost entirely consumed with pulse generation. DMA is still active, but under normal circumstances, the only DMA channel that should be operating is that controlling memory refresh. At worst, memory refresh causes a one- to two-microsecond jitter in the delay pulse. Although it's viewable on a scope, that jitter is not a concern when burning EPROMs.

Data storage

Data that will be put into or taken out of an EPROM must be stored in memory—but where? BASIC doesn't permit dynamic memory allocation as C or Pascal do. So we have arbitrarily chosen absolute address 60000 hex. If you run BASIC on a machine without a lot of TSRs and device drivers installed, it will probably reside well below 50000 hex, including its stack. As long as you have at least 512K of memory, the area from 60000 to 70000 hex should be safe for storage. Admittedly, this is not the most elegant memory-allocation scheme, but it does work.

Data can come from many sources; however, the only source discussed here will be another EPROM. If you want to burn an EPROM with data from another source, you have to get it loaded into memory at address 60000 hex. After the data is loaded, you can use DOS's DEBUG program to modify it. Listing 5 shows how to copy data from an existing EPROM. After the contents of an EPROM is loaded into memory, it's a simple matter to save it as a file. Then next time it's needed, it can be reloaded without using the original EPROM.

Other EPROMs

Until now, this discussion has centered on the 27128. The good news is that the same principles also apply to the 2764, 27256, and 27512 devices, all of which are packaged in a 28-pin DIP. The 2764 can be viewed as half of a 27128. The 2764 uses the same wiring diagram; the only difference being that high-order address line A13 (pin 26) has no function.

On the other hand, moving up to the next largest device (the 27256) requires another address pin. Since all 28 pins are already used, the 27256 multi-

LISTING 4—INTEGRATING THE ASSEMBLY LANGUAGE ROUTINE

```
7050 FOR X=1 TO 30 '# of code bytes to read
7060   READ N
7070   MC$=MC$+CHR$(N) 'generates string of machine code
7080 NEXT X
7090 PTR=VARPTR(MC$) 'use to find address of code
7100 BASE=PEEK(PTR+1)+PEEK(PTR+2)*256 'start address of assembly program
7110 NOINT=BASE+1 'skip 1st instr which disables interrupts
...
7140 CALL NOINT
...
7610 DATA 250 , 186 , 7 , 1 , 176 , 101 , 238 , 184 , 16 , 0
7620 DATA 185 , 0 , 0 , 73 , 117 , 253 , 72 , 117 , 247 , 176
7630 DATA 102 , 238 , 251 , 203 , 244 , 244 , 42 , 60 , 52 , 0
```

LISTING 5—ACCESSING DATA

```
180 def seg = &H60000 rem initialize segment pointer
190 out 262, 150 rem initialize to read EPROM
... then "inside the address loops"
240 V = inp(260) rem read value
250 poke (HI*256 + LO), V rem stores value to memory
```

plexes the chip-enable line (pin 20) with the program pulse, assigning address A14 to pin 27. The only change to the program is that the initialization constant for a read (as shown in Listing 5) changes from 150 to 149. Figure 2 shows how to update the wiring diagram originally shown in Fig. 1 for a 27256.

Moving up to the 27512 requires yet another pin. This one combines output enable (pin 22) with V_{PP} and assigns address line A15 to pin 1. Pin 22 must now cycle between zero volts (output enable) and V_{PP}. To provide program control over that capability, additional components must be added, as shown in Fig 3. Four parts are required: an open-collector hex inverter (provided by a 7406), two 22K resistors, and a switching transistor. The EPROM read procedure is identical to that for a 27256, but the verify-during-burn procedure must be changed to first lower V_{PP} to zero. The verify sequence is as follows: 170, 150, 149, 150, 170. The burn sequence remains the same for all EPROMs.

The less-dense 24-pin EPROMs follow the same pin usage as outlined above, except that four fewer address lines are needed. The 2716 (shown in Fig. 4) follows the 27256, while the 2732 (shown in Fig. 5) follows the 27512. In addition, the 2732 requires extra control circuitry like the 27512. The only software difference lies in the address loop counters.

The complete program

Now you know how to "fish." But in case you're looking for a "canned" solution, a full-function BASIC program has been written for burning all the following EPROM types: 2716, 2732, 2764, 27128, 27256, and 27512. As with many programs, much of the code is concerned with the user interface. The program is menu-driven; it incorporates many error-trapping routines. You can download a copy of the program from the *Electronics Now BBS* as part of the PCIO.ZIP file. Try it, modify it, improve it.

Before starting the program, wire the ST-1 breadboard for the type of EPROM to be burned, but do not install the EPROM yet. Make a special directory for EPROM burning, and copy EPROMBRN.BAS, DEBUG.EXE, and GWBASIC.EXE into that directory. Make this your current directory and then run GWBASIC EPROMBRN from the DOS prompt.

The program begins by calculating loops/millisecond for your machine. This may take up to 20 seconds, so be patient. Remember not to change your turbo switch after the speed has been calculated. The program then presents you with a menu for choosing the type (size) of EPROM, and the burn voltage. The value you enter for size will affect the address loop constants, but the burn voltage value is displayed only as a reference. Note that EPROMs requiring a 12.5-volt burn voltage should work fine with the 12 volts available on the breadboard.

Next you'll see the main menu, which will allow you to copy, load, save, verify, and burn an EPROM. An additional option allows you to run DEBUG from within the programmer, for purposes of altering memory contents. Press the first letter of the desired command, and you'll enter the appropriate submenu. At this level, you must follow all entries with a carriage return. Typing an incorrect value or no value at all will return you to the main menu.

As discussed above, all data must be stored in memory at address 60000 hex. The typical method of obtaining that data would be to copy it from an existing EPROM using the copy command. Follow the screen commands by installing the source EPROM, then select Go. The entire EPROM will be copied into memory, and a simple arithmetic checksum will be displayed in both decimal and hex.

You can modify the EPROM values in that memory image using DEBUG. Return to the main menu and press D. The program will pass control to DEBUG. Now you can examine and change memory, using the procedures described in your DOS manual. When done, press Q followed by Return, and you'll fall back into the main menu.

Data stored in memory can be saved to a file by selecting Save EPROM from the main menu. Enter an eight-character filename with no extension; the program automatically adds the extension ROM. Regarding the save, you should know that BASIC can save a maximum of only 64K bytes of data, several bytes of which are reserved for header information. Hence when saving a 27512 EPROM (64K), the program saves the file in two pieces, one with the extension ROM, and the other with the extension RON.

After data has been saved to a file, it can be recalled with the LOAD EPROM command. Enter the filename (with the .ROM extension), or press L to list all (*.ROM) files in the current directory. If a program has been split, enter only the filename with the ROM extension; both parts will be loaded. Whenever the main menu is displayed, you can obtain a checksum of either the currently installed EPROM or the current memory data by selecting Verify.

With a valid data file in memory, you can burn an EPROM by selecting Burn EPROM from the main menu. The program will optionally verify that a device has been erased, then beep and request that you apply the selected burn voltage. Press B to burn the data into the device. The program burns the first byte and checks for success. If successful, the program continues on to the next byte, and so on until all bytes in that segment have been burned. Then

ORDERING INFORMATION

The following items are available from DAGE SCIENTIFIC, P.O. Box 144, Valley Springs, CA 95252, (209) 772-2076:

- Complete kit including manual and all parts (model ST-1)—$119
- Set of 2 PC boards and manual (model ST-2)—$40

All orders add $3.95 shipping and handling. CA residents add sales tax.

the segment number is incremented and the process repeats. After burning each segment, the program displays the remaining number of segments on the screen. That gives an indication that everything is working; it also helps you gauge how long the entire process will take. You can stop the program between segments by pressing S. After completely burning the EPROM (or after you press S), the program will beep to remind you to remove the burn voltage. Additional EPROMs may be burned using only this menu selection.

What next?

Although it's simple, the 50-millisecond programming method has its down side. It could take seven minutes to burn a 2764, and as long as an hour for a 27512. That may be acceptable for occasional use, but you may get impatient.

Most manufactures have developed fast programming algorithms, which typical commercial EPROM burners call High Performance Programming. This type of algorithm delivers a variable number of short (0.1–1.0 millisecond) pulses, with the number of pulses depending on when the to-be-programmed value changes. Higher voltages and closer tolerances are required for V_{CC} and V_{PP} Writing the necessary loops is easy using GW-BASIC, as is generating the short pulses. The limiting factor is the overall slow-running interpreted GW-BASIC. Maybe now it's time to change to C. Ω

AMATEUR TV

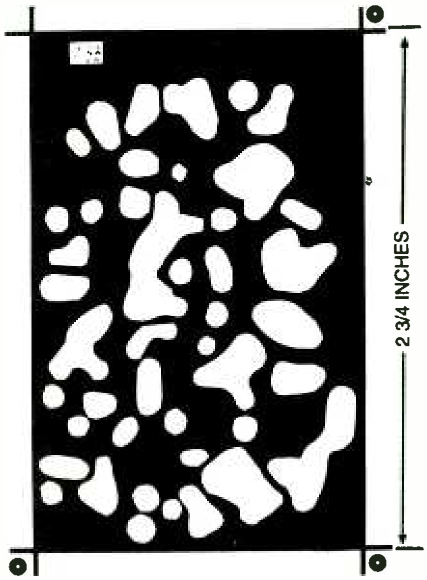
continued from page 52

Next set both C19 and C26 on the power amplifier to mid positions (capacitor plates should be halfway meshed). Apply 13.8 volts DC to the transmitter. First adjust C19 and C26 quickly for maximum power output, and then adjust C13 and C14. Repeat these adjustments for maximum RF output. Repeat this with the higher crystal frequencies (434 or 439.25 MHz). If no output is seen at first, adjust C13 and C14 before readjusting C19 and C26.

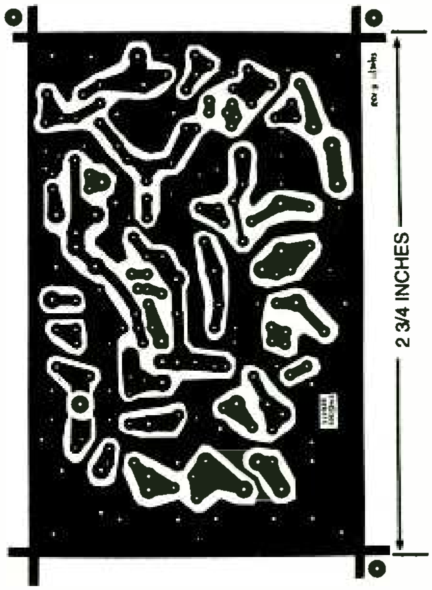
At least 5 watts output should be obtained at each crystal frequency after their final adjustments. The power amplifier will draw about 700 milliamperes under these conditions. If 5 watts cannot be obtained, change the sizes of L8 and L9. Cut the loops with diagonal cutters, overlap the cut ends, and solder them together. If 5 watts is still not obtained, check C20 to C23, and all components in the collector circuit of Q9 for correct values. Expect the heatsink to become warm after about 5 minutes operation, but not hot enough to make it painful to touch. Vary R18; it should control the RF output smoothly from 0 to 5 watts.

Note: You can skip this section if you are either building the 5-watt transmitter or any of the ¾-watt versions.

To check out the downconverter, first connect an RF probe, RF millivoltmeter, TV receiver, or monitor to the downconverter that will respond to 61.25 MHz (CH 3) or 67.25 MHz (CH 4). Next, apply +13.8 volts to both the junction of R43, C55, and R52, and the free end of R40. Verify the voltages given in Table 1. Set R50 so that about +5.5 to +6 volts is present on the wiper of R50.



COMPONENT SIDE of the Mini ATV board.



SOLDER SIDE of the Mini ATV board.

Next, adjust C59 for a 378-MHz reading on the counter. Verify that R50 will vary the frequency from about 367 MHz to 382 MHz if channel-3 intermediate frequency (IF) is used. If a channel-4 IF is desired, set C59 for a frequency range of 361 to 376 MHz. A 15-MHz change in local-oscillator frequency is desirable, although 13 MHz will be acceptable. If you cannot obtain this reading, C 58 can be replaced with a 6.8 pF capacitor if a wider tuning range is needed.

Next, set trimmer capacitors C43, C46, and C51 to midway (capacitor plates half meshed). With the L.O. set at 378 MHz (channel 3 IF) or 372 MHz (channel 4 IF), apply a 439.25-MHz signal (±2 MHz) to the antenna lead. The signal level should initially be about 20 millivolts. Tune C43, C46, and C41 for maximum IF output at 61 or 67 MHz as seen on the indicator connected to the converter output. Reduce the input signal to the converter as required. Next, peak the slug in L20 for maximum output. This is a broad adjustment. You should obtain

Continued on page 74

RESTORE IT RIGHT!

GARY McCLELLAN

Follow a set of logical steps when restoring vintage electronics, and you'll get years of additional service.

YOU CAN TAKE PRIDE IN OWNING faithfully restored vintage electronic products from the vacuum-tube era—radios, tuners, amplifiers, or test instruments. They will remind you of an earlier time when America was the dominant power in consumer electronics and people didn't worry too much about product size, weight, or power consumption. But those products had personality and gave a lot of pleasure.

Just think, you could be the only one on your block to own an authentic piece of American electronic history. Most of the products of that day have long since been crushed and swallowed up in land fill.

Some say those "old timers" sounded better and were easier to operate because they only had a couple of knobs. Contrast them with their modern counterparts—miniaturized, transistorized, and characterless black boxes with their confusing arrays of pushbuttons and switches.

This is the first of two articles that will guide you through the process for restoring golden-age electronics equipment. This first article will define the steps to be taken to assure successful project completion and tips on selecting suitable projects. It also offers advice on quality workmanship and the selection of appropriate cleaning and restoration materials. The second article focuses on finding sources for tubes and other "period" parts.

A bit of technical history

Many of you recall that most electronic products for sale in this country before about 1960 were made here completely—tubes, resistors, capacitors, transformers, chassis, and all. Many like the five-tube AC/DC "All American Five" superheterodyne radio receiver shown on page are circuit classics known to most people who studied or worked with electronics in the immediate post-World War II years.

The schematic for that receiver has been reproduced here. All of its receiving tubes were widely used in their day: the 12BE6 pentagrid converter; the 12BA6 IF amplifier; the 12AV6 diode detector, automatic volume control, and audio amplifier; the 50C6 power amplifier; and the 35W4 rectifier.

A high-end, Williamson-type amplifier high-fidelity audio amplifier is pictured on page. Its tube complement includes four 7408 beam power tubes, four 12AX7 high-mu twin triodes, and one 12AU7 medium-mu twin triode.

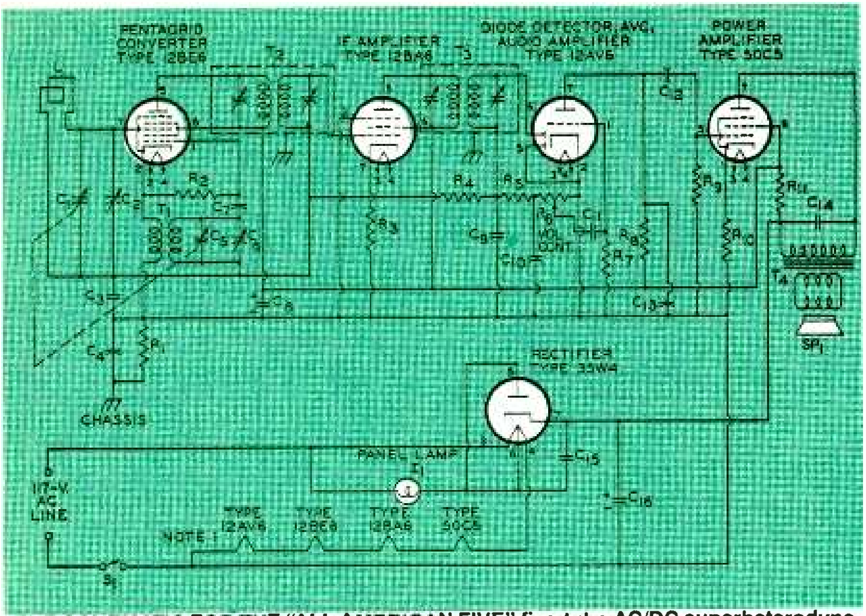
Selecting the candidate

If you own vintage electronic equipment that is gathering dust in your attic or basement, you might consider restoring them. You probably replaced them with more modern transistorized products but did not throw them out for sentimental reasons. Or maybe you thought about fixing them up some day—if you could ever find the time. How about now?

On the other hand, if you threw out—or never owned—any vacuum-tube electronics, you might be looking for a suitable "golden oldie" to restore. In either case, if you intend to restore an old vacuum tube circuit to working condition so that it has a new lease on life, be sure to follow a logical restoration procedure.

Ignoring or bypassing any of the steps to save money or time could mean ending up with a temporarily repaired product that could fail at any time. Moreover, the electronic product might never perform up to its full capabilities.

It is important that anyone restoring tube-type electronics—especially newcomers—be constantly aware of the fact that this equipment is powered di-



THE SCHEMATIC FOR THE "ALL AMERICAN FIVE" five-tube AC/DC superheterodyne radio receiver, a popular circuit in the 1950's.

rectly from the 120-volt AC line. This voltage can deliver a lethal electric shock! Be alert for decayed jackets on line cords, broken wires, or faulty components that could cause short circuits and fires when the equipment is plugged in. Be sure to take proper safety precautions to avoid possible electric shock when aligning, or tuning powered circuitry!

It is important that you pay attention to details and work carefully on any restoration project. Poor workmanship or the substitution of a component with the wrong value could result in the destruction of the circuit. Today's circuits powered by 6- to 12-volt DC are a lot more forgiving.

Select a candidate for restoration very carefully. Even if the old equipment is known to be in operating condition, it still must be carefully restored, so don't short-cut any steps. The fact that all the tubes light up when the circuit is powered does not mean it is in the best of health. However, if you start restoration from that favorable position, your task will be a lot easier than starting with a dead circuit. Further tests will reveal weak or suspect components.

If, when powered, the circuit doesn't work—or if it is obvious from seeing that key parts are missing—you'll be starting with a disadvantage. Your first task will be to troubleshoot the circuitry and isolate its faults. This can be difficult if you do not have a schematic or instruction manual.

You must first determine if the product is worth restoring, because of its value to you or its probable value to collectors, should you elect to sell it. Your decision should be based on your ability to find proper replacement parts and your anticipated investment in time to do the work. But perhaps you welcome the challenge.

Don't buy a vintage tube-type electronic product unless you have had a chance to inspect it carefully first! The only exception to this might be if the selling price is so low that you can afford to take a chance. If it can't sensibly be restored and is not a source of replacement parts, you can junk it with little loss.

If the selling price for an elderly product not in working condition seems high, try to obtain a written agreement from the seller that you'll receive a refund if you can't find the necessary replacement parts for less than the selling price.

Follow six well defined steps: *Inspection; List replacement; Obtain replacements; Reassemble*, and *Test and adjust*.

Cleaning procedures should be carried out in a logical order when appropriate during the restoration process.

Inspection

When you have the equipment at home on your workbench and are free to remove the chassis from its case, re-examine it again for the defects listed in Table 1, "Defects To Look For in Vacuum-Tube Electronics." Remember, even if the product is in working condition, its tubes could be weak and about to fail. Also, an old unit that has been in storage for years without maintenance could fail at any time.

Caution: Do not remove any parts during this inspection process just for the sake of cleaning them until you have performed step 2: list replacement parts.

List replacement parts

When you are ready to start removing components, be pre-

TABLE 1
DEFECTS TO LOOK FOR IN VACUUM-TUBE ELECTRONICS

- Thick accumulations of dust or grime.
- Missing components or mechanical parts.
- Burn marks on components, particularly resistors.
- Deposits of melted wax or oil on the chassis indicating past overheating of components.
- Leakage from capacitors or batteries that shows up as powder or liquid residue.
- Crumbling insulation on the line cord or chassis wiring.
- Cold or broken solder joints.
- Loose or damaged mechanical parts indicating the unit has been dropped or handled roughly.
- Oxidation or rust on metal chassis or components (indicating storage in a location with high humidity or water leaks).
- Blown fuse or no fuse in a fuse holder—if it had one.

Tube testers and tube testing

The end of a vacuum tube's useful life usually occurs when its cathode is no longer able to supply enough electrons to sustain proper operation. A meter on an emission-type tube tester can indicate this condition with a low plate current reading.

If a tube has an open circuit or is at the end of its useful life, an emission-type tube tester can also indicate this defect on the *reject* part of its meter scale. But this tester tests only the plate current, a static characteristic— not the ability of the grid to control the plate current

A tube can show normal emission and still function poorly because its efficiency depends on the ability of its grid voltage to control plate current. Thus, tube faults are best found by measuring dynamic rather than static characteristics.

Dynamic characteristics are not the same as static characteristics because, when a load impedance is present, the voltage at the plate of the tube differs from the plate supply voltage by the drop across the load impedance. Thus the difference between the dynamic and static characteristic is due to plate load impedance.

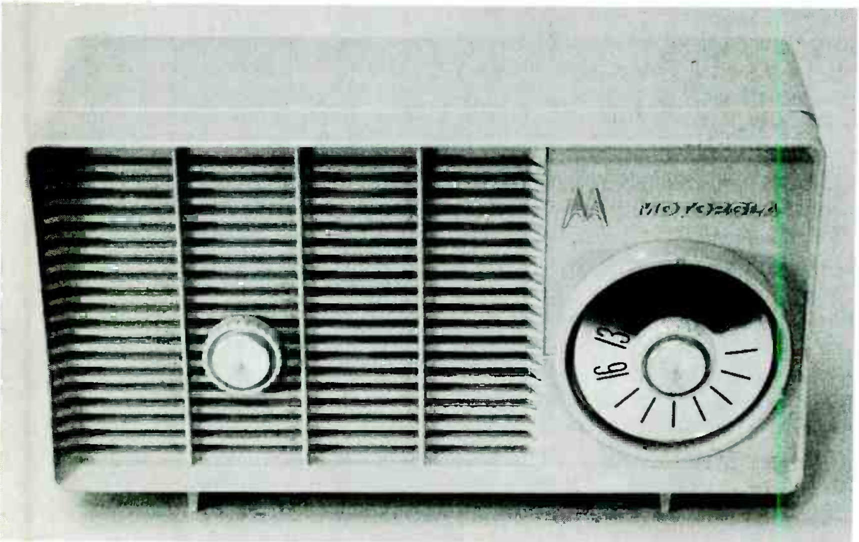
A transconductance or mutual-conductance tube tester can test dynamic characteristics because it effectively places the tube in a working circuit. These tube testers measure the dynamic mutual conductance of the tube, and they can carry out six important tube tests: 1. line test, 2. short-circuit test, 3. noise test, 4. gas test, 5. rectifier test, and 6. quality test.

The *line test* is made with the tube in the tester by pushing the *line test* button that connects the tester's meter to indicate its B+ supply voltage. A line adjustment variable resistor adjusts the voltage so that the meter's pointer remains centered across the scale for each tube.

A *short-circuit test* is performed by indexing a switch on the tester through five different positions to connect various pairs of tube electrodes in sequence across the test terminals. If the tube has a permanent short between elements, an AC circuit is completed to light a lamp. The *noise test*, made with the same circuit, checks for intermittent short circuits or microphonic noise. The *gas test* is performed by pressing a button to apply the proper plate and grid voltages to the tube and cause a definite amount of plate current to flow. Pressing another button inserts a high value resistor in the grid circuit so gas in the tube will cause grid current to flow. That grid current caused by gas develops a voltage across the resistor to reduce the normal bias and increase plate current. The tester's meter will indicates if the gas is tolerable or excessive.

The *rectifier test* makes emission tests on full-wave rectifiers and diodes. An AC voltage is applied across the tube and the tester's meter indicates the rectified current.

The *quality test* for amplifier tubes is based the test for dynamic mutual conductance. The tester circuit establishes the proper plate voltage, DC grid bias, and AC voltage to produce the grid-voltage change required to perform this test. If the tube is defective the meter's pointer will move to the RED section of the scale; if it is not defective, the pointer will move to the GREEN section.



A RESTORED MOTOROLA FIVE-TUBE AC/DC superheterodyne radio receiver made near the end of the receiving-tube era.

pared with a notebook or paper to make sketches or other written notes about the orientation, polarity, value, method of mounting, and color coding of any wiring to components you remove. You could have trouble replacing even direct replacements if you forget how they were originally installed.

If you can't identify a component's value, write a description of its size and appearance so the part can be identified later by measuring it with test instruments. Remove and test all vacuum tubes with a suitable tube tester (See the *Tube Testers and Tube Testing* sidebar.) Discard all the known bad tubes and list the weak ones for replacement.

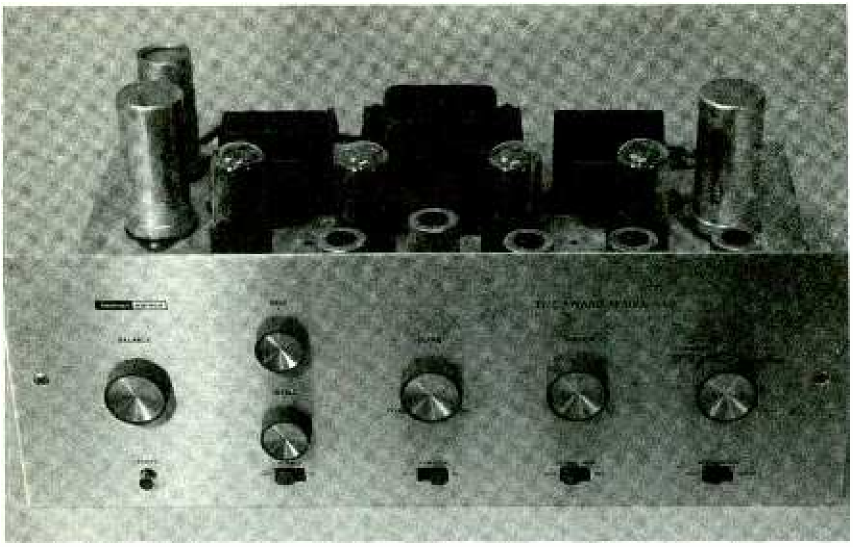
Some useful tube characteristics can be determined with an ohmmeter and other standard electronic test instruments, but the best and fastest results can be obtained only with a tube tester, preferably a transconductance or mutual-conductance model.

If you do not own one, look for a local radio/TV repair shop in the telephone book Yellow Pages, and call it to find out if anyone there would be willing to test your tubes. Offer a fee that would cover the time to make the tests. The shop might sell replacement vacuum tubes so tube testing would be free if you buy any replacements there.

Plan to replace all components that are burned or damaged. Replace all paper dielectric and aluminum electrolytic capacitors without question, and consider replacement of any film-dielectric types.

Spot-check the values of some of the original resistors by unsoldering and measuring them to verify that they are still within tolerance. If your tests reveal wide resistance tolerance variations, replace the resistors—unless they are molded carbon composition such as those made by Allen-Bradley.

Even good carbon-composition resistors can show wide variations in tolerance. Normal variations can be exceeded if the resistors have been in storage or inactive for years because they absorb moisture. However, they are likely to recover after the circuit has been powered up for an hour or so.



A RESTORED AUDIO AMPLIFIER, A Williamson-circuit for stereo systems. It has four beam power tubes, four high-mu twin triodes, and one medium-mu twin triode.

If you must replace a carbon-composition resistor, be sure to find a true equivalent; carbon-film units might not be able to withstand the same transients and current surges as the carbon composition units—one reason why they were so popular in AC-powered circuits.

If the color-coded value bands are obscured or missing from any faulty resistors—or if the resistor is missing—try to find a schematic that will give you the value. If you don't have a schematic for the specific circuit you are restoring, you might be able to determine a reasonable "ballpark" value from schematics of similar circuits in reference books.

Plan to replace all line cords, especially those whose rubber or PVC jacketing is crumbling or decayed. However, before replacing any line cord, measure its resistance with an ohmmeter to determine if it contains a resistive wire. If it does, obtain a fixed resistor of equivalent value to mount on the chassis in series with the new line cord. If you are seeking authenticity in a true "antique" radio, look for a replacement fabric-covered line cord.

You might find that you must replace parts such as transformers or potentiometers that were custom made for the equipment you are restoring. If you are unable to find a suitable off-the-shelf substitute, consider contacting the manufacturer. If that is not feasible because the manufacturer is out of business, you might be forced to seek out a comparable product to "cannibalize" the needed electronic components.

You could, of course, contact various custom transformer manufacturers for a quote on custom winding a replacement part, but the chances are you would find the single-unit price higher than you are willing to pay.

If you find a selenium rectifier mounted on the chassis (it looks like a small stack of square metal plates) replace it. Old units deteriorate with age and selenium, a toxic substance, is likely to flake off. Try not get any loose selenium flakes on your hands when you remove and dispose of the old rectifier. It can be replaced with one or more 1N4004 silicon diodes and a resistor of 2 to 100 ohms.

If you do not have a schematic for the circuit you are restoring, visit your local library or technical book store and look for books on vacuum-tube circuits. The RCA Receiving Tube Manual, last published in 1973, is a good starting reference. In addition to receiving-tube data sheets, it contains a receiving tube characteristics chart and replacement guide as well as schematics for popular entertainment-electronics circuits.

Record the vendors' stock numbers on your shopping list when you find what you are looking for. This will save you a lot of time whether you buy over-the-counter or through mail order.

Obtain replacements

When you have completed your shopping list, it is time to look for sources. This subject is covered in greater detail in the second part of this article. Obviously, one place to start is in your own "junkbox" or collection of old parts.

Preliminary cleaning

Clean the chassis before you replace any parts that you have removed. Remove as much dust and grit as possible from both sides of the chassis, the inside of the case or cabinet, and the outside surfaces of large components such as transformers by dry brushing before resorting to any cleaning solutions. Use a variety of small, stiff brushes in a well ventilated room. Old toothbrushes, for example, are handy tools for cleaning in restricted spaces.

To clean stains, grease, or mildew that does not respond to dry brushing, start first by dipping a soft, clean, cotton cloth or cotton swab in a solution of mild household cleaner and rubbing gently. Move up to higher strength cleaning materials only when the milder solutions won't work. Always work on small areas at one time, and *never* flood a surface with water or cleaning solution.

Mild abrasive cleaner applied on cotton cloth or a swab will remove most stubborn stains on plastics and metals and faint rust on ferrous metals. Fine grit sanding boards will remove stubborn rust spots.

Remove cadmium oxide, the white powder that accumulates on cadmium-plated chassis that have been stored for years, with a cotton cloth or swab dipped in WD-40, a petroleum-based fluid that is both a lubricant and an oxide removal agent. Be sure to wipe off all residue from the cleaned surfaces with a clean, dry cloth.

Caution: never use gasoline, paint thinner, acetone or other toxic or flammable chemicals. In addition to the health hazards they pose, they can damage plastic surfaces.

Replace faulty parts

After you have collected all of the replacement parts, you are ready to start replacing components. Before you start, look for any broken or faulty soldered connections not related to the replacement components and resolder them first. Tighten all loose nuts and bolts or ring nuts that secure chassis-mounted components, and install all replacements for any missing hardware or fasteners.

Begin component replacement by replacing all capacitors. Replace any of the resistors or potentiometers that you have previously identified as suspicious or faulty. Replace any other damaged parts found during your inspection. Replace the line cord and its through-chassis grommet.

If the equipment you are restoring does not have a fuse, you might consider installing one as a safety measure. AC line voltages are higher today than when most tube circuits were popular.

Inspect your soldering carefully for cold solder joints, inadvertent solder bridges, and other errors. Finally, install all replacement tubes and those known to be good, shields and other above-chassis parts that you removed.

Test and checkout.

Check for short circuits across the line-cord plug pins with the power switch off, and then to ground. Also check for shorts to ground on the B+ wires.

Consider placing a variable transformer (Variac) in series with the AC power line. It will permit you to increase AC line voltage slowly as the tubes warm up while you look for "hot spots" on components or any unusual behavior of the tubes indicating faults. Watch for any smoke, and be aware of any burning odors. If the circuit is not working correctly, shut off the power immediately and repair all the faults that you find.

If the restored equipment has internal adjustments, make those adjustments. It is not possible to give specific advice that will apply to all restored circuits, but here are some general suggestions:

Amplifiers:

1. Adjust hum balance by disconnecting any inputs and turning up the volume until you hear a hum. Then adjust that control until you eliminate or minimize hum. 2. Where appropriate, adjust the output balance so that the currents in both tubes are equal. Then adjust the bias for the specified current through each tube. (It might be necessary to disconnect any shorting links to measure voltage drops to accomplish this.) 3. To find the bias current value, refer to the manufacturer's service manual. If one is not available, consult the data pages for the tube in an RCA Receiving Tube Manual, and estimate the bias current.

Radio receivers:

1. RF circuits can be adjusted by aligning the front-end and the IF stages. The performance of most vacuum-tube radio receivers will be improved with careful alignment of the local oscillator, mixer and any RF stages. Receivers made before WW II, might require IF alignment, especially if they have IF transformer cans with two screws on top. However, most receivers made in the 1950s have IF transformers that usually do not need alignment. 2. Align the front end by adjusting the local oscillator so that the set picks up the correct signals at the 10% and 90% positions on the dial. On an AM receiver, they will be at 600 and 1400 kHz, respectively. Then peak the mixer and RF stages at the same points. To peak at 600 kHz, adjust the coils, and to obtain the best reception at 1400 kHz, adjust the trimmer capacitor. 3. Adjust the IF for maximum output at its rated frequency (typically 455 kHz). Perform all IF adjustments with an insulated alignment tool to avoid detuning.

Sources

1. Vacuum-tube circuit schematics
2. Vacuum-tube circuit components

Howard W. Sams Service (1)
2647 Waterfront Parkway East Drive
Indianapolis, IN 46219
800-428-7267

Antique Electronics Supply (2)
6221 S. Maple Ave.
Tempe, AZ 85283
602-820-5411

Antique Radio Classified (1)(2)
A.R.C. P.O. Box 2
Carlisle, MA 01741
508-371-0512

Audio Classics, Ltd.(1)(2)
P.O. Box 176
Walton, NY 13856
607-865-7200

Vern Tisdale (2)
8402 N. 18th Ave.
Phoenix, AZ 85021

Enclosure restoration

Clean any transparent glass or plastic surfaces on the enclosure with a soft, clean, dry cotton cloth dipped in window cleaning solution. Use care to avoid damaging lettering or numbers silk-screened on the dial. Place a drop of light oil on the control shaft bearing if it has one. Cycle it a few times to distribute the oil evenly.

The exterior of plastic enclosures can be cleaned by the steps outlined earlier. However, limit the cleaning of the exterior finish on a wood enclosure to wiping with a dry cloth and perhaps polishing with a quality furniture polish. Limit any repairs you make on a wood cabinet to regluing hidden joints, seams or delaminations, unless you have woodworking skills. A discussion of refinishing wood cabinets is beyond the scope of this article.

Grease and grime can be removed from plastic or metal knobs by the methods outlined earlier, but they could be soaked in a cup of mild cleaning solution to speed up the process. However, limit the cleaning of wooden knobs to rubbing them with cloth dampened in a mild cleaner. Follow this up by rubbing in furniture polish after they are dry. Ω

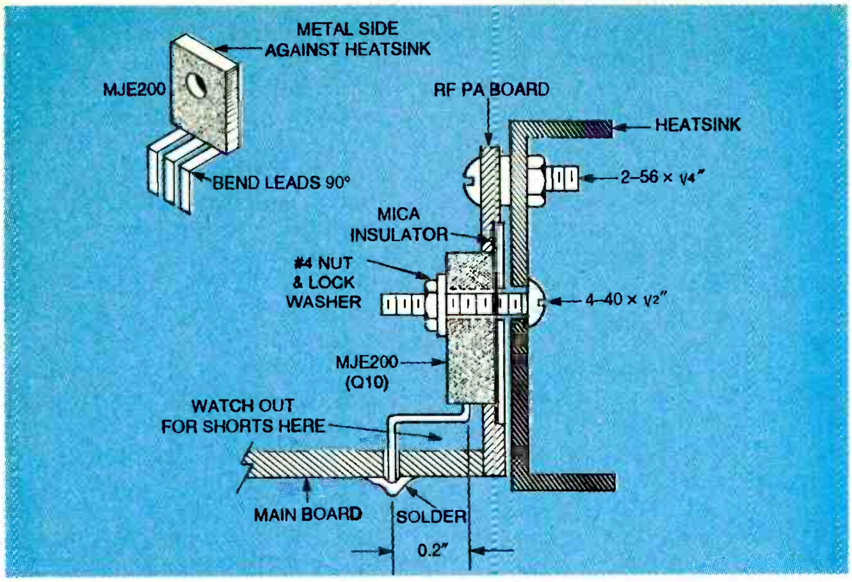


FIG. 12—REMOVE Q10 from the main board, form its leads as shown here, and mount it to the heatsink. Place a mica or Teflon insulator between Q10 and the heatsink.

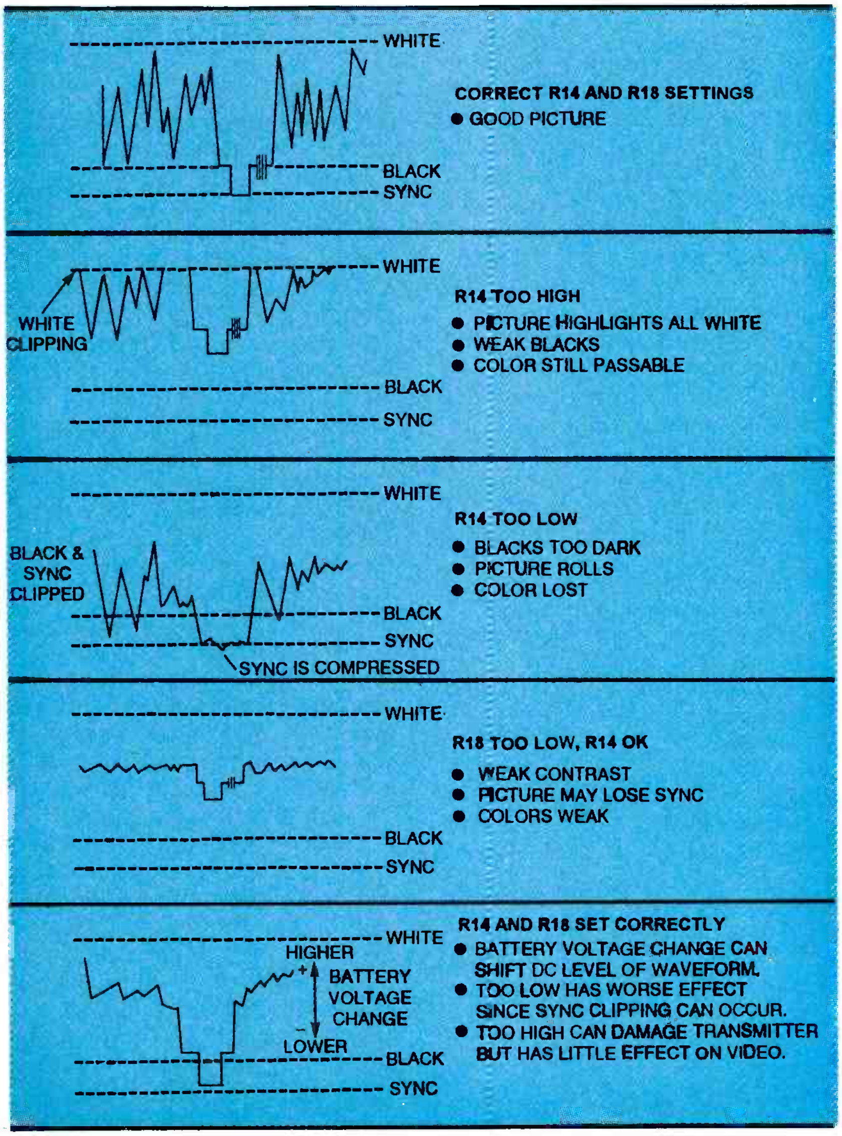


FIG. 13-NORMALIZED WAVEFORMS seen when aligning the ATV units.

AMATEUR TV

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at least 30 dB gain from the converter when it has been properly aligned.

If you do not have access to RF test equipment, use an off-the-air signal. Connect a monitor to the converter output tuned to CH3 or CH4 as desired. Connect an antenna to the converter input. Set C43, C46, and C51 to halfway, and R50 as before (+6V on wiper). With a 439.25-MHz signal (from another amateur), tune C58 until the signal is received, then peak C43, C46, and C51 for best reception.

The line sampler function is verified by applying +13.8 volts to the collector of Q14. About +3 volts should be measured at the emitter of Q14. Operation of the transmitter (unmodulated) should cause the DC voltage across R56 to drop to about 1.5 volts or less. An oscilloscope connected between the negative lead of C68 and ground should show a video signal identical to that applied to the transmitter when all controls are properly adjusted.

Final video and audio adjustments can now be made to the 5- and ¾-watt units. Connect the transmitter output to a 50-watt dummy load. Apply 13.8 volts DC to the transmitter section. Adjust R20 (R18 in the ¾-watt unit) to about halfway. Next, adjust R18 (R14 in the ¾-watt unit) for about half power output. Next, connect a video source providing 1-volt p-p, negative sync (standard NTSC video) to the video input of the transmitter.

On the transceiver versions, connect an oscilloscope to the negative lead of C68. A video waveform should be seen. (Verify that the Q14 sampler circuit is connected to +13.8 volts if you are testing the PC board before installing it in a case).

Adjust R18 for maximum sync amplitude without clipping. Make sure that no clipping occurs on the white levels (top of waveform). See Fig. 13. If you cannot avoid white clip-

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WHAT'S NEWS

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decoder, pen input circuitry, and liquid-crystal display panels for text, graphics, and full-motion video at an operating voltage of 1.1 volts.

Intel Corp. reported on a low-power version of its Pentium microprocessor that operates from 3.3 volts and runs at 133 MHz. It includes power management features for selectively powering down certain sections that are not in use. Made with 0.6 micron BiCMOS technology, the P54C chip consumes 40% less power than the 5-volt, 66-MHz standard Pentium.

IBM Corp reported on two newly developed low-power microprocessors. A 66-MHz complex instruction set (CISC) chip consumes only 1.8 watts and has a halt mode that stops its internal clock whenever a halt instruction is executed. A special memory area stores the data while the computer is off.

An 80-MHz reduced instruction set (RISC) chip, based on Power PC architecture, has power management logic that determines on a cycle-by cycle basis if a logic block is to be used. It then disables the clock to idle the blocks. IBM reports that this permits a 12 to 20% power reduction.

Researchers from Stanford University described their very low voltage, ultra low-power CMOS devices with thresholds near 0 volts that are tuned by back-biasing the substrate or wells.

AT&T licenses VideoPhone technology

Four major Japanese consumer electronics manufacturers have signed licensing agreements with American Telephone and Telegraph (AT&T) that will allow them to introduce and promote new products compatible with AT&T's VideoPhone.

The licensing agreements were signed with Hitachi, Sanyo, Sharp and Victor of Japan (JVC) allow them to develop VideoPhone products and sell them in Japan and worldwide. AT&T reports that Sony and Canon are also considering becoming licensees.

AT&T sees the agreements as evidence that its Global VideoPhone Standard (GVS) is becoming the standard for consumer video telephones. According to AT&T, VideoPhone 2500 was the world's first phone able to transmit full-color video (at a rate of 10–12 frames per second) and voice over public telephone lines. Introduced two years ago, it is now available in 37 countries.

CVS technology controls and serves as an interface between a VideoPhone's audio and video compression and decompression systems and a high-speed modem. It also provides the protocols for end-to-end VideoPhone communications and services.

"Smart battery" specifications available

Duracell and Intel announced the availability of two "smart battery" specifications. A "smart battery" is rechargeable battery with circuitry that provides present battery status along with calculated and predicted information on the remaining useful battery energy to the host system under software control.

The jointly produced specifications define the Smart Battery Data (SBD) and the System Management Bus (SMBus). According to Intel, the specifications will be made available as a proposed industry standard.

In addition to providing present and predicted information on battery status, host systems that follow the specifications will allow the product to be powered by different kinds of batteries and program the proper charge rate for each. Typical host systems for the "smart battery" include notebook computers, cellular telephones, pagers, and video camcorders.

Copies of the Smart Battery Data (SBD) and the System Management Bus (SMBus) Specifications are available from the Intel Literature Center, P. O. Box 7641, Mt. Prospect, IL 60056-7641, or by calling 800-253-3696 (U.S. and Canada). International inquiries can be made at 916-797-4216. Request literature packet SBS5220. Specifications can also be obtained from Duracell by calling 800-422-9001, ext. 423. Ω

SATELLITE IMAGES

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and images made in visible light are easy to interpret because clouds and snow are white and land masses are usually dark gray.

By contrast, infrared images are more difficult to interpret unless you are aware of the inverse characteristics of infrared sensors: High temperatures appear black and cold temperatures appear white. High clouds, for example, are colder than low ones, so they appear whiter in infrared images than low clouds.

Your ability to distinguish between the different kinds of clouds and weather phenomena is important if you want to interpret satellite images. Timed sequences of images will permit you to estimate the course and speed of storm movement so that you can estimate the probable time of arrival of rain, snow, or high winds in your local area. The high- and low-pressure areas and the jet stream that govern weather movement must be inferred from cloud contours because they are the only visible indicators. They could, of course, be confirmed by measurements.

Formal courses or home study in meteorology will be helpful in interpreting satellite images if you have had no training in the subject. This training is given in flight schools, naval and maritime academies, and military aerography schools. The subject is also covered briefly in Power Squadron courses. A list of books and articles on satellite image interpretation is given here under References.

One of the books listed, *Exploring The Environment Through Satellite Imagery* by Dr. E. Ann Berman presents a basic course in satellite meteorology and illustrates each topic by referring to actual satellite photographs. Readers who have successfully completed at least a high school physics course should have no trouble understanding this well illustrated text.

With practice, you should be able to identify the many different clouds; cold, warm and stationary fronts; dangerous thunderstorm cells; troughlines and ridgelines; zonal flow; the jet stream; and other common weather phenomena.

Because you will be able to track prominent storms or hurricanes both night and day with data from APT satellites, you can compare your predictions of their paths and severity with those obtained from the National Oceanic and Atmospheric Administration (NOAA) or your local radio or TV stations. Ω

AMATEUR TV

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ping, adjust R20 and readjust R18. The goal is to obtain maximum waveform amplitude without either white or black clipping. If you are building a transmitter only, directly view the transmitted picture on a TV receiver.

If you do not have a TV set capable of tuning 420 to 450 MHz, or have not yet built a downconverter, you can install a CH14 or CH15 crystal (see ordering information in Parts List) and temporarily tune the transmitter with this crystal. *Do not* try to optimize the picture with the RF adjustments. You will get many false readings and erroneous results. Always tune the RF adjustments for maximum power. The picture is optimized with R18 and R20. The same applies to the ¾-watt versions. In this case, R14 and R18 adjust picture quality, and the RF adjustments are set for maximum RF power output.

The final adjustments are for the audio channel of the 5-watt versions, or the Mini ATV. Proceed as follows:

Remove any video input from the transmitter. Connect a frequency counter capable of reading 10 MHz or more to the emitter of Q10 (Q7 in the case of the Mini ATV). Adjust C37 (in the 5-watt version) or C24 (in the ¾-watt Mini ATV) for a reading of 4.495 to 4.505 MHz. If you "run out" of adjustment, and cannot reach 4.500 MHz, then add or subtract a turn from toroidal coil L13 (L10 in the ¾-watt Mini ATV).

The windings specified for the toroid will typically have one turn more than is needed, producing a frequency that is too low. This was specified deliberately because it is easier to remove a turn than add one. Alternately, if the frequency is too high, you can place a 10 pF capacitor across the toroid rather than rewind it.

Next, connect an audio source to an audio input, and adjust the audio level control for about 2 volts p-p at the collector of Q4 (Q8 in the ¾-watt unit). You can adjust this by ear for clean audio at the same volume as that of a commercial station. Any sync buzz encountered indicates either excessive video drive, incorrect linearity adjustment, or an off-frequency sound subcarrier. Some slight buzz can be expected, but it can be reduced 40 dB down below peak sound level.

When the transceiver/transmitter is complete, check out the circuit with a video source such as a camera or VCR. Avoid overloading the TV monitor with too strong a signal. Connect the transmitter to a dummy load. Overloading will give false results, and you might end up spending hours tracing a "problem" that doesn't exist.

External connections

Figure 14 shows typical wiring diagrams for interfacing the units to cameras and other video sources. The usual application for the transceiver board is an amateur two-way TV station. Its basic requirements are a video source, a microphone if sound transmission is desired, an antenna with a VSWR of bet-

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HARDWARE HACKER

Is dowsing for real? Fundamental research tools can lead you to an answer.

DON LANCASTER

Just after last month's column deadline, I managed to find a real nice tutorial on solitons. See Russell Herman's *Solitary Waves* in the July-August 1992 issue of the *American Scientist*. I also came across another neat property of solitons: If two ordinary waves crash into each other, they'll self-destruct. But if two solitons crash into each other, they'll pass right through each other without any damage!

Fundamentals of research

One recent helpline caller became rather upset when I told him I did not believe in dowsing. His main point was that if you can buy dowsing rods at *Northern Hydraulics*, that confirms it right there. Doesn't it? Well, not necessarily.

Dowsing clearly meets my "looks like a duck and quacks like a duck" pseudoscience definition. It is certainly reasonable to approach any pseudoscience topic with a lot of skepticism.

On the other hand, it is not fair to categorically dismiss something out of hand you know little about. So, to be fair about this, I decided to feature dowsing for this month's resource sidebar, and let you decide this yourself. Actually, I needed an excuse to describe the major research tools that I use. Dowsing is as good a topic as any to research.

There are three types of research, *primary*, *secondary*, and, *tertiary*. Primary research is that research which you do personally. It can often be the best research of all provided, of course, that you keep any bias in check, use reasonable tools and methods, and don't get in over your head.

Secondary research requires study of the published literature. The quality of secondary research depends on how thorough you are, the references you cite, and the overall credibility and competence of the references.

Other less polite names for tertiary research include *anecdotal evidence*, *hearsay*, *mythology*, *hype*, *hoaxes*, *scams*, *wishful thinking*, *urban lore*, *hidden variables*, *blind faith*, or simply plain old outright *lying*.

Now, it is not fair to assert that tertiary research will always be dead wrong. But it is fair to say that teriary research quality will nearly always be very low and highly suspect. You'll need a lot more of it to prove a point—an *awful* lot more. At the very least, *multiple and independent* sources are absolutely essential. All extraordinary claims *demand* extraordinary evidence.

Let me show you how both primary and secondary research helps me answer this question of great importance.

Is dowsing for real?

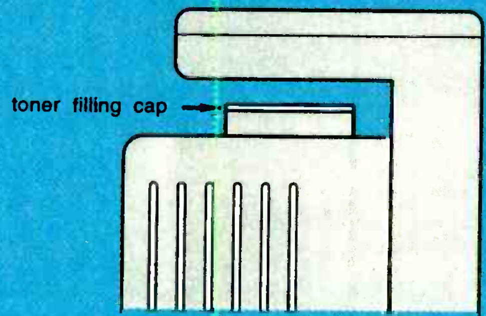
My primary research experience with dowsing is fairly limited. Years ago, I was given some dowsing rods to play with. I could not get them to work. People I loaned them to who claimed they "believed" could not get them to work either. I have seen employees of my local water utility routinely using dowsing rods. I think I know one reason why my utility bills are so high.

CANON "EX" CARTRIDGE RAPID RECHARGE

NOTE: Use this method only on a cartridge having a good drum and lots of extra room remaining in the spent toner tank. You can usually get three or four refills before the spent toner tank overflows. Drum permitting.

1– Set the EX cartridge on its end, top away from you, such that the serial number is up and the "Made in Japan" is down.

2– Using a large screwdriver, pop open and remove the large white toner filling cap. Set this cap aside.



3– Pour in a bottle of EX toner, using a bottle with a flexible filling snout. Replace the toner filling cap.

4– Carefully vacuum any remaining loose toner and wipe everything with a soft and clean cloth. Run a dozen test pages that alternate white and black sheets to test your work.

FIG. 1—THE "RAPID RECHARGE" METHOD for an EX laser cartridge refill.

I am a caver, and most cavers will aggressively use any tools they can to find new caves. In all of caverdom, not once have I ever seen or heard of anyone successfully dowsing caves—at least not firsthand.

On to some secondary research. First, you should try to find some dowsers. Start with the *Encyclopedia of Associations*, and you'll find a listing of the 3500-member *American Society of Dowsers* which also publishes *American Dowser* magazine. You'll find that *Borderlands Research* and the *Society for the Application of Free Energy* also sometimes have a strong dowsing focus.

The *Skeptical Enquirer* is bound to have touched on this at one time or another. And *Rex Research* has one or two of his *Infolios* that provide some dowsing information.

By far my favorite research tool is *Ulricht's Periodicals Dictionary*. But in its listing of more than 600 magazines on water resources, the *only* one of interest is *American Dowser*.

The *Divining Rod* entry is a good example of what researchers call a *false hit*.

The *Thomas Registry of Manufacturers* is of no help at all, because none of the manufacturers listed will admit to providing any dowsing supplies. *Northern Hydraulics* does carry rods as stock No. 15554-384. *American Dowser* should list other sources of supply.

Books in Print lists no titles under the subject of *dowsing*, but it suggests that you refer to *divining* or to *radioesthesia* instead; there you'll find several dozen titles. I've picked some of these for our listing.

By the way, one of the really big problems in doing any research is getting your key words right. More often than not, the insiders will be calling things by different names. *It is of utmost importance to find these "correct" names as early in the game as you possibly can.*

The ultimate heavy weapon in any research work is usually the *Dialog Information Service* now offered on *GEnie* 24 hours a day. There are about a half *billion* abstracts on line. Last month, I was overwhelmed when a search for soliton information produced around 8,300 references. How many dowsing references do you suppose they now have on line?

Would you believe *seven*?

Yup. As near as I can tell, there has been darn little serious dowsing research *ever* done. But three of the papers are quite interesting.

The first is a Utah study in which a powerful correlation was observed between a big group of dowsers and *something*. The study points out emphatically that the researchers were totally unable to correlate that "something" to either ground water or its related magnetic fields.

The second interesting paper describes a British study in which dowsers were invited to find a big hidden flowing-water pipe. While "something" was apparently happening, the dowsers were unable to find the pipe reliably. Perhaps more telling, professional dowsers did no better than amateurs.

The third interesting paper is a careful analysis of a pendulum. When any pendulum is driven near its resonance frequency, there is an expected normal physical reason why a pendulum will suddenly start bobbing around. This is explained by the underlying math of driven oscillators. No further external cause of any type is needed. No, you don't even have to invoke chaos or non-linear coupling effects.

And that's about as far as I got with secondary research. The next step would be a thorough study of the books, back issues of the publications, and attempts to contact the authors of the key papers. Very often, the *Science Citations Index* can let you find an older paper and see who references it. This magic directory is one of the few resources that can let you move *forward* through time, gaining *new* material as it is published.

If you have anything useful to add to all this, send it to me. I'll send you a free copy of my *Incredible Secret Money Machine II* book for your trouble.

PostScript review

I just received a reader letter that was full of dead-wrong misconceptions about the PostScript language. So I think a review of the fundamentals is once again in order.

I really like PostScript because it is an ideal Hacker's general purpose computing language. It is also superb for the fast and device-independent electronic distribution of high quality technical information in a new *Hacker Data Format*.

I use PostScript for everything as my primary language. "Everything" includes engineering design, fractals, stock market analysis, printed-circuit layouts, video compression, fuzzy data fitting, hot-tub controllers, fancy numeric analysis, exotic half-toning, wavelet studies, and direct dedicated homebrew CAD/CAM control. I also use PostScript to create everything you see here and in my other columns.

You can talk to PostScript with ordinary text files from any old word processor or editor. Or you can let fancy application packages write the code for you. PostScript is one of the easiest-to-use languages I have ever seen. The more you play around with it, the more powerful it becomes.

PostScript is definitely a general-

NAMES AND NUMBERS

Adobe Systems
PO Box 7900
Mountain View, CA 94039
(800) 833-6687

American Scientist
Box 13975
Research Triangle, NC 27709
(919) 549-0097

Appliance Service News
PO Box 789
Lombard, IL 60148
(708) 932-9550

The Bell Jar
35 Windsor Drive
Amherst, NH 03031
(603) 429-0948

Robert Bosch
38000 Hills Tech Drive
Farmington Hills, MI 48331
(313) 553-9000

Computer Hot Line
15400 Knoll Trail Drive, #500
Dallas, TX 75248
(800) 999-5131

Deep Vision 3-D
6457 Santa Monica Blvd
PO Box 38386
Hollywood, CA 90038

Dialog
3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700

Digital Video
80 Elm Street
Peterborough, NH 03458
(800) 441-4403

GEnie
401 N Washington St
Rockville, MD 20850
(800) 638-9636

Global Micro-Parts Depot
11151 Denton Drive
Dallas, TX 75229
(800) 325-8488

Magnets in Your Future
PO Box 250
Ash Flat, AR 72513
(501) 856-3877

NewTek
215 SE 8th Avenue
Topeka, KS 66603
(800) 765-3406

Northern Hydraulics
PO Box 1499
Burnsville, MN 55337
(800) 533-5545

Radio World
5827 Columbia Pike #310
Falls Church, VA 22041
(703) 998-7600

Recharger
3340 Sunrise Avenue #102
Las Vegas, NV 89101
(702) 438-5557

SAE
400 Commonwealth Drive
Warrendale, PA 15096
(412) 776-4841

Science Resources
1260 Liberty Way, Ste B
Vista, CA 92083
(619) 727-6933

Service News
38 Lafayette Street
Yarmouth, ME 04096
(207) 846-0600

Synergetics
PO Box 809
Thatcher, AZ 85552
(602) 428-4073

Tapeswitch
100 Schmitt Blvd
Farmingdale, NY 11735
(516) 694-6312

Don Thompson
6 Morgan #112
Irvine, CA 92718
(714) 855-3838

purpose computer language. All of the required language features and constructs are in place. As with any general-purpose computer language, there are strengths and weaknesses. PostScript does certain jobs better than C++ and C++ does some tasks better than PostScript. PostScript's massive strengths lie in its ability to fill up otherwise clean sheets of paper with stunning mixed text graphic and text layouts—especially those that need lots of transforms or bunches of computation.

Nothing even remotely compares with PostScript. Its big weakness lies in its ability to interact with the outside world. PostScript is often limited to marking up sheets of paper, writing files to disk, returning information over any communications channel, or sending out commands to external devices.

Absolute proof that PostScript is a general-purpose computer language is found in the PSRT RoundTable on *GEnie*. Of the more than 1000 files in the library, many use PostScript for totally non-graphical, general-purpose computing needs. They also use extensive computations combined with only an incidental graphic output.

PostScipt is an example of a stack- and dictionary-oriented, extensible, threaded, interpretive, and reentrant language. It is a distant relative of *Forth*.

Important features of PostScript include its total device- and resolution-independence, and its ability to draw graceful curves and work with sparse data descriptions.

Yes, you can get a low cost PostScript host interpreter. The most popular one is known as *GhostScript*, and is available for the downloading from many BBS sources, including the GEnie PSRT. GhostScript provides on-screen previewing on *any* host platform. Full source code is available, again by downloading.

Other host PostScript interpreters include various forms of Adobe's CSPI, an acronym for a *Configurable Software PostScript Interpreter*. There are now dozens of other third-party interpreters available.

PostScript works best when it is inside a dedicated computer that is designed from the ground up to meet its needs. Most of these dedicated PostScript computers usually have an obscenely misleading and a horribly restrictive label placed on them. These awful labels say "printer" on them.

Instead, I prefer to call all of those HUCC's, which is short for *Hacker's Universal Coprocessing Computer*. I believe that PostScript provides the most outstanding emerging opportunities for *Electronics Now* readers today.

For instance, I'll routinely use the 68030, the twelve megabytes of RAM, and the hundred megabyte hard drive of my *LaserWriter* Pro630 HUCC as a fine "mother's little helper" coprocessor for the 6502 in my Apple IIe. It lets me explore non-obvious subjects powerfully and profitably in non-traditional ways.

PostScript can be compiled easily. The simplest example is the PS *bind* operator. An intermediate example is PostScript's *binary object format*. Some highly profound compiling takes advantage of PostScript's *form* capabilities. A cached form can dramatically improve runtime speed.

External compilers are also available that greatly improve the efficiency and speed of runtime code. Examples of these include Adobe's *Distillery* and *Acrobat Distillery*, or my *Maudedoc* and *Triple Distilling* techniques.

Yes, PostScript is strongly object-oriented. But only if you want it to be. The crucial keys to an object-oriented language are modules that have a single input, one output, and

DOWSING RESOURCES

Associations:

American Society of Dowsers
Brainerd Street Box 24
Danville, VT 05828
(802) 881-7165

Borderland Sciences
Box 429
Garberville, CA 95440
(707) 986-7211

Free Energy Application Society
1315 Apple Avenue
Silver Spring, MD 20910
(301) 587-8686

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

Rex Research
Robert Nelson
Box 19250
Jean, NV, 89109

Skeptical Enquirer
Box 703
Buffalo, NY 14226
(716) 636-1425

Books:

William Barrett
Divining Rod
Carrol pub
University Books, 1967

Gabriele Blackburn
Science & Art of the Pendulum
Idylwild Books, 1984

Bill Cox
Techniques of Swing-Rod Dowsing
Life Understanding, 1971

R. Davies
Dowsing: The Art of Finding Hidden Things
Aquarian Press, 1979

Harvey Howells
Dowsing for Everyone
Viking Penguin, 1979

R. Simmons
Professional's Complete Dowsing Course
Dowsing Institute, 1978

Robert Steffy
The Dowser's Primer
Halldin Publishers, 1980

Evon Vogt
Water Watching USA
University Chicago Press, 1979

Critical papers:

F.E. Irons
Concerning the nonlinear behaviour of the forced spherical pendulum
European Journal of Physics
vol.11, no.2, p.107-15, March 1990

B. Walti & U. Jenzer
Dowsing and electromagnetic fields
Bulletin de l'Association Suisse des Electriciens
v.75, #15 p.903-6, 4 Aug. 1984

Ian Killip
Geophysical dowsing
Civil Engineering for Practicing Engineers
vol 4, n 4, p 343-360, Apr 1985

O. Vyzkumu
Proceedings of the Conference on Psychotronic Research
Joint Publications Research Service
Arlington, VA, 227p, 6 Sep 74

Duane G. Chadwick
The Detection of Magnetic Fields Caused by Groundwater and the Correlation of Such Fields with Water Dowsing
Utah Water Research Lab, Jan 71

that perform one well-defined task—otherwise known as a PostScript procedure inside a PS dictionary.

Study any Acrobat output for examples of PostScript object use or investigate PostScript's *execuserobject* and its related commands.

For more on PostScript, start with Adobe's red and blue books. Then look at my files STARTUP.PS and SPEEDUP.PS on *GEnie* PSRT or write or call for more help.

Toner-cartridge reloading

Brand new toner cartridges for popular laser printers might cost as much as $140 each. You can easily refill toner cartridges several times at a cost as low as $4.25, and you can do it in a minute or two.

The primary reason for cartridge refilling is economics. New cartridges yield toner costs of around a nickel per printed page—which is much higher than jiffy printing. Recycled cartridges yield toner costs as low as 0.1 cent per page. That's a 50:1 cost reduction which can completely blow away old line printing. It also makes book-on-demand publishing quite attractive.

Refill toner can also be better than the factory original material. It can give you such options as blacker graphics, longer cartridge life, color, check-printing MICR magnetics, or thermal dye-sublimation for T-shirt printing.

A typical toner cartridge includes a *fresh toner tank*, the *magnetic feed roller*, a *photosensitive drum*, and a *spent toner holding tank*.

In general, there are many reasons why a toner cartridge fails. The most common is that it simply runs out of toner. A plain old quick refill takes care of this problem.

The second most common problem is caused by drum defects. Factory drums seem to be designed to fail shortly after one tank of toner is used. They might drop in sensitivity, or pick up scratches or dropouts. There's now a lively third-party *hard coated drum* industry today. Swapping to one of these hard drums can let your cartridge be recycled dozens of times.

The third most common cartridge problem is holding tank overflow. This typically will happen after three or four refills of the newer cartridges. The obvious preventive step is to empty the tank before it overflows. Recycling the recovered spent toner is *not* recommended.

I have shown how to recycle the older *Canon* CX, SX, and LX carts in previous columns. The step-by-step details also appear in the *Hardware Hacker II*, my *Intro to PostScript* video, and on *GEnie* PSRT.

This month I will tell you how to recycle the popular *Canon* EX cartridge that is used on such machines as the *Hewlett-Packard* LaserJet 4M+ or in the *Apple* LaserWriter Pro630. This EX cart is much easier to recycle than the earlier cartridge.

There are two recycling methods that I'll explain here. The *Rapid Recharge* method of Fig. 1 just adds toner. Pop the cap, pour in the toner, and replace the cap. This works *only* if the drum is still in good condition and the spent toner tank is far from full. You can make up a special flexible snout refill bottle to make it easier to put the toner into the tank. A length of heat-shrink tubing works fine.

The *Total Teardown* recharge of Fig. 2 takes longer, but it can fix most cartridge problems. On the other hand, it can cause more problems than it solves—stripped screws, dropped parts, loose wipers, fingerprinted or light-flashed drums. It can easily *raise* your per-page toner costs.

Removing two screws separates the EX cartridge into two pieces. The toner-tank half can be refilled by the rapid recharge method. Two other screws can be removed to provide access to the entire bottom of the tank. Mixing brands of toner is *not* a good idea.

You can install a new hard-coated drum in the other half cartridge. Try to avoid getting fingerprints or scratches on it or exposing it to strong light. The spent toner tank is also on this half. Removing two screws gives you access to the bottom of the tank.

Cartridge recycling is best done outdoors or in a hooded area with a vacuum cleaner available. A face mask is recommended.

By the way, it pays to monitor and label the history of each cart carefully. I use brand new cartriges only for my camera-ready art. Prime recycled cartridges are used for my book-on-demand production and catalogs. I use problem cartriges for in-house work.

If you start up your own cartridge recycling service, one key rule is to a seven mile service limit just like pizza delivery: Go beyond seven miles and the pizza gets cold, and you will get into big arguments over the anchovies. As soon as you advance to commercial shipments and unknown sources and histories of carts, your problems will increase and your profits will go down. So will your customer satisfaction.

Be sure to hand carry all your carts to your customers. Each customer should get his own cart back, each and every time. In some markets, you can charge as much as $15 to $19 for a cartridge refill.

Several big printer suppliers offer "recycling" programs. This is really a blatant attempt to *prevent* personal or third-party cartridge recycling. It is ecopornography at its very worst. If you ever get a prepaid recycling pack from any printer supplier, put a brick in it and send it back.

The leading trade journal for the toner recycling industry is *Recharger* magazine. You will find lots of ads for the toner, drums, tools, and services in it. This industry has matured, with many outfits now offering first quality products. But there still are some scams and flakes on the fringe, so always check on the reliability of a supplier before you lose a lot of money.

NEED HELP?

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

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ 85552

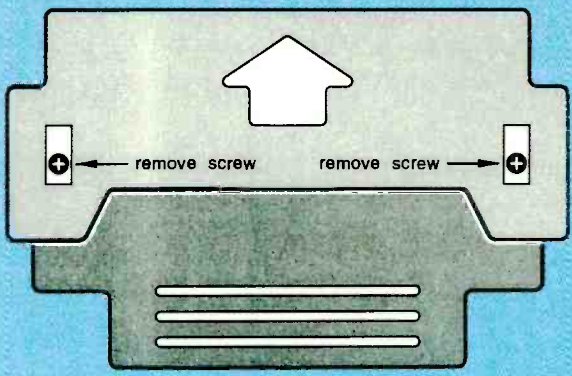
(602) 428-4073

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

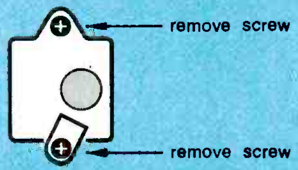
CANON "EX" TOTAL TEARDOWN CARTRIDGE RECHARGE

1– Set the EX cartridge right side up on a cloth surface in an area where toner dust can be safely managed.

2– Use a Phillips screwdriver to remove the screws holding the cartridge retainer dogs in place. Squeezing the cartridge frees the dogs. Set these plastic dogs, the screws, and their springs aside. Separate the cartridge halves.

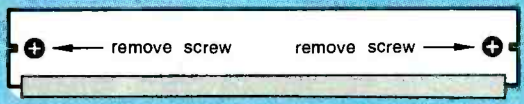


3– Carefully set the fresh toner tank half aside. Observe the photo drum retainer bracket on the right side of the spent toner tank half. Remove the two Phillips screws and this bracket. Then carefully remove the photo drum and set it on a soft cloth. Avoid any fingerprints or exposure to strong sunlight.



4– Snap the gray cylindical charging roller out of its holders. Wipe it carefully with a slightly dampened soft cloth to restore its light gray color. Set this charging roller aside.

5– Remove the two Phillips screws securing the spent toner wiper blade. Remove the wiper blade and set it aside. Carefully vacuum or dump any toner in the spent toner tank. Reuse of this toner is not recommended.



6– Carefully clean the wiper blade with a soft cloth. Replace the wiper blade assembly and its two Phillips screws.

7– Snap the toner charging roller back in place. Inspect the old photo drum for scratches while carefully cleaning it with a soft cloth. If you are substituting a new hard drum, do so at this time. Inspect and clean the photo drum retainer bracket. Replace drum, retainer bracket, and two Phillips screws.

more...

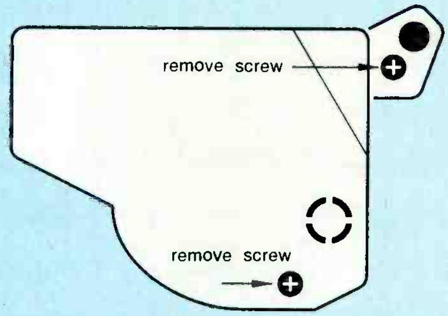
FIG. 2—THE "TOTAL TEARDOWN" METHOD for an EX laser cartridge refill.

It does *not* pay to buy toner in bulk unless you are recycling over 2000 cartridges per month. Use the refill bottles instead.

A superb source for laser printer repair and maintenance training is *Don Thompson*, who now offers his seminars worldwide. He also provides low-cost replacement parts and modules.

EX CARTRIDGE RECHARGE, continued...

8– Remove the two Phillips scews on the end cap of the fresh toner tank half. Very gently remove this end cap, making sure that none of the three internal gears pop off their posts. Vacuum the gears if needed.



9– Flip up the white lever holding the magnetic pickup roller in place. Carefully remove the magnetic pickup roller. Vacuum it and gently wipe it with a soft cloth. Snap the end cap back in place (without screws) to retain the gears.

10– Make a fixture (such as a cardboard box with a rectangular hole in it) that lets you firmly support this module so that the black magnetic transfer roller area sits horizontally on top.

11– Remove the two Phillips screws holding the fresh toner wiper blade. Remove the wiper blade, and carefully clean it with a soft cloth.

12– If you are changing brands of toner, remove any remaining old toner. Then carefully pour a new bottle of toner into the exposed toner tank. Level the fresh toner as you pour it. Wear a face mask.

13– Replace the fresh toner wiper blade and its two Phillips screws. Carefully remove the end cap. Make sure the gears are all free to rotate. Inspect and clean the magnetic transfer roller supports and snap the roller back into place. Replace the end cap and its two Phillips screws.

14– Note how the two hinge pins hold the two cartridge halves together. Insert the cartridge halves together, squeeze them slightly, and replace the cartridge retainer dogs. Replace the final two Phillips screws.

15– Carefully vacuum any remaining loose toner. Run a dozen test pages that alternate white and black sheets to test your work.

THE "TOTAL TEARDOWN" METHOD continued.

New tech lit

The Society of Automotive Engineers (*SAE*) is now offering the third edition of the 840-page *Robert Bosch* classic *Automotive Handbook*. It costs $29 for nonmembers, and includes new coverage of sensors, driver information systems, and GPS navigation.

NewTek has just introduced a stunning new, nonlinear video-editing system it calls a *Video Flyer*. It uses hard disks instead of videotape to give you random video access. The Video Flyer eliminates most of the overpriced junk previously associated with serious video post-production. It offers broadcast quality that is free of any generation loss. Demonstration videos are offered.

The *Bell Jar* newsletter continues to offer exceptional information for those interested in high-vacuum techniques. A recent issue shows how to build your own scanning-electron microscope.

Speaking of vacuum concepts, new make-your-own vacuum tube *kits* are offered by George Schmermund of *Science Resources*. After you build your own vacuum tube triode, you put it to work in a regenerative receiver.

More on RBDS shows up in *Radio World* for April 20, 1994. Including a list of curently active FM stations.

Super cheap red and green glasses for 3-D video experiments are offered by Steve Gibson of *Deepvision 3-D*. Touch switches and driveway sensors are offered by *Tapeswitch*. A new desktop magazine is *Digital Video*.

Here are several good servicing resources: *Global Micro-Parts Depot* has replacement oven parts, both regular and microwave. *Appliance Service News* describes small appliance and TV repairs in depth. *Service News* is a trade journal for computer service technicians, and support now in its fourteenth year. The all-ads *Computer Hot Line* lists sources for printer, hard disk, and monitor parts.

One new monthly pseudoscience publication is *Magnets in Your Future*. It is intended for motors-and-magnets perpetual motion enthusiasts. The publication is expensive and even more outrageous than most—very strange indeed.

More on book-on-demand publishing appears in my *Book-on-demand publishing kit* from *Synergetics*. I also have a brand new catalog with a greatly expanded "insider technical secrets" section. You can write, call, or E-mail me for a free copy.

Most of the items mentioned are found in the *Names & Numbers* or *Dowsing Resources* sidebars. Be sure to check here first before calling our no-charge technical helpline. Let's hear from you. Ω

It's our first experience with interactive TV.

AMATEUR TV

continued from page 76

ter than 2:1 (preferably less than 1.5:1), and a monitor capable of receiving channel 3 or channel 4 (VHF). The system is also compatible with European PAL. Standard video levels (1 volt into 75 ohms, negative sync) are supplied by most cameras or other video equipment.

On-board gain controls for video and sound are provided, but external gain controls accessible from a front panel might be desired. Selectable video inputs, audio subcarrier control, frequency switching, and external transmit/receive switching might be required.

- Power Supply—For the transceiver, the DC voltage should be well regulated (1% or better) and be capable of 1.2 amperes or more. For ¾-watt units, any voltage from 8 to 14 volts is acceptable. The higher the voltage, the higher the RF output power. For the 5-watt transceiver and transmitter, higher voltages will be dissipated as heat, so adequate heat sinking must be provided.

Any ripple will show as hum bars in the transmitted video signal. Poor regulation of the power supply can cause video instability, sync clipping, poor low-frequency response, and make it difficult to receive the transmitted video. Do not use a power supply with an output voltage of more than 15 volts because the RF power amplifier will be damaged. Lead-acid or nickel-cadmium rechargeable batteries will permit portable operation.

- Antenna—A good Yagi array, log periodic array, collinear array, or other antenna with 6 to 18 dB or more gain will give far better results than a simple 6-inch whip antenna. (Remember that 5 MHz bandwidth is needed.)
- Monitor—Any black-and-white or color receiver that can tune to channel 3 or channel 4 VHF.
- Camera—Any black-and-white or color camera that provides 1 volt into 75 ohms will be satisfactory. It can be a camcorder, a security camera, or a miniature CCD camera. The miniature CCD cameras consume little power and can operate from 12 volts DC. They are

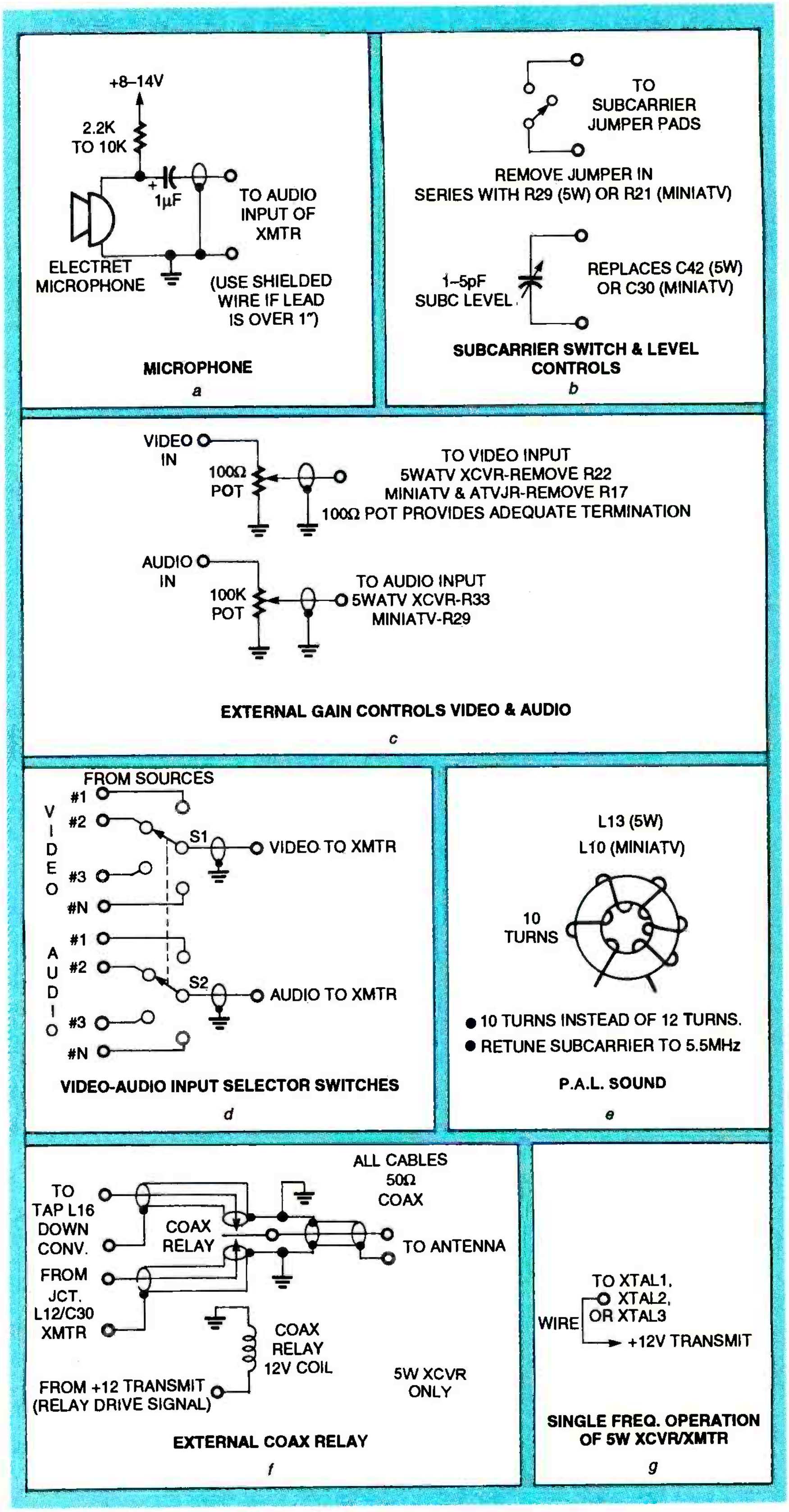
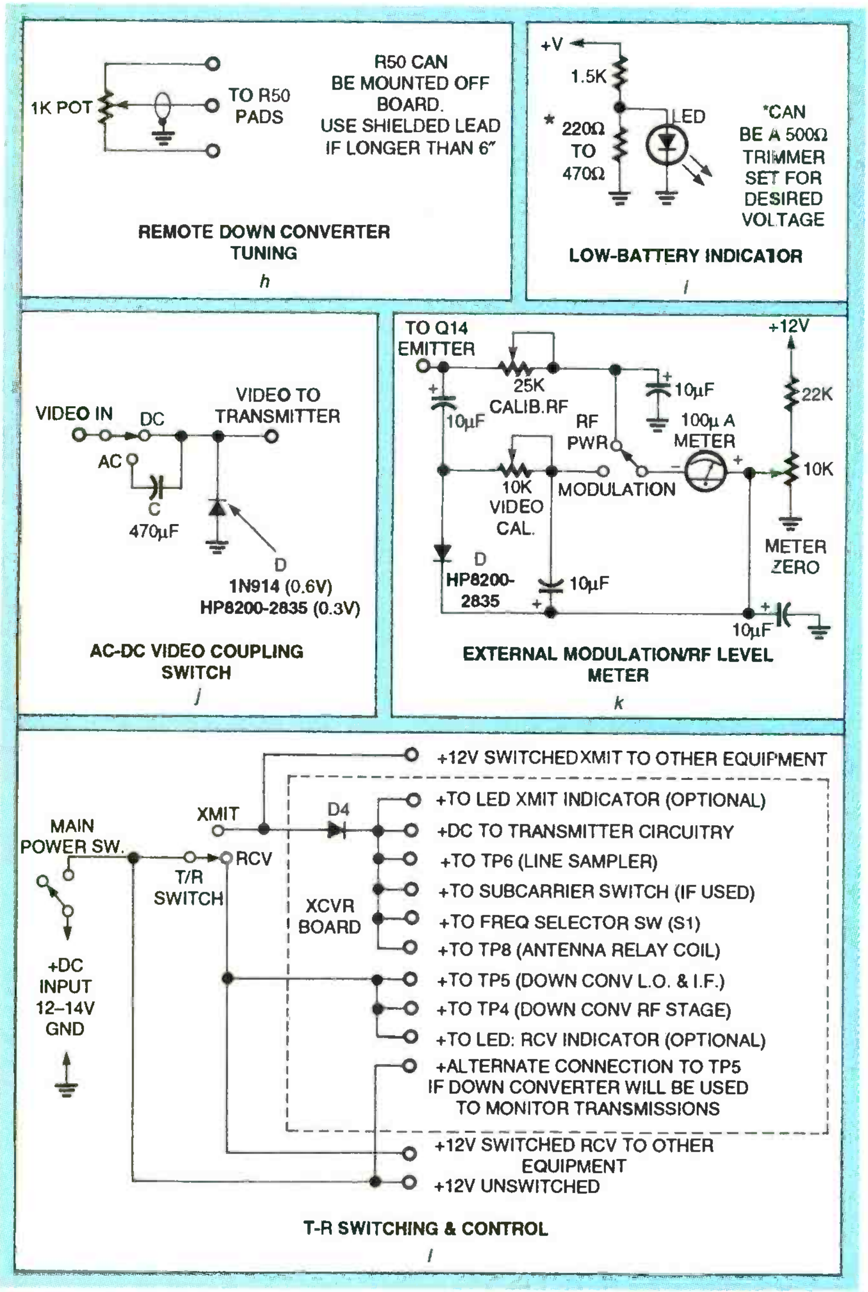


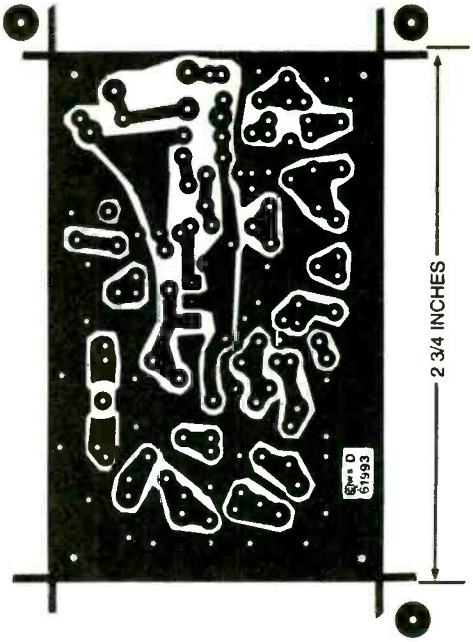
FIG. 14—OPTIONAL ACCESSORIES can be added to the ATV units.

light in weight and compact for portable operation.

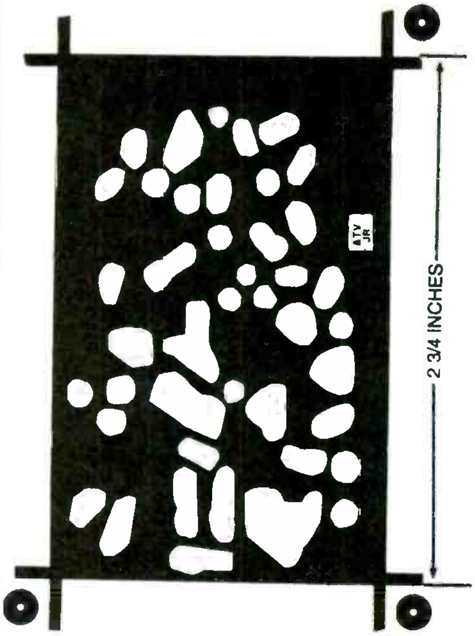
- Microphone—If sound transmission is desired, a microphone that provides audio of at least 5 to 10 millivolts RMS into a high-impedance load (5000 ohms) will be satisfactory. Electret microphones are an inexpensive alternative (see Fig. 14-*a*). Most amateur-radio or citizen band-grade microphones are satisfactory. If a microphone has a built-in push-to-talk switch, the transceiver can usually be controlled by this switch (see Fig. 14-*l*).
- External gain controls—These controls are helpful in transmitter or transceiver applications where several different video and audio sources are used, or whenever gain adjustments need to be easily set. The 82-ohm input terminating resistor (R22 in 5-watt units, R17 in ¾-watt units) can be replaced by a 100-ohm potentiometer (see Fig. 14-*b*).

Select a carbon or cermet potentiometer, and not a wirewound unit. With this arrangement, the on-board video-gain controls can be set so that, with the external gain control at maximum, video clipping just begins to occur.





COMPONENT SIDE of the ATV jr. board.



SOLDER SIDE of the ATV jr. board.

- Sound subcarrier switch and level adjustment—A switch in series with the supply line to the audio circuitry can eliminate the 4.5-MHz subcarrier for applications where sound is not required (Fig. 14-*c*). If this feature is not needed, install a wire jumper on the PC board. The sound subcarrier level can be adjusted by replacing C70 (5-watt units) or C30 with a 1 to 5 picofarad trimmer capacitor (Fig. 14-*c*). After setting the

PARTS LIST—MINI ATV

All resistors are ⅛-watt.
R1, R27, R28—33,000 ohms
R2, R19, R24—10,000 ohms
R3, R12, R16—330 ohms
R4, R7,—R10—100 ohms
R5—2200 ohms
R6—10 ohms
R8—470 ohms
R9, R11—33 ohms
R13—3300 ohms
R14, R18—1000 ohms, potentiometer
R15—3300 ohms (2200 to 4700 ohms)
R17—82 ohms
R20—not used
R21—680 ohms
R22—1000 ohms
R23, R26—100,000 ohms
R25—4700 ohms
R29—100,000 ohms, potentiometer

Capacitors
C1, C7—56 pF, ceramic NPO
C2—39 pF, ceramic NPO
C3—2.2 pF, ceramic NPO
C4—18 pF, ceramic NPO
C5, C28—0.01 µF, Disc GMV
C6—33 pF, ceramic NPO
C8—470 pF, ceramic disc GMV
C9, C11, C13, C14—2–10 pF trimmer (yellow body)
C10, C15, C18—1 pF, ceramic NPO
C12, C24—2–18 pF trimmer (green)
C16, C17—100 pF, chip
C19—10 pF, ceramic NPO
C20—10 µF, 16 volts, chip
C21—120 pF, ceramic NPO or SM
C22—68 pF, ceramic NPO
C23—0.0022 µF, 50 volts, Mylar
C25–C27—0.47 or 1.0 µF, 35 volts, tantalum electrolytic
C29—10 µF, 16 volts, electrolytic
C30—1 to 3.3 pF, NPO (1 pF, and 2.2 pF supplied in Mini-ATV kits)

Inductors (all coils wound on 8-32 × ¼" form unless noted—inductances below 50 nH are approximate and may vary ± 10 nH)
L1—125 to 300 nH (7½ turns No. 22 AWG enameled with 8-32 × ¼" Cambion Blue slug)
L2, L3—50 to 100 nH (3½ turns No. 22 AWG enameled with 8-32 × ¼" Cambion Blue slug)
L4—30 nH (4 turns No. 22 AWG tinned)
L5, L8—39 nH (5 turns No. 22 AWG tinned)
L6—5 nH (½ turn No. 22 AWG tinned 0.375" dia.)
L7—10 nH (1½ turns No. 22 AWG tinned)
L9—25 nH (2½ turns No. 22 AWG tinned)
L10—11 µH (12 turns No. 22 AWG enameled on toroid)

Semiconductors
D1—1N4007 diode
D2—Motorola MV2112 varactor diode
D3—1N754 diode
Q1—2N3563 transistor
Q2, Q3—Motorola MPS3866 transistor
Q4—Motorola MRF559 transistor
Q5—2N3904 transistor
Q6—2N3906 transistor
Q7—Motorola MJE180 transistor
Q8—2N3565 transistor
Q9—Motorola MPF102 FET

Other components
XTAL1—54.90625 MHz crystal
Miscellaneous: Mini ATV PC board, 8-32 screw for coil winding form

ORDERING INFORMATION

Note: The following items are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053:

- **5-watt transceiver kit (contains PC boards, all parts that mount on them, chassis connectors suitable for basic operation, heatsink, and three crystals for 439.25, 434.0, and 426.25 MHz)—$179.00**
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- **¾-Watt Mini-ATV kit (contains PC board and all parts that mount on it with crystal for 439.25 MHz operation)—$79.00**
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trimmer for the desired subcarrier level, recheck the frequency of the subcarrier and reset it as required.

• Video/audio input selector—A simple two-pole, multi-position switch can be installed to select one of multiple video/audio inputs (Fig. 14-*d*). For applications where two inputs are required, a DPDT toggle switch can be used. A center-off switch can provide a no-input setup condition.

• Phase-Alternation Line (PAL) sound (5.5 MHz)—The toroidal coil (L13 or L10) can be modified for 5.5-MHz operation. Remove two turns from the coil and adjust the oscillator frequency to 5.5 MHz (see Fig. 14-*e*). No video modifications are necessary.

• External relay or RF switching—Bypass the internal relay as shown in Fig. 14-*f*. A voltage from the transceiver can control signals for external relays.

• Single frequency operation—To operate a 5-watt unit on a single frequency, install a jumper as shown in Fig. 14-*g*.

• Remote downconverter tuning—Potentiometer R50 can be mounted off-board, if desired. Shielded leads will avoid spurious signal pickup (see Fig. 14-*h*).

• Low battery indicator—A voltage divider can form a low-battery indicator. (See Fig. 14-*i*.)

• AC-DC video coupling switch—Some applications require AC video coupling because of the presence of DC levels on the video signal. This can be done by switching a coupling capacitor into the video line. (See Fig. 14-*j*.) The capacitor value should be large enough to avoid excessive low-frequency phase shift and loss. That will lead to "tilt" and trailing streaks around highlights in the video image. A low-frequency cutoff of 10 hertz or less is recommended. For a 75-ohm system, this means a capacitor value of at least 470 microfarads. A clamping diode can be installed across R22 or R17 as shown, to re-establish DC levels to avoid excessive white level clipping.

• RF power and modulation meter—This can be set up for the transceiver with the line-sampler circuit. The meter can be calibrated, or it can provide a relative indication (see Fig. 14-*k*). Ω

continued from page 38

asserted when a video and audio blank is ended. Interrupt 3 (IR3) occurs once each second and is used to keep track of the time of day. Interrupt 4 (IR4) responds to the edit abort switch which quickly ends the edit operation. Interrupts 5–7 are used when a time setting or day of the week switch is depressed.

The controller includes 8K of EPROM and 32K of static RAM; the commercial editor uses only a fraction of both. The extra memory was included to add flexibility for future projects that might be more memory-intensive. The software is stored in and is executed from the 2764 EPROM (IC3), while variables and commercial history are stored in the 43256 static RAM (IC4). The RAM is backed by four AA batteries. Should a loss of power occur, the commercial history should remain intact. During a loss of power, the time of day will remain stored, but it will not be updated.

When an interrupt signaling a video and audio blank is received, the time that has elapsed since the last such interrupt is computed. Based on this time, the editor determines whether the blank signals the first commercial in a set (interrupting a program) or the beginning or end of a subsequent commercial. If a commercial set is beginning, past history is examined for a commercial set that occurred around the same time of day on the same day of the previous week. If one is found, the duration of the current commercial set is predicted and the edit mode is engaged. The firmware keeps track of when it should end the edit and does so when a blank period occurs near that time. As this process continues, a log of the current activity is stored for use one week later.

Power supply

AC line voltage is fused by F1 and transformed by T1, a 120- to 12.6-volt, 3-ampere transformer. The secondary of T1 is full-wave rectified by D1 and D2 and filtered by C1 and C2. Regulation for the 5 volt supply is performed by IC1 (an LM323K) mounted on a heatsink external to the case. If a switching regulator is desired, then D7 and C5 should be included to guard against overvoltage. For added protection you can add a metal-oxide varistor (MOV) across the line-voltage input.

The secondary of T1 is also full-wave rectified by D3–D6 configured as a bridge to obtain a positive and negative supply for the analog circuitry. The bridge-rectified outputs are filtered by C3 and C4. The positive and negative supplies are regulated by Zener diodes D6 and D7 in the detection and user interface circuit. Because of this, the transformer rating should be strictly observed, as overvoltage will cause overheating of current-limiting resistors R23 and R24; undervoltage will cause poor regulation of the analog circuitry. One side of T1's secondary winding is also used by the detection and user interface circuit for timekeeping.

Construction

For best results, assemble this project on printed circuit boards. Boards are available from the source given in the Ordering Information box. The foil patterns are provided here for those who would like to make their own boards. Also note that a programmed EPROM is available from the same source, and the binary code for the EPROM is available on the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) as a file called COMEDIT.BIN.

The parts-placement diagrams for the interface board and the controller board are shown in Figs. 7 and 8, respectively. All ICs should be mounted in sockets. The display components should be set at right angles from the board so they can be seen while the board is lying flat. Alternatively, you can mount the display board vertically. Notice that the calibration potentiometers are adjusted from the back of the interface board, so holes should be made in the cabinet so that adjustment is possible after the case is closed. The two boards are interconnected by two ribbon cables between P2 and P3. Before installing the ICs, check power at each socket and at other critical areas. Then remove power and discharge the filter capacitors. Insert the ICs and, if you have an oscilloscope, look for the clock and other signals that feed the microprocessor. If the unit is operating normally, the time display on power up should show 12:00 AM, and the time colon should flash each second. Figure 9 shows the inside of the author's prototype unit.

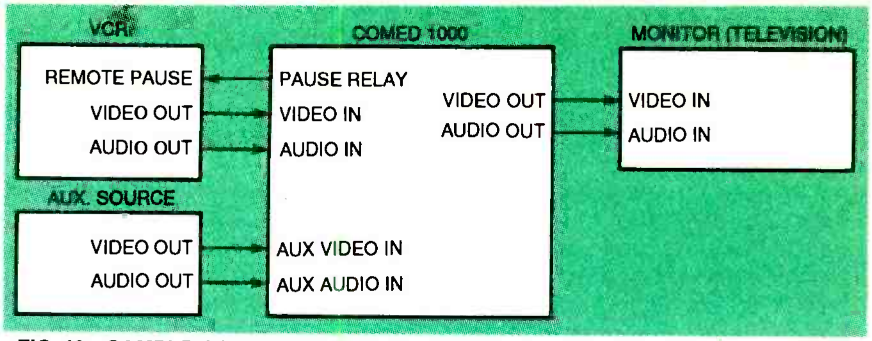

FIG. 10—SAMPLE CONFIGURATION. The auxiliary source will be switched in during commercial breaks.

Calibration

After the unit is operating normally, it must be calibrated. This requires some time and patience, but is critical for reliable performance. You should start by preparing a test tape; record about fifteen minutes of nothing but commercials including the blank periods between each commercial. Then connect the line-level audio and video signals from the VCR to the appropriate jacks on the commercial editor. Allow the commercial editor to run where you plan to put it with the cover on for more than half an hour so it will reach normal operating temperature.

Calibration is best performed with an oscilloscope—if you don't have one, use a high impedance voltmeter. If you do have an oscilloscope, connect channel one to the video input signal. Set the sweep and trigger so that a single frame of video is displayed. Connect the second channel to the pull-up side of R6 (the side that goes to pin 2 of IC3) on the interface circuit. Adjust R5 for 0.29 volt on pin 10 of IC4. With the test tape playing, adjust R5 so that when there is any picture at all, the output of the comparator (channel 2 of the oscilloscope) is about 5 volts. When a blank in the video occurs, the output of the comparator should be about 0 volts.

Next, connect channel one of the oscilloscope to the audio input. Channel two should then be connected to the pull-up side of R3 (the side that goes to pin 3 of IC3) on the interface circuit. Adjust R4 for 0.07 volt on pin 5 of IC4. With the test tape playing, adjust R4 so that if there is any sound at all, the output of the comparator (channel 2 of the oscilloscope) is about 5 volts. When no sound is present, the output of the comparator should be about 0 volts.

If you don't have an oscilloscope, adjust R5 for 0.29 volt on pin 10 of IC4 and R4 for 0.07 volt on pin 5 of IC4 on the interface circuit. These settings put you in the "ballpark" for most VCRs. Observe the decimal points on the time display while running the test tape. If the unit is calibrated properly, the decimal points should light for one or two seconds when a blank interval occurs. If the decimal points light for a silent, low-light picture, then lower the video comparator threshold by turning R5 clockwise. If the decimal points light at a low-sound, dark picture, then lower the audio comparator threshold by turning R4 clockwise. If the decimal points do not light or do so inconsistently, then one or both of the comparators is set too low. Raise them by turning the adjustment controls counterclockwise. Bear in mind that the voltages on pins 5 and 10 of IC4 can be in a range between −5 and +5 volts. For normal operation, the threshold voltages should always be positive, between about 0.05 and 0.60 volt. By running the test tape repeatedly, you should be able to detect trouble spots and calibrate them accordingly.

Observe a regular television signal using the VCR as a tuner. Watch the decimal points during normal operation to see that they come on only when a simultaneous blank of audio and video occurs. If it does not operate properly, repeat the calibration steps with a regular television signal rather than your test tape. The adjustments are sensitive, so make small corrections and be sure the threshold voltages stay between 0.05 and 0.60 volt. Fortunately (or unfortunately) you don't have to wait long for commercials to appear on screen.

Calibration is complete when you are satisfied that the decimal points come on at the appropriate times. After calibration, enter the correct time. Move the Edit/Standby switch to the Standby position to enable the time-setting switches. Advance each digit by pushing its associated switch. When the correct time of day and day of week are set, return the Edit/Standby switch to the normal Edit position.

The commercial editor is now in its operational mode. Over the next week the editor will "watch" what you watch when you use the VCR for the tuner. It will log commercial breaks, and after a week is through, it should effectively edit as you watch. A default commercial log is coded in EPROM and, until your personalized log is stored, it will use this for reference.

During operation, the four status lights indicate what the commercial editor is doing. The TIME EXPIRED indicator lights when the expected time of edit has ended. When this occurs, the edit will end when the next break occurs or when fifteen seconds elapses. The BREAK indicator lights while the unit is in its edit mode. The LEARN indicator lights when no suitable past history is found and the edit is not engaged. The NO SIGNAL indicator lights when neither audio or video signals are detected.

Selection of the signal you want blanked or substituted during an edit is made with switches S6 and S7. The auxiliary inputs of the selected signal will be switched to the output when an edit occurs. For example, if you want the audio muted during an edit, move the audio select switch to the auxiliary position, and don't provide an auxiliary audio input. Figure 10 shows a sample configuration.

No commercial-editing scheme is foolproof. This unit works best when a regular schedule of television viewing is followed. If you like to "channel surf" with the remote, do so only during commercial breaks or you will reduce the unit's effectiveness. Also, if you rarely watch movies on television, no behavior pattern for that type of program will be logged. Therefore, it will not edit as effectively as it could. Ω

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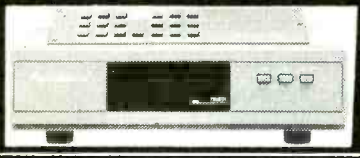

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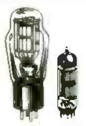

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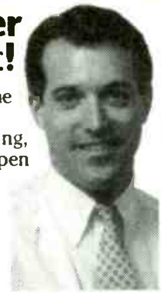

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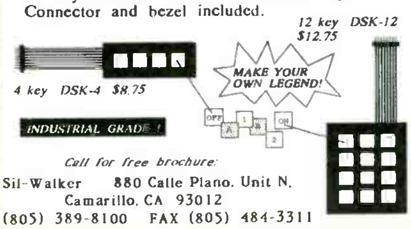

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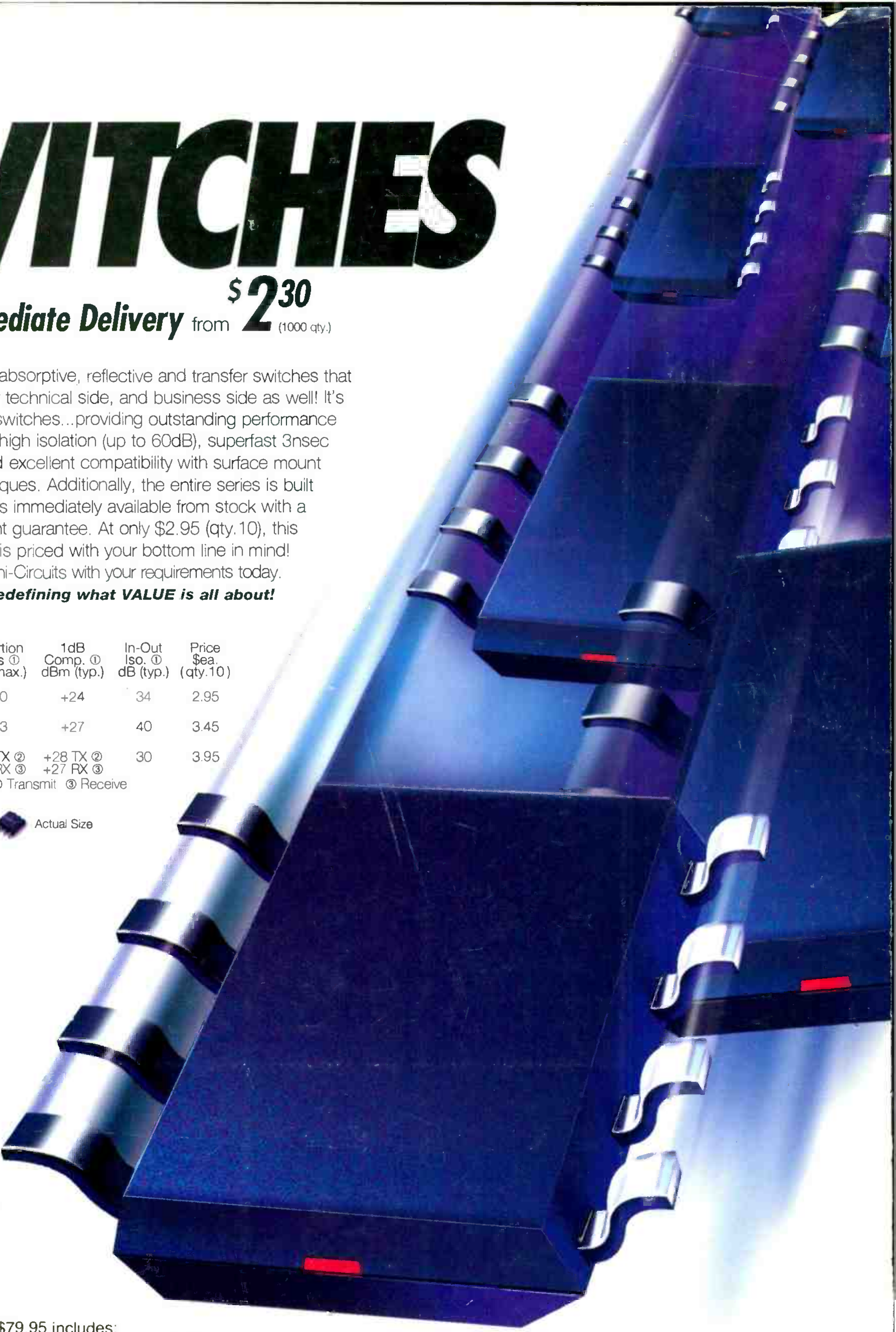

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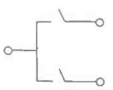

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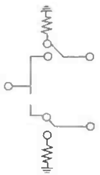

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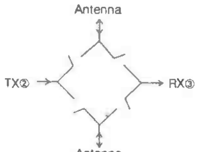

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