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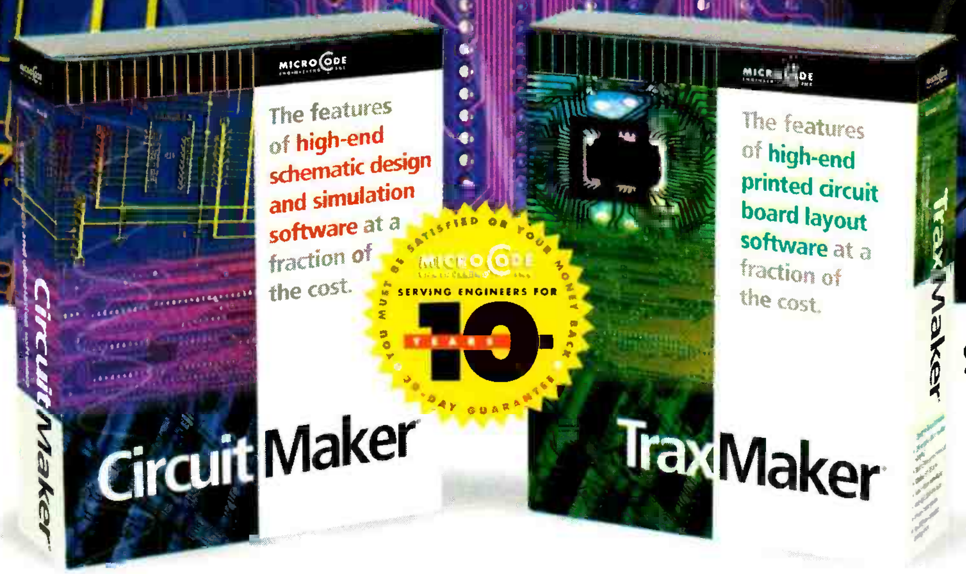

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EDITORIAL

Holy Cow

You know, by now you'd think that in the realm of science and technology, very little would surprise us. After all, we've seen virtually every off-the-wall, they'll-never-be-able-to-do-that piece of sci-fi technology and gadgetry from our—and our parents'—childhoods turned into reality.

Still, every once in a while, you hear about something new that makes you just stop and say "Holy Cow" (or something similar). The other day, I had one of those experiences.

In case you missed the news reports, it seems that researchers have developed an implant that can allow paralyzed individuals to communicate directly with a computer using only brain impulses.

We don't have the space to go into the technical details here (though we are planning to do an in-depth report in a future issue). Suffice it to say that one completely paralyzed volunteer (though alert and intelligent, he was unable to speak or move any limb) is now able to control a cursor on a laptop well enough to be able to stop it on an icon and click it.

That ability allows him to use the computer to say words and phrases. Researchers have even added an alpha-numeric keypad on which the patient has been practicing writing his own name, and they hope that the patient will become proficient enough in using his thoughts to control a computer to be able to go online and generate and send e-mail.

Progress has been slow, but the fact that there has been any progress at all seems mind boggling. Further, the implications here are staggering, because once you can control a computer using only thoughts, you can control almost anything. There is now hope that someday paralyzed individuals will be able to regain at least some mobility, as well as the ability to communicate effectively. For the rest of us, well, there seems to be no limit to the possibilities.

Carl Laron

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Editor

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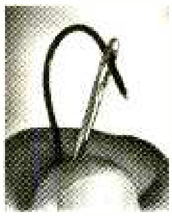

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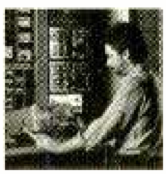

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Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

What Is Ground?

Q *I have a beginner's question about the article you wrote, "Build the No-Parts PIC Programmer (NOPPP), which appeared in the September 1998 issue of* **Electronics Now**, *and about other project circuits. The diagram shows one common ground, but the picture of the NOPPP shows two pins both labeled "ground." Are they connected together? Are all these ground pins connected to the negative side of the batteries or power supplies? "Ground" is a confusing idea for me; I've read several basic books but none of them seem to explain it.—E. I., Durham, NC*

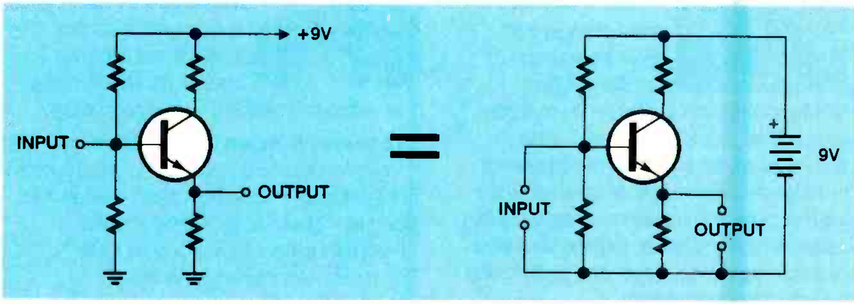

FIG. 1—A GROUND SYMBOL IN A SCHEMATIC shows points that are connected to each other and to the common side of the power supply, input, and output. As a result, these two simplified circuits are identical. Despite the term, ground does not imply a connection to the circuit's enclosure or to the Earth.

A In my early days, "ground" puzzled me too. I knew that electrical power systems are grounded (connected to the earth) for safety reasons, and antenna systems sometimes use the earth as a counterpoise. But that didn't explain why almost all circuits have ground symbols in their schematics, even small battery-operated devices that can't possibly be connected to the earth.

Eventually I came across a book that defined "ground" as "common negative," or more generally, "common," and the light dawned.

Look at the diagram in Figure 1, which shows an imaginary but typical circuit (it could be some kind of DC amplifier). The diagram on the left uses the ground symbol; the diagram on the right does not.

The right-hand diagram shows that one side of the input, one side of the output, and one side of the battery are all connected together via the line at the bottom. This connection is "common to" (shared by) the input, output, and power supply. In the diagram on the left, the common connection is denoted by the ground symbol.

All the points marked by the ground symbol are connected together. Where the diagram shows only one connection for a two-terminal device, such as a battery, microphone, or speaker, the other terminal always goes to ground. Likewise, the "voltage at" any point in a circuit is measured by connecting a voltmeter between that point and ground. Cable shields are usually connected to ground.

Ground isn't always negative. A power supply marked -9V, as in an op-amp circuit, could consist of a battery with the negative terminal connected to that point and the positive terminal grounded. If the circuit shows +9V, -9V, and ground, it usually means that two batteries or the equivalent are involved, connected in series with the midpoint grounded.

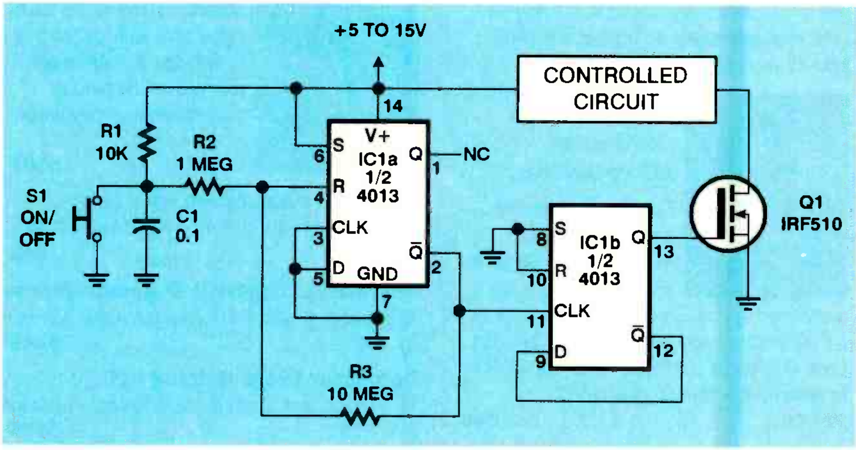

FIG. 2—HERE'S THE PUSH-ON, PUSH-OFF circuit that was originally published in the April 1998 installment of this column.

Push-On, Push-Off, Again...

Q *In the "Push On, Push-Off" circuit in your April 1998 column (and reprinted here as Fig. 2), the last paragraph states, "A disadvantage of the circuit is that you can't predict the state of the flip-flop when power is first applied."*

I think you can force IC1b into the reset state with an RC delay circuit (see Fig. 3). While the capacitor charges, the reset pin is held high by the charging current; then the resistor holds the reset pin low so the flip-flop can function normally. When power is turned off, the diode rapidly discharges the capacitor to protect the IC, and the series resistor, R5,

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Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www.motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online. Extensive information about how to repair consumer electronic devices and computers can be found at www.repairfaq.org.

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

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

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

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1994 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

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Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, PO Box 549, Tooele, UT 84074.

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

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

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

limits the current applied to the reset pin under power supply transient conditions—Charles Hansen, Tinton Falls, NJ

A Thank you very much for a reliable, conservatively designed circuit modification. Not everyone would have thought of including the diode and R5, which aren't necessary under most conditions but are desirable to keep from overstressing the IC's input protection diodes and thereby make the chip last longer. We checked, and the 4013 data sheet doesn't specify any limits on rise or fall time of the reset signal, so there's no need for a Schmitt trigger or transistor in the reset circuit, as there would be with a microcontroller.

. . . And Again . . .

Q *I'm sending you a simpler push-on, push-off circuit that I've always had good luck with (see Fig. 4). I used a 74C74. The debouncing is done by R1 and C1. From my experience, the Q output is always 0 (low) at power-up.—A. M. DePaz, Globe, AZ*

A Thanks for the circuit; it's a nice example of something that works better than it ought to (so to speak). According to the 74C74 data sheet, the flip-flop won't operate reliably unless the input signal makes the transition from low to high in less than 5 nanoseconds. In your circuit, the transition may or may not be that fast, depending on the impedance of the power supply. Fortunately, the flip-flop is clocked by the capacitor charging (which happens very fast), not discharging (a much slower process).

More importantly, there is no reason to expect the flip-flop to always power up in a particular state, though you may well have found one, or even a whole batch, that are "set in their ways" and happen to work consistently because of a mismatch between transistors on the chip.

As the diagram shows, the set and reset pins of the 74C74 are active low (not high) and are therefore inactivated by connecting them to V+ rather than ground. A similar circuit with a 4013 would work (or not work) about as well, with the set and reset pins grounded.

. . . And Finally!

While researching these questions I came across a completely different way to build a push-on, push-off circuit (see Fig. 5). Two inverter gates make a Schmitt trigger that uses a capacitor for memory as well as debounce. The circuit always powers up with the load turned off, then switches on or off every time you press the button.

This is an adaptation of a circuit by T. J. Byers originally published in *Nuts and Volts*, May 1998. Here's how it works: Positive feedback ensures that the output of the second gate is always either fully "off" or fully "on." The output of the first gate is always in the opposite state.

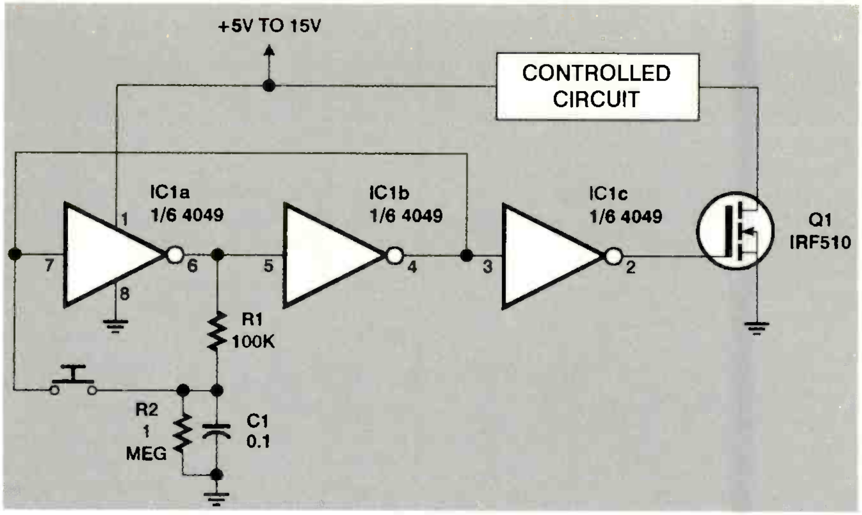

FIG. 5—HERE'S YET ANOTHER push-on, push-off switch. It draws less than one μA of current when in the "off state." Be sure to ground the unused inputs of IC1.

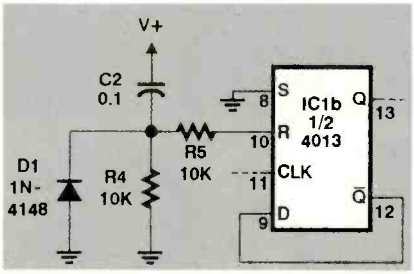

FIG. 3—THIS MODIFICATION TO APRIL'S circuit guarantees that the circuit is off when power is first applied.

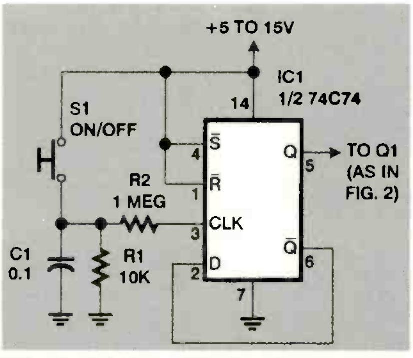

FIG. 4—WHILE UNDER SOME circumstances, the circuit shown here will work as a push-on, push-off switch, it relies on undocumented performance of the flip-flop. Also note that the flip-flop requires a fast-rising input signal.

Resistor R2 ensures that the capacitor will be discharged if the circuit has been off for a while, so at power up, the output of the first gate is low. It stays that way until you press the button and connect the capacitor to the output of the second gate, which is high. Then the Schmitt trigger changes state; the output of the first gate goes high and keeps the capacitor charged. When you press the button again, the point to which you will be connecting the capacitor is now low, so the circuit will change state again. Debouncing is provided by the fact that the capacitor takes some time to charge. Unfortunately, the button is not returned to ground, so the buttons in some keypads are not usable.

While breadboarding this circuit, I learned another way *not* to use a digital multimeter (see Fig. 6). The power supply voltage seemed to be fluctuating strangely, in a stairstep pattern, as the circuit switched on and off. Why? Because my autoranging digital multimeter, set on a low mA range, was changing its resistance as it automatically switched from one range to another. I turned off autoranging and everything was fine again. More tricks of modern technology!

Connecting Two Telephones Together

Q *I have several ordinary telephones like you would find in a house. My daughters enjoy playing with them. Is there any way to connect the phones together so they can actually talk to each other without going through the phone line? Of course I would like them to ring when calling each other.—B. G., Clintwood, VA*

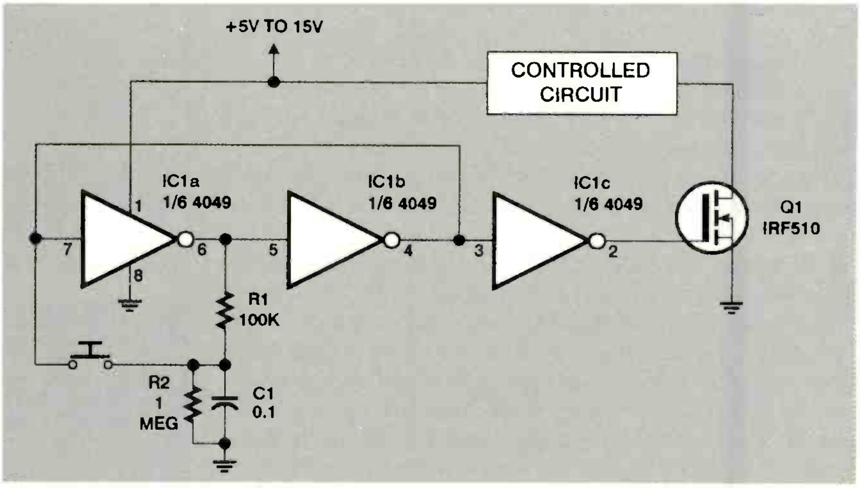

FIG. 6—AS THIS AUTHOR LEARNED from experience, avoid this situation when taking measurements with an autoranging meter. Otherwise, you'll get erratic results caused by changing meter resistance as the unit switches from range to range.

A What you propose is actually a handy way to test telephones. Connect them in series with a 6- to 9-volt battery (see Fig. 7). Current flows only when both phones are off the hook; hanging up either one turns off the circuit. The usual polarity is green positive, red negative (possibly the only place in electronics where red doesn't indicate positive), but very few telephones are sensitive to polarity.

Ringing is the hard part. It requires 90 volts AC, together with a circuit to sense that the telephone is on the hook before applying the ringing voltage. I suggest you set up a separate buzzer for signaling, as the telephone company used to do for telephone intercoms.

Which PIC To Pick?

Q *I'm building the NOPPP PIC programmer in your September issue and don't know which variety of PIC16C84 chip to buy. The types available include PIC16C84-04IP, -04ISO, -04P, -04SO, -10EP, -10IP, -10ISO, -10P, -10SO, and possibly others. The article does not specify which version should be used. Can you tell me which chip to use and where to get one? — M. B., Phoenix, AZ*

A Sorry about the confusion—many ICs, including these, are made in a wide variety of subtypes that are almost completely interchangeable. The differences are explained in the manufacturer's data book.

The most obvious difference is the package; you want the P package (plastic DIP), not SO (surface mount). (Some PICs, though not this one, also come in a JW package, which is a ceramic DIP with a quartz window for UV erasing.)

The second difference is the temperature range; I and E denote extended ranges, and the versions without those letters are cheaper. Finally, there are both 4-MHz and 10-MHz versions of this chip. So the PIC16C84-04P and PIC16C84-10P are the ones to order, the latter only if you need to run the clock faster than 4 MHz.

Many distributors' catalogs explain these differences, at least briefly. Digi-Key (701 Brooks Ave. South, Thief River Falls, MN 56701; Tel: 800-DIGIKEY; Web: www.digikey.com) has a nice set of catalog pages that will help you pick the right PIC; they sell the chips at reasonable prices with no minimum order. You can also get the most common PICs from Jameco (1355 Shoreway Road, Belmont, CA 94002; Tel: 650-592-8097; Web: www.jameco.com) and many other suppliers.

Audio Clean-Up Software Found

In the September issue, a reader asked about software to remove scratches and noise from old audio recordings that have been digitized using a sound card. Richard Dzick, N8MQU, advises us that such a feature is included in the deluxe edition of Adaptec Easy CD Creator. The new tool is called "CD Spin Doctor." The basic edition of Easy CD Creator, without the audio clean-up software, is bundled with many CD-R drives. Adaptec, Inc., can be contacted at 691 South Milpitas Boulevard, Milpitas, CA 95035; Tel: 408-945-8600; Fax: 408-262-2533; Web: www.adaptec.com They also supply cables for linking your stereo to your computer, as well as many other input-output products.

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PS Form 3526, September 1995 (Reverse)

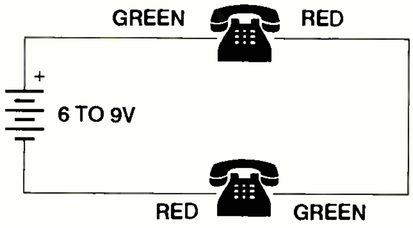


FIG. 7—IF ALL YOU WANT TO DO IS TALK over two telephones, this simple set-up can be used. Polarity, while indicated here, is not critical. Note that the phones will not ring using this circuit; the easiest way around that is to use a separate buzzer circuit.

That's not all. Art Givens recommends Cool Edit Pro, by Syntrillium, and Sound Forge, by Sonic Foundry. Syntrillium can be reached at P.O. Box 62255, Phoenix, AZ 85082-2255; Tel: 602-941-5327; Web: www.syntrillium.com Sonic Foundry's address is 754 Williamson Street, Madison, WI 53703; Web: www.sonicfoundry.com Both companies sell software online.

Finally, Greg Johnson, of Mount Vernon, IL., recommends Ray Gun, from Arboretum Systems, 75 Aura Vista, Pacifica, CA 94044; Tel: 650-738-4750; Web: www.arboretum.com A demonstration version of the program can be downloaded from their web site.

Writing to Q&A

As always, we welcome your questions. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication) and give your full name and address (we'll only print your initials). If you are asking about a circuit, please include a complete diagram. Send your letters to Q&A, **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735. Sorry, but due to the volume of mail we receive, it is not possible to give personal replies. EN

BY JEFF HOLTZMAN
COMPUTER EDITOR

Hard Disk Upgrades

CONSIDER THE FOLLOWING SITUATION: LOW DISK SPACE AND LAGGING PERFORMANCE ON A 180-MHZ PENTIUM PRO SYSTEM WITH 64 MB OF RAM. THE SYSTEM IS USED PRIMARILY FOR SOFTWARE DEVELOPMENT UNDER A VARIETY OF OPERATING systems, including DOS 6.2, Windows 3.1, Windows 95, Windows 98, Windows NT 3.51, and Windows NT 4.0. The collection of operating systems is spread across three IDE hard drives mounted in plug-in cartridges, primarily to accommodate isolated test environments for the several operating systems. The main drive also uses the excellent System Commander to boot multiple operating systems.

Here are the possible solutions: 1) Buy a new machine, and reinstall everything. The only problem here is the high cost and the huge time drain. 2) Add a hard disk to the primary controller and use it as secondary storage, leaving the existing drives as is. 3) Add new drive as primary storage and continue using existing drives as operating system (OS) plug-ins.

The best solution, at least in my eyes is the last: I obtained a fast new hard-disk, a new controller, and some utility programs; installed it; transferred everything on the main drive to the new drive; disabled the old main drive; and continued to use the plug-ins as is. That was the approach that let me get back to real work as quickly as possible.

Components

The components of this upgrade consisted of the hard-drive cartridges, the new hard disk, the controller, and several utility programs. The cartridges came from CyberGuys, distributor of all sorts of useful, interesting, and sometimes cute computer accessories. The cover of their catalog says "Wholesale Catalog," but the company is happy to sell in small quantities to people like us. CyberGuys has great prices on slim-line cable adapters, printer stands, and all sorts of things. The company also has the lowest-price removable hard-drive system I've seen. For IDE, the fixed unit costs about $18, and the cartridges about $12. SCSI units are available at slightly higher prices. These are not the most rugged units I've seen; I wouldn't use them in a commercial airliner, for example. But for low-volume use in a "friendly" environment, they're fine.

For years, IDE lagged SCSI in performance by a considerable amount. Recently, however, the gap has been closing; competitive drives have been introduced by numerous manufacturers (though for overall performance, flexibility, expandability, and compatibility, SCSI remains king). I selected a 10-GB unit, part of the Deskstar GXP series made by IBM. And yes, you can actually have more than 8.4 GB in a single partition, as shown in Fig. 1.

Average seek time of the GXP series is rated at 9.5 ms, although I measured 7.7 ms. The big news is that rotation speed is 7200 rpm, and that translates into a big performance boost over the 5400 rpm units in common use today—theoretically, 33% better performance. Practical results come close to the ideal. For example, time to boot and log the test machine on the network improved about 30%. Faster drives are available—10,000 rpm—but quite a bit more expensive. Currently, 7200 rpm hits the sweet spot on the price/performance curve.

Handling data at the increased DTR (Data Transfer Rate) requires an Ultra IDE interface. That in turn required a new controller. (Some newer motherboards have built-in Ultra IDE support; check your documentation to be sure.) I selected the Ultra33 made by Promise Technology. It is possible to run an Ultra IDE drive off a standard IDE interface, but performance will be limited to the maximum supported by that interface: 16.7 MB/sec vs. 33 MB/sec under Ultra IDE.

The Ultra33 is widely available for under $70. Under DOS and Windows 3.1, the Ultra33's on-board BIOS provides full performance and access to drives greater than 8 GB. Under Win95, Win98, and NT, a driver is required. Driver updates are easily accessible from the company's Web site. The Ultra33 can function in addition to or instead of the on-board IDE controller, for a maximum of eight IDE devices (master and slave devices each on the primary and secondary channels of the motherboard and Ultra33 controllers). With no boot device connected to the motherboard controller, the Ultra33 can boot your system.

I've written here in the past about a program called PartitionMagic, from PowerQuest. The company also makes DriveImage, a special utility program used to clone disk partitions from one physical drive to another. In the simplest case, DriveImage can literally clone one drive to another, optionally resizing partitions along the way. You can also use the program to create and save a partition image as a regular disk file, and later "restore" that image to the same or

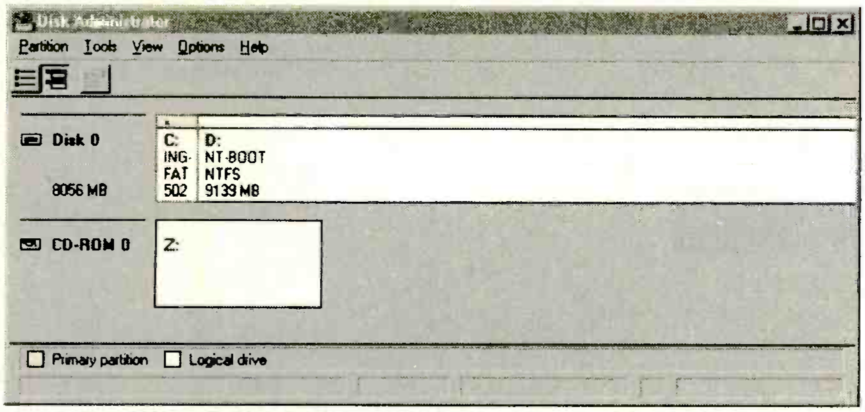


FIG. 1-YES, NINE GB IN A SINGLE PARTITION really is possible. The Promise Ultra33 provides a data-transfer rate up to 33 MB/sec, and has BIOS support for large drives under DOS and Windows.

LISTING 1-SAMPLE BOOT.INI

```
[boot loader]
timeout=4
default=multi(0)disk(0)rdisk(0)partition(2)\WINNT
[operating systems]
multi(0)disk(0)rdisk(0)partition(2)\WINNT="Windows NT Workstation Version 4.00"
multi(0)disk(0)rdisk(0)partition(2)\WINNT="Windows NT Workstation Version 4.00
[VGA mode]" /basevideo /sos
C:\="MS-DOS"
```

another drive. DriveImage is powerful and easy to use. It costs about $70 and can be purchased directly from the company's Web site.

I love DriveImage. However, $70 is a bit steep for one-time use. In addition, the license allows use on only one machine. PowerQuest needs to revamp its pricing and license structures to correspond to the way the product is actually used. On the other hand, PowerQuest also sells a program called DriveCopy for about $30 that only does disk-to-disk copying. DriveCopy is intended for one-time disk upgrades like that discussed here.

Before using DriveImage, I tried a program called Ghost, which performs a similar function, although it is primarily aimed at corporations wishing to clone large numbers of systems simultaneously over a network. Despite having heard good things about Ghost, I was unable to get it to work; it repeatedly crashed with various error messages. However, Symantec recently bought the company, so I would expect the bugs to be cleaned up and a better pricing and licensing scheme instituted. A "Pro" version of DriveImage competes more directly with Ghost.

The Process

The upgrade process involves installing the new controller and drive, cloning the old drive to the new, and then reconfiguring the system to boot from the new drive. The Initial hardware installation is simple: Insert the Ultra33 into an empty PCI slot, and connect the new hard drive to the primary channel of the new controller with a standard IDE cable. At this point you should be able to see the drive using FDISK or the Disk Administrator under NT. Note: You don't need to create or format any partitions prior to using DriveImage; in fact, doing so would be a waste of time.

Under Win95, Win98, or NT, you need to install the driver before disabling the original drive. Otherwise you may not be able to boot, or you may not see the whole drive (i.e., anything over 8.4 GB).

Next, boot to DOS, and use DriveImage to clone the old drive to the new. Regardless of which operating system(s) you run, you must run DriveImage from DOS. With DriveImage, you can copy one or more partitions, optionally resizing any or all in the process. The program has a step-by-step Wizard-based interface; most options are explained well. It's quite easy to use; and if you change your mind or make a mistake, as long as you don't do anything to the original drive, you can always just start over.

The amount of time it takes depends on several factors, including the number of partitions being copied, the amount of data on each, and verification options set within DriveImage. I found I could clone well over 1 GB of data in about an hour.

The third step is to disable the on-board controller or remove the original drive. At that point you should be able to boot from the new drive. If you only boot from drive C—the first and primary (and possibly only) partition—and run any Microsoft OS other than NT, you should be in business. If you boot from another drive (under NT, OS/2, or some version of UNIX), you may have to tweak things to be able to boot. Let's look at what we are talking about in the case of NT.

Tweak for NT

While enabling and disabling the various hard drives, NT may get confused about where the boot partition is located. NT stores that information in a text file called BOOT.INI in the root directory

TABLE 1-DATA TRANSFER RATE COMPARISON

Drive	Controller	DTR (kb/s)	Average Seek Time (ms)
IBM 371010	Ultra33	28565	7.7
Seagate ST31277A	Ultra33	12925	10.4
Seagate ST31277A	Internal	7857	10.3
Western Digital Caviar AC21600H	Ultra33	1378	9.1
Western Digital Caviar AC21600H	Internal	8033	9.5
Quantum XP31070W	2940UW	16281	9.2
Fujitsu M2954S-512	2940UW	965	8.6
IBM 34560	2940UW	31605	7.9

FOR MORE INFORMATION

CyberGuys
Tel: 800-892-1010
Web: www.cyberguys.com

IBM
Web: www.ibm.com/harddisk

PowerQuest
Tel: 801-226-8977
Web: www.powerquest.com

Promise Technology
Tel: 408-452-1180
Web: www.promise.com

of drive C (the first physical partition of the first physical drive). When it boots, NT presents a menu of options, depending on which operating system(s) you had installed on the drive before installing NT. Typically, you might see options to boot DOS, NT in normal mode, and NT in VGA mode (which parallels the "safe" mode of Win95).

BOOT.INI normally has the hidden, read-only, and system attributes set, so to edit it you must issue a command like the following:

```
C:\>attrib -h -r -s boot.ini
```

When you're through, to be safe, return those attributes to their default states:

```
C:\>attrib +h +r +s boot.ini
```

Internally, BOOT.INI looks something like what's shown in Listing 1; depending on where, what, and how you boot, your mileage may vary. In the file, the values within parentheses specify the drive and partition where each bootable OS recognized by Windows resides. In particular, the value for partition(n) may change. I had to manually edit BOOT.INI several times to enable NT to boot (part of that involved installing a CD-ROM writer, which in turn changed drive lettering and partition assignments).

Another point is that the PowerQuest programs in general understand a lot about disk formats under DOS and all versions of Windows, and that includes the new FAT32 format native to Win98. They also seem to be pretty intelligent about NetWare, but I have no experience with that. Their understanding of UNIX is minimal, so although they can do sector-by-sector disk copies, most of their speed and robustness advantages are lost. So if you run Linux, BSD, or some other UNIX—beware.

(Continued on page 23)

EQUIPMENT REPORT

PROTEK SCOPE CARD 220 PC-BASED OSCILLOSCOPE

If you already have a PC, you can also have a digital storage oscilloscope for very little money when you install this versatile add-on card .

CIRCLE 15 ON FREE INFORMATION CARD

As any regular reader of **Electronics Now** could tell you, an oscilloscope is one of the most important pieces of test gear one can have. That's why many readers of this magazine already own an oscilloscope. For those who don't, the chief reason is their high cost. Even a basic 10 or 20 MHz analog scope could easily run $500.

Well, if you already own a personal computer, and most of you do, there is a less expensive alternative—the Protek Scope Card 220. Even better, what you'll have is not a simple analog unit, but a digital storage oscilloscope, or DSO. Among their advantages, DSOs can store information and waveforms for you, so taking down measurements with a pencil and pad is eliminated.

If you are worrying that you'll need to have the latest Pentium II powerhouse running Windows 98 or NT to use the Scope Card 220, don't. In fact, anything from a 486 on up will work just fine. So, if you have a long-since replaced 486 sitting in your closet, you can combine it with the Scope Card and get a great DSO for just $230. You won't even need to buy scope probes, as the unit comes with two sets. Let's look at some details.

The Scope Card 220

The Scope Card 220 is a dual-channel, 20-megasample per second digital oscilloscope that takes the form of an ISA expansion card for any 486 and up PC. Software is provided for Windows 95 only, which should not be a problem for most. We installed the card under Windows 98, and that went quite smoothly.

While most 486 or higher computers will do nicely, there are some minimum requirements that must be observed. The Scope Card 220 requires VGA graphics, and you'll probably want to have at least 16 megabytes of memory to run Windows 95, as required by the software. Ten megabytes of disk space is also needed.

The benefits of tying an oscilloscope to a personal computer are many. For example, captured waveforms are instantly stored in RAM and can even be logged to disk. What's more, a computer's processing power makes short work of plotting of data, with hard-copy readouts readily available from any Windows-compatible printer.

The Scope Card 220 comes with "virtual oscilloscope" software that places the test instrument readout and controls on-screen. That powerful software allows multiple boards to operate together. Simultaneous data acquisition from up to 16 channels with sampling rates up to 20 megasamples per second (20MS/s) is possible. Signals and system setups can be saved for future access. The 8-bit ISA card has two BNC scope inputs and an external trigger input.

Maximum input voltage is 300 volts, with auto setup for signals from 30Hz to 2MHz, $35V_{pp}$ maximum. Input protection is diode-clamped with input impedance at 1 megohm. The card can trigger off Channel 1, Channel 2, or the external trigger input. Time per division can be set from 50ns/div. to 0.5s/div., with the display set for Channel 1, Channel 2, Dual, or Add. Volts per division can be set from 50mV/div. to 5V/div. An X-Y mode is provided, and the grid on the display can be turned on and off. The software allows placement of cursors on various parts of waveforms to provide accurate digital readouts of signal measurements. A Scroll mode display, which lets the unit function like a chart recorder, can be set in six ranges from 10 seconds up to an hour.

Limitations

The Scope Card 220 makes a great audio troubleshooting and analyzing tool, and it's especially well-suited for schools that already have PCs. It is also good for long-term data recording and analysis that's simple and affordable.

However, there are some limitations you should be aware of. The Scope Card 220's practical bandwidth is only 4 megahertz (MHz), or even just 2 MHz depending on how you look at it. With a maximum sampling rate of 20 MS/s, you end up with only 10 samples per cycle of a 2 MHz signal and only 5 samples (the bare minimum) at 4 MHz. So even though the unit technically is a DSO, you can't necessarily troubleshoot digital circuitry with it.

The worst thing about this product is its instructions, or lack thereof. Weak help comes in the form of poorly translated text files on the CD-ROM and related help files in the software. Nowhere does it even mention which of the BNC inputs is which. The documentation is also unnecessarily confusing so avoid using it.

That's not as much of a problem as it sounds. Anyone familiar with PCs will have no trouble installing the card and running the install software. It is also quite easy to get the card to work, and the virtual controls are intuitive to use for anyone that has already used an oscillo-

(Continued on page 23)

Prototype

Wearable Computer Helps Detectives Collect All The Evidence

Computers are playing an ever increasing role in law enforcement. One new application is to increase the efficiency and accuracy in collecting, identifying, tagging, and storing evidence at the scene of a crime. Researchers at the Department of Energy's Pacific Northwest National Laboratory working with Mnemonic Systems Inc. are developing the Team Leader. This is a portable computer system designed specifically for use in the field to prevent contaminating or compromising evidence during collection. This is critical because even a tiny slip-up can make the difference between a criminal being convicted or going free.

HERE AN INVESTIGATOR WEARING THE TEAM LEADER computer on a waistband enters information on a wrist-worn keyboard. A small display screen and microphone is worn on the headband.

A Wearable Computer

The heart of the Team Leader is a Xybernaut Corporation *Mobile Assistant* "wearable" computer. The rugged, weatherproof, IBM-compatible personal computer is belt-worn. A tiny, head-worn display screen, attached microphone, and voice controller frees both hands to work with the evidence. The Team Leader has a variety of data collection tools with accompanying software. These include digital video and still cameras, voice recorder, bar-code scanner, and several specialized sensors. Data can also be entered manually using a small wrist-worn keyboard.

Team Leader's sophisticated capabilities include the ability to capture and use satellite images, terrain features, architectural drawings, site plans, and other information to precisely pinpoint the location of evidence as required for a thorough investigation. Useful here is the latest in geographical information systems (GIS) together with global positioning, multi-media computing, and communication technologies.

The Team Leader can also function as a portable crime library with access to volumes of stored or online information, such as maps; facility floor plans; crime and criminal databases; reports; forms; investigation protocols; and scientific, technical and legal reference material. The user can also easily access off-site computers, printers, and fax machines.

At The Crime Scene

At complex crime scenes, up to eight Team Leaders could be operated by investigators who could exchange information and communicate simultaneously. The Team Leader can be used for voice and video conferencing.

As evidence is collected, each item can be digitized, "tagged" with an assigned bar code, and the data transferred immediately to an evidence custodian. Using the bar code, it could be recalled months or even years later such as during a trial. Acquired information is sent back to "headquarters" by fax, e-mail, or wireless local area network (LAN) lines.

As one example, detectives at a murder scene could use the Team Leader while tracking the route of the suspect to create a very precise and detailed map of the scene. If a murder weapon is discovered, investigators could link the evidence to its geographical position with laser measurements and positional data, take still and video pictures, and document detailed audio and text notes to record a complete story that could later be used in court.

Because of the variety of tools available and the on-line capability, one person can do the work of a whole team of investigators. Fewer people on the scene not only reduces the manpower required to complete an investigation, it also means less chance of inadvertent evidence contamination from fingerprints, footprints, hair, fiber, or other sources besides the person who committed the crime.

The Team Leader features a modular design so it can be easily customized for a variety of applications. For example, Pacific Northwest and Mnemonic, with guidance from the National Forensic Science Training Center, are customizing versions of the Team Leader for a range of law-enforcement and forensic applications. The technology and hardware could be adapted for use in search and rescue, disaster recovery and relief, hazardous material cleanup, and fighting fires.

Another important aspect of the research is establishing the standards and criteria by which digital evidence is accepted by the U.S. criminal justice system. Here the researchers are working with the FBI, American Society of Crime Laboratory Directors, and others. They are also working with the law-enforcement and forensic communities to establish and equip Team Leader with specific directions or protocols for processing crime scenes. These protocols could set an industry standard.

After the Team Leader is field tested by police departments in Baltimore, Miami (Metro-Dade) and Los Angeles, Mnemonics will be marketing a commercial version of the product. This should occur by early 1999.—**By Bill Siuru**

PT

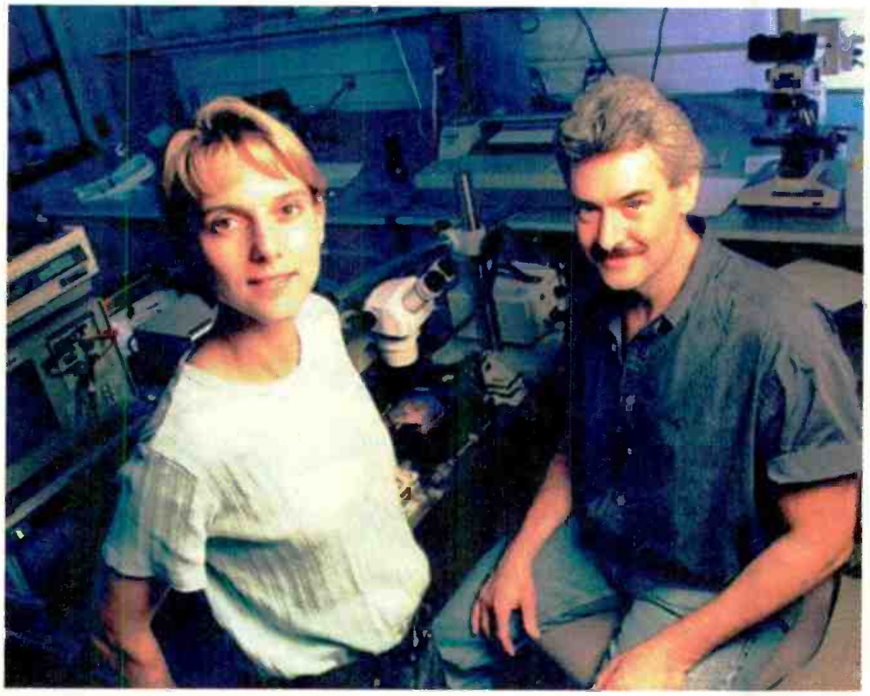
FOR MORE INFORMATION

Pacific Northwest National Laboratory
PO Box 999
Richland, WA 99352
Web: www.pnl.gov

Xybernaut Corporation
12701 Fair Lakes Circle
Suite 550
Fairfax, VA 22033
Web: www.xybernaut.com

Mnemonic Systems Incorporated
2001 L Street, N.W., Suite 1000
Washington, DC 20036

Low-Cost Lasers



DR. DENNIS DEPPE AND DR. DIANA HUFFAKER and their team created a semiconductor laser using quantum-dot technology.

Using a new technology known as "quantum dots," engineers at the Microelectronics Research Center at The University of Texas (UT) at Austin have created a semiconductor laser. The quantum-dot technology allowed the engineers to use gallium arsenide to create the 1.3-micron laser wavelengths in high demand by industry.

Currently commercial lasers that work at 1.3 microns are made from iridium phosphide that is not only ten times more expensive, but also less heat tolerant. The 1.3-micron wavelength allows optical fibers in telephone lines to transmit much more information over long distances, and maintains truer sound and images in high-speed data applications such as the Internet.

"Because of the significant cost savings, the telecommunications industry has been pushing hard for a gallium arsenide laser that operates at this wavelength," said Dr. Dennis Deppe, associate professor of electrical and computer engineering.

Using quantum dots to create the lasers is a relatively new approach. Also known as "artificial atoms" because they have an electronic structure similar to natural atoms, the quantum dots are tiny clusters of semiconductor material that trap electrical charges. As the trapped charges lose their energy, they emit light, which can be used in high-speed lasers. Deppe, Dr. Diana Huffaker, and their research team found that by engineering the quantum dots, which are 20,000 times smaller than the diameter of a human hair, they could increase the laser wavelengths of gallium arsenide to record levels.

Incorporating the same technology last year, Deppe's group collaborated with Dr. Joe Campbell, a UT professor of electrical engineering, to use quantum dots to create the detector for this type of laser. "To bring fiber interconnects to businesses, homes and computers, we needed inexpensive, gallium arsenide lasers that until recently did not exist at this wavelength, and until now did not perform well," said Deppe. "With both the laser emitter and detector demonstrated in the laboratory, the technology can become a reality. An especially important application to obtain low cost will be the Vertical Cavity Surface Emitting Laser, or VCSEL, a device that is very difficult to make using iridium-phosphide technology."

Bar code scanners, digital video discs, and read/write CDs also use VCSELs. Because of the longer wavelength, a variation of the quantum-dot laser technology can also become important when future computer chips use light instead of wires to transmit information from chip-to-chip, noted Deppe. The laser is estimated to be at least two years from commercial production. PT

Chaos-Based Computing Paradigm

A revolutionary computing technique uses a network of chaotic elements to "evolve" its answers. This "dynamics-based computation" may be well suited for optical computing. "This is a glimpse of how we can make common dynamic systems work for us in a way that's more like how we think the brain does computation. It's an entirely new computing paradigm," stated Dr. William L. Ditto, professor of physics at the Georgia Institute of Technology.

The system has so far demonstrated an ability to handle a wide range of common operations, including addition and multiplication, as well as Boolean logic and more sophisticated operations such as finding the least common multiplier in a sequence of integers.

Ditto and collaborator Sudeshna Sinha of the Institute of Mathematical Sciences in Madras, India devised an experiment to see if a simple network of chaotic computer elements could be made to handle computations. They joined the chaotic elements into a lattice using an adaptive connecting mechanism that would open whenever an element exceeded a certain critical value. The mechanism was designed so that the researchers could set a wide range of critical values to vary the connection between elements.

Using a variety of different techniques, the researchers encoded values into the chaotic lattice. They then stimulated the elements to begin interacting. Elements containing values above the critical level triggered the connecting mechanism, allowing the excess value to "avalanche" into neighboring elements, which led to additional avalanches in other connected elements. With additional stimulation, the domino effect continued until the imbalance was conducted out of the system—as the answer to the mathematical problem.

For example, values of three and four would be encoded into a system set with a critical value of one. The values would create an imbalance that would avalanche through the chaotic elements until it was conducted out of the system—as the value of seven.

Chaotic elements are useful to this system because they can assume an infinite number of behaviors that can be used to represent different values or different systems, such as logic gates. This flexibility allows a single generic system to perform a variety of computations. In conventional computing, systems are more specialized.

"We are not really setting up rules in the same sense that digital computers are programmed," Ditto explained. "We...let the dynamics do the work of finding a pattern that performs the desired operation.

"There are a surprisingly large number of ways that the system can perform the computations and give you the answer," he added. "By slightly changing the connectivity and the parameters of the chaotic system, we can have it multiply several different ways through the system's self organization. It might be better than digital computing for activities that digital computing doesn't do very well—such as pattern recognition or detecting the difference between two pieces of music."

Ditto believes the new system would work particularly well in optical systems. "Potentially, we could simulate a very fast system of coupled lasers to perform a highly complicated operation like very fast arithmetic operations, pattern detection, and Fourier transforms," he explained. "We have something that very naturally performs an operation in an optical system. This would provide an alternative to existing efforts, which try to make optical systems do operations more like transistors."

A number of engineering issues may hamper development of a practical system based on this computing paradigm. But Ditto notes that in their early days, digital computers had to overcome daunting obstacles to overtake earlier techniques. PT

Biosensor Bacteria

Bacteria that eat pollutants have been adapted to create live bacterial biosensors that detect and signal the presence of phenol pollution. Phenols are a family of harsh pollutants widespread in the manufacture of dyes, photographic chemicals, wood preservatives, and pesticides.

The reporter bacteria are modified so that instead of making digesting enzymes when they contact complex phenols, a protein in the bacteria produces an easy-to-observe and -measure signal. These biosensors can indicate the presence of eight of the priority pollutant phenols listed by the Environmental Protection Agency. Further research may lead to the design of proteins to detect other chemicals. PT

World's Smallest Hard-Disk Drive

IBM recently unveiled the world's smallest and lightest hard-disk drive with a disk platter about the size of a large coin. Although IBM's new microdrive weighs less than an AA battery, it can hold over 200 times more data or images than a floppy disk.

With its small size and high-performance, the microdrive can bring high-capacity storage to almost any handheld digital device. It is ideally suited for use in companion PCs, GPS navigation systems, cellular phones, and still and digital video cameras. Digital photographers can now take more photos before having to download the stored images. They can also take higher resolution "megapixel" photos more economically.

Microdrive fits into a CompactFlash Type II slot, an increasingly popular standard that has already been built into handheld devices made by companies such as Canon, Inc. Microdrive can be used with a standard PC card adapter if a device does not have this slot.

Unlike other portable storage formats such as flash memory, microdrive uses hard-disk-drive technology to store information. Compared with similarly sized flash memory cards, the 340-MB microdrive device has a much lower cost per MB

IBM's microdrive will allow for data to be shared among different handheld devices, for example, a notebook computer, digital camera, and printer. Or a companion PC user could easily carry additional data and software programs on a business trip with the vast amount of storage offered by microdrive.

Microdrive is expected to stimulate the invention of new devices. Since the advance hard-drive technology is so small, it could fit almost anywhere—even in a wristwatch-sized device for storing phone numbers or schedules.

It will be available in mid-1999 on retailer shelves or directly from IBM. Further technical and application information can be found at IBM's hard-drive Web site: www.ibm.com/storage/microdrive PT

WITH A DISK PLATTER ABOUT THE SIZE of a large coin, IBM's new microdrive can hold over 200 times more data or images than a floppy disk.

Refrozen Food Detector

If frozen food thawed while being transported cross-country, was then refrozen, and you bought it, how would you know the food wasn't fit to eat? Perhaps by a color change in an inexpensive thaw indicator placed in the package.

The indicator, originated and patented at Sandia, changes color when its temperature rises above 32 degrees F. The color doesn't change back if the temperature then drops below freezing, says Sandia researcher David Martinez.

The invention, a byproduct of a solar research project, depends upon an inexpensive "smart" material—a thin wire that "remembers" multiple shapes and acts as a sensor. Using no power source except warming or cooling, the wire changes shape markedly and powerfully at appropriate temperatures. When warmed, movement of the wire tears a colored green paper to reveal the red color underneath. When cooled, the wire returns to its prior position but because the paper is torn, the warning color remains visible.

Martinez and co-developer Mo Shahinpoor of the University of New Mexico have developed eight preliminary designs, all patented, in which a smart-material sensor exposes a color-coded paper. The wire actuators utilize nitinol, a smart material consisting of nickel and titanium.

Manufactured by the thousands or millions, the crucial elements in the design—a wire about the size of a piece of thread less than $^3/_8$-inches long—would cost "pennies for the raw materials," says Martinez. "When there's pressure from Washington on food processors, transporters, and displayers to protect consumers against spoiled food, we have a technology patented to do just that." PT

LCDs + UV = Innovation

Recently, the development of an innovative process that promises to greatly increase production yields of Liquid Crystal Displays (LCDs) was announced by The MicroDisplay Corp. This form of non-contact alignment uses UV light directed from a laser, which could revolutionize the production of both standard and miniature LCDs.

Traditional LCDs are basically large glass sandwiches, filled with liquid crystal. Microdisplays replace one of the glass "slices" with silicon. The industry standard LCD manufacturing process for liquid crystal alignment uses velvet cloth, which causes the greatest yield loss due to high probabilities of contamination, mechanical damage, or damage due to electrostatic discharge.

Experiments have been conducted in recent years to replace the mechanical rubbing process with non-contact alignment, sometimes called UV rubbing. MicroDisplay's non-contact alignment process replaces the velvet with a precisely controlled laser beam of UV light. This alignment process works by subjecting the panes to holographic exposure: directing two coherent beams of UV light at the panes of the display. Because the panes were coated with a chemical that reacts very predictably to the carefully regulated laser light, this exposure produces the alignment of liquid crystal material required by LCDs.

According to Xiaodong Wang, Senior Research Engineer at the MicroDisplay Corp., "Non-contact alignment is particularly significant in the production of miniature displays. For example, because the pixels of a miniature display are so small, one speck of dust can ruin more than one pixel. By removing the rubbing cloth from the process, non-contact alignment promises to virtually eliminate the occurrence of these contaminants by keeping the displays in a sterile environment throughout production." The MicroDisplay Corp. has filed a patent to cover this innovative UV rubbing process. Experiments are currently under way to prove the viability of the process in the production of both standard and miniature LCDs. PT

BY SAM GOLDWASSER
SERVICE EDITOR

Monitor Safety, CRTs, and Adjustments

THIS MONTH WE WILL CONTINUE OUR DISCUSSION OF COMPUTER AND VIDEO MONITORS. FIRST OFF, WE'LL COVER THE EXTREMELY IMPORTANT SAFETY INFORMATION AND WARNINGS. WHILE YOU HAVE PROBABLY SEEN A SET OF GUIDELINES similar to these in our series on microwave oven repair, it never hurts to repeat them. Then, we'll move on to CRT basics, degaussing, and monitor adjustments.

Safety

TVs and computer or video monitors are among the more dangerous of consumer electronics equipment when it comes to servicing. In case you are wondering, microwave ovens are probably the most hazardous due to high voltage at flesh frying and cardiac arresting high power. There are two areas that have particularly nasty electrical dangers: the non-isolated line power supply and the CRT high voltage.

Major parts of nearly all modern TVs and many computer monitors are directly connected to the AC line—there is no power transformer to provide a safety barrier and/or to minimize the risk of equipment damage. In the majority of designs, the live parts of the TV or monitor are limited to the AC input and line filter, degauss circuit, bridge rectifier and main filter capacitor(s), low voltage (B+) regulator (if any), horizontal output transistor and primary side of the flyback (LOPT) transformer, and parts of the startup circuit and standby power supply. The flyback generates most of the other voltages used in the unit and provides an isolation barrier so that the signal circuits are not line connected and safer. Higher quality monitors use a separate switch-mode power-supply, limiting non-isolated circuitry to the supply's input (the deflection/flyback runs off isolated DC).

The high voltage to the CRT, while 200 times greater than the line input, is not nearly as dangerous for several reasons. First, it is present in a very limited area of the TV or monitor—from the output of the flyback to the CRT anode via the fat HV wire and suction cup connector. If you don't need to remove the main board or replace the flyback or CRT, then leave it alone and it should not bite you. Furthermore, while the shock from the HV can be quite painful due to the capacitance of the CRT envelope, it is not nearly as likely to be lethal since the current available from the line-connected power supply is much greater.

Safety Guidelines

These guidelines are to protect you from potentially deadly electrical shock hazards as well as to protect the equipment from accidental damage. Note that the danger to you is not only in your body providing a conducting path, particularly through your heart, but that any involuntary muscle contractions caused by a shock, while perhaps harmless in itself, might cause collateral damage—there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe! With that in mind, here we go:

- Don't work alone—in the event of an emergency another person's presence may be essential.
- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.
- Wear rubber bottom shoes or sneakers.
- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current or get caught in moving parts.
- Set up your work area away from possible grounds that you might accidentally contact.
- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the AC line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment!
- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks—plastic or wood.
- If you need to probe, solder, or otherwise touch circuits with power off, discharge the large power-supply filter capacitors. If you are removing the high

voltage connection to the CRT (to replace the flyback transformer, for example) first discharge the CRT contact (under the suction cup at the end of the fat HV wire). See below for more details on these procedures.

- For TVs and monitors in particular, there is the additional danger of CRT implosion—take care not to bang the CRT envelope with your tools. An implosion will scatter shards of glass at high velocity in every direction—there are several tons of force attempting to crush the typical CRT. While implosion is not really likely even with modest abuse, why take chances? However, the CRT neck is relatively thin and fragile, and breaking it would be very embarrassing and costly. Always wear eye protection when working around the back side of a CRT.
- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to reach locations.
- If you must probe live circuits, put electrical tape over all but the last $^1/_{16}$-inch of the test probes to avoid the possibility of an accidental short that could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.
- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.
- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac is not an isolation transformer! The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea, but it will not protect you from shock from many points in a line-connected TV or monitor, or the high-voltage side of a microwave oven, for example. A fuse or circuit breaker is too slow and insensitive to provide any protection for you or, in many cases, your equipment.
- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool—deductive reasoning—will not be operating at full capacity.
- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

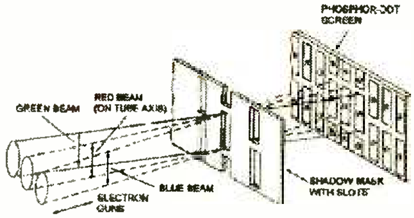


FIG. 1—COLOR CRTs USED IN VIDEO monitors and TV sets have a shadow mask or aperture grill located a fraction of an inch behind the phosphor screen to direct the electron beams for the red, green, and blue video signals to the proper phosphor dots.

Dealing with Capacitors

It is essential—for your safety and to prevent damage to the device under test as well as your test equipment—that large or high voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line-operated equipment store a potentially lethal charge.

This doesn't mean that every one of the 250 capacitors needs to be discharged every time you power off and want to make a measurement. However, the large, main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found after powering off (or before any testing—the CRT capacitance in a TV or video monitor, for example, can retain a dangerous or at least painful charge for days or longer!)

Use a suitable power resistor rather than a screwdriver to do the dirty work. Why? There are three reasons: 1) It will not destroy screwdrivers and capacitor terminals; 2) it will not damage the capacitor (due to the current pulse): and 3) it will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

As far as values, for the main capacitors in a TV or monitor power supply, which might be 400 µF at 200V, use a 5000-ohm, 10W resistor. For the CRT, use a several megohm resistor rated at 30KV or more (or a string of lower value resistors to obtain this voltage rating). A $^1/_4$-watt unit will just arc over! Discharge to the chassis ground connected to the outside of the CRT—**not signal ground on the main board** as you could damage sensitive circuitry. The discharge time needed is short—a millisecond or so. However, repeat a few times to be sure, then use a shorting clip as these capacitors have a way of recovering a painful charge if left alone.

Finally, when discharging capacitors, it is obviously vital to make sure that you are well insulated. And always double check that the capacitor has indeed been discharged before beginning your work.

Tools, Test Equipment, Troubleshooting Tips

These topics were covered in depth in numerous previous "Service Clinic" columns. If you do not have your back issues of **Electronics Now**, you can find the information at my Web site (www.repairfaq.org). Look for the document titled "Troubleshooting and Repair of Consumer Electronics Equipment."

Color CRTs

All color CRTs use a shadow mask or aperture grill located a fraction of an inch ($^1/_2$-inch typical) behind the phosphor screen to direct the electron beams for the red, green, and blue video signals to the proper phosphor dots (see Fig. 1). Since the electron beams for the R, G, and B phosphors originate from slightly different positions (individual electron guns for each) and thus arrive at slightly different angles, only the proper phosphors are excited when the purity is properly adjusted and the necessary magnetic field free region is maintained inside the CRT.

The shadow mask consists of a thin steel or InVar (a ferrous alloy) sheet with a fine array of holes—one for each trio of phosphor dots—positioned about $^1/_2$-inch behind the surface of the phosphor screen. With some CRTs, the phosphors are arranged in triangular formations called triads with each of the color dots at the apex of the triangle. With many TVs and some monitors, they are arranged as vertical slots with the phosphors for the 3 colors next to one another.

An aperture grille, used exclusively in Sony Trinitrons (and now their clones as well), replaces the shadow mask with an array of finely tensioned vertical wires. Along with other characteristics of the aperture grille approach, this permits a somewhat higher possible brightness to be achieved and is more immune to other problems like line-induced *moiré* and purity changes due to local heating causing distortion of the shadow mask.

However, disadvantages include a heavy structure, higher price, a cylindrical screen (though this may be considered an advantage depending on your preference), and 1, 2, or 3 fine horizontal stabilizing wires (depending on screen size) which may be objectionable or unacceptable for certain applications.

Degaussing

Degaussing might be required if there are color purity problems with the display. On rare occasions, there might be geometric distortion caused by magnetic fields, but no associated color problems. The CRT can become magnetized if the TV or monitor is moved or even just rotated, there has been a lightning strike nearby, a permanent magnet was brought near the screen (*e.g.*, kid's magnet or megawatt stereo speakers), or some piece of electrical or electronic equipment with unshielded magnetic fields is in the vicinity of the TV or monitor.

Degaussing should be the first thing attempted whenever color purity problems are detected. First try the internal degauss circuits of the TV or monitor (always present though they could be faulty) by power cycling a few times (on for a minute, off for 20 minutes, on for a minute, *etc.*). If this does not help or does not completely cure the problem, then you can try manually degaussing.

Commercial CRT Degaussers are available from parts distributors like MCM Electronics and consist of a hundred or so turns of magnet wire in a 6- to 12-inch coil. They include a line cord and a switch. You flip on the switch, and bring the coil to within several inches of the screen face. Then you slowly draw the center of the coil toward one edge of the screen and trace the perimeter of the screen face. Then return to the original position (with the coil being flat against the center of the screen). Next, slowly decrease the field to zero by backing straight up across the room as you hold the coil. When you are farther than 5 feet away, you can release the line switch.

The key word here is *slow*. Go too fast and you will freeze the instantaneous intensity of the 50/60 Hz AC magnetic field variation into the ferrous components of the CRT, and could make the problem worse.

It looks really cool to do this while the CRT is powered. The kids will love the color effects (but then lock your degaussing coil safely away so they don't try it on every TV and monitor in the house!).

Bulk tape erasers, tape-head degaussers, open-frame transformers, and the tail-end of a soldering gun can be used as CRT demagnetizers, but it just takes a little longer. (Be careful not to scratch the screen face with anything sharp.) It is imperative to have the CRT running when using those "wimpier" approaches, so that you can see where there are still impurities. Never release the power switch until you're 4 or 5 feet away from the screen or you'll have to start over.

Keep degaussing fields away from magnetic media. It is a good idea to avoid degaussing in a room with floppies or back-up tapes. When removing media from a room, remember to check desk drawers and manuals for stray floppies, too.

Preventive Maintenance

Preventive maintenance for a monitor is pretty simple—just keep the case clean and free of obstructions. Clean the CRT screen with a soft cloth just dampened with water and mild detergent or isopropyl alcohol. This will avoid damage to normal as well as antireflection coated glass. DO NOT use anything so wet that liquid may seep inside of the monitor around the edge of the CRT. You could end up with a very expensive repair bill when the liquid decides to short out the main circuit board lurking just below.

In really dusty situations, periodically vacuuming inside the case and the use of contact cleaner for the controls might be a good idea, but realistically you will not do this so don't worry about it.

Getting Inside

Before we continue, it is important to note that by removing the rear cover of a monitor you will void the warranty—at least in principle. There are usually no warranty seals on a monitor, so unless you cause visible damage or mangle the screws or plastic, it is unlikely that this would be detected, but the decision to go ahead is yours to make. Of course, a monitor still under warranty should probably be returned for warranty service for any covered problems except those with the most obvious and easy solutions. Another advantage of using warranty service is that should your problem actually be covered by a design change, a related repair will be performed free of charge, and, you cannot generally fix a problem that is due to poor design!

Opening up a monitor is usually quite simple, requiring only the removal of 2 to 10 Philips or $^1/_2$-inch hex head screws; these will mostly be around the edge of the cabinet, though some could be underneath and perhaps in the rear. Set the screws aside and make notes if they are not all of the same length and thread type—putting a too-long screw in the wrong place can short out a circuit board or break something else.

Once all visible screws are out, try to remove the cover. There still may be hidden catches or snaps around the edges or seams, or hidden beneath little plastic or rubber cosmetic covers. Sometimes, the tilt-swivel base will need to be removed first.

As you pull the cover straight back (usually) and off, make sure that no other wires are still attached. Often, the main circuit board rests on the bottom of the cover in some slots. Go slow as this circuit board may try to come away with the back. Once the back is off, you may need to prop the circuit board up with a block of wood to prevent stress damage and contact with the work surface.

Once the cover is removed, most—but not all—monitors can be safely rested either on a still-attached tilt-swivel base or on the bottom of the frame. However, some will require care as the circuit board will be vulnerable.

Larger monitors are quite heavy and bulky. Get someone to help, and take precautions if yours is unstable when the cover is removed. If need be, the monitor can usually safely be positioned on the CRT face if it is protected by foam or a folded blanket.

Once the cover is off, you'll see something resembling what is shown in Fig. 2. One thing you'll find is anywhere from none to a frustratingly large number of perforated and/or solid sheet-metal shields. Depending on which circuit boards need to be accessed, one or more of those shields may need to be removed. Make notes of which screws go where and store them in a safe place. However, manufacturers often place holes at strategic locations in order to access adjustments—check for these before going to a lot of unnecessary bother. Note: sheet metal usually has sharp edges. Take care.

Monitor Adjustments

In the next sections we'll discuss the use of the controls accessible to the user (and often not understood) as well as internal adjustments that may need to be touched up due to the aging of components or following a repair. There's a lot to do, so lets get to it.

User Picture Adjustment

For general viewing, subdued lighting is preferred. Avoid backlighting and direct overhead lighting if possible.

Display an image with a variety of colors and the full range of brightness from deep shadows to strong highlights. For PCs, a Windows desktop is generally satisfactory. An outdoor scene on a sunny day is excellent for studio monitors. Alternatively, use a test pattern specially designed for this purpose.

Turn the brightness and contrast controls (or use the buttons) all the way down. Increase the brightness until a raster is just visible in the darkest (shadow) areas of the picture and then back off until it just disappears. Increase the contrast until the desired intensity of highlights is obtained. Since the brightness and contrast are not always independent, go back and forth between the adjustments until you get the best picture.

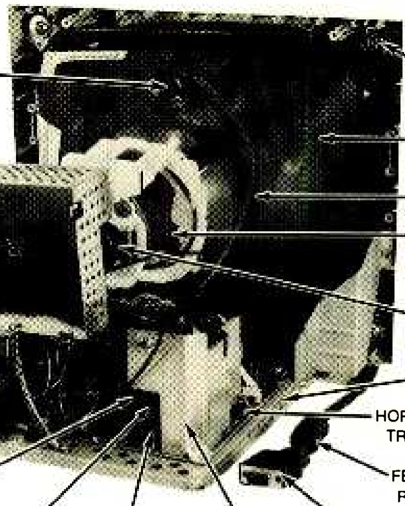


FIG. 2—HERE'S A LOOK INSIDE a typical computer monitor. The key adjustments, boards, and other items you'll find in most units are identified.

Focus Adjustment

One of the most common complaints is that the monitor is not as crisp as it used to be—or just not as sharp as expected. Assuming that the focus has just been gradually getting worse over time, tweaking the internal focus control may be all that is needed to correct this.

Some monitors have the focus adjustment accessible through a (possibly unmarked) hole in the side or rear of the case. If there is a single hole, it is almost certainly for overall focus. If there are two holes, one may be the screen (G2—master brightness) or the two adjustments may be for different aspects of focus.

Better monitors will have H and V focus controls. There may be both static (more-or-less uniform in all areas of the screen) as well as dynamic focus (compensates for changing distance to electron guns at the edges and corners of the screen). The most sophisticated schemes use a microprocessor (or at least digital logic) to specify the waveform for each section of the screen with a map of correction values stored in non-volatile memory. You might need a custom adapter cable and PC software to adjust values for these!

Brightness and Color Balance

A monitor that has a picture that is too dark or too bright and cannot be adequately set with the user brightness and contrast controls could need internal adjustment of the screen (the term, screen, here refers to a particular electrode inside the CRT, not really the brightness of the screen you see, though it applies here), master-brightness, or background-level controls. As components age, including the CRT, the brightness will change, usually decreasing. The following procedure will not rejuvenate an old CRT but may get just enough brightness back to provide useful functionality for a few months or longer. If the problem is not caused by the age of the CRT, then it may return the monitor to full brightness.

The controls might be located on the flyback transformer, CRT neck board, or main board. In some cases, they are accessible without removing the cover.

Display a black and white picture at the video resolution you consider most important. Select one that has both full blacks and full whites—a nice sunny outdoor scene that has been converted from a color image, for example. Set the user brightness control to its midpoint and the user contrast control as low as it will go—counterclockwise.

Let the monitor warm up for at least 15 minutes so that components can stabilize. If there is a master-brightness or background-level control, use it to make the black areas of the picture just barely disappear. Then, increase it until the raster lines just appear. (They should be a neutral gray. If there is a color tint present, then the individual color background controls will need to be adjusted to obtain a neutral gray.) If there is no such control, use the master screen control on the flyback (usually the bottom potentiometer).

If there are individual controls for each color, you may use them, but be careful as you will be affecting the color balance. Adjust so that the raster lines in a black area are just visible and are a dark neutral gray.

Now for the gain controls: On the little board on the neck of the CRT or on the video or main board, there will be controls for R, G, and B drive (also may be called gain or contrast—they are the same). The knobs or slots may even be color coded as to which primary (R,G,B) it affects. If there are only two, then the third color is fixed and if the color balance in the highlights of the picture was OK, then there is nothing more you can do here.

Set the user contrast control as high as it will go—clockwise. Now adjust each internal color drive control as high as you can without that particular color "blooming" at very bright vertical edges. You may need to go back and forth among the three drive controls, since the color that blooms first will limit the amount that you can increase the contrast settings. Set them so that you get the brightest neutral whites possible without any single color blooming.

Note that this is ignoring the effects of any beam current or brightness limiter circuitry. Any recommendations in the service manual should be followed to minimize the chance of excess X-ray emissions, as well as to avoid burn-in of the phosphor screen.

Now check out the range of the user

controls and adjust the appropriate internal controls where necessary. You may need to touch up the background levels or other settings. Check at the other resolutions and refresh rates that you normally use.

If none of this provides acceptable brightness, then either your CRT is in its twilight years or there is something actually broken in the monitor. If the decrease in brightness has been a gradual process over the course of years, then it is most likely the CRT.

Position and Size Adjustments

Position and size are usually user controls on computer and video monitors, but not on TVs. On monitors with digital controls, they might usually be set for each resolution and (automatically) stored in non-volatile memory so they will be retained when the monitor is turned off. On cheaper monitors, there may be knobs on the front or back panel that might need to be readjusted whenever the scan rate/resolution is changed. Sometimes, the adjustments are located internally. There may be separate adjustments for each scan range, and those may or may not be accessible through holes in the back panel.

There might also be an adjustment called horizontal phase, which controls the relative timing of the horizontal-sync pulse with respect to retrace. Its effect is subtly different than horizontal position, which actually moves the raster. If possible, center the raster and then use horizontal phase control to center the picture.

Size can be set to your preference for each scan rate (if they are independent). For computer work, slight underscan is often preferred as all of the frame buffer is visible. However, any slight geometric problems with the raster will be all too visible when compared with the straight sides of the CRT bezel.

Note that resolutions like 640 × 480, 800 × 600, and 1024 × 768 all have a 4:3 aspect ratio. The edge of the image will line up with the bezel on most if not all monitors, since CRTs are made to a 4:3 aspect ratio. However, resolutions like 1280 × 1024 and 1600 × 1280 have a 5:4 aspect ratio. With those, in order to get (highly desirable) square pixels, the horizontal size must be adjusted slightly smaller than that required to fill the screen.

Of course, parameters controlling your video card also affect position and size. There is no best approach to reconciling the effects of monitor and video-card position adjustments. But, in general, start with the monitor controls centered within their range or use the memory defaults as appropriate. Then, use the video card setup program to optimize the settings. Only if these do not have enough range should you use the monitor controls.

Pincushion Adjustments

Horizontal pincushion refers to any bowing in or out on the vertical sides of the raster. There is not usually any explicit vertical pincushion adjustment. Adjustment usually uses two controls—amplitude and phase. Pincushion amplitude, as its name implies, controls the size of the correction. Pincushion phase affects where on the sides it is applied. Don't expect perfection.

If the controls have no effect, there is probably a fault in the pincushion correction circuitry. It is best to make these adjustments with a crosshatch or dot test pattern

CRT Purity and Convergence

Purity assures that each of the beams for the three primary colors—R, G, B (red, green, and blue)—strikes only the proper phosphor for that color. A totally red scene will appear pure red and so forth. Symptoms of poor purity are blotches of discoloration on the screen. Objects will change shades of color when they move from one part of the screen to another. There may even be excess non-uniformity of pure white or gray images.

Convergence refers to the control of the instantaneous positions of the red, green, and blue spots as they scan across the face of the CRT so that they are as nearly coincident as possible. Symptoms of poor convergence are colored borders on solid objects or visible separate R, G, and B images of fine lines or images,

The first thing to do here is to cycle power on and off a couple of times to degauss the CRT (1 minute on, 20 minutes off). If the built in degaussing circuits have no effect, use an external manual degaussing coil to be sure that your problems are not simply due to residual magnetism. For more on degaussing, see the appropriate section earlier in this column.

Space does not permit us to cover the detailed procedures for purity and convergence adjustments here. More details are provided at my Web site (www.repairfaq.org), but my general recommendation would be to leave it alone unless these problems are severe—it is very easy to make things worse.

Tilted Picture

You have just noticed that the picture on your monitor is not quite horizontal—not aligned with the front bezel. You also might notice some keystoning or other geometric distortion as well, where the top and bottom (or left and right) edges of the picture are not quite parallel—it might have always been there; you just never have noticed it until now. There are several possible causes for a tilted picture:

- Monitor Orientation: The horizontal component of the earth's magnetic field affects this slightly. Therefore, if you rotate the unit you may be able to correct the tilt. Of course, best results could occur when the monitor faces the wall! Also, other external magnetic fields can sometimes cause a rotation without any other obvious effects—have you changed the monitor's location? Did an MRI scanner move in next door?
- Need for Degaussing: Most of the time, magnetization of the CRT will result in color problems that will be far more obvious than a slight rotation—but not always.
- The Problem Has Always Existed: That means, of course, that nothing has changed: Don't dismiss this offhand. It is amazing how much we ignore unless it is brought to our attention. Are you a perfectionist? Did your friend just visit boasting about his cutting-edge screamer and point the tilt out to you?
- Misadjusted tilt control.
- Deflection Yoke Orientation: The deflection yoke was somehow rotated, or perhaps it was not oriented correctly at the time of the set's manufacture.
- CRT Position: The CRT might have rotated slightly with respect to the front bezel.

Wrap Up

That's all we have space for this month. Next month we will begin discussing actual troubleshooting, starting with low-voltage power supply problems. Until then, check out my Web site, www.repairfaq.org. I welcome comments (via e-mail at sam@stdavids.picker.com) of all types and will reply promptly to requests for information. See you next time! EN

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

"Möbius Circuit" Revisited

When I read the article, "Möbius Circuit" (**Electronics Now**, October 1998), it brought back some childhood memories of a "Magic Trick" that I learned. As I read it through, something seemed incorrect and not as I remembered. I had to try it to refresh my memory.

The article correctly states that cutting around a paper loop with a half twist in it will result in a loop twice the circumference of the original with a full twist in it. It then erroneously goes on to say that cutting around the resulting loop will result in a loop with four times the circumference of the original with more twist in it. The author obviously has not tried this, or he would have found that the result of the second cut would be two loops of the same circumference as the loop resulting from the first cut. These two loops are intertwined and could not be separated except by tearing one of them.

Nonetheless, the article was interesting and informative.

ROBERT F. BLUM
Huntington Station, NY

NOPPP Updates

Here are some further updates for NOPPP, the "No Parts" PIC Programmmer featured in the September 1998 issue. First, the NOPPP software, available from the NOPPP Web page (www.mindspring.com/~covington/noppp), now includes a test mode so you can use a voltmeter to make sure your programmer is wired correctly.

Second, we've heard that some readers have had some problems getting NOPPP to work correctly. Here are some tips that could help:

1. Make sure to tie together all the ground pins (18, 19, 20, 21, 22, 23, 24, and 25) where the parallel port cable connects to the NOPPP circuit; grounding through just one pin may not be enough to prevent crosstalk and glitches.
2. Use a short cable between NOPPP and PC (less than two feet). Some parallel ports will drive a longer cable cleanly: some won't.
3. In a few cases, it may be necessary to replace the 1N914 diodes with germanium diodes (1N34A or equivalent), or even Schottky diodes, to get better logic levels.

Finally, arrangements are being made to market NOPPP as a kit, which will be available from Ramsey Electronics (793 Canning Parkway, Victor, NY 14564; Web: www.ramsey-electronics.com).

MICHAEL A. COVINGTON EN

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

COMPUTER CONNECTIONS

continued from page 11

Results

Table 1 shows overall data transfer rate for several drives of several types connected to various controllers. First I compared performance of several IDE drives connected to both the Ultra33 and the on-board controller. Both the Western Digital and the Seagate drives posted roughly 50% better performance on the Ultra33. For comparison, I also tested several SCSI drives running on an Adaptec 2940UW controller. The IBM SCSI drive was the clear performance leader, followed by the IBM IDE drive.

Operationally, the upgrade produced a noticeable speed improvement, not to mention a greatly augmented space for installing the ever-expanding development tools from Inprise (Borland), Microsoft, Sun, and others. With so much space, I'm looking at some CD-emulation software that allows you to create images of CD-ROMs and access them much faster and more conveniently directly from the hard drive. More later; until then you can stay in touch by writing me at jeff@ingeninc.com. EN

EQUIPMENT REPORTS

continued from page 12

scope. One thing that could hang you up is the fact that two separate install programs must be run: one for the card's Normal mode and another for the Scroll mode. But now that you know about that—thanks to this review!—that should no longer be a problem.

Most installations will involve just a single card, and a jumper block that sets the card's address can be left in the factory-default setting. We found that Windows 98 did not detect the card, but the card worked right after installing the software. If you want to install more than one Scope Card 220, you have to set a unique address for each card you install. Though you won't find a PC with eight free expansion slots, in theory the software allows up to eight cards to work at once.

Not state of the art by an means, the Scope Card 220 is still a very useful troubleshooting tool and learning aid. It also provides functionality that many expensive high-bandwidth oscilloscopes just don't, such as the ability to log data directly to hard disk. If you have an old 486 hidden away somewhere and have been wondering what to do with it, the Scope Card 220 could be the ticket to pulling the computer out of retirement. Otherwise the Scope Card can live unobtrusively in your everyday working PC, coming out to help you troubleshoot circuitry once business is over and hobby time begins.

For more information on the Protek Scope Card 220, contact the manufacturer (Protek, 154 Veterans Drive, Northvale, NJ 07647; Tel: 201-767-7242; Web: www.hcprotek.com) directly, or circle 15 on the Free Information Card. EN

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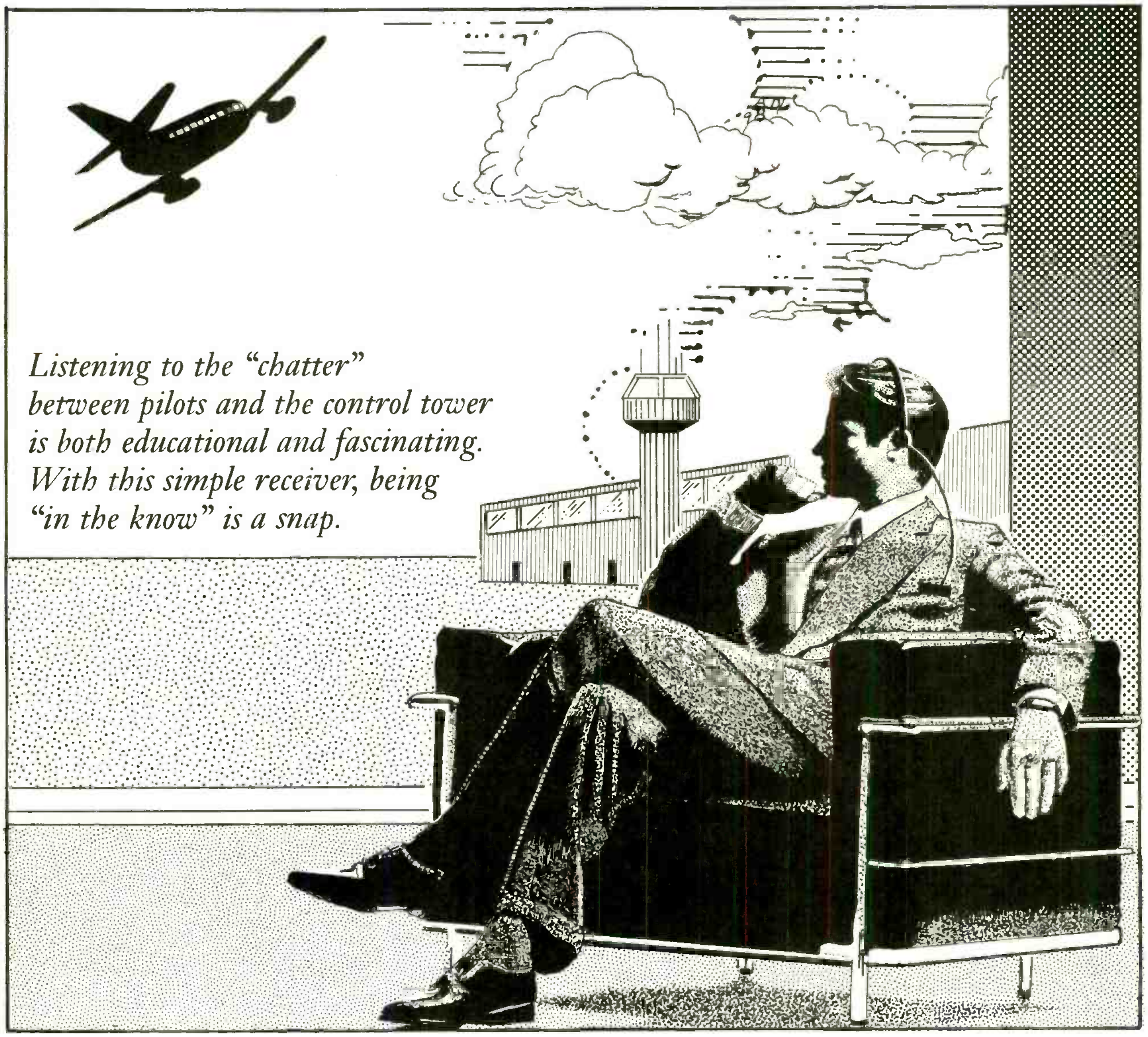
THE AIRPORT BUDDY



Listening to the "chatter" between pilots and the control tower is both educational and fascinating. With this simple receiver, being "in the know" is a snap.

ANTHONY J. CARISTI

If you find yourself spending a lot of time at airports waiting for an outgoing or incoming flight, or if you have an interest in aviation in general, you've probably wondered about the type of communication that occurs between the pilots and the tower. Being "on the inside" has always fascinated people. If you want to be "in the know" in terms of aviation operations, then the Airport Buddy is a must-build project. This low-cost receiver will let you eavesdrop on communications between the control tower and aircraft flying above, and you will be able to keep up with what's going on. Even if you don't have that type of interest in aviation radio, the Airport Buddy will make a unique gift for a friend or relative who does fly frequently.

The Airport Buddy is a one-chip VHF superheterodyne receiver that is easy to build, compact, and small enough to fit into a pocket. It is designed to receive audio communications in the 108- to 135-MHz frequency band, which is used for ground-to-air communications.

The project consists of a small PC board that is powered by a common 9-volt battery and fits in a small case. A pair of headphones is used to hear the received audio signals. A knob-adjustable frequency control (either a single- or a multi-turn type) is used to tune in whatever conversations are taking place at the time. An optional volume control is easily added to the circuit.

Since all of the difficult design requirements of the circuit have been taken care of by a suitable PC board layout, a receiver that works well is easily built simply by following the construction details given here.

How It Works. The schematic diagram for the Airport Buddy is shown in Fig. 1. The heart of the receiver is IC1, a sophisticated IF (intermediate frequency) amplifier chip that contains a mixer, a local-oscillator transistor, and a pair of high-gain IF amplifiers. Also included is a received-signal-strength indicator (RSSI) circuit that is used as an AM detector. The chip also has a built-in FM-quadrature detector; since air-traffic communications use AM instead of FM, it is not used here.

A short piece of wire or a telescoping radio antenna is used to pick up the RF signals. The RF is coupled to the mixer input of IC1 through coupling capacitor C1.

The emitter and base of the built-in local-oscillator transistor appear at pins 3 and 4 of IC1, respectively. The circuit is a Colpitts oscillator, with C3 and C4 forming the voltage-divider capacitor pair that is connected between the ground and the internal transistor's base and emitter. Coil L1 and varactor diode D2 form a parallel-tuned circuit that sets the local-oscillator frequency. Potentiometer R6 is a front-panel tuning control that adjusts the DC bias on D2. That sets the local-oscillator frequency for tuning the radio; it can be varied over the range of about 108 to 135 MHz.

The intermediate frequency of the circuit, 455 kHz, is set by RES1 and RES2. An interesting feature of the Airport Buddy is the lack of RF preselection. That feature lets a received signal appear in two places on the dial. The advantage to that approach is that it becomes easier to find an active communication channel.

Within IC1 is a pair of high-gain IF amplifiers that are designed to provide limiting of the received RF signal. Limiting is needed for FM communications—the original use for the chip. The RSSI circuit mentioned before normally monitors the current drawn by the IF amplifiers. The RSSI outputs a voltage on pin 7 that is proportional to the amplitude of the received signal.

In order to demodulate the AM signal, the local oscillator is tuned either to 455 kHz above or below one of the sidebands of the received signal frequency. Because of that, the RSSI circuit makes a good demodulator for the received AM signals.

The demodulated audio on pin 7 of IC1 is coupled to the gate of Q1 through C8. The amplified signal is then coupled to an external headset through T1.

Power to operate the circuit is provided by a common 9-volt transistor-radio battery. Current draw is about 10 milliamps, giving over 35 hours of use from a new alkaline battery.

The small size of the Airport Buddy's PC board lets the entire unit fit into a small case that can be easily carried in a shirt pocket. Here is the author's prototype. Note that ANT1 is simply a length of insulated wire.

Construction. Because of the high frequencies involved, the Airport Buddy should be built on a PC board. When RF frequencies are involved with any circuit, a double-sided board with a large solid-copper ground plane helps to contain any stray RF radiation from the circuit. Any circuit trace that is carrying a signal in the RF-frequency band

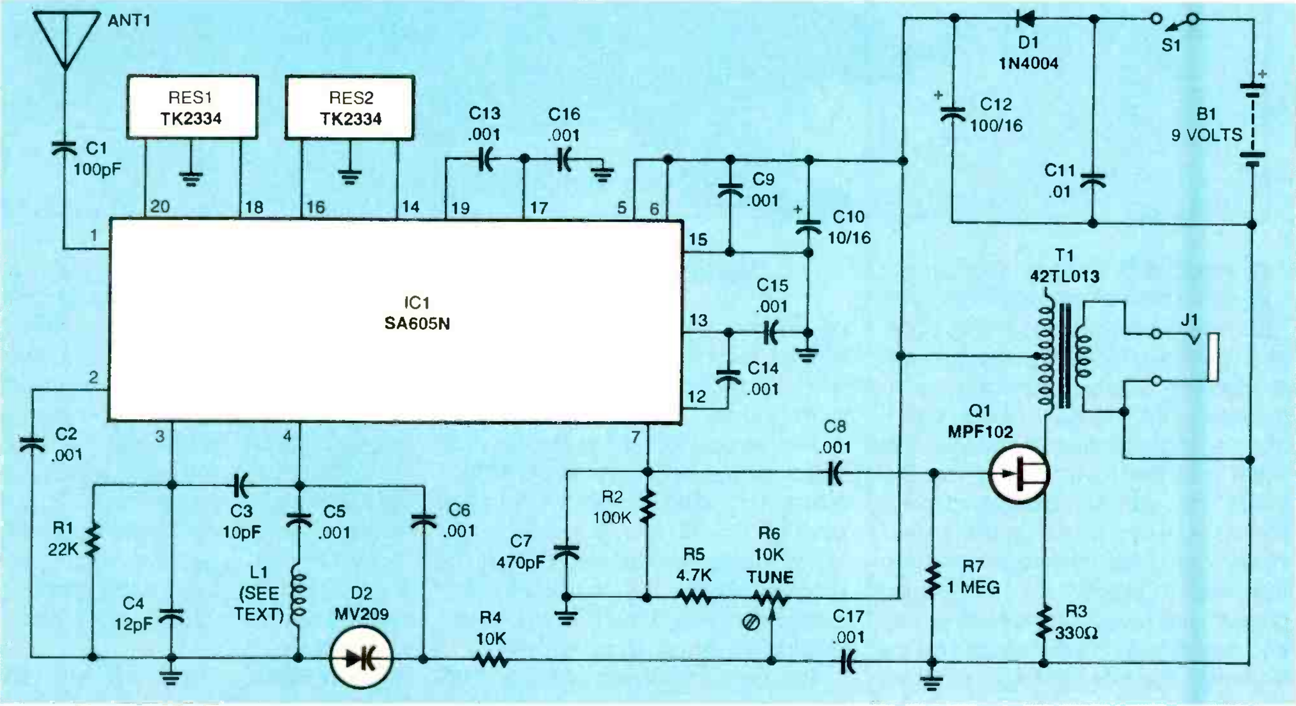


Fig. 1. The Airport Buddy is a simple receiver that is tuned to pick up frequencies used by aircraft. Although IC1 was originally designed to be used in an FM radio, it does a superb job with the AM-style method used by aircraft and airports.

TABLE 1
COMPONENTS GROUNDED TO GROUND PLANE

R1	C11
R2	C15
R3	C16
R5	C17
C2	IC1 pin 15
C4	D2
C7	L1

can act like a miniature broadcast antenna, resulting in the disruption of any other receivers that happen to be close enough to the source of the RF leakage.

Foil patterns for the Airport Buddy have been included. If you do not wish to fabricate your own board, one may be obtained from the source given in the Parts List. If you are going to etch your own board, note that only one foil pattern is needed. That pattern is for the solder side of the board—the component side is left as a single ground plane. An easy way to etch the board is to coat the ground-plane side with resist; common shellac can be used. The other "foil pattern" only shows the locations of the holes that should be cleared of copper ground plane before building the circuit. Use a sharp knife to clear a small amount of copper from around the indicated holes. The component leads that will be inserted into those holes should not touch the ground plane. The other holes that will not be cleared will be used as ground connections on the top side of the board.

The parts-placement diagram shown in Fig. 2 is to be used for locating the various components if you are using a purchased board or one made from the foil pattern. Be sure to double-check the orientation of the polarized components before soldering them in—especially the semiconductors. For example, D2 has an unusual package—it looks like a two-leaded transistor. Note, however, that RES1 and RES2 are *not* polarized. Do not install IC1 or C9 at this time.

Because of the high frequencies involved, keep the lead lengths as short as possible. Before installing T1, use an ohmmeter to measure the resistance of each of the windings. One winding, the primary, will measure about 50 ohms; the secondary will measure about 1 ohm. Mark the windings with a "P" and an "S" to be sure that the transformer is inserted properly into the circuit. The primary of the transformer is driven by Q1; the secondary feeds the earphone jack.

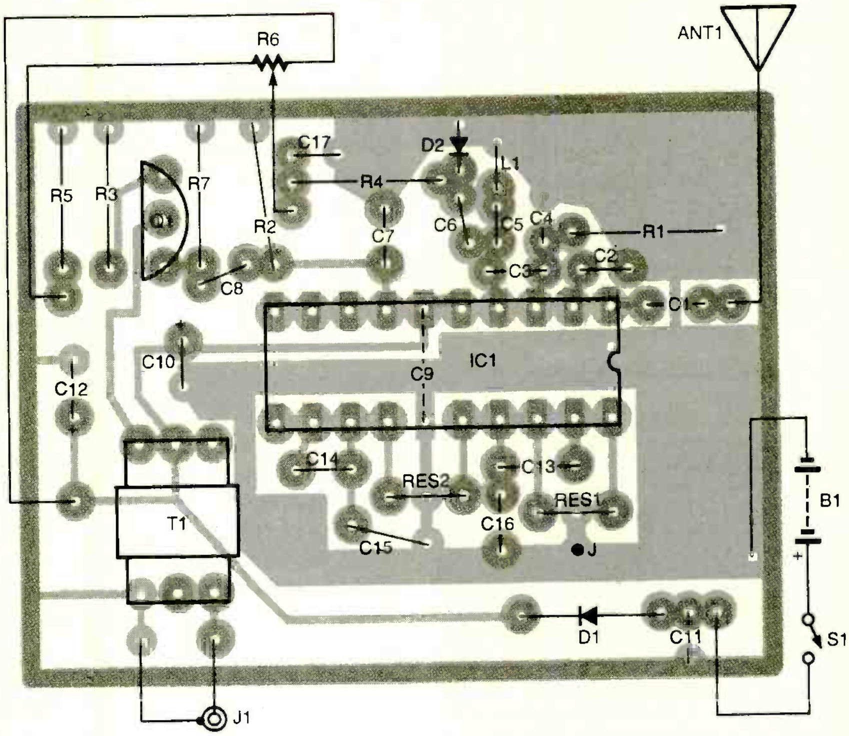


Fig. 2. Here's the parts-placement diagram for the Airport Buddy. Note that C9 is tack-soldered to the solder side of the board between the pins of IC1. Keep the body of C9 flat to the board.

Coil L1 will be made from a piece of solid wire wrapped around a form. Following the dimensions shown in Fig. 3, wrap 3½ closely-spaced turns of insulated 22- or 24-gauge wire around an $^1/_8$-inch-diameter form such as a drill bit. Following the height dimension shown in Fig. 3, insert the coil into the board and solder it in place. The coil can also be made from bare wire; however, the turns should not short out to each other or to the ground plane.

Table 1 lists the components that must have ground connections to the ground plane on the topside of the board as well as the bottom. Additionally, one through-hole wire is used to connect the ground plane to circuit ground; it is located next to RES1.

Once those components have been installed, use an ohmmeter to check the connections of all of the ungrounded components to be sure that there are no short circuits to ground. Carefully examine all of the solder joints—they should be shiny and smooth. Correct any problems now before proceeding.

Check that all of the holes for IC1 on the topside of the board are clear of copper except for pin 15. When IC1 is inserted, none of those

TABLE 2
NORMAL VOLTAGES ON IC1

Pin No.	Voltage
1	1.4
2	1.4
3	5.4
4	6.2
5	6.3
6	6.3
7	0.25*
8	2.1
9	2.1
10	3.7
11	1.7
12	1.7
13	1.7
14	1.7
15	0 (gnd)
16	1.7
17	1.7
18	1.7
19	1.7
20	5.1

* The voltage on pin 7 depends upon signal strength.

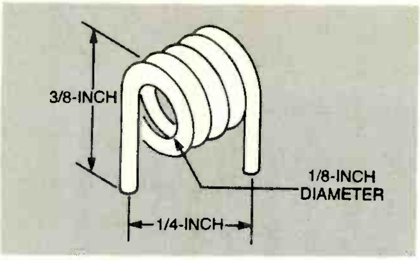


Fig. 3. It is easy to wind L1. Take a 3½-inch length of 22- or 24-gauge insulated wire and wind 3½ turns around a 1/8-inch-diameter drill.

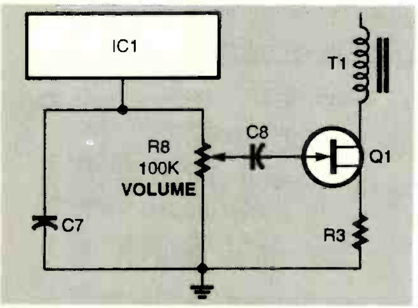


Fig. 4. If you want to add a volume control to the Airport Buddy, simply replace R2 with R8 as shown here. Lift the lead of C8 that would normally be connected to R2 and C7 and connect it instead to the wiper of R8.

pins should be touching the ground plane. Integrated circuits usually have pins designed to sit on top of the hole. If everything looks good, install and solder IC1 into the circuit. Be sure to solder pin 15 on both sides of the board.

Once IC1 has been soldered in place, turn the board over to the solder side. Capacitor C9 is tack-soldered underneath IC1 between pins 6 and 15. The leads of C9 must be cut as short as possible, and the body of the capacitor should lay as flat as possible against the board.

Any small case that can hold the PC board, a 9-volt battery, and the controls will work well. For example, a small case with a built-in battery compartment that fits easily into a shirt pocket can be used. Drill appropriate holes for J1, S1, and R6. You can use a single-turn potentiometer for R6 and draw a dial on the case, but it will be a bit more difficult to tune the Airport Buddy to a particular frequency than if you were to use a multi-turn potentiometer.

An option to consider is that of a volume control. If you want to use that option, which is detailed in Fig. 4, R8 must also be mounted in the case.

An additional hole will be needed for the antenna. The Airport Buddy will work fine with a simple whip antenna made from a length of insulated wire. The hole should be as close to the point on the PC board where the antenna is connected as possible.

As an alternative, a telescoping antenna can be used instead of the length of wire. In either case, the length of the antenna is not critical. Although the ¼-wavelength at the frequencies is about two feet, the receiver will work with 16 inches of wire.

Once the cabinet has been properly prepared and assembled, wire the battery clip and S1 to the circuit. Be sure to observe the correct polarity of the battery clip. If in doubt, use a DC voltmeter and a battery to verify the polarity of the leads. Make the final connections to R6 and J1 as shown in Figs. 1 and 2. Be sure to wire R6 so that clockwise rotation causes the voltage at its wiper to increase. That will give higher received frequencies with clockwise rotation of the knob. If you are going to use a stereo jack for J1, you should connect both left and right together on the jack.

Checkout Procedure. Before connecting B1 to the clip, check all of the wiring thoroughly once more to be sure that it is 100% correct. It is far easier to correct any problems or mistakes now rather than later if you find that the Airport Buddy does not work. Using an ohmmeter, measure the resistance across C12 to verify that there is no short circuit to ground on the main power line. Turn S1 off and clip a fresh alkaline 9-volt battery to the battery connector. Insert a headphone set into the jack. The Airport Buddy will work with any stereo or monaural headphones. However, the volume of the audio is directly proportional to the quality of the headset. Very low-cost headphones are relatively inefficient and will not produce as much volume as higher-quality units. Good headsets are readily available for less than $20.00.

Turn S1 on. You should be able to hear a very soft "white noise" or static as the tuning knob is rotated over its range. If there are any aircraft nearby, you might hear voice communications.

If the receiver is working correctly, you can take your Airport Buddy to an airport and verify that you are able to listen in on aircraft communications. Otherwise, refer to the

(Continued on page 44)

PARTS LIST FOR THE AIRPORT BUDDY

SEMICONDUCTORS

IC1—SA605N intermediate-frequency decoder/demodulator, integrated circuit
D1—1N4004 silicon diode
D2—MV209 varactor diode
Q1—MPF102 field-effect transistor

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—22,000-ohm
R2—100,000-ohm
R3—330-ohm
R4—10,000-ohm
R5—4700-ohm
R6—10,000-ohm, linear-taper potentiometer, panel mount
R7—1-megohm
R8—100,000-ohm linear- or audio-taper potentiometer, panel mount (optional volume control, see text)

CAPACITORS

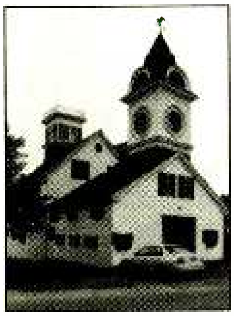
C1—100-pF, ceramic-disc
C2, C5, C6, C8, C9, C13–C17—0.001-µF, ceramic-disc
C3—10-pF, NPO ceramic-disc
C4—12-pF, NPO ceramic-disc
C7—470-pF, ceramic-disc
C10—10-µF, 16-WVDC, electrolytic
C11—0.01-µF, ceramic-disc
C12—100-µF, 16-WVDC, electrolytic, low-leakage

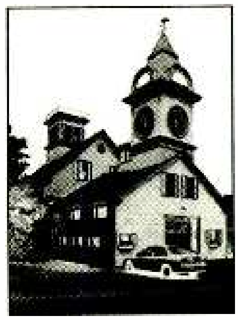
ADDITIONAL PARTS AND MATERIALS

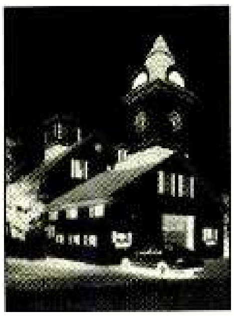
ANT1—Whip antenna, 16–24 inches (see text)
B1—9-volt transistor radio alkaline battery
J1—Earphone jack (stereo or monaural as needed)
RES1, RES2—455-kHz ceramic filter, Digi-Key TK2334
S1—Single-pole, single-throw, toggle or slide switch
T1—1000-ohm to 8-ohm audio transformer (Mouser 42TL013 or similar)
Enclosure (PacTek K-HM-9VB or similar), panel-mount adapter for R6, 9-volt battery clip, tuning knob, headset, hardware, etc.

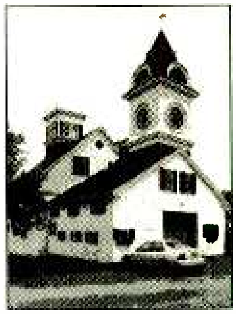
Note: The following items are available from: A. Caristi, 69 White Pond Road, Waldwick, NJ 07463: Etched and drilled PC board, $15.75; IC1, $12.50; D2, $3.00. Please add $5.00 for postage and handling. NJ residents add 6% sales tax.

THE VIDEO PALETTE II: A LOW-COST VIDEO-EFFECTS DEVICE









Fascinated by video effects but can't afford the equipment or time to learn how to use it? Now you can create some basic special effects with this low-cost unit.

WILLIAM SHEETS, K2MQJ AND RUDOLF F. GRAF, KA2CWL

Often in home-video work, some type of special effects would be useful to "liven up" an otherwise dull scene or create a more professional transition between scenes. That, unfortunately, usually means some expensive equipment that costs more than a thousand dollars. You could try using a fast multimedia PC—video-input hardware and huge hard drives are becoming the norm. Hardware is only half of the equation—expensive software packages would then be needed to manipulate the video data along with the time and discipline to learn how to use it. That is often out of the question for a home-video hobbyist on a limited budget. What is needed is a box of some kind that is able to produce a few special effects. It should be low cost and shouldn't need a college course and hours of practice to learn how to use.

The Video Palette II is just what a budding video artist is looking for. It works with a single video source and is a stand-alone device that can do several video effects such as:

Input amplification
Video inversion (negative image)
Posterization ("Cartoon" effects)
Solarization
Fadeout to black, gray, or white
Contrast reduction
Fade between normal and effects with mix
Any of those effects in combination

A number of years ago, the authors published an article describing such a device. The original Video Palette worked well but was somewhat complex, had two PC boards that needed a lot of interconnecting wiring and needed an oscilloscope to set up. Advances in electronics have resulted in a new design. While based on the older system, it is much simpler to build, uses only one PC board, has fewer controls, has an added fade feature, and only needs four simple setup adjustments. No oscilloscope is required, unless you are curious and want to experiment.

A large-scale integration (LSI) sync-separator and sync-generator chip eliminates all of the timing adjustments that the original design had, as well as any drift. It is as close to "plug and play" as an analog circuit of this type can be. Wiring has been greatly simplified by the use of DC-controlled signal switching and by having all of the controls mounted on the PC board. With one

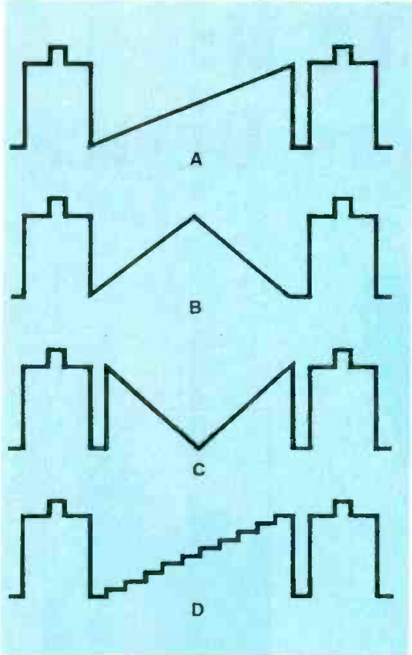


Fig. 1. The difference between solarization and posterization is in how the video waveform is modified. When a normal video signal (A) is solarized, darker hues are brightened at a much greater rate; and the lighter hues are darkened (B). A variation of solarizing is inverse solarizing (C). Posterizing (D) "digitizes" the signal into several discrete steps.

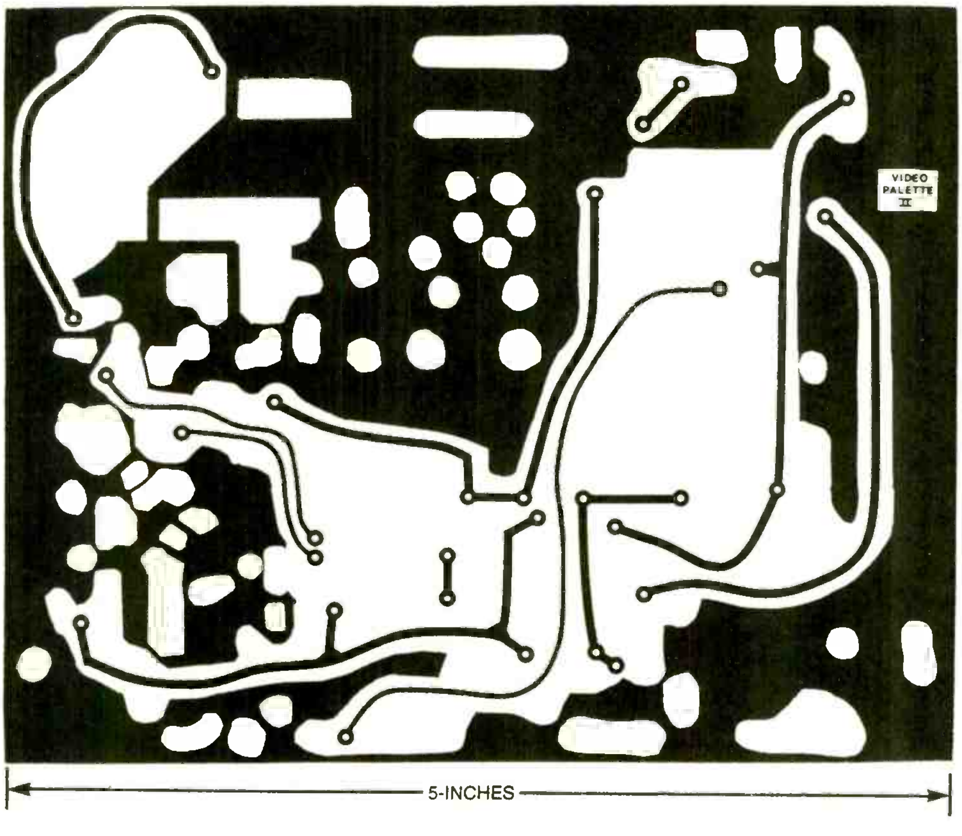
exception (a DPDT bypass switch), all of the mechanical switches are SPST types that either switch a single lead to ground or control AC power. The entire system can be built for around $100 depending on how you package the unit and what parts you have on hand.

A useful device for photography buffs as well as videographers, the Video Palette II can simulate many photographic effects that are commonly produced in a photo darkroom. It can also be used with a video camera and a monitor for inspection and evaluation of photographic negatives. For example, the invert feature can be used to view the positive image from a negative. A low-cost black-and-white video camera that can be fitted with a close-up lens can be used to inspect black-and-white negatives before printing them. A dedicated setup using a standardized light source and a monitor calibrated with an image of a known-good negative can be used as a video analyzer to determine the exposure and the contrast-grade paper required to print an unknown negative. The composition and content of a negative can also be viewed to see if it is worth printing. If you do a lot of printing with 8- by 10-inch paper costing 35 to 40 cents a sheet, you can save a good bit of money in paper and chemicals over the long run, not to mention time and frustration. Color can be accommodated with a color camera and monitor, and a light source that can be fitted with an appropriate filter.

Videographers can use the Video Palette II to generate interesting video effects, to experiment with video signals, or to try out ideas before shooting. It can be used as a tool in editing and production of home videos at low cost, where specialized computer and software is unavailable or too costly, or as an introductory device before investing large sums of money in a more complex system.

Special Effects. One of the most useful effects is inversion, which is simply what the name says that it is—a video signal that has its luminance and chrominance parts inverted. In a sense, inversion is the act of "subtraction from pure white." Therefore, blacks become whites, dark grays become light grays, and so all tonality is reversed. In addition, a similar relationship holds for the individual red, green, and blue components; colors are reversed so that they become their complements. Blue becomes yellow, brown (actually a dark orange) becomes a light blue, pink becomes a dark cyan (blue-green), etc. That happens because both the hue and brightness are inverted, resulting in the complementary color. The inverted image is like an unmasked color-photo negative (clear background instead of the usual orange).

Another effect is *solarization*. Solarization is produced by distorting the



Here's the foil pattern for the component side of the Video Palette II. Be sure to connect all of the holes together between the two sides of the PC board.

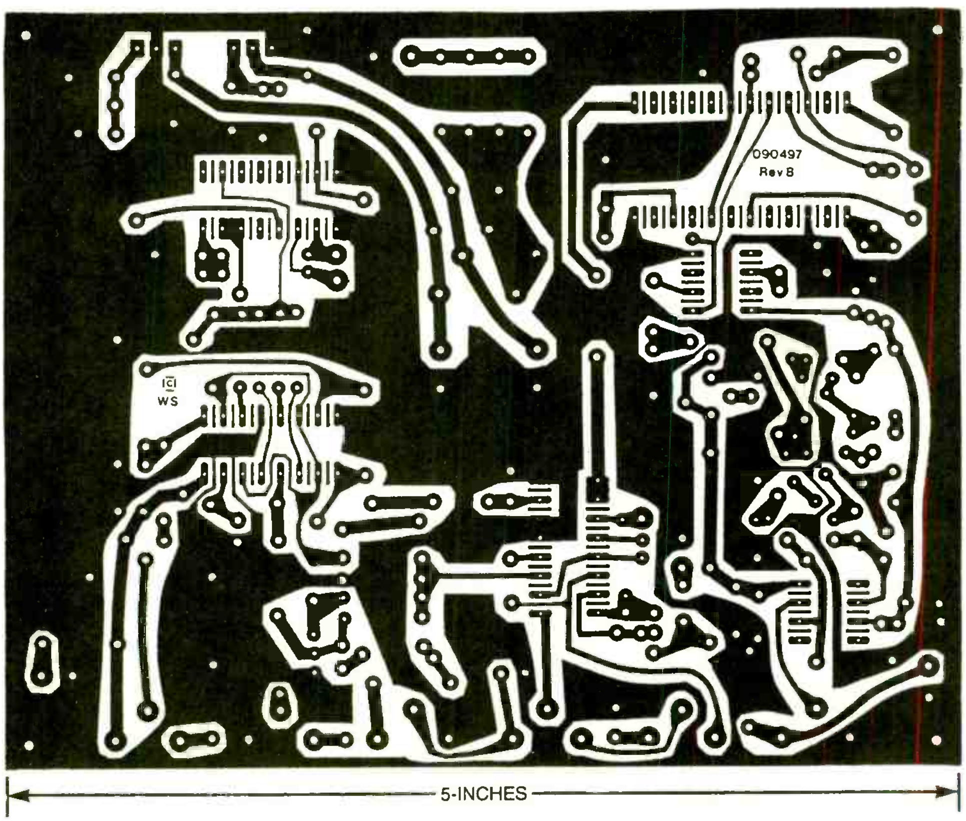
gray scale (luminance) in a non-linear circuit so that it folds back on itself. An illustration of the effect is shown in Fig. 1. Figure 1A shows a single line of a video signal that goes from pure white to pure black. Applying solarization to that signal results in the waveform shown in Fig. 1B. The shape of the response curve of the solarization circuit determines the exact effect, and there is no "right way" or perfect method of doing that. The "idealized" waveform shown would not really produce an esthetically-pleasing effect since most of the midtones (grays) would turn bright white—a chalky, unpleasant effect. The best results come from skewing the curve so that only the highlight or lowlight areas are modified. Sometimes, inverting the video before solarization produces a better effect; that waveform is shown in Fig. 1C. A pleasing effect also depends on the scene—one scene might look better with a different effect setting than some other scene. In working with color signals, the chrominance information is distorted with generally unpredictable results. In practice, solarized video will look better when mixed with some unprocessed video. Again, it is an area where science leaves off and art must take over.

Posterization is the effect of quantizing a video signal into a finite number of discrete levels. For example, if all levels from light gray to white were converted to white, and the middle grays to one tone of gray, and all darker grays to solid black, we would have a video image with only three possible shades: white, medium gray, and black. That gives the appearance of a cartoon drawing or a poster drawn with a very limited color palette. Another example is the "banding" or "pixelated" effect seen on older computers with limited graphics, where only 16 colors could be displayed at any one time. In posterizing, tonality is discarded. The effect, however, is useful in some applications where contrast must be high, such as in line drawings—an extreme example where only solid black and solid white are needed. Other applications include contrast enhancement, such as in text viewing, and in artistic applications. The effect is sometimes used in music videos. As with solarization, posterized video will look better if it is mixed with some unprocessed video.

Fades are done by mixing a DC level and video in various proportions. The DC level determines ultimately what background the video fades to. In the Video Palette II, fades can be to any shade between and including black or white. Fades to a colored background need an internally-generated color subcarrier that is phase locked to the original color burst. That would require extra circuitry that would make the project much more expensive in relation to the added capability. Besides, most fades are done to black. The fade control can also be used to control contrast and brightness for effects purposes.

How It Works. The Video Palette II separates the composite video information from the sync and color-burst components. The video is modified with analog circuitry for the various effects. The sync pulses and color-burst portion of the signal is passed on to the output without any modification. That part of the composite video signal must be preserved since it controls the monitor-sync and color-reference circuits. For example, if inverted video is needed, simply inverting the *entire* composite signal (including sync pulses) will not work; any output monitor will probably not be able to lock onto sync pulses with the wrong polarity, and the DC levels (brightness) will be upset. Also, distorting the video will distort the sync pulses and color-burst.

After processing the video portion of the signal, it is recombined with the sync/color-burst signals and then fed to the output. Effects produced include video inversion, solarization, posterization, and fades to a neutral background (black, grays, or white). The effects can be applied simultaneously in any combination, and the degree of effect



Here's the foil pattern for the solder side of the Video Palette II. Note the large areas of ground plane.

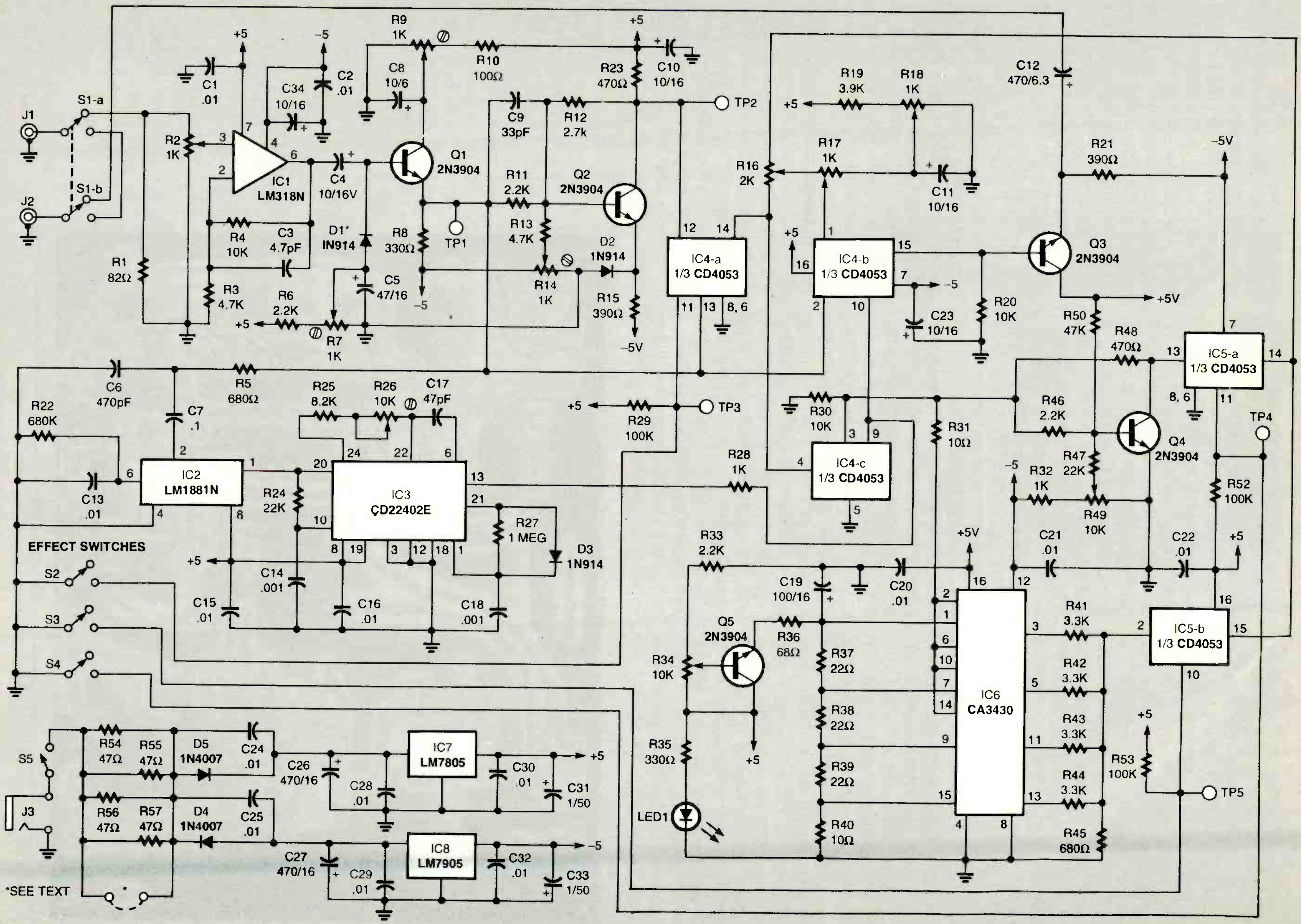


Fig. 2. The Video Palette II uses several circuits to achieve the different effects.

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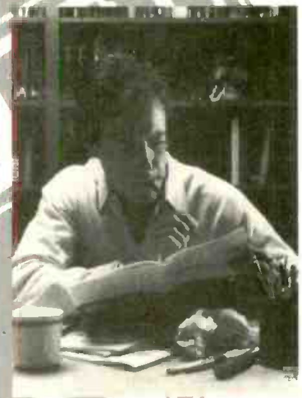

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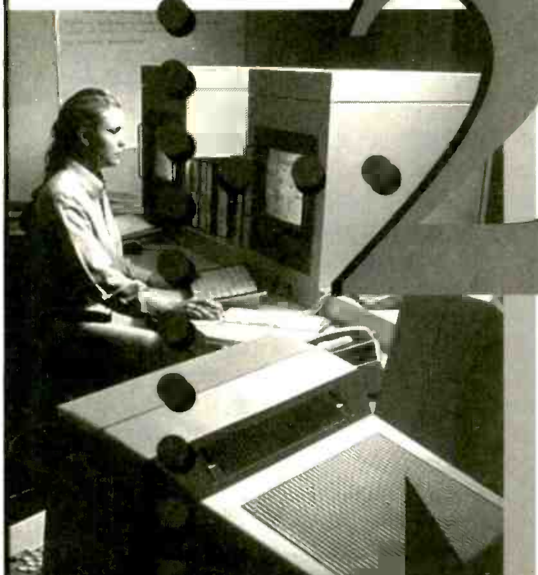

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A school of thousands. A class of one. Since 1934. AE136 produced can be mixed with a normal or inverted signal for obtaining a wide variety of effects from subtle to intense.

Circuit Description. Referring to the schematic diagram shown in Fig. 2, composite NTSC video between 0.5 and 3 volts peak-to-peak from J1 is fed through S1. That switch is used to bypass the Video Palette II circuit and send unmodified video out through J2 if the effects are not needed; that saves the trouble of switching cables. Resistor R1 provides termination, and R2 is a level control. The setting of R2 is crucial to the operation of the effects circuits; the effects-circuits' inputs are level sensitive. Video amplifier IC1 is configured as a non-inverting amplifier with a gain of 3. That way, input signals as low as 0.5V p-p can still be used—lower levels might not be adequate for the effects circuits.

Signals from IC1 (about 1.4 volts p-p) are fed through C4 to the clamp circuit made up of C4, D1, and Q1. Diode D1 can be replaced with a Schottky diode for better clamping at the relatively low signal voltages here. The clamp level is set by R7 for the correct DC level on a normal video signal with C5 as a bypass capacitor. White-level clipping is obtained by limiting the collector voltage on Q1 with R9, R10, and C8.

The output of Q1 (a clamped but unaltered video signal) is fed to analog switch IC4-b, video-inverter stage Q2, and sync-separator circuit IC2. Inverter stage Q2 is fed by R11 and C9. Resistor R12 is a feedback resistor, and a variable negative-DC bias is fed from R14 through R13 to the base of Q2. Bias for Q2 comes from R15, D2, and R23. Gain of the stage is -1.2; that slight gain (remember that this is an inverting stage) compensates for any losses in the analog switches and for circuit-loading effects.

The output signal at the collector of Q2 is a mirror image of the signal at the emitter of Q1. Both signals are applied to the inputs of analog switch IC4-a. The voltage at pin 11 of IC4-a selects which signal is sent to the output; it is set by S2.

The normal video signal from Q1 is fed to IC2 through R5, C6, and C7. The time constant for IC2 is set by R22 and C13. Composite sync from pin 1 of IC2 is fed to sync generator IC3, which controls the "genlock" for the Video Palette II. Only the blanking information from pin 13 of IC3 is needed; it is used for separating the sync signals from the main video signal by controlling IC4-b and IC4-c. Video from IC4-a is fed to IC4-c, which passes video (but not any sync pulses) to the effects circuitry; the result is a sync-less video signal.

The effects section consists of two nonlinear circuits: a solarizer and a posterizer. The amount of solarization is set by R49. The circuit uses a transistor to form a video amplifier powered by its own input signal. At low-input levels, Q4 is cut off by an adjustable negative bias from R47 and R49. At the junction of R48, pin 13 of IC5-a, and the collector of Q4, the input video signal under that condition is unchanged. As the video-signal level increases (set by R49), enough bias is produced at the junction of R46 and R47 to turn on Q4. That causes the video output to turn negative, or "fold over." The output is fed to IC5-a. When solarization is desired, pin 11 of IC5 is grounded by closing S4. The solarized video appears at pin 14 of IC5-a and is fed to effects control R16. Note that sufficient video level is needed to properly drive the circuit. Levels that are too low to turn on Q4 will not produce any solarization. Although the the chroma and luminance signals should be processed separately for a true solarizing effect, the results do not look as good as when both parts of a color-video signal are distorted together.

Posterization is done by IC6 and its associated components. The circuit uses the high-speed comparators in IC6 to form a rudimentary flash analog-digital converter feeding a simple resistive digital-analog converter. A continuous-tone video is applied to all four comparators at their non-inverting inputs. The inverting inputs are fed a set of reference voltages from divider string R36–R40. The "trip" voltages for the comparators are nominally 0.12, 0.37, 0.62, and 0.87 volts. They can be varied with posterize control R34. The divider is driven from R34 through Q5. The outputs of the comparators are each fed to a summing network comprised of R41–R45 with the output signal appearing at R45. The output will be one of five levels, ideally zero, 0.25, 0.5, 0.75, or 1.0 volt. That results in a stepped-output waveform with sharp transitions between the levels, apparing as black, dark gray, medium gray, light gray, and white. The actual output levels are higher to allow for circuit losses, but the principle is the same. The resulting pictures have a "blocky" look with all gradation of tones lost, as in a cartoon drawing. Level control R2 must be set so the circuit has adequate input signal. The output of the circuit is fed to analog switch IC5-b. Closing S3 causes IC5-b to pass the posterized video to R16.

One side of R16 has the combined outputs of IC5-a (solarization) and IC5-b (posterization). The other side of R16 has straight video. By positioning the wiper of R16, the amount of processed video and straight video can be varied. The mixture of normal and processed video is fed to one side of fader control R17. A DC level (0 to 1 volt) from the wiper of fade background control R18 is fed to the other side of R17. By varying the position of the wiper of R17, the video level can be varied from full to any given brightness from black to white or any intermediate shade of gray. The fade control can be used to control contrast.

The final video signal from R17 is fed to pin 1 of IC4-b, with the sync signal from the emitter of Q1 at pin 2. With the genlock signal from IC3 controlling IC4-b, the final composite-video signal appears at the output of IC4-b (pin 15). The output signal is amplified by Q3 and sent to S2 and J2 through C12. Overall system gain is unity, depending on the setting of gain control R2.

Power from an 8- to 14-volt AC transformer is applied to J3, with S5 acting as a master on-off switch. Since both +5 and -5 volts are needed by the Video Palette II, the AC power is half-wave rectified by D4 and D5 to create a bi-polar power source without the need for a center-tapped transformer. For that reason, a DC power source will not work. The dropping resistors, R54–R57, help reduce the power that IC7 and IC8 must disippate when regulating the voltages. If a lower-voltage power source (8 to 12 volts) is used, R54–R57 can be eliminated and a jumper wire put in their place. Higher voltages than 15 volts are not recommended because of excessive heat resulting from the increased dissipation. However, voltages up to 24 volts AC can be used as long as IC7 and IC8 are given adequate heatsinking, along with the use of higher working voltages (35 or 50 WVDC) for C26 and C27.

Construction. In spite of the Video Palette II's sophistication, it is quite straightforward to build. If you do not wish to purchase a PC board from the source given in the Parts List, foil patterns for the Video Palette II's PC board have been included here. Note that the PC board is double-sided; connections on both sides of the board must be soldered. Many grounded leads have connections on both sides of the board; soldering both sides of those connections will help connect both top and bottom ground planes together for good grounding. That will help get a clean, noise-free picture with no ringing or other undesirable transients.

The parts-placement diagram for the Video Palette II is shown in Fig. 3. Because of the high-frequency signals, all parts must be mounted close to the board. Short lead lengths are a must for low noise and clean operation. Unless you have the ability to make reliable plated-through holes, a short jumper wire must be soldered to both sides of the board in any hole that does not have a component in it (pass-through).

Begin construction by connecting all of the pass-through holes that will not have components installed in them. The first components to be installed will be the power-supply components: R54–R57, D4, D5, C24–C33, IC7, and IC8. Before continuing, test the supply circuits by applying 9- to 15-volts AC to the input terminals where J3 and S5 will be connected. Check for +11 to +20 volts across C26 and –11 to –20 volts across C27. When the Video Palette II is completely built, the current load will result in a somewhat lower voltage at that point in the circuit. For now, the voltage might be higher then the voltage ratings on C26 and C27; only apply power for a short time (less than 10 to 20 seconds). If everything seems fine to this point, check for +5 volts across C31; pins 8 and 19 of IC3; pin 16 of IC4, IC5, and IC6; pin 7 of IC1; pin 8 of IC2; and the collector pads of Q3 and Q5. Similarly, –5 volts should appear across C33, pin 4 of IC1, pin 7 of IC4 and IC5, and pin 7 of IC6.

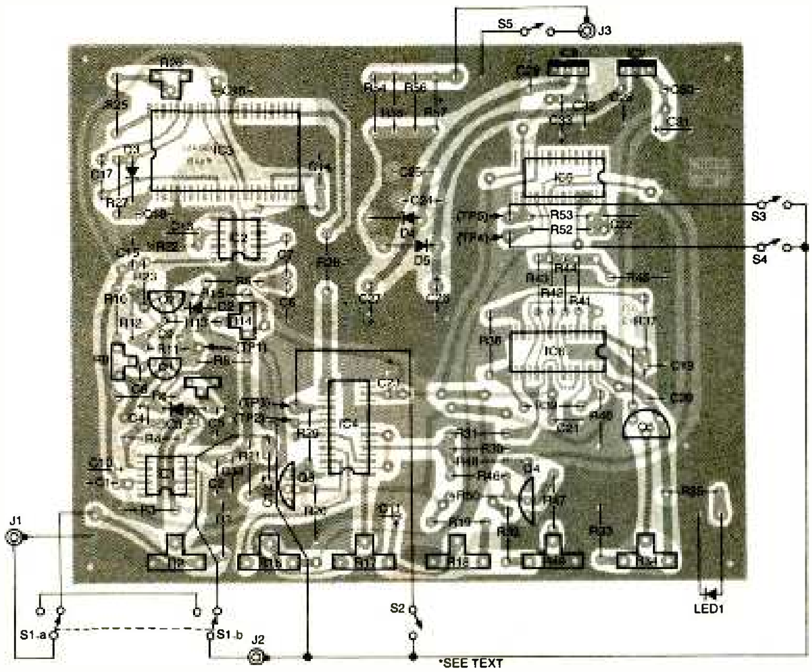


Fig. 3. The Video Palette II is built on a double-sided board with large areas of ground plane. Don't forget to solder connections on both sides of the board where there are pads on the top side—including jumper wires through the holes that don't have any components installed in them.

Use an ohmmeter to check the continuity of all traces that have jumpers connecting them to the opposite side of the PC board. Carefully examine the board for any possible shorts between traces, and if any ground plane is too close to a component hole. If there are any problems or questionable areas due to board etching, trim away the excess ground plane with a knife or razor blade, as needed.

Mount all of the fixed resistors, making sure to solder any connections on the top side of the board as well as the bottom side. Once the resistors are installed, proceed with the capacitors. Any capacitors that come with preformed leads should have their leads straightened out with pliers so that they fit as close to the board as possible. Watch for the correct polarity of all electrolytic capacitors when installing them.

The transistors and diodes are installed next. All transistors should be mounted $^1/_8$ inch from the surface of the board. After the potentiometers are installed, carefully check all of the work done so far for accuracy and orientation of polarized components. Reapply power briefly and verify that the 5-volt supplies are still working. If they are not, a short has occurred somewhere; carefully recheck your work. If the power check is OK, remove power and wait one minute for the capacitors to discharge.

Finally, install the integrated circuits. Again, inspect all of your work so far. Orientation mistakes on the ICs might destroy them the first time power is applied to them. Look for errors such as solder shorts, poor joints, missing parts, and incorrect parts placement.

The Video Palette II is now ready for testing.

Setup and Testing. In order to set up the Video Palette II, you will need the following items:

- A baseband-video source such as a camera or VCR
- An NTSC monitor with baseband video input
- A DVM or analog meter that can easily read 2–3 volts

Fig. 4. Because the Video Palette II uses simple control signals, no high-frequency signals need to leave the PC board. That feature lets you design the front panel to your own requirements. Here's the front-panel design that the authors used on the prototype.

PARTS LIST VIDEO PALETTE II

SEMICONDUCTORS

IC1—LM318N or LM6362N op-amp, integrated circuit
IC2—LM1881N sync separator, integrated circuit
IC3—CD22402E sync generator, integrated circuit
IC4, IC5—CD4053 or MC14053P analog switch, integrated circuit
IC6—CA3430P quad comparator, integrated circuit
IC7—LM7805N 5-volt positive voltage regulator, integrated circuit
IC8—LM7905N 5-volt negative voltage regulator, integrated circuit
D1–D3—1N914 or 1N4148 silicon diode (see text for D1)
D4, D5—1N4007 silicon diode
Q1–Q5—2N3904 NPN silicon transistor

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—82-ohm
R2, R17, R18—1000-ohm potentiometer, horizontal PC mount
R3, R13—4700-ohm
R4, R20, R30—10,000-ohm
R5, R45—680-ohm
R6, R11, R33, R46—2200-ohm
R7, R9, R14—1000-ohm potentiometer, trimmer
R8, R35—330-ohm
R10—100-ohm
R12—2700-ohm
R15, R21—390-ohm
R16—2000-ohm potentiometer, horizontal PC mount
R19—3900-ohm
R22—680,000-ohm
R23, R48—470-ohm
R24, R47—22,000-ohm
R25—8200-ohm
R26—10,000-ohm potentiometer, trimmer
R27—1-megohm
R28, R32—1000-ohm
R29, R52, R53—100,000-ohm
R31, R40—10-ohm
R34, R49—10,000-ohm potentiometer, horizontal PC mount
R36—68-ohm
R37–R39—22-ohm
R41–R44—3300-ohm
R50—47,000-ohm
R51—not used
R54–R57—47-ohm

CAPACITORS

C1, C2, C15, C16, C20–C22, C24, C25, C28–C30, C32—0.01-µF, ceramic-disc
C3—4.7-pF, ceramic-disc
C4, C10, C11, C23, C34—10-µF, 16-WVDC, electrolytic
C5—47-µF, 16-WVDC, electrolytic
C6—470-pF, ceramic-disc
C7—0.1-µF, Mylar
C8—10-µF, 6-WVDC, electrolytic
C9—3.3-pF, ceramic-disc
C12—470-µF, 6.3-WVDC, elecrolytic
C13—0.01-µF, Mylar
C14, C18—0.001-µF, Mylar
C17—47-pF, ceramic-disc
C19—100-µF, 16-WVDC, electrolytic
C26, C27—470-µF, 16-WVDC, electrolytic
C31, C33—1-µF, 50-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

J1, J2—RCA or BNC jack, panel-mount
J3—Coaxial power jack, 2.5-mm
LED1—Light-emitting diode, red
S1—Double-pole, double-throw toggle switch
S2–S5—Single-pole, single-throw toggle switch
Potentiometer shafts, 9–14-volt AC wall transformer, case, hardware, wire, etc.

Note: The following items are available from: North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053; e-mail: NCRadio200@aol.com; Web: http://www.northcountryradio.com: Complete kit of parts including a drilled and etched PC board and all parts that mount on it, switches, jacks, and power connector, $87.50: etched and drilled PC board (non-plated-through holes), $25; wall transformer, $9.50; undrilled metal case, $21.50; hardware/connectors/wires package, $10.50. Please add $4.50 for postage and handling within US ($10 for orders outside US) on all kit and PC-board orders; $1 for postage and handling on all non-kit items. NY residents must add appropriate sales tax.

A source of 8-14 volts AC
Cables and connectors to hook up your equipment

Make temporary connections for J1–J3. Connect J1 to a video source and J2 to a monitor. Set R2 to $^2/_3$ clockwise rotation, R16–R18 fully counter-clockwise, and all of the other potentiometers to the middle of their rotation.

None of the effects switches are needed for calibration; S2–S4, if they've been connected, should be off (open). If you've connected S1, switch it to OUT—video should pass through to the monitor. Set S1 to the IN position for the tests. Make sure that S5 is on if you've connected it, and apply power. Check for +5 volts at TP1 and –5 volts at TP2. Those readings should be within 0.25 volts. Check to see that IC7 and IC8 are not getting too hot. A short or more than +14 volts at their inputs can cause that. At most, IC1–IC6 should get barely warm. Measure the AC voltage drop across R54 and see it does not exceed 3 volts AC. Those checks will show if there are any major shorts in the circuit.

Next, check for the following voltages:

Pin 6 of IC1: 0 volts ±0.25
Emitter of Q2, Q3: –0.6 volts
Emitter of Q5: 2.0 volts (varies with R34)
Collector of Q1: 2.5 V (varies with R9)

If all is OK, set the potentiometers as follows:

Set R9 for +2.2 volts at collector of Q1
Set R7 for -0.35 volts at emitter of Q1 (TP1)
Set R14 for +1.65 volts at collector of Q2 (TP2)
Set R26 half way (if not done before)

With video applied to J1, you should see a good quality picture. Adjust R2 for a normal picture. If R2 is set too high, the picture will show blocked (white solid areas) highlights. If it is set too low, the picture might be washed out and lose sync. Too low a setting might produce a good picture, but the effects con-

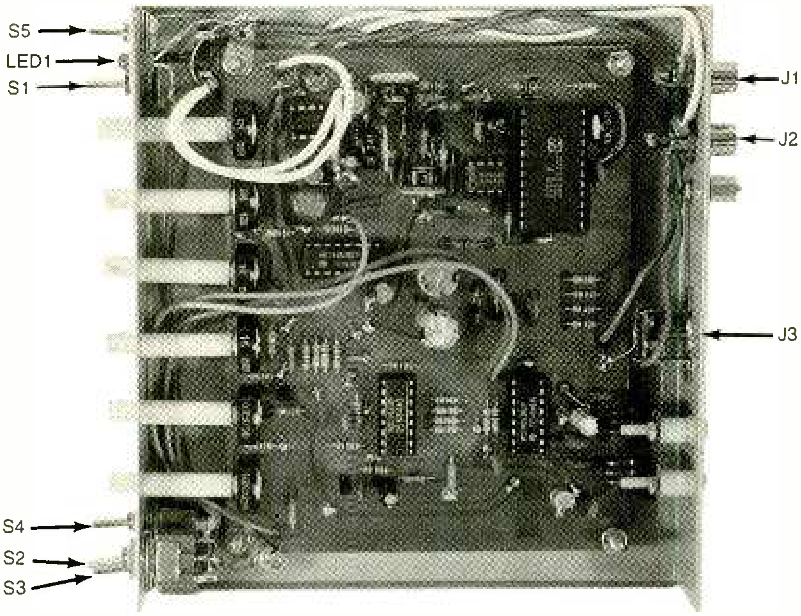


Fig. 5. The Video Palette II has a very neat appearance when wired up.

trols might not work well—especially the level-dependent effects such as the solarizer. In general, R2 will be between one-half and two-thirds open with the video levels produced by most equipment. If there is no picture, check that your source, monitor, and cables are good. If that is not the problem, check your construction again. The Video Palette II should work well on the first try if the construction is correct and error free.

Test the invert function by closing S2 or grounding pin 11 of IC4-a. You should get a negative image. If the picture breaks up and/or has lines through it, adjust R26 for a stable picture that completely fills the screen edge to edge. Verify that the inverted picture is stable with no loss of sync occurring when switching between normal and invert. Adjust R14 slightly if needed for the best-appearing negative image.

Open S2 and close S4 (or ground pin 11 of IC5-a) to check the solarizer. Rotate R17, clockwise and then rotate R49 both ways. You should see a pronounced effect on the video; it will be obvious if the circuit is working. Vary R17 and verify that the degree of solarization can be varied. If little effect is noted, set R2 higher.

Open S4 and close S3 (ground pin 10 or IC5-b). Set R17 fully clockwise and vary R34. You should get a posterized picture. There will be some speckles in the posterized areas. They represent the former darkest or lightest points of tonality and show up as a different tone level than the surrounding areas, appearing as noise specks. Vary R17 to mix the posterized and normal video. Level control R2 will affect the results.

Open S3 and reset the front-panel controls to their initial settings. You will get back to a normal unmodified picture. Set R17 to midway. Varying R18 should change the picture brightness. Rotate R17 to the extreme clockwise position. The picture should fade to a blank gray screen. Varying R18 should change the gray from black through shades of gray to white. At any setting of R18, it should be possible to fade the video from no picture to full picture.

If all of the tests have passed, the Video Palette II is ready for final assembly.

Final Assembly. The Video Palette II can be mounted in any suitable case. Metal is preferred from an electrical standpoint, but if RFI and stray noise pickup in the video is not a problem, plastic or wood is suitable. Since all of the control switches are handling either DC or low-frequency signals, the layout of the front panel can be anything you like. The layout of the author's prototype is shown in Fig. 4. If the leads to S1 will be over a few inches long or run close to AC or other video leads, it might be best to use 75-ohm shielded cable.

Figure 5 shows the Video Palette II board mounted in a small metal case. Note how IC7 and IC8 are mounted to the metal case. One precaution: the case of IC7 is at ground while IC8 must be insulated electrically from ground. The Video Palette II uses about 3 watts of power, so heat is not a problem. Small knobs can be used for the front-panel controls, although the plastic-knurled shafts provided with the potentiometers are satisfactory by themselves.

The board is mounted in the case with four metal standoffs and hardware. The result is a clean, simple package with few wires and plenty of access room. Most of the wiring centers around S1.

Using the Video Palette II. Operation of the unit is best learned by experimentation. It is interesting and fun to play with, and you cannot damage anything in the circuit with any combination of control settings. Simply return all controls to the default settings, and a normal picture comes back.

Those with access to an oscilloscope might want to probe around and experiment with video adjustments, examine waveforms, and observe their effect on operation. There are no exact rules or best settings as long as the circuits operate the way you wish. If you are getting satisfactory results, do not worry too much about the exact particulars.

When using the effects at the same time, some slight interaction between controls is normal. If the solarization and posterization effects are not used, it is best to set R16 counter-clockwise in order to avoid some loss of contrast. Note that R2 affects the results and must be set correctly. In normal operation, the Video Palette II is set up for the desired effect and S1, the bypass switch, is used to insert an effect as needed. Alternatively, the front-panel controls can be manipulated,

(Continued on page 60)

WORKING WITH MIXERS

As long as you follow some basic rules, mixer circuits are easy to understand and use.

JOSEPH J. CARR

Mixer circuits are designed to operate as frequency translators. They are nonlinear circuits that produce an output frequency spectrum that includes various products of two input frequencies. As shown in Fig. 1, if two input frequencies, F1 and F2, are combined in a nonlinear mixer, then the output spectrum will include the products:

$$F = mF1 \pm nF2 \quad (1)$$

where F represents the output products, F1 and F2 are the two input frequencies, and m and n are integers (0, 1, 2, 3...). In any given circuit the mixer products may be out to several higher orders. It is commonly, and erroneously, assumed that the output spectrum looks like Fig. 2. Assume that the two inputs are F1 and F2. The outputs will include F1, F2, F1+F2 (sum frequency) and F1-F2 (difference frequency). Of these frequencies, we usually only need one.

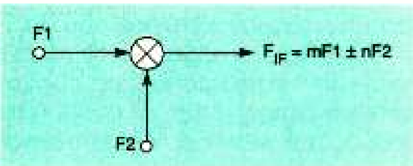


Fig. 1. If two input frequencies, F1 and F2, are combined in a nonlinear mixer, then the output spectrum will include the products F = mF1 ± nF2.

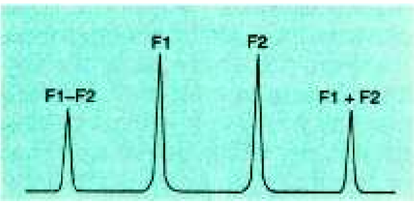


Fig. 2. It is commonly, and erroneously, assumed that the output spectrum of a mixer looks like the graph shown here.

Although there are a number of applications for the mixer, let's take a look at only one. The most common application is the *superheterodyne* receiver design. Nearly all radio and TV receivers sold today are "superhets." In the superhet the incoming RF signal (F_{RF}) is converted to an *intermediate frequency* (IF) by "beating" a local oscillator (LO) signal (F_{LO}) against the RF frequency. That process is called *heterodyning*, from which the name superheterodyne was derived.

Figure 3 shows the block diagram of a typical superhet receiver. The radio signal at F_{RF} is picked up by antenna, and then (sometimes) amplified in an RF amplifier circuit. This signal is mixed with F_{LO} in the mixer to produce two output signals, in addition to F1 and F2: F1+F2 (sum) and F1-F2 (difference). These frequencies correspond to the results of Eq.(1) when m = n = 1.

The IF amplifier is used to process the output signal of the mixer. Either the sum or the difference signal can be used for the IF, as they are mirror images of each other. In AM and FM broadcast band (BCB) receivers, the difference frequency is typically used. In the United States and Canada, manufacturers usually use 455 kHz as the AM BCB IF, and 10.7 MHz as the FM BCB IF. In car radios, 262.5 kHz is used as the AM BCB IF. European and Japanese radios have sometimes used other frequencies for the IF, but they are close to these values. In recent years, we have seen high frequency (HF) shortwave receiver designs that use two conversion steps. The first IF is around 50 MHz, but this frequency is later down converted to a second IF such as 9 MHz, 8.83 MHz, or 10.7 MHz. In Fig. 3 the difference frequency F_{LO}-F_{RF} is shown being selected.

The IF amplifier provides most of the signal gain found in the receiver. It also provides most of the selectivity of the receiver. The reasons for doing the frequency conversion is that the IF amplifier operates at one frequency only, and that means it is easier to obtain quality selectivity characteristics (the best filters are single-frequency devices) and high gain without either variation in gain with frequency or spurious oscillations.

Mixer Problems. One of the most common problems in using a mixer is the image response. Figure 4 shows how that works. The LO and RF are separated by the amount of the IF. Unfortunately, that means that there are two frequencies separated from the LO by the amount of the IF. In Fig. 4 the RF is located at F_{LO} - F_{IF}. Ideally, that is the only frequency that is received. But notice that F_{LO} + F_{IF} (the "image" frequency) is also valid. Any signal that appears at the image frequency will also appear to the receiver as a valid IF signal.

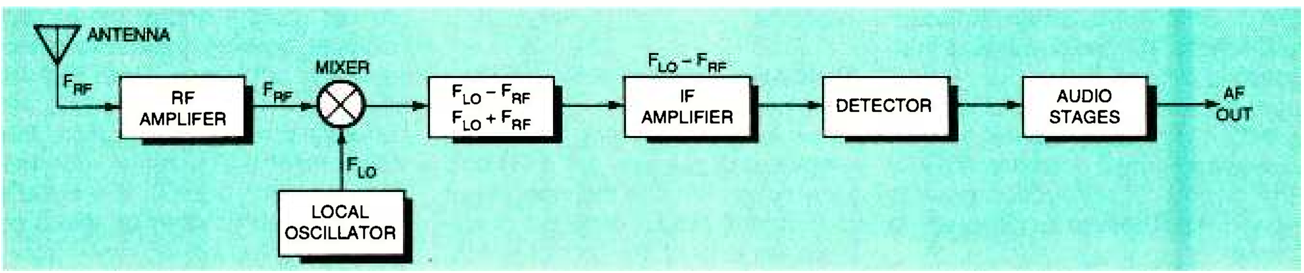


Fig. 3. A block diagram of a typical superheterodyne receiver. Though the difference-signal output of the mixer is used here, either the sum or difference signal output could be used.

The problem doesn't end there, unfortunately. The receiver has a certain bandwidth (BW). No signal has zero bandwidth, so a receiver designer will match the bandwidth with the modulation being received.

Typically, an AM BCB signal likes to see 10 kHz, an AM shortwave signal 6 kHz, an SSB signal 2.7 kHz, a land-mobile FM signal 5 kHz, and an FM BCB signal 200 kHz. Any signal that falls within the bandwidth will appear in the IF amplifier as a valid signal. Thus, all of the signals at F_{RF} - (BW/2), *i.e.* around the RF signal in Fig. 4, and F_{RF} + (BW/2), *i.e.* the image, will appear in the IF amplifier.

Notice in Fig. 4 that the baseline is not a nice clean line as it was in our ideal case of Fig. 2. Rather, there is a lot of noise in the system. The noise might be noise from the environment (both natural and man made), or it might be noise generated by the circuits inside the receiver. Even a simple resistor with no current flowing in it will produce a noise signal due to thermal agitation of the electrons inside the resistor material. Thus, in addition to any radio signals that might be present in the vicinity of the RF and image frequencies, any noise present will also appear in the IF amplifier.

It gets better: The local oscillator signal might be somewhat imperfect. Indeed, it will be imperfect . . . there's no "somewhat" about it. Three problems exist: LO harmonics, LO noise, and *discretes.*

Figure 5 shows the situation with respect to harmonics. All signals other than a perfect sinewave produce harmonics, *i.e.* signals of integer multiples of the basic signal. Thus, a 1000-kHz signal will have harmonics of 2000 kHz, 3000 kHz, 4000 kHz, and so forth, unless they are truly pure sinewaves (not likely).

In the example of Fig. 5 the LO signal (F_{LO}) has harmonics of $2F_{LO}$ and $3F_{LO}$. Any signals or noise that falls within the bandwidth (or passband) also appears around those harmonics plus or minus the IF: $2F_{LO} \pm (F_{IF} \pm (BW/2))$.

Figure 6 shows another problem with the LO signal: noise. The LO signal is ideally a spike with only amplitude and no width. That doesn't occur in practice. The real LO signal will have several different forms of noise around it. There will be signal components caused by thermal noise in the oscillator circuit. There will also be single-sideband phase noise present. These are difficult to filter out unless the LO is a single-frequency circuit, and its output signal can be passed through a very narrow (high Q) bandpass filter.

Discretes are modulation of the LO signal (either AM or FM) caused by other frequencies in the circuit. Of course, it's possible for oscillators and other signals within the circuit to modulate the LO, but the principal source of discretes is improperly filtered DC power-supply voltages. The AC power-line frequency in North America is 60 Hz (in some other parts of the world 50 Hz is used). When full-wave rectified, this produces a 120-Hz (twice the line frequency) ripple-frequency signal on the DC output of the power supply. If the ripple signal is allowed to remain on the DC power line, then it will modulate the LO signal and possibly cause problems.

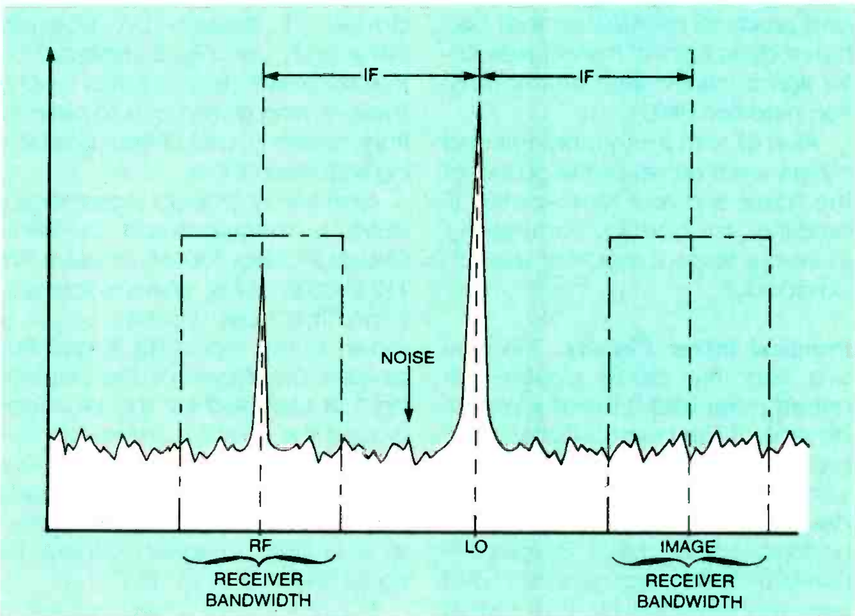


Fig. 4. While the RF signal located at F_{LO} - F_{IF} is the desired one, an image signal located at F_{LO} + F_{IF} is also valid.

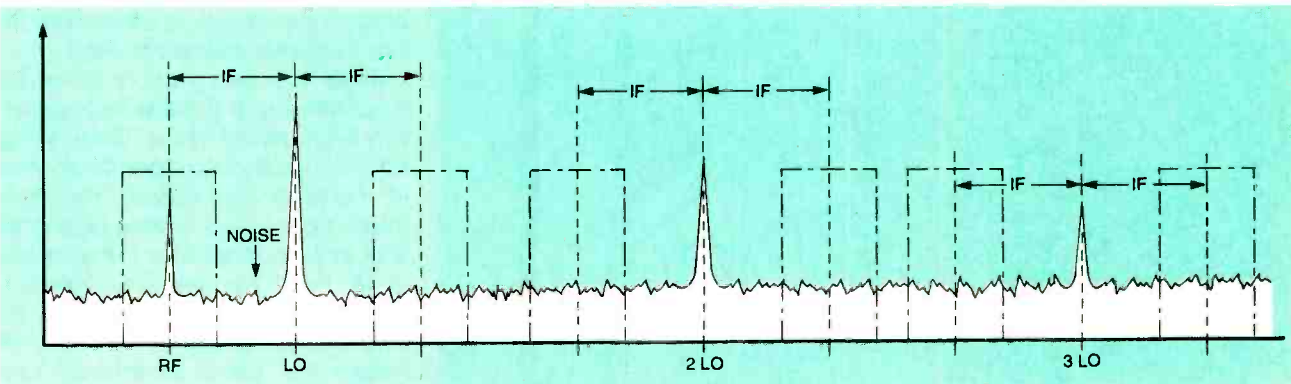


Fig. 5. Any noise that falls within the receiver's passband also appears around any internally generated harmonics.

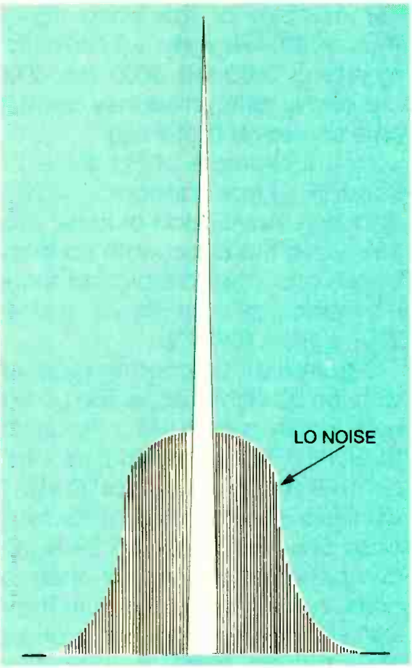


Fig. 6. While the LO signal is ideally a spike with only amplitude and no width, a real LO signal will have several different forms of noise around it.

Power supply discretes fall so close to the LO signal that they cannot usually be filtered out of the LO signal. They must be filtered out before they arrive at the LO. To cure this problem with the LO (as well as others), it is customary in high-quality receivers to provide adequate decoupling and filtering of the DC power lines and to provide the LO circuit with a voltage regulator of its own. The voltage regulator must be separate from any others used for the rest of the receiver.

Noise produced by the oscillator itself can be minimized by using a low-noise transistor or IC device, and by proper mounting of the components. A major contributor to phase noise, for example, is movement of the components. Remarkably small amounts of motion on frequency-determining components, or other components that affect frequency indirectly, can cause FM, PM, or phase noises.

Note that the spectrums shown in Figs. 4 and 5 assume that there are only two frequencies present (F1 and F2, or F_{RF} and F_{LO}). That rarely occurs in real situations. In the radio receiver, for example, there are a lot of signals arriving at the antenna simultaneously. They can cause problems even if they are not situated at the RF and image frequencies (or at their phantoms around the harmonics of the LO). If a group or spectrum of signals appears at the RF input port, then all of them will be converted by the LO. In addition, they will beat against each other and produce new signals that also heterodyne against the local-oscilator signal. This is called intermodulation distortion (IMD)

All in all, with these problems and others, what arrives at the output of the mixer is a real mess for the IF amplifier to handle. Fortunately, there are some things that we can do about it.

Practical Mixer Circuits. The passive Schottky diode double-balanced mixer (DBM) circuit is probably one of the best solutions to the problems normally encountered with mixer circuits, especially if the desired effect is to keep signals not needed out of the IF amplifier. A non-balanced mixer (which is what is in most AM and FM BCB radios) passes the two input frequencies and all of their products to the IF output (as in Fig. 2). A single-balanced mixer will suppress either F_{LO} or F_{RF}, but not both. A double-balanced mixer, on the other hand, suppresses both F_{LO} and F_{RF} in the IF output, so the output only contains the sum and difference products. A well-designed DBM will also suppress the even harmonics of the LO and RF input signals.

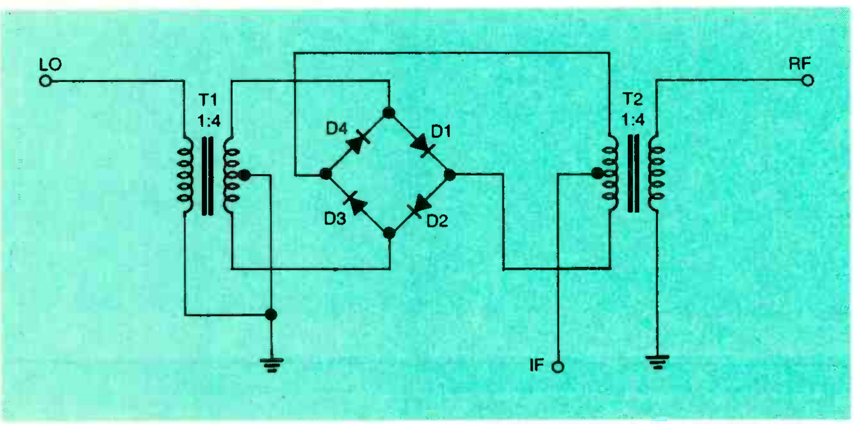


Fig. 7. Here's a generalized schematic for a diode-ring double-balanced modulator.

The DBM circuit in Fig. 7 consists of a diode ring (D1–D4) of Schottky devices, and two 1:4 BALUN transformers in which the 4R winding is center-tapped. The LO and RF signals are applied to the ends of the ring, and the IF is taken from the center-tap of T2, the RF input transformer. The degree of suppression of F_{RF} and F_{LO} is determined by the degree of balance. The balance is controlled by the construction of transformers T1 and T2, and by the matching of diodes D1 through D4. Isolation between F_{LO} and F_{RF} is improved by the diode switching action of D1-D4. The switching action acts to prevent transformers T1 and T2 from interacting with each other.

One line of popular commercial DBMs is manufactured by Mini-Circuits (P.O. Box 350166, Brooklyn, NY 11235-0003; Web: www.minicircuits.com). The basic internal circuit is shown at the top of Fig. 8, and the pin-outs are shown at the bottom. Pin 1 is identified by the blue dot around the terminal. There are several models popular with amateur builders, and these are summarized in Table 1. These mixers are designed for a +7 dBm LO signal level and RF signal levels up to +1 dBm.

Figure 9 shows a basic circuit in block-diagram form for using the Mini-Circuits' mixers. In this case the SBL-1 is selected, but the same pinouts are found on others. The RF input signal is applied to Pin 1.

Note the presence of some RF input filtering. It is there to improve the IMD performance. Depending on the application, specifically the RF frequencies involved, the filter might be a low-pass filter, high-pass filter, or bandpass filter. If the range of RF input frequencies is limited, then opt for the bandpass filter so that undesired signals above and below the band of interest are attenuated. Otherwise, determine where the interfering signals are

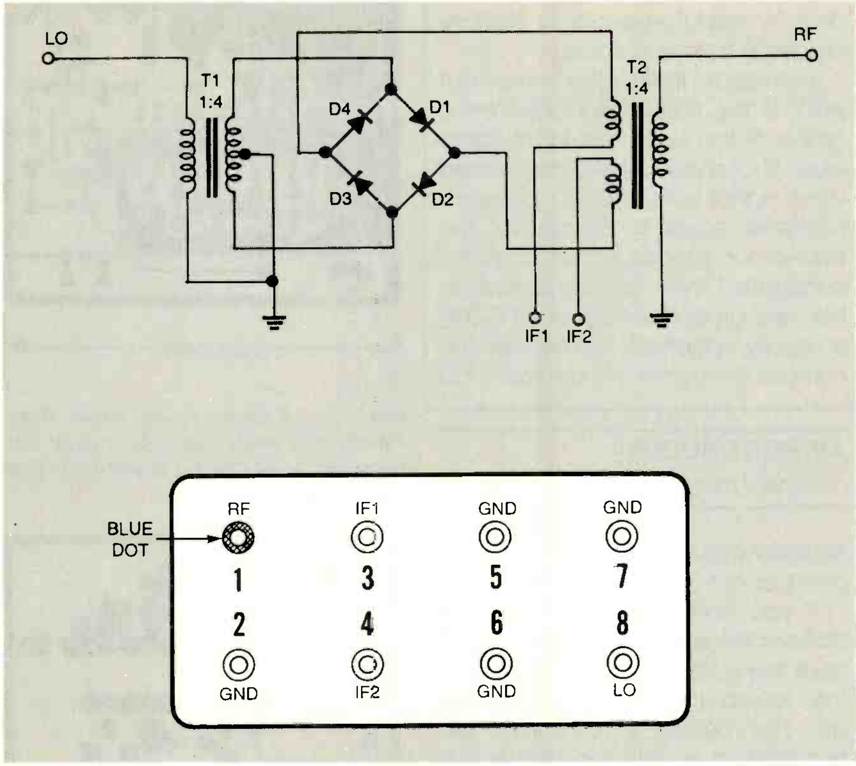


Fig. 8. One popular line of DBMs is made by Mini-Circuits. Here is the basic circuit and pinouts for the members of the series. More details can be found in Table 1.

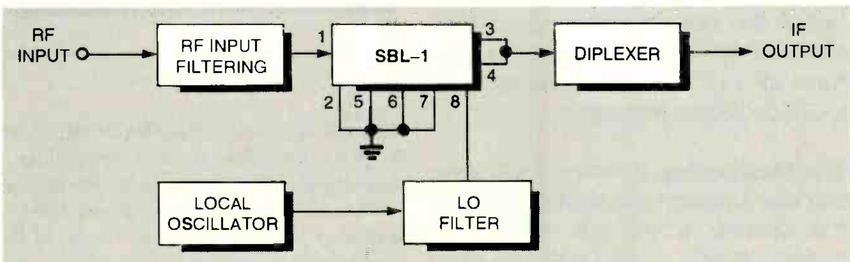


Fig. 9. This block diagram shows how the Mini-Circuits' DBM is typically used.

TABLE 1—MINICIRCUITS MIXERS

Model No.	LO/RF	IF	RF Pin	LO Pin	IF Pin	Ground Pins	Case
SRA-1	0.5-500	DC-500	1	8	3,4*	2,5,6,7	2
SRA-1-1	0.1-500	DC-500	1	8	3,4*	2,5,6,7	2
SRA-2	1-1000	0.5-500	3,4*	8	1	2,5,6,7	2,5,6,7
SBL-1	1-500	DC-500	1	8	3,4*	2,5,6,7	None
SBL-1-1	0.1-400	DC-400	1	8	3,4*	2,5,6,7	None

* Pins must be connected together

with respect to the desired signal and select a type of filter and cut-off frequency that either gets rid of the most signals or the most dominant signal. Whichever filter is selected, however, it must be designed to terminate in a 50-ohm resistive impedance.

If a very pure frequency conversion is necessary (as in a high-quality receiver or converter), then place a filter in the line between the LO output and the mixer's LO input. As with the RF filter discussed above, select the filter that eliminates the greatest amount of undesired energy. For the most part this means a low-pass filter with a cut-off frequency above the highest LO frequency and the lowest harmonic. Sub-harmonics are also an issue, but are usually less of a problem. If they are, then either use a bandpass filter centered on the LO range, or cascade a low-pass and high-pass filter.

The local oscillator must be able to produce an output level that will produce a power level of +7 dBm at the LO input (pin 8). The LO output power must be sufficient to overcome the losses of the filters and any other components in the signal path, yet still produce +7 dBm at the LO input of the mixer. For example, if the filter has a 2 dB insertion loss, then the LO must produce +9 dBm output power into a 50-ohm load.

Some designers place a 1- to 3-dB fixed broadband attenuator in each of the signal lines of the mixer. The idea is to damp impedance excursions and to allow the mixer to see a constant 50-ohm source or load impedance at each pin. If you use well-designed filters for the inputs and terminate the IF output properly, then the attenuator should not be necessary. If you prefer to use attenuators, however, the Mini-Circuits' catalog (see their Web site) has examples.

The best way to terminate the IF output of the mixer is to use a diplexer circuit. A diplexer is a circuit that produces a constant impedance over a broad range of frequencies, and will pass a desired frequency and (here is the important part) absorb undesired frequencies. One way to build a diplexer is to connect both high-pass and low-pass filters at the IF output of the mixer. Depending on whether you want the sum or difference frequencies, connect the output of one filter to the load being served (*e.g.* a following amplifier) and the other to a resistive dummy load that is matched to the system impedance

Diplexer Design. Figure 10 shows a practical bandpass diplexer design intended for use with mixers. The values of the R_O resistors is the system design impedance (50 ohms in most cases). The values of L1, L2, C1, and C2 are determined by the center frequency (f_O) of the desired pass band. The Q of the filter is f_O divided by the necessary bandwidth (BW). The values of these components for

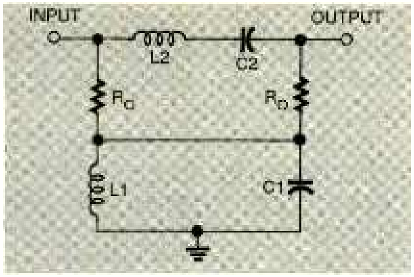


Fig. 10. Here's a practical bandpass diplexer design intended for use with mixers. Values are calculated using the equations in the text.

any given frequency can be calculated from the equations below:

$$Q = \frac{f_o}{BW_{3dB}}$$

and

$$\omega = 2\pi f_o$$

The component values are:

$$L2 = \frac{R_o Q}{\omega}$$

$$L1 = \frac{R_o}{\omega Q}$$

$$C1 = \frac{1}{L1\omega^2}$$

$$C2 = \frac{1}{L1\omega^2}$$

Mixer Selection. Several different specifications may be applied to a mixer when making a selection. First you want to select the frequency range. Don't select a mixer that barely covers the frequency you are interested in. For example, if you want to handle an RF input signal of 1.2 MHz, don't select a 1- to 400-MHz device. Select a device with a 0.5- or 0.1-MHz lower end. Keep in mind the RF, LO, and IF frequencies when selecting the mixer for an application. Here are some other specification to keep in mind:

Isolation. The LO-RF, LO-IF and RF-IF isolation tells you something about how much signal will feed through the pathway specified. For example, the LO-RF isolation tells you the amount the LO signal is attenuated when it reaches the RF port. Numbers such as 30 to 60 dB are common.

Dynamic Range. This specification tells you the power range in which the mixer works properly. It is a good idea to obtain the highest dynamic range possible.

-1 dB Compression Point. The input signal level that causes a 1 dB drop in output level, *i.e.* a 1 dB increase in conversion loss.

Intercept Point. The intercept point is the theoretical point on a graph of the output-*vs.*-input signal levels that shows where the desired input signal and the n^{th} products become equal in amplitude. The third-order products are normally considered the most important, so the third-order intercept point (TOIP) is usually specified. The higher the number the better the device. Ω

AIRPORT BUDDY

(continued from page 28)

troubleshooting hints below to locate and correct the fault in the circuit.

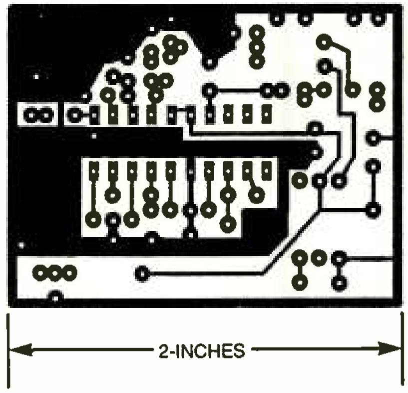
If you notice a large group of stations transmitting voice or music near the maximum CCW setting of the tuning control, those stations are commercial stations that are transmitting at the top of the FM-broadcast band. If you want to eliminate those stations, you can tweak the adjustment range of the receiver by slightly spreading the turns of L1; that will increase the local-oscillator frequency.

Troubleshooting. If the headphones are silent, check the voltage across the battery when the receiver is turned on with a voltmeter. The battery voltage should be at least 8 volts—weak batteries will not drive the Airport Buddy. Also measure the current; the normal value is about 10 milliamps. The polarized components (D1, IC1, Q1, and the electrolytic capacitors) should be checked for proper orientation. The voltage at pins 5 and 6 of IC1 should be at least 7 volts. If it isn't, D1 might be installed backwards.

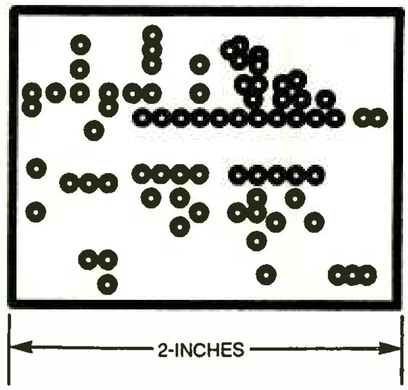
If power to the circuit is normal, check the voltage at pin 7 of IC1. It will normally be about 0.25 volts or less when no signals are being received and increase when an RF carrier is detected.

Check the voltage at the source of Q1. If it is about 1 volt, the transistor is drawing current. If not, check its orientation or try a new transistor.

If it is suspected that IC1 is not operating, carefully check the components that form the local oscillator: R1, C3–C6, L1, and D2. Check the bias on D2 to be sure that it changes when R6 is turned. Measure the voltage at each pin on IC1 and compare the reading with Table 2. The voltages listed assume that the battery voltage is at least 7 volts. If any pin on IC1 does not seem right, carefully check the wiring for short circuits. If a fault cannot be found, replace IC1.



Here's the foil pattern for the Airport Buddy. The circuit is simple enough for a single-sided layout; the other side is a simple solid-copper ground plane.



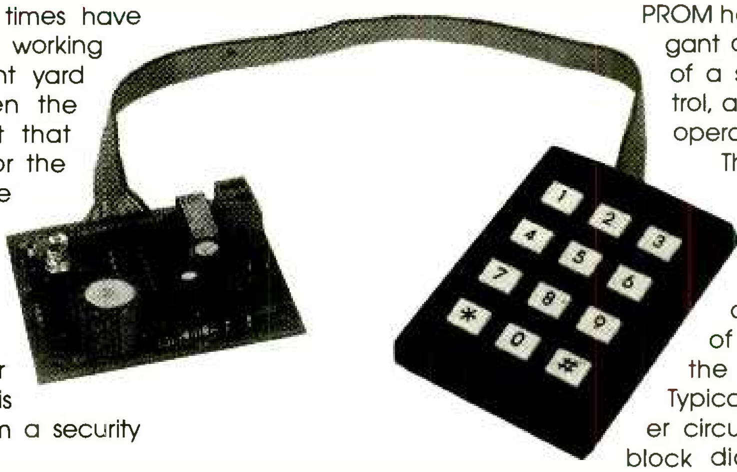
Although this is not a foil pattern for the Airport Buddy's ground plane, it shows the locations of the holes where copper should be cleared away so that the component leads do not short to ground. If you wish, a negative image of this layout could be used as a "foil pattern" that will only etch away a ring around the holes that need to be clear.

Using the Airport Buddy. When receiving signals at the airport, adjust the tuning control over its range very slowly to search out any possible transmissions. Once you have found the active frequency of the control tower, you can then keep the tuning control in that general vicinity to hear the audio communications as each aircraft arrives and takes off. Ω

A Garage-Door Keypad

Operate a garage-door opener without having to find the remote transmitter!

REINHARD METZ AND DAVID WICKLIFF



How many times have you been working in the front yard and wanted to open the garage door—except that the remote control for the garage door is in the car...*in the garage*? Perhaps you have a particular model of opener that doesn't have a keyless-entry module as an option or that has an option that is not well designed from a security standpoint.

The Garage-Door Keypad presented here will work with almost any type of mechanism. In addition to the convenience of providing keyless entry for members of your household, you'll find it useful in many other circumstances: going out for a bike ride, working in the back yard, etc. Its advantage over commercially-available units is that it is self-powered from the two-wire relay circuit that already exists with most installed openers—no battery, no separate 110-volt AC or inconvenient outlet transformer is needed! It's also designed to be more secure than conventional keyless entry systems. In addition to its added convenience, it's another excellent opportunity to learn about the popular PIC microcontroller and serial EEPROM devices, which are at the heart of the unit.

Functional Overview. The Garage-Door Keypad is extremely simple to operate: To program an entry code, a program button is pressed inside the unit (normally out of reach inside the garage). A sequence of numbers up to 127 digits long is entered followed by the "#" button. The unit then stores that number sequence. Access is allowed (by operating a relay) when the same sequence is typed in followed by the "#" button. Additional security is provided by time-outs. Furthermore, only the keypad is located outside the garage. It is connected to the electronics by a ribbon cable. Thus, a potential intruder will not be able to pry the unit off its mounting and short the two wires going to the door mechanism to gain access. That scenario, unfortunately, is quite possible with some commercial units or key-based switches.

Design Overview. The basic hardware of the Garage-Door Keypad consists of just four main components: a PIC 16C54 microcontroller for the logic, a 93AA46 serial EEPROM for access-code storage, the keypad itself, and a power circuit. Figure 1 shows the schematic diagram. The PIC microcontroller, IC1, scans program button S1 and keypad S2 through a matrix formed by eight I/O lines. The lines are pulled up by R4 so that IC1 always sees a valid logic level. When scanning the matrix, one output line is grounded. If a key connected to that line is pressed, the input line that it is connected to is also grounded. The scanning process will be described later.

The microcontroller connects to IC2 with three leads. The serial EEPROM has a very simple and elegant operation, which consists of a sequence of serial control, addressing, and data I/O operations.

The self-powering part of the Garage-Door Keypad is provided by BR1, which rectifies what typically appears as an AC or DC voltage of from 10 to 24 volts from the garage-door opener. Typically, a garage-door opener circuit works similarly to the block diagram shown in Fig.2. Normally, the opener's switch activates the mechanism by shorting the relay wire to ground. That closes a relay or circuit in the opener. The Garage-Door Keypad "steals" some of the current that appears across the switch. What makes this "trick" work is that the Garage-Door Keypad uses less current than is needed to energize the relay—thanks to the low power requirements of IC1.

To energize the opener, RY1 shorts the control leads for one second. During that time, the Garage-Door Keypad is without power. The circuit is kept alive during that time by the energy stored in C3. That is the reason for the extremely high value of C3—47,000 µF. Finally, IC3 regulates the filtered power to 5 volts for the logic. While many—especially older models—garage-door openers will work with that power scheme, some newer models might not. In that event, a pair of jumpers can be removed so that power is not drawn from J1. Instead, the circuit can be powered from an auxiliary wall transformer connected to J2.

Firmware Overview. The software for the Garage-Door Keypad is written in PIC assembly language and is programmed into the on-chip EEPROM of the microcontroller. Both the source code file and a compiled hex file for programming IC1 are available for downloading from the Gernsback FTP site (ftp.gernsback.

com/pub/EN/garage.zip).

The software is written in the form of a large loop that executes repeatedly. The flow chart of the software is shown in Fig. 3. When power is applied to IC1, several program variables that are used by the software are set up.

The first step of the main loop is to set up the input- and output-port pins of IC1. That must be done every time that the main loop is run. That's because the port settings are reset each time IC1 is reset from either power being applied to IC1 or, as we will see later, a "watchdog" reset.

Next, the keypad is sampled for any new key presses. A key press is considered valid if the same key value is sampled on two consecutive passes of the main loop. That is done to "de-bounce" the key contacts. At the speed that IC1 can execute instructions, a single press of a key might be seen as several presses because the contacts of mechanical switches tend to open and close rapidly when being pressed or released. The "bouncing" action is measured in microseconds. Although that bouncing doesn't affect traditional electronic circuits, high-speed digital systems such as the Garage-Door Keypad need to consider such effects. The value of a valid key press is flagged and stored for later use by the state-machine software that will be discussed in the next section.

After the keypad is scanned, a keypad-entry-timeout variable is decremented. On each pass of the main loop, this counter is decremented by one. If the count ever reaches zero, all key presses are cleared. However, whenever a key is pressed, the counter is set to a large value. That way, the keypad counter will clear any partial key sequences entered that are not completed within about 60 seconds (If, for example, the neighbor's kid is playing with the keypad or a basketball hits it). Therefore, the next time someone enters a valid key sequence it will be recognized correctly.

After updating the key-entry time-

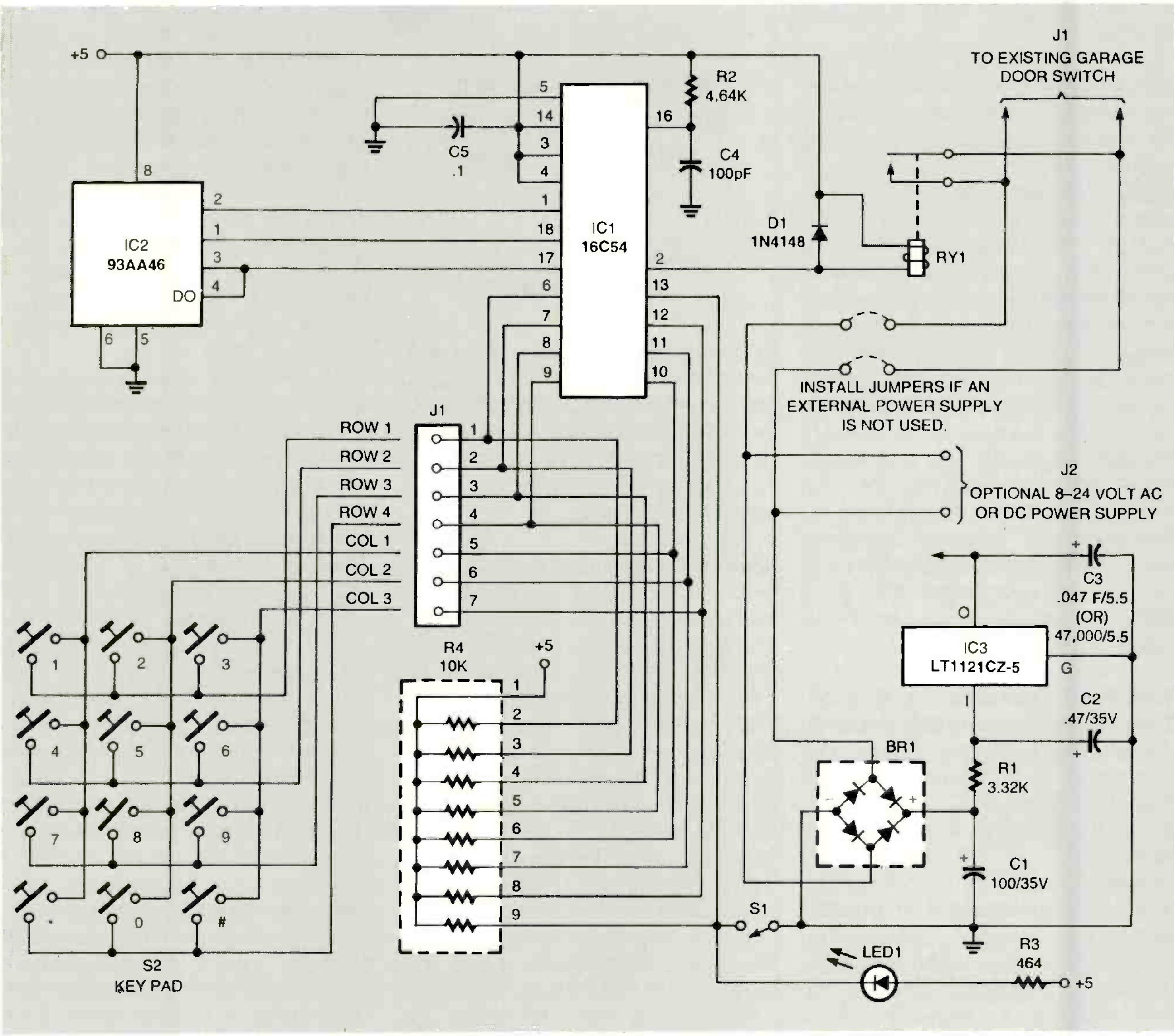


Fig. 1. The Garage-Door Keypad is a simple circuit that is built around a PIC microcontroller. The entire circuit draws less than one milliamp, so it can be powered by the voltage that comes from the garage-door opener connected to J1. Since RY1, when operating the garage-door opener, shorts out the power source, C3 is used as a battery backup—keeping the circuit alive until RY1 releases.

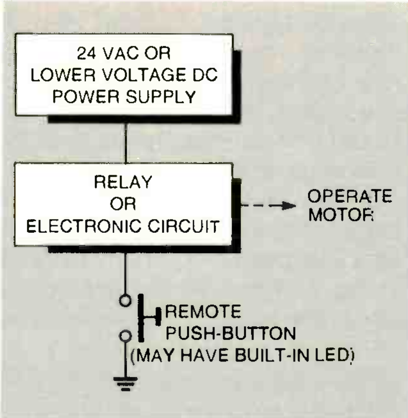


Fig. 2. Most garage-door openers have a voltage present across their remote pushbuttons. As long as less current than what the garage-door opener's relay needs to trigger is drawn, an additional circuit (like the Garage-Door Keypad) can be powered without tripping the garage-door mechanism.

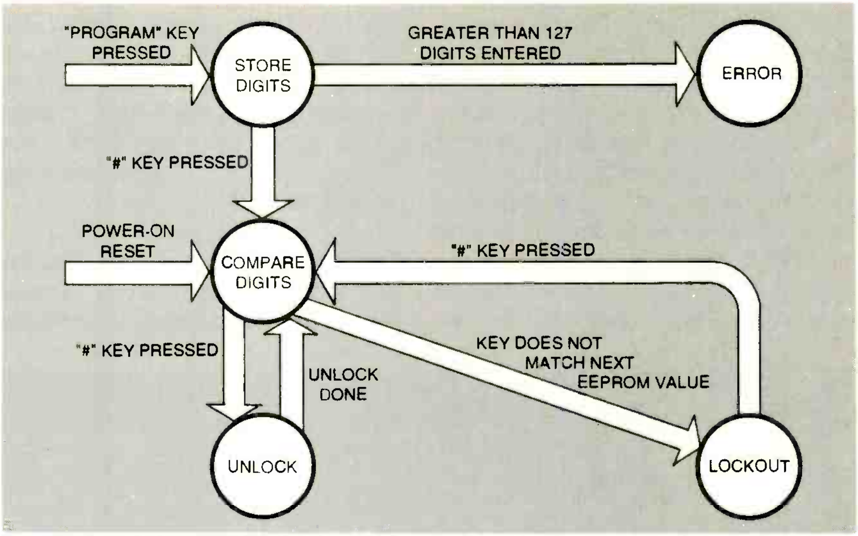


Fig. 4. One way to write a complex program is to divide up the task into many small tasks; the approach is called the "software-state machine." That approach is used by the Garage-Door Keypad. This diagram shows the various states and their relationships to each other.

out, the state-machine routine is run. As we will see in the next section, that routine performs most of the Garage-Door Keypad's functions.

Finally, the loop ends with a "sleep" command, shutting down IC1. An on-board watchdog timer resets IC1 when it times out (about every 18 milliseconds), starting the software loop over again. Normally, a watchdog timer is used to prevent accidental "lockup" of the microcontroller. When it is used that way, the software would frequently clear the watchdog timer so that it is not allowed to time out.

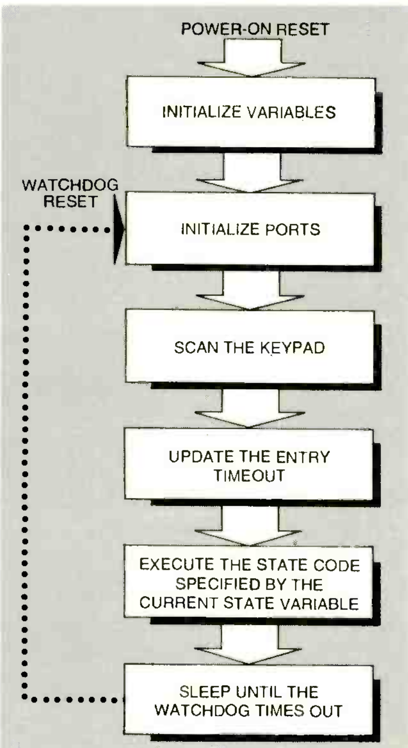


Fig. 3. The Garage-Door Keypad's software is a simple loop that executes once and "goes to sleep" until an on-board timer in IC1 triggers, resetting IC1 and starting the loop over again.

The Software-State Machine. Most of the software in the Garage-Door Keypad is organized using a software programming technique called the *software-state machine*. In that method, the various "states" of a program are diagrammed with a traditional state diagram. A small piece of software code is then written for each state in the diagram. A variable is used to identify in what state the machine should be. That variable determines what piece of code should be run. The software-state method lets a programmer organize and breakdown a large problem into smaller and more manageable pieces. An example of a software-state diagram—the Garage-Door Keypad's software-state diagram—is shown in Fig. 4.

The state variable in the Garage-Door Keypad's source code is simply called STATE. The main loop software uses the current value of STATE to pick the correct software segment to run each time through the loop. One interesting programming technique is when a code segment changes the value of STATE, thereby forcing the state machine into a different state.

A power-on reset starts the state machine off in the COMPARE DIGITS state. Any entered keys are compared to the series of key values that are stored in IC2. The state machine remains in the COMPARE DIGITS state as long as the entered keys match the xmachine advances to the UNLOCK state. If ever an entered key does not match the next key stored in EEPROM, then the state machine advances to the LOCKOUT state. An example of that is if the stored combination is "1-2-3-4." If the keys "1," "2," "3," and "4" were pressed, the "#" key would change the state machine to UNLOCK. If, on the other hand, only the keys "1," "2," and "3" were pressed, the "#" key would change the state machine to the LOCKOUT since the two codes don't match.

The UNLOCK state simply activates RY1 for about one second, opening or closing the garage door. The LOCKOUT state will ignore any additional entered keys until the "#" key is pressed. In that way, a potential intruder is not alerted to the fact that the key sequence that was entered has stopped matching the stored sequence in IC2.

If S1 (the "program" key) is pressed at any time, the STORE DIGITS state is entered. In that state, any entered keys are sequentially stored in IC2 until the "#" key is pressed. As a general rule when designing state-machine code, the software segments for each state should not loop within themselves; they should perform the desired action only once and then exit. As an example of that, the code for the STORE DIGITS segment stores only one digit at a time.

You can see the logic behind the STORE DIGITS state in the flow chart shown in Fig. 5. The STORE DIGITS state-software segment, as well as the other state-software segments, makes use of a number of support subroutines for blinking the LED (*BlinkLED* and *WinkLED*), reading data from IC2 (*EEPRead*), writing data to IC2 (*EEPWrite*), and delaying any further action for a specified period of time (*Delay*). See the source code file for details.

Construction. The circuit for the Garage-Door Keypad is simple enough to be laid out on a single-sided PC board. If you wish, you can make your own board; a foil pattern has been provided here. As an alternative, an etched and drilled board can be purchased from the source given in the Parts List.

If you do use a purchased PC board or one made from the foil pattern, the parts-placement diagram in Fig. 6 shows where the various parts are located. Before installing

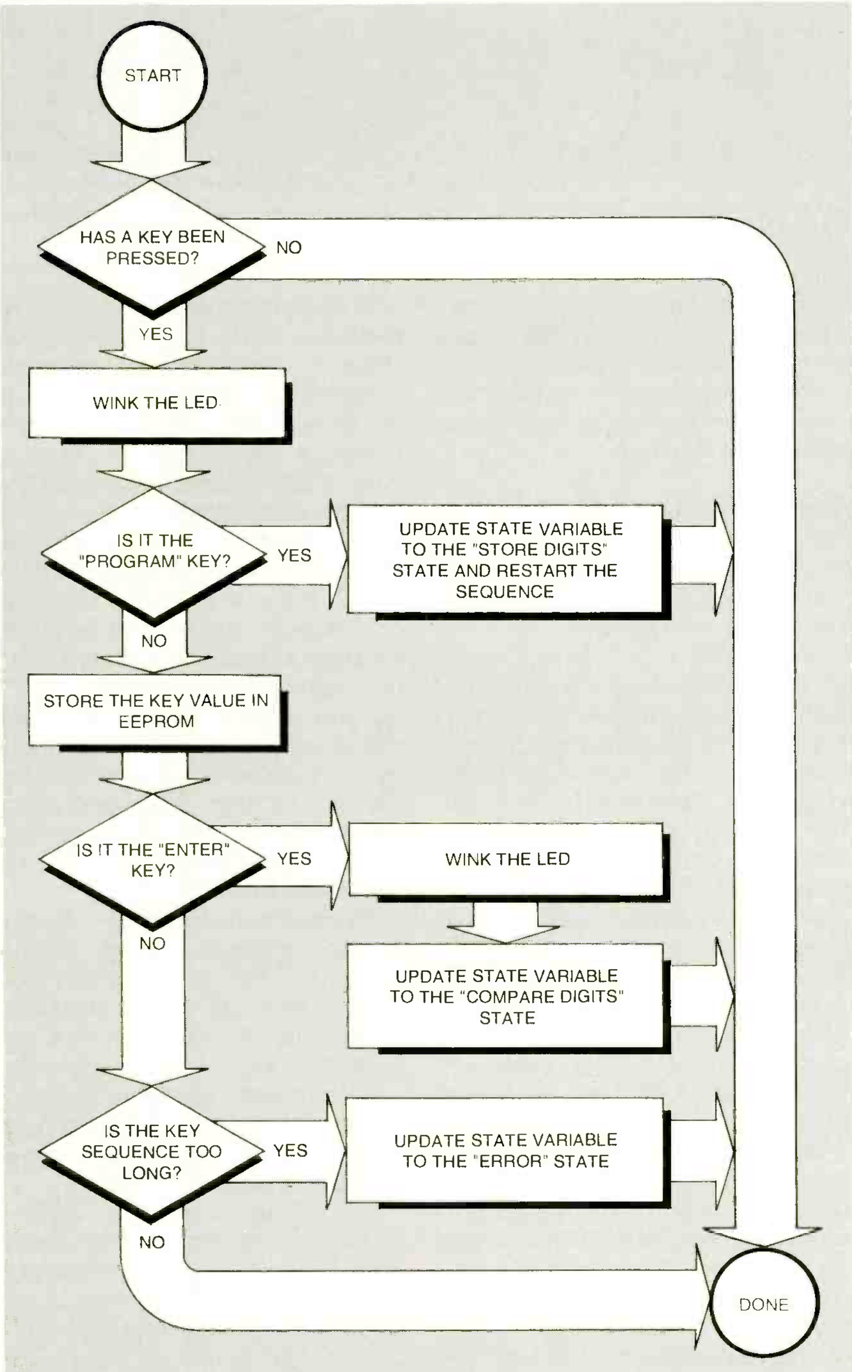


Fig. 5. An example of how the Garage-Door Keypad uses the state-machine concept is shown in this flowchart of the STORE DIGITS state. Note that, like any well-designed state-machine code, the routine is executed only once and exits—it does not loop back to itself.

PARTS LIST FOR THE GARAGE-DOOR KEYPAD

SEMICONDUCTORS

IC1—PIC 16C54-RCI/P microcontroller, integrated circuit
IC2—93AA46/P serial EEPROM, integrated circuit
IC3—LT1121CZ-5 5-volt regulator, integrated circuit
BR1—1-amp, 100-volt bridge rectifier
D1—1N4148A silicon diode
LED1—Light-emitting diode, red

RESISTORS

(All resistors are ¼-watt, 1% metal-film units unless otherwise noted.)
R1—3320-ohm
R2—4640-ohm
R3—464-ohm
R4—10,000-ohm, 10-pin resistor pack, single-inline package

CAPACITORS

C1—100-µF, 35-WVDC, electrolytic
C2—0.47-µF, 35-WVDC, electrolytic
C3—0.047-farad or 47,000-µF, 5.5-WVDC, electrolytic
C4—100-pF, ceramic-disc
C5—0.1-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

J1, J2—2-contact terminal, screw contact
RY1—Single-pole, single-throw 5-volt relay (Magnecraft W107DIP-1 or similar)
S1—Single-pole, single-throw miniature pushbutton switch, momentary action
S2—12-digit keypad (Digitran KL0054W or similar)

Note: The following items are available from: A and T Labs, Box 4884, Wheaton, IL 60189, Fax: 630-668-7870: etched and drilled PC board, $15 plus $3 shipping/handling within US, $5 shipping/handling outside US; kit of all parts including PC board and water-resistant keypad, $39 plus $4 shipping/handling within US, $7 shipping/handling outside US. Check, VISA, MasterCard accepted. IL residents must add appropriate sales tax.

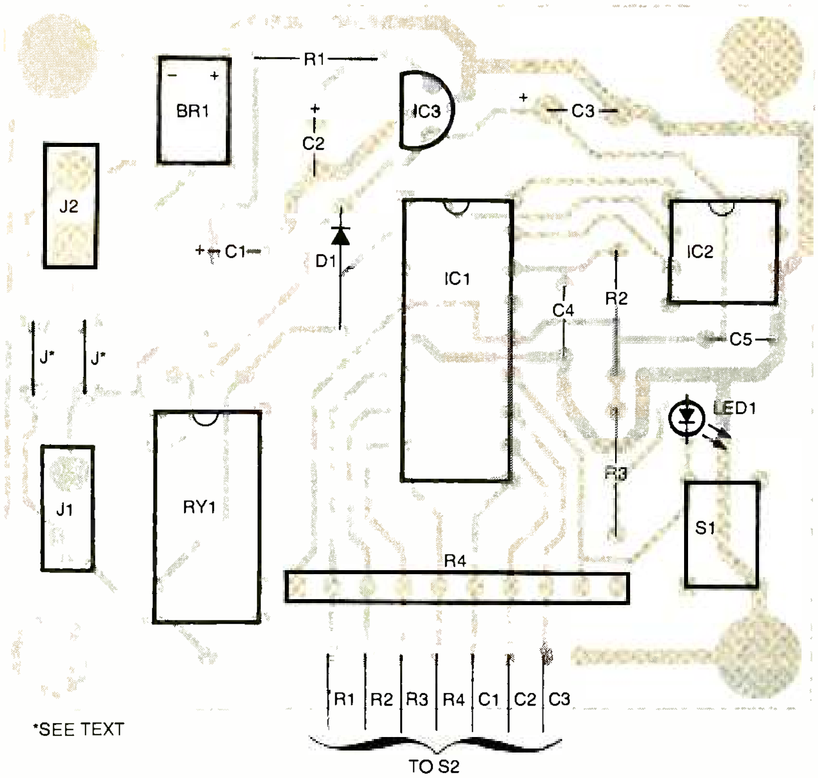
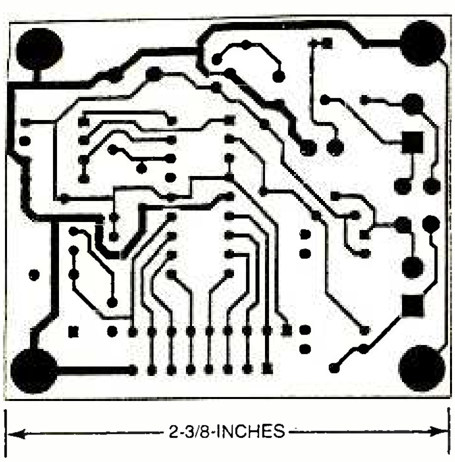


Fig. 6. The Garage-Door Keypad is easily built on a single-sided PC board. If your garage-door opener can supply the current needed to run the Garage-Door Keypad, install the two jumpers; J2 can then be left out as it will not be used. If, on the other hand, you will be powering the unit from an external power supply, leave the jumpers out and connect the power supply to J2. Don't worry about polarity on J2—either AC or DC can be used.

IC1, make sure that it has been programmed with the Garage-Door Keypad software; the PIC chip available from the source given in the Parts List is already programmed.

Install all of the board-mounted components with the exception of the two jumper wires, carefully checking resistor values and component orientations as you work. Temporarily connect keypad S2 as shown in Fig. 1. Using a bench power supply, apply 10 to 24 volts AC or DC through a 1000-ohm resistor in series to J2. Push program button S1; LED1 should light. Enter a short digit sequence followed by the "#" key. Re-enter the same sequence of numbers, again followed by "#" key. With each key press, LED1 should flash. Once you have entered the correct combination of keys, you should hear RY1 operate for about one second.



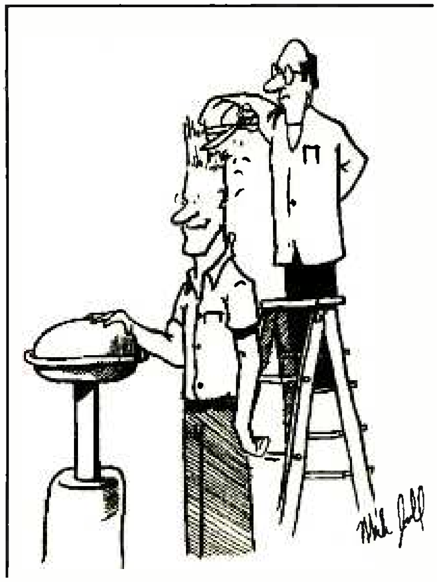
Here's the foil pattern for the Garage-Door Keypad. The simple circuit fits nicely on a small single-sided board.

Wait a few moments and type in a wrong code. Check that RY1 does not operate when the "#" key is pressed; LED1 should continue to indicate key presses. The correct code should not activate RY1 unless the "#" key is pressed before entering it.

If you will be powering the Garage-Door Keypad directly from the garage-door opener, install the two jumper wires.

Installation. Choose a suitable mounting location for S2. If you are using the suggested keypad, drill four small corner holes that match the mounting studs in the keypad. Drill an additional hole or slot for the ribbon cable. A slot can be cut by either sawing or drilling a series of holes. Thread the ribbon cable through the wall and mount the keypad with a bead of clear silicon rubber inside the back perimeter of the keypad. Run the ribbon cable to the PC board and mount the PC board inside the garage as desired. Connect two wires from J1 to the opener-operating contacts or in parallel with an existing garage-door-operating button inside the garage. If, on the other hand, you cannot power the Garage-Door Keypad directly from your garage-door opener, simply leave out the two jumpers on the board and connect J2 to a wall transformer that supplies from 10 to 24 volts, AC or DC.

Other Applications. You can easily use the Garage-Door Keypad for keyless operation in a variety of other applications; the uses are limited only by your imagination. If those other applications are not able to power the Garage-Door Keypad as described above, then you can simply leave out the jumpers and power the board from a DC or AC power source that supplies from 10 to 24 volts. Less than one milliamp of current is needed by the Garage-Door Keypad. Ω



NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

The Golden Age of Televisions

by Philip Collins
General Publishing Group, Inc.
2701 Ocean Park Blvd., Suite 140
Santa Monica, CA 90405
Tel: 310-314-4000
Fax: 310-314-8080
$15.95

CIRCLE 338 ON FREE INFORMATION CARD

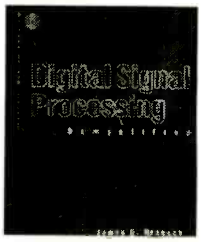
Whether they are 45-inch monstrosities or 2- by 2-inch pocket pals, today's televisions display a uniform slickness. In this book, the author presents a time when televisions were virtually works of modern industrial art—from the smallest screen and futuristic designs that never quite took off to wooden cabinets rivaling the finest of fine furniture.

Through words and images, Collins—a noted visual historian—explains the important role these televisions played in our culture and their social relevance. They were the center of every home. This 120-page journey through nostalgia is not only for collectors and historians, but also for anyone who loves TV.

Designed by Kosh, a pop-culture artist, this eye-catching glossy 8½- by 9½-inch book is filled with 100 color photographs. It takes readers through 70 years of design, history, and programs. Evoking memories of growing up in the golden age of TV heroes, the work recalls the names of early TV manufacturers: Philco, Dumont, Silvertone, Crosley, Airline, RCA, Emerson, Arvin, Admiral, and Motorola.

Digital Signal Processing Demystified

by James D. Broesch
LLH Technology Publishing
3578 Old Rail Road
Eagle Rock, VA 24085
Tel: 800-247-6553 (for credit card orders) or 540-567-2000
Fax: 540-567-2539
Web: www.LLH-Publishing.com
$49.95



CIRCLE 339 ON FREE INFORMATION CARD

Digital signal processing (DSP) is one of the fastest growth areas in electronics, making its way into everything from surveillance satellites to talking toys. This book is a readable, practical tutorial that focuses on the design-oriented information needed by working engineers.

The 232-page book is accompanied by a CD-ROM containing the DSP Calculator suite of educational software routines that interactively illustrate the fundamentals of DSP. The tools included with the DSP Calculator enable the student to create waveforms, design filters, filter the waveforms, and display and analyze the results. The book and the software, which is designed to run under Windows 3.1 or 95 on a minimal 386 system with at least 4 MB of RAM, work hand-in-hand to bridge the gap between theory and engineering design practice. Together they create a "virtual laboratory" for experimenting with basic DSP principles. The purpose of this volume is to give readers both practical knowledge and a sound foundation.

Topics covered include components of a DSP system, the mathematical basics underlying DSP, sampling theory, the Fourier series, orthogonality and quadrature, transforms, FIR filters, IIR filters, and DSP tools. Although the book is written for engineers, the mathematics is kept as simple as possible. The book will also be useful to students about to embark on formal DSP educational training and to program managers and marketing personnel who need to develop an understanding of real-world DSP concepts.

1998/1999 Power Product Guide and Catalog

Hewlett-Packard Company
Test and Measurement Organization
5301 Stevens Creek Blvd., MS54LAK
Santa Clara, CA 95052
Tel: 800-452-4844, ext. 5921
Web: www.hp.com/go/power
Free

CIRCLE 340 ON FREE INFORMATION CARD

The 16-page Guide (Literature No. 5966-1707) contains a concise overview of Hewlett-Packard's power product line, highlighting key features and specifications. In addition, the 65-page Catalog (Literature No. 5966-1706) provides R&D and production engineers with complete technical information on more than 125 models of dynamic measurement DC sources, AC power source/analyzers, harmonic/flicker test systems, DC power supplies, DC electronic loads, solar array simulators, and modular power systems.

New products featured in the publications are the HP 6610 and 6630 series precision-measurement single-output system DC power supplies and the HP E4351B solar array simulator, an addition to the HP E4350B series. With the power supply, users can take measurements without having to configure external shunts, relays, and digital multimeters. The solar simulator simulates the I V curve of solar rays accurately, allowin test engineers to perform satellite testin with greater precision and efficiency.

(Continued on page 6

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

"Heads-Up" Digital VOM

DESIGNED FOR INDUSTRIAL AND residential electricians, the VisualEYEzer uses "heads-up" technology to project the VOM display in front of the user's right eye. Always in sight—no need to look away to get a reading—this display feature allows the electrician to use both hands to do testing.

The two-piece system consists of a belt pack and a headset that is optically isolated from it. Connected to the belt pack by a breakaway cable, the lightweight headset comes with an adjustable, padded headband. Resembling a typical fanny pack, the belt pack is made of rigid black plastic. Its sloped top panel displays the pack's only controls—an on/off slide switch and contrast- and loudness-up and -down pushbuttons.

Readings are taken from the belt pack and displayed on the headset. The latest model of the VisualEYEzer features a more rugged eyepiece with a 20% larger viewing surface. An adjustment arm has been added for positioning the eyepiece to keep it fingerprint free, and an adjustable friction hinge keeps the eyepiece in place.

CIRCLE 20 ON FREE INFORMATION CARD

The viewing lens is a transparent, semi-silvered mirror that projects the red, 4000-count display and annunciators, which are quite readable—even in low-light areas. The image appears to float at a comfortable 18 inches in front of the user's right eye and permits unobstructed vision of whatever else the viewer is seeing.

Two different eyepieces are available: one for indoor use (supplied) and the other (optional) for use outdoors or in bright conditions. Lenses can easily be changed in less than 30 seconds.

Voltage ranges have been extended to 600 volts for work on 480-volt AC lines. Each newly designed test probe tip now contains a high-energy 1-amp/600-volt-rated BBS fuse that prevents damage from going any further than the probes when a fuse blows.

Two multifunction pushbuttons located on the test probes replace the traditional range and function controls. These pushbuttons allow the user to change ranges and functions without looking away from the unit under test. Pressing the black probe pushbutton selects the desired function. Pressing the red probe pushbutton changes the range. Simultaneously, the display cycles through the different LED annunciators, indicating the function or range selected.

The VisualEYEzer comes complete with belt pack and adjustable web belt, headset and padded headband, 60-inch fused test leads, screw-on alligator clips, connecting cable, indoor eyepiece assembly, and instruction manual. It is conveniently stored in a hard-sided, foam-lined carrying case and is powered by four C-cell alkaline batteries or by the included AC power supply. Its list price is $369.

TRIPLETT CORP.
One Triplett Drive
Bluffton, OH 45817
Tel: 800-874-7538 or 419-358-5015
Fax: 419-358-7956
Web: www.triplett.com

Surveillance Clocks

THE TWO LATEST I-SPY CAMERAS from American Innovations, Inc., the MC-985 Mahogany Clock Cam (7 inches wide by 8 inches high) shown here and the CL-985 Carriage Clock Cam (4 inches wide by 5 inches high), blend into any home or office setting. Ideal for surveillance operations, each clock covertly conceals a color video camera with a horizontal resolution of 380 lines and a super low 2-lux sensitivity rating. Each camera also has built-in backlight compensation, enabling it to function in a room with minimal lighting. The custom-designed pinhole lens offers a 92-degree viewing field through an opening that measures only 2mm.

CIRCLE 21 ON FREE INFORMATION CARD

Since the cameras use standard video signals, they can be connected to the TV or VCR. Users can set the timer function on the VCR to check an area at predetermined times and/or intervals.

The clock cameras can be used in the office to monitor the performance of employees. They can be placed in a store to protect merchandise and prevent losses. These cameras are also perfect for working parents who want to keep an eye on the nanny and/or housekeeper while they are away at work. The special introductory price for these two I-spy color clock cameras is $350 each.

AMERICAN INNOVATIONS, INC.
119 Rockland Center, Suite 315
Nanuet, NY 10954
Tel: 914-735-6127
Fax: 914-735-3560
Web: www.spysite.com

Continuity Tester

DESIGNED SPECIFICALLY FOR the electronics manufacturing industry, the Short Finder Brush (SF 10) is a high-speed continuity tester that eliminates the tedious, time-consuming, point-to-point testing method. The continuity tester's ergonomic design (8.4- × 1.3- × 1-inches) makes it ideal for every day use by personnel in electronics and PCB manufacturing and in production testing; by field service engineers; and by electronics, telephone, electronic service/repair, and field installation technicians.

CIRCLE 22 ON FREE INFORMATION CARD

The Short Finder Brush is used by holding the reference probe in contact with the point of test, and then sweeping the circuit with the low-voltage stainless steel brush-tipped probe until continuity is localized by an audible tone. The search probe identifies the actual point of continuity by conducting a point-to-point search within the area previously identified by the brush. Low-test voltage, which is limited to 0.5 volts DC at 100 μA, protects sensitive circuitry and eliminates false continuity indications.

The brush probe allows technicians to sweep over multiple test points and instantaneously find the location of shorts in complex electrical circuits, such as printed circuit card assemblies, multiconductor cables, mass termination systems, backplanes, connectors, and IC sockets. Two AAA batteries provide portable operation. The Short Finder Brush (SF 10) has a list price of $35.95.

WAVETEK CORP.
9405 Balboa Avenue
San Diego, CA 92123
Tel: 800-854-2708 or 619-279-2200
Fax: 619-450-0325
Web: www.wavetek.com

Undercover Pen

LOOKING LIKE AN ORDINARY pen in your pocket, the VP-300 Color Video Pen Camera has a micro-miniature color CCD camera hidden inside.

CIRCLE 23 ON FREE INFORMATION CARD

Though small, the unit delivers excellent picture quality. Images can be recorded by using a standard portable video recorder or by being fed into a video transmitter for remote time recording and/or observation. Perfect for law-enforcement operations, private investigators, and undercover news reporters, this unit is a revolutionary way to record live events that require the utmost discretion.

The VP-300 Pen boasts a TV resolution of over 330-line horizontal lines, a low 2-lux sensitivity, and the ability to capture video in low-light settings. Its 3.6mm- pinhole lens delivers a field of vision of 92 degrees. This pen protects your next undercover assignment by making sure that everything is caught on tape.

Optional components (Sony 8mm-video recorder and battery pack) fit neatly into a small waist pack. Since there is no cumbersome video equipment to carry, this easy-to-use unit will always be kept close to hand. Set up takes only a few seconds.

The VP-300 sells for $2400.

AMERICAN INNOVATIONS, INC.
119 Rockland Center, Suite 315
Nanuet, NY 10954
Tel: 914-735-6127
Fax: 914-735-3560
Web: www.spysite.com

BY DON LANCASTER

Optical Rangefinding, The Right Way to Measure AC Power, and More

FROM THE NUMBER OF INFOPACK QUERIES I GET ON THE TOPIC, AN ABILITY TO EXACTLY MEASURE SHORT DISTANCES IS VERY MUCH IN DEMAND. AS IT TURNS OUT, THERE IS ONE HIGHLY EFFECTIVE, EMINENTLY USABLE, AND LITTLE-KNOWN static optical rangefinding DX technique. Let's take a look at it.

Position-Sensitive Detectors

Look way on down the street. Now look at the tip of your nose. Do you see how your eyes tilt inward to view a closer object? That principle is the basis of the parallax distance measurement method shown in Fig. 1A.

You probably also know this as the split-image method, commonly used in military spotting and better-grade cameras. If you know the baseline width and the tangent of the inward tilting angle, you calculate distance by using:

$$\text{distance} = \text{baseline} \times \tan\Theta$$

Your results can be quite accurate close in, but get progressively worse as the angle nears ninety degrees and its tangent approaches infinity. The trick is to come up with some method that uses parallax but has no moving parts. The secret to doing that lies in Fig. 1B.

Shine some infrared light on an object; use a laser for accuracy or a plain LED in a cheaper system. Focus the returned light on a special semiconductor device. The position of the light should move from right to left across the device as a function of the distance. Measure position to sense distance.

Now your "special semiconductor device" could be nothing but a pair of side-by-side IR photodiodes. But it turns out there are position-sensitive detector chips that do a better job.

There is one inside trick: How do you make the system respond only to the position of the reflected light and not to the intensity? Simply by use of normalizing. Let L be the intensity returned by the left side of the sensor and R be the intensity returned by the right side of the sensor. Then you can go ahead and calculate:

$$\text{position} = (L-R)/(L+R)$$

This returns an "amount of offset" independent of the actual strength of the light. The offset is then related to distance as a tangent function. Yes, the division is hard to do in the analog world, but is no big deal digitally.

Sharp Optoelectronics has a nice GP2D02 chip that can do all the work. Details are shown in Fig. 2. Arrange the optics so the reflected infrared light moves across the chip as a function of distance. The built-in IR diode pulses your target. The return image traverses its internal position-sensitive detector.

NEED HELP?

Phone or write all your US Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher AZ, 85552
Tel: 520-428-4073

US email: don@tinaja.com
Web page: http://www.tinaja.com

Goodies in the chip do the needed difference sensing, A/D conversion, and DSP.

The output is a serial 8-bit digital number. That number is easily related to distance using a calibration curve and table lookup. A Basic Stamp or a PIC is ideal to gather and display the range information. See the Sharp data sheet for timing and readout information.

The measurement cycle takes 70 milliseconds, followed by eight clock pulses of 0.2 milliseconds maximum and a stop pulse of 1.5 milliseconds. The effective range of this chip is 8 to 120 centimeters, or roughly three to forty inches. The supply current is 17 milliamps operating and 8 milliamps standby on a 5-volt supply.

A few obvious uses include camera autofocus, parking-lot or garage auto obstacle avoidance, and auto-power for hand dryers. Plus, of course, there are scads of close-in robotic-sensing apps.

The chips work best with *specular* or diffuse reflection. Yes, any hot spots could be a problem. But the infrared system is largely color independent. Fancier techniques can be added if other ranges are needed.

Sharp also has announced the GPD212 analog and GPD215 digital devices. Those are stand-alone and need no external computer control. They also offer PD3101 and PD3151 detector PSD chips that they intended for camera auto-focus uses. One competitor is Hamamatsu with their S4282-11 and S4282-72 devices. A second alternate PSD supplier is Ricoh.

One source for further PSD information is SPIE, also the Society of Photo Optic Engineers. Their *Proceedings #2002* on Photodetectors and Power Meters is one possible starting point. A PSD fundamentals tutorial can be found at www.nts.mh.se/~johma/psd

A really great FAQ on just about everything involving LEDs can be downloaded at the www2.whidbey.net/optoinfo/ LED_FAQ.html site. I have got a detailed custom InfoPack available on optical rangefinding; see www.tinaja.com/info01.html

Another Look at AC-Power Measurement

Until quite recently, it had been very difficult to accurately measure AC power. Especially in the presence of any strange waveshapes, reactive energy, noise, or sparking. Nearly all casual measurements tend to end up low, often ridiculously so, leading to all sorts of pathetic claims that relate to circuit "efficiencies" and to "overunity" operation.

All average-responding voltmeters and ammeters are useless for much of real world power measurement. So is staring at some oscilloscope without having the foggiest clue what you are looking at. All of which leads us to beginning EE student blunder #01-A—that of confusing average and rms voltage or current.

We've done a bit on this, but I'd like to return to this topic one more time, hitting it from a slightly different angle. We'll start with these fundamental rules:

instantaneous power = instantaneous voltage × instantaneous current

and

efficiency = (average power out)/(average power in)

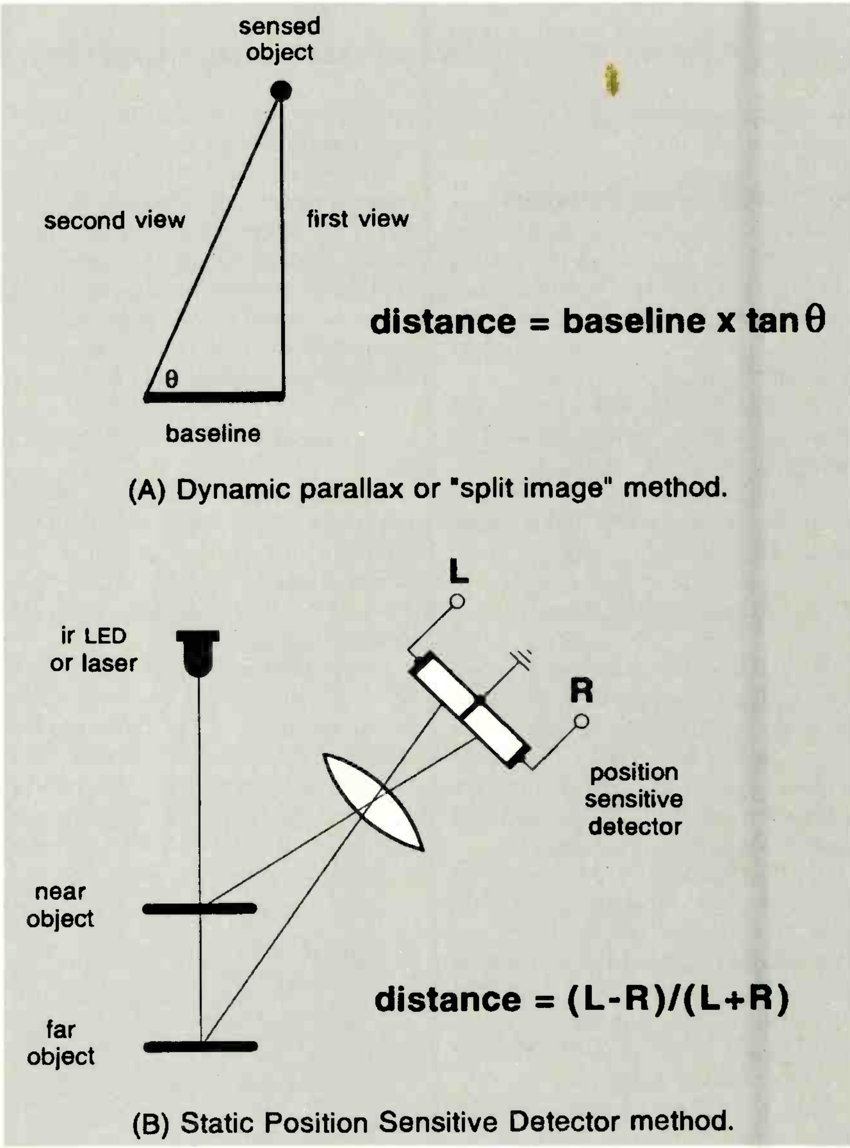


FIG. 1—HERE ARE TWO METHODS of optical rangefinding. Basic parallax rangefinding is shown in A, while B shows a method that uses electronics and no moving parts.

The latter will always be a number from 0 to a tad under 1. That value often is multiplied by 100 to get a percent efficiency from 0 to 99.9 The losses will almost always be in the form of low-grade heat.

Any efficiency above 100% is experimental error. Or (in the case of a heat pump) does not account for all of the energy inputs. This is true every time and without exception.

Suppose you have a box with two terminals on it. Make a very brief and a simultaneous measurement of your voltage and the current. Make sure that your measurement is brief enough that neither one changes much during your measurement time, and clean enough that noise will not be a factor. Accurately multiply the voltage and current values together to get your instantaneous power. Sum these over time and then divide by the number of samples to get average power.

If the voltage and current samples are both positive or both negative, then your box is acting as a load. The box should be getting hot, adding to its internal E and H energy fields, doing work, or otherwise converting energy into some other form.

If measured voltage and current have opposite signs, your box acts as a source. Your box is cooling down, removing strength from its internal energy fields, is being mechanically worked upon, or otherwise should be converting energy from other inputs into output electricity.

Sometimes a box might cyclically accept energy and then later return it, which happens when internal electric or magnetic fields are getting bigger or smaller. We refer to this back-and-forth process as reactive energy. All reactive power will average to zero over the long term.

Because of reactive energy, an AC motor will typically act as a load for most of the time, but as a source for the remainder. We did see examples of this back in MUSE123 (May 1998 issue of **Electronics Now** or on my Web site).

For accurate results, you multiply first and average last. Why? Because average first and multiply last almost always gives you low results. Also remember that the average of products is not the same as the product of averages!

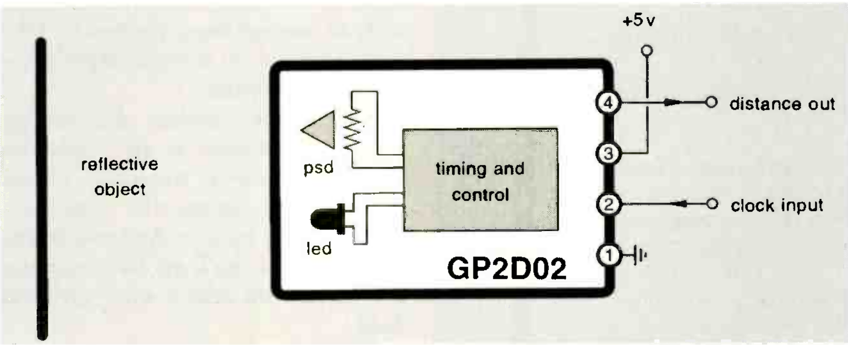


FIG. 2—THIS POSITION-SENSITIVE DETECTOR (PSD) module with no moving parts from Sharp accurately measures short distances.

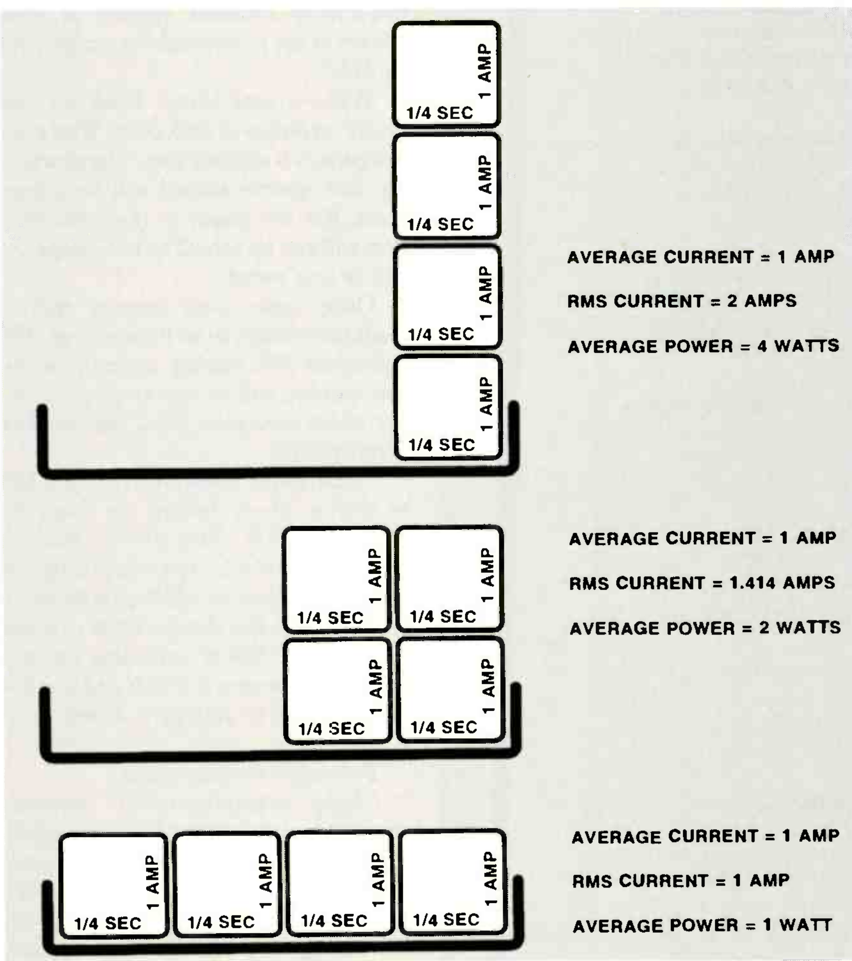


FIG. 3—THE SHAPE OF A WAVEFORM very much determines its average power. Average current (common to most meters) is meaningless for most power measurements. This is a common beginner's mistake.

Playing With Blocks

Suppose you have four wooden blocks. Each block is labeled as 1.0 amp of current high and 0.25 second of time wide.

Suppose further that you've got a time bin that is one second wide. Should it matter how you pile your blocks into your bins? Can the exact arrangement of the four blocks affect your circuit power?

Assume a 1-ohm resistive load for now. Later on, the type and size of load will not matter.

In Fig. 3, we first place all four blocks side by side. The average current is obviously 1 amp. The energy in your first quarter second will be 0.25 watt seconds. The energy in quarters two through four should also be 0.25 watt seconds. Your total energy will be one watt second, and the average power will be one watt.

So far, so good. If we replaced our blocks with a continuous block that had equivalent heating power, it also would result in an average current of one amp and an average power consumption of one watt.

Now stack your four blocks up two high, and an amazing thing happens. You still have one amp of average current, because we have two amps for half a second and zero amps for half a second. But during your active half second, either the input voltage had to double or else the circuit load resistance halved. Using our above formula, the power in the first quarter second will now be two watts.

The power in your next quarter second should also be two watts. The power in the third and fourth quarter seconds should be zero. The average power should be *two* watts!

Hmmm. In one group, a one-amp average current gives us one watt of average power. In the second, a one-amp average current will give us two watts of average power.

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Average current is meaningless when calculating power. We instead have to find out what continuous equivalent current would give us the identical average power.

Well, our power turns out to be current squared times load resistance for a resistor. Or input current times input voltage for any load. Done either way, your equivalent DC continuous current needed turns out to be related to the square root of your average power. In this case, an average input current of 1.414 amps gives you an average output power of exactly two watts.

You might visualize this average continuous current as an "equivalent DC heating power" waveform. Or you can call this current the rms (root-mean-square) current. And rms is simply the results you'll get from counting the blocks and seeing what each one does.

Reviewing: The stacked average current will be 1.00 amp, but the rms current is 1.414 amps. Clearly, any average-responding ammeter (typical of most meters in use today) ends up reading low by 41%!

Wait—it gets worse. Stack all four blocks up on top of each other. Your average current is still one amp. The power in the first quarter second will be sixteen watts. But the power in the other time slots will end up zero. The average power will be four watts!

Once again, your average current reads low enough to be meaningless. The equivalent DC heating current, or the rms current, will be two amps. An average meter here gives you a one hundred percent error!

What about sinewaves? We did lots of fancy block piling on back in MUSE112.PDF (June 1997). You can pile up tiny blocks, use fancy math, or use the simulator we will look at below to conclude that the average value of a half sinewave is 0.684 of peak; that the rms value of a sinewave is 0.707; and that the ratio of peak to average is found to be 1.1106.

But only for whole cycles!

Cheap averaging-meter suppliers cheat and relabel their AC scales high by eleven percent. Such an averaging meter is totally useless to measure AC power. First, because of partial cycles or possible strange waveforms. And second, because of reactive currents that place instantaneous voltages and currents out of phase.

Summing up: The average power depends upon the duty cycle and the shape of the waveform involved. One proper way to measure your average power is to take many narrow voltage and current samples. You multiply your samples together to find instantaneous power, sum the samples to get accumulated power, and divide by the number of samples to get average power. This needs to be carefully done over either a very long time or an integer number of full cycles.

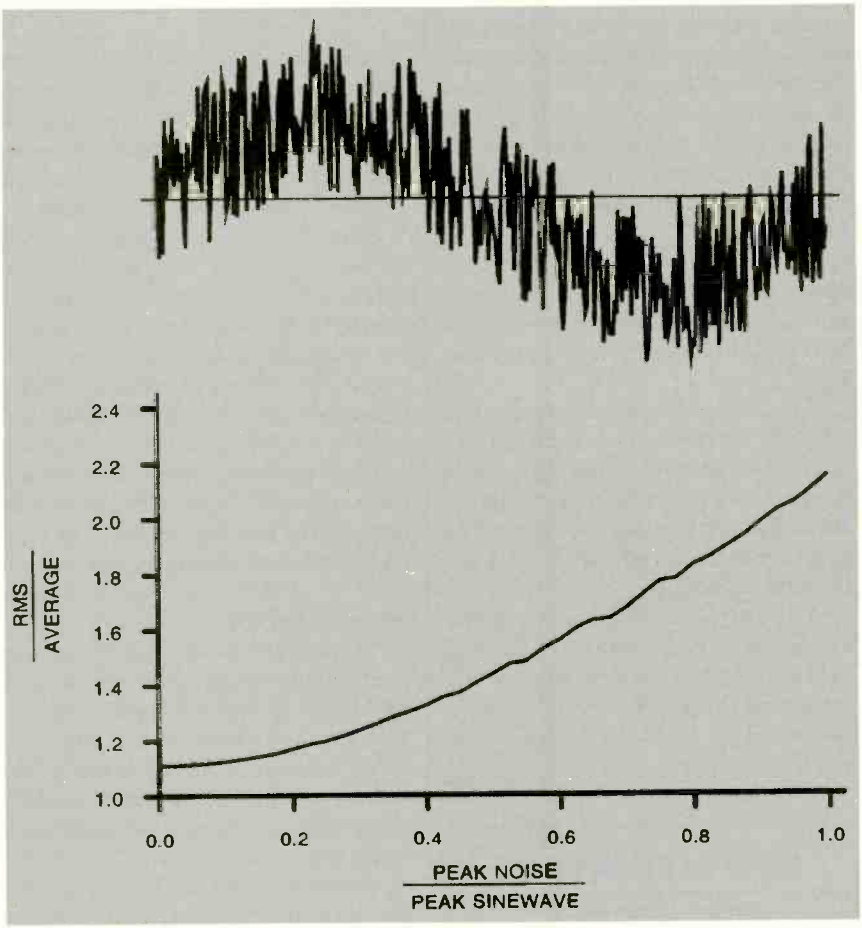

FIG. 4—ADDING NOISE to a sinewave increases the energy and raises its rms to average ratio. Noisy systems often lead to wildly wrong conclusions about power and efficiency, and to outrageous "overunity" claims.

Some Error-Correcting Code Books

Principles of Digital Communication (Andrew Viterbi)
1997 Error Correcting Code Symposium (Harold Mattson)
Algebraic Algorithms and Error-Correcting Codes (John Alton)
Applicable Algebra Error-Correcting Code Algorithms (Beth, Th.)
CDMA; Principles of Spread Spectrum Communications (Andrew Viterbi)
Coded Modulation for Fading Channels (Hamidreza Jamali)
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Introduction to Error-Correcting Codes (Michael Purser)
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Theory & Applications of Error-Correction Codes (Jiri Adamek)
Trellis Coding (Christian Schlegel)
Voice & Data Communications Handbook (Regis Bates)
Understanding Data Communications (Gilbert Held)

Since analog multipliers get into severe crest factor problems, digital is the only way to go here. A number of effective low-cost AC power measurement tools are found at Brand Electronics. And, yes, they easily deal with strange or unusual waveforms. Click their banner link at www.tinaja.com

These days, it is simple enough to use a PIC and simultaneous A/D chips like the Maxim MAX125/126 to make the 12,000 or more minimum samples per second needed to do the job right. Almost any better grade PC data-acquisition plug-in can also be used with appropriate care. Regardless of how you go about things, knowing your precise waveforms is crucial.

What About Noise?

A question came up on the web over what effect noise has on power waveforms. The specific questions dealt with noise caused by the bubbling in a cold-fusion cell or the cavitation in a Griggs pump.

Figure 4 shows what happens if you add random-noise energy to any sinewave. As expected, the ratio of rms to average goes up, causing any average responding meter to further under-report.

By an astounding coincidence, the under-reporting seems to end up the same size as certain overunity claims, proving that free-energy enthusiasts are a source of noise.

Such simulations are both trivial and fun to do using PostScript. These models also let you use simple math to replace fancy calculus and related advanced calculations. I've posted the source code for the simulation and the Fig. 4 artwork at MUSE131.PDF on www.tinaja.com

Error-Correcting Codes

Say you add one bit to a data word designed to always make the number of ones in the word even. Test that bit on reception. Should you have an odd number of ones, then an error likely has occurred. You then can ask for a correcting retransmission.

This is an example of a simple parity check. Now arrange all of your words into blocks. Add parity to row and column. This time, on reception, a row-parity violation and a column-parity violation often can "point" to a problem bit that can be fixed. You've got an error-correcting code.

By looking at fancier combinations of

bits using polynomial math, you can conjure up codes that can correct themselves better and can do so even in the presence of multiple errors. I've gathered together a few of the books on error-correcting code as this month's resource sidebar. The classic text is A. Vitribi's *Principles of Data Communications*, but it is out of print and may be hard to find. More information on these titles is up at www.tinaja.com/amlink01.html

New Tech Lit

From Phillips Business Information comes a free North American Satellite Access wall chart. From Sensory Systems, there are details on a Voice Dialer speech recognition chip intended for telephone uses.

From Dallas, there's a new booklet on Thermal Management chips. They've got some really interesting, accurate, and low-cost chips here. A well-done tutorial on RFID radio frequency identification appeared in *RF Design* for July 98, pp. 38-44.

More details on "pushme-pullyou" Hexapod machine systems that can be amazingly accurate, quite simple, and completely eliminate sliding ways are found at www.i-way.co.uk/~storrs/lme/LMEHexapodMachine.html Some related tutorial information is found at www.tinaja.com/flut01.html

Tech magazine update: Check out the *Amateur Television Quarterly*; the expensive *Fuel Cell Technology News*; MRT, which used to be *Mobile Radio Technology*; *Flow Control* on fluid handling; *Wireless Integration*; and *Biomass & Bioenergy*.

Electronics Bench Reference is a labor-of-love published by Dick Tormet. It is full of useful data. It is available through RMT Engineering.

Low-cost "Cash and Carry" InfoPack consulting services can now be found at www.tinaja.com/info01.html

From Loctite comes a booklet on light-cure technology—adhesives that set up in the presence of strong ultraviolet light. It also has a good review of UV fundamentals. From DuPont comes details on their upgraded Somos 7100 stereolithography resins. These can be used in Santa Claus machines. For other suppliers and background information, see www.tinaja.com/santa01.html

Lots of free samples this month. A large packet of Schottky power diodes is available from International Rectifier; some really good NukeTape silicon-rubber splicing tape from United Controls; and SiBar thyristor surge protectors from the folks at Raychem.

Wireform is a new flexible screen product from Paragona Art Products. This should have all sorts of mockup and prototyping uses as well.

For most individuals and smaller scale startups most of the time, any involvement whatsoever with patents is nearly certain to end up a net loss of time, energy, money, and sanity. Details in *My Case Against Patents* package, along with my tested and proven real-world alternatives. See my nearby Synergetics ad for full details.

Bunches of surplus test equipment, optics, and robotics bargains are now up at www.tinaja.com/bargte01.html There's even a full PC-board plate-through hole lab.

The latest additions to my Guru's Lair Web site include a free technical user forum; fast "power nav" buttons; more on buying military surplus; tips on finding test-equipment manuals; new typesetting secrets; and some updates on Book-on-Demand publishing.

As usual, most of these mentioned items appear in a Names & Numbers sidebar. Be sure to check here before calling our no-charge US technical help line mentioned in the "Need Help?" box you'll find nearby.

Let's hear from you. EN

NEW LITERATURE

continued from page 50

Measurement Products Catalog 1998/1999

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The 700-page soft cover catalog includes a full-color, new product section that features over 70 new products and measurement solutions. Throughout, the catalog highlights ISO 9001-compliant products as well as products meeting CE certification. In addition to detailed product descriptions, the catalog lists tutorials, application notes, and technical briefs. Extensive indexes list products by name and by function, as well as by categories such as oscilloscopes, logic analyzers, VXI systems, telecommunications, and television test.

In addition to the paper catalog, product information is available on CD-ROM and on the Tektronix Web site: www.tek.com/Measurement, both of which contain everything found in the paper catalog, plus the latest updates, news, educational material, application notes, and technical briefs. Information on products on the disk can be updated directly from the Web. Directly from the Web or via CD-ROM access, users can also go to the oscilloscope product selector to choose the right oscilloscope or download the latest software drivers. EN

VIDEO PALETTE

(continued from page 39)

but the bypass switch allows for more flexibility.

Generally, one would not use the effects purely by themselves, but in a mixture with the straight video signal. However, that is a matter of taste, and one's individual preference is neither right or wrong. There is a definite artistic component in both how the effects are best produced and used; no purely technical criteria is necessarily valid in a given case. The best way to get a feel for the best settings is through individual experimentation. Ω

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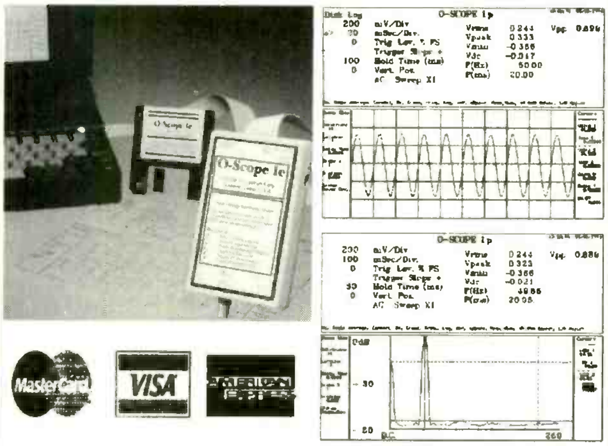

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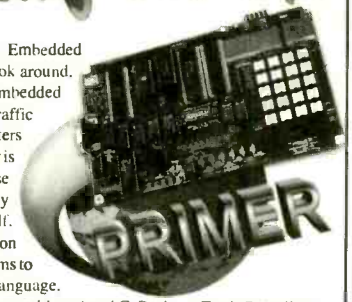

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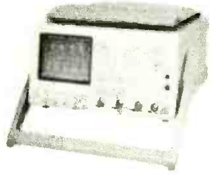

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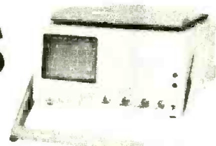

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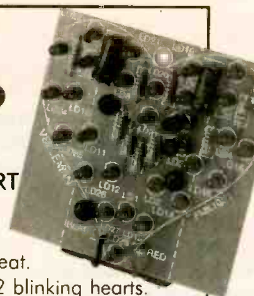

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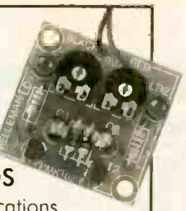


MK102
FLASHING LEDS
For different applications (such as model construction) and educational purposes.
Adjustable flashing speed.
Power supply : 9V battery

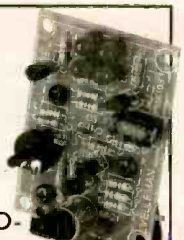
30pc•kit

$14.95

MK104
ELECTRONIC CRICKET
This cricket turns on when it gets dark.
Great as practical joke.
The tone and repetition between two crickets is adjustable.
Power supply : 9V battery

34pc•kit

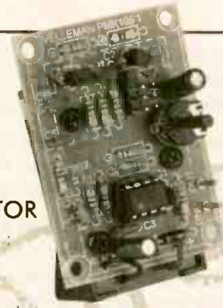
$9.95



MK103
LED SOUND-TO-LIGHT UNIT
For different funny and practical applications. 4 high-intensity leds light up and react simultaneously on every sound.
Power supply : 9V battery

36pc•kit

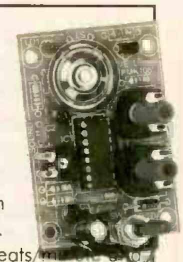
$10.95



MK105
SIGNAL GENERATOR
Several signal outputs : square wave, triangle, sine and integrator which are selectable with a jumper.
The signal frequency is about 1KHz (fixed)
Ideal to learn electronics!
Power supply : 9V battery

26pc•kit

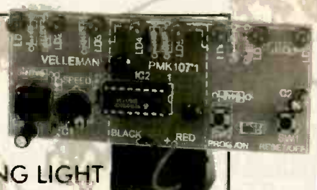
$14.95



MK106
METRONOME
The beats per minute are given by a built-in speaker and by a led.
Adjustable volume, beats/minute and sound. With on/off switch.
Power supply : 9V battery

36pc•kit

$12.95



MK107
LED RUNNING LIGHT
8 leds running light
Different running effects are selectable (by prog push button).
Adjustable effect speed.
Power supply stand-by by push button
Power supply : 9V battery

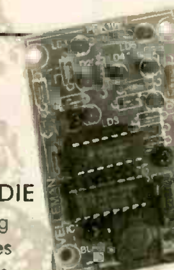
8pc•kit

$7.95

MK108
WATER ALARM
Never let you surprise by flooding!
Gives alarm sound when water is detected.
Incorporated alarm buzzer. Water sensor can be placed at distance by cutting the board and using wires to connect the sensor. Power supply : 9V battery

35pc•kit

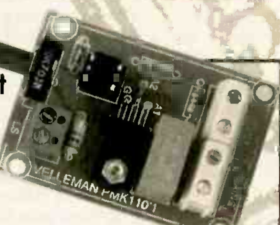
$9.95



MK109
ELECTRONIC DIE
No more cheating allowed ! The eyes of the die are leds
Rolls out when the push button is released.
Power supply : 9V battery

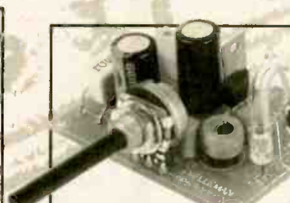
17pc•kit

$12.95



MK110
SIMPLE ONE CHANNEL LIGHT ORGAN
With loudspeaker input. The lamp flashes on the beat of the music. Optical isolated loudspeaker input with adjustable sensitivity : 2W to 60W.
Maximum load : 120W at 120Vac.

17pc•kit



$19.95

K5300
STROBOSCOPE
Adjustable flash frequency : 5-15Hz
Power supply : 120Vac
Power consumption : 13W max.

21pc•kit

$12.49

K2637
SUPERMINI 2.5W AUDIO POWER AMPLIFIER
Superb audio amplifier with incredible tiny dimensions.
Integrated circuit has a pre- and power amplifier which can be used separately.
Max. output power : 2.5W @ 4ohm
Frequency characteristics : 60Hz to 15KHz
Power supply : 4.5V to 15Vdc / 400mA

Exists also as module : M2637 **$17.49**

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- 150KHz/hour stability
- Built-In tracking generator(Model 2620A)

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- Built-In tracking generator(Model 2630A)

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- Component Tester

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S-1390 $895
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- Dual Time Base
- TV Sync

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S-1345 $569
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- Component Tester

S-1340 $475
- Analog / TV Sync
- 1mV Sensitivity

2 Year Warranty

25/30MHz

DS-303 30MHz $895
- Analog / Digital Storage
- 20MS/s Sampling Rate
- RS232 Output

DS-203 20MHz $695
- Analog / Digital Storage

S-1330 $439
- 25MHz Analog
- Delayed Sweep

S-1325 $325
- 25MHz Analog
- TV Sync
- 1mV Sensitivity

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F-75II $129 — List $149

F-79II $175 — List $199

F-87 $289 — List $335

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- Accurately measures capacitance, resistance and inductance.
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- Disturbance Indicator
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MX-9300

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RF Data Modules

AM Transmitter

- Sub Miniature module
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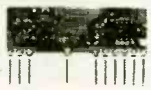
- No adjustable components
- Low current - 2.5mA
- Supply 2.5-12Vdc
- 418MHz or 433MHz
- Range up to 300ft
- CMOS/TTL data input
- 7 x 11 x 4mm !

AM-TX1-xxx $12.60

AM Receiver



- Compact Hybrid Module
- Very stable
- CMOS/TTL output
- Patented Laser Trimmed
- 5Vdc, 0.8mA (HRR6)
- 2kHz data rate
- Sensitivity -105dBm
- 38 x 12 x 2 mm

AM-HRR6-xxx... $16.33

FM Transceiver

- Only 23 x 33 x 11mm
- Up to 40,000bps data rate
- Up to 450ft. range.
- 5V operation
- 418MHz or 433MHz FM
- 5V CMOS logic interface
- Fast 1mS enable
- Power saving feature
- Carrier Detect output

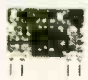
BiM-xxx-F $87.36

RS232 Transceiver

- 3wire RS232 interface
- 19.2Kbps half duplex
- 418MHz or 433MHz FM
- 7.5-15Vdc, 20mA
- TX/RX Status LED's
- Up to 400ft. range
- 1/4 wave ant. on board
- User data packetizing
- 58 x 40 x 15mm

CYPHERNET $139.30

AM Transmitter



- Range up to 250ft.
- SAW controlled stability
- Wide supply range 2-14V
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- Low current. 4mA typ.
- Up to 4kHz data rate
- Small: 17 x 11mm

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READ BY ELECTRONIC BUYERS AND SELLERS AND TRADERS

INSTRUCTIONS FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for each additional one (a photo copy of this form will work as well). Place a category number in the space at the top of the order form (special categories are available). If you do not specify a category, we will place your ad under miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $2.50 per word. Minimum charge is $37.50 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

If you use a Box number you must include your permanent address and phone number for our files. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues. **Boldface (not available as all caps)**, add .40 per word additional. **Entire ad in boldface**, add 20%. **Tint screen behind entire ad**, add 25%. **Tint screen plus all boldface ad**, add 45%. **Expanded type ad**, add $4.00 per word.

General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. ELECTRONICS NOW is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

CONTENT

All classified advertising in ELECTRONICS NOW is limited to electronics items only. All ads are subject to the publishers' approval. WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.

AD RATES: $2.50 per word, Minimum $37.50

Send you ad payments to:
ELECTRONICS NOW 500 Bi-County Blvd, Farmingdale, NY 11735-3931

CATEGORIES

100 – Antique Electronics	270 – Computer Equipment Wanted	450 – Ham Gear Wanted	630 – Repairs-Services
130 – Audio-Video Lasers	300 – Computer Hardware	480 – Miscellaneous Electronics For Sale	660 – Satellite Equipment
160 – Business Opportunities	330 – Computer Software	510 – Miscellaneous Electronics Wanted	690 – Security
190 – Cable TV	360 – Education	540 – Music & Accessories	710 – Telephone
210 – CB-Scanners	390 – FAX	570 – Plans-Kits-Schematics	720 – Test Equipment
240 – Components	420 – Ham Gear For Sale	600 – Publications	730 – Wanted

CLASSIFIED AD COPY ORDER FORM

Place this ad in Category #________ **Special Category $30.00 Additional ______________**

1 - $37.50	2 - $37.50	3 - $37.50	4 - $37.50	29 - $72.50	30 - $75.00	31 - $77.50	32 - $80.00
5 - $37.50	6 - $37.50	7 - $37.50	8 - $37.50	33 - $82.50	34 - $85.00	35 - $87.50	36 - $90.00
9 - $37.50	10 - $37.50	11 - $37.50	12 - $37.50	37 - $92.50	38 - $95.00	39 - $97.50	40- $100.00
13 - $37.50	14 - $37.50	15 - $37.50	16 - $40.00				
17 - $42.50	18 - $45.00	19 - $ 47.50	20 - $50.00				
21 - $52.50	22 - $55.00	23 - $57.50	24 - $60.00				
25 - $ 62.50	26 - $65.00	27 - $67.50	28 - $70.00				

Total words ________ $2.50 per word = $_______

Bold Face ________ $0.40 per word = $_______

Special Heading ________ $30.00 = $_______

Other ________ = $_______

TOTAL COST OF AD $ ________

Total classified ad payment $________ enclosed

[ ] Check [ ] Mastercard [ ] Visa [ ] Discover Card # _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Expiration Date _ _/_ _

Signature______________________________

Name ______________________________ Phone ______________________________

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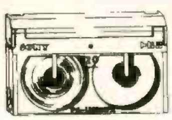
Sanyo "Rechargacell"™ # N-6PT
7.2 v 120 mAH battery
for 9 Volt applications.

$2.00 each CAT# NCB-91

10 for $30.00

"HI-8" Video Cassette



SONY Hi-8 Top quality, metal particle 120 minute video cassettes. *Used for a short time, then bulk-erased.* Each cassette has its own plastic storage box.

CAT # VCU-8 **$3.00 each**

10 for $28.00 • 100 for $250.00

3 Volt 35 mAh Lithium Coin Cell

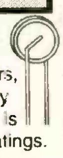
Sony CR1220
3 Volt, 35 mAh. 0.48" (12 mm) diameter x 0.08" (2 mm) thick. Fresh, 1997 date code. Large quantity available.

CAT # LBAT-19 **2 for $1.00**

100 for $35.00 • 1000 for $200.00

Surface mount holders available for coin cells.

Resettable Circuit Protector 0.65 - 1.3 Amp

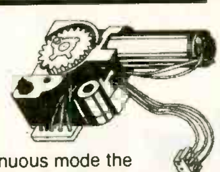


Raychem "Polyswitch" # RXE-065S-1
General purpose circuit protectors for power supplies, alarm systems, speakers, motors etc. Unlike traditional fuses, they automatically reset when fault condition is cleared. Can be paralleled for higher ratings. Current: 0.65 Amps. Trip Current: 1.3 Amps. Max Voltage: 60 Volts. 0.33" diameter. UL, CSA listed.

CAT # RXE-065 **3 for $1.00**

100 for $20.00 • 500 for $85.00
1000 for $150.00

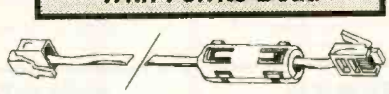
Mini-Right Angle Gearhead Motor with Control Circuit



Omron # R2DG-41
These unusual little motors have built-in control circuits that allow them to be used in a continuous or a pulsed mode. In continuous mode the final drive gear turns at 22-45 RPM (3-6 Vdc). In the pulsed mode the final drive gear turns one revolution each time the controller is momentarily pulsed. The motor assembly is 1.75" x 1.25" x 0.5" overall. The nylon final gear is 0.62 diameter and has a little nipple slightly off-center to which a small push-rod could be attached. Motors are in good condition, removed from equipment. Hook-up instructions included.

CAT # DCM-110 **$7.50 each**

7' Modular Phone Cord With Ferrite Bead



Standard RJ-11(4 pin) telephone cord with ferrite bead to reduce RFI interference. Bead is detachable if you want to use it in another application.

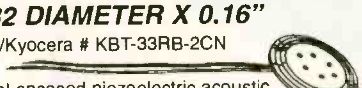
$1.25 each CAT # MT-260FB

10 for $10.00
100 for $85.00

Piezoelectric Element

1.32 DIAMETER X 0.16"

AVX/Kyocera # KBT-33RB-2CN



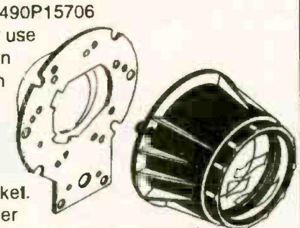
Metal encased piezoelectric acoustic generator. High durability. Small, thin shape. Designed for telephone use. Inside the metal case is a 1.28" diameter piezo element with 5.5" leads attached. If you're looking for a plain element with leads, the case can be pried apart fairly easily. CAT# PE-39

2 for $1.00

100 for $40.00
1000 for $250.00
(25¢ each)

Projection TV Lens

Mitsubishi # 490P15706

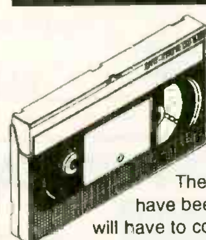


Originally for use in a three-gun TV projection system. High-impact plastic lens housing and support bracket. 5.35" diameter x 2.92" long at maximum focal length. Lens can be disassembled to yield five elements including a 3.1" dia. glass concave / convex lens, a 2.93" diameter glass convex-convex lens and three plastic correction elements.

$7.50 each CAT # LNS-10

12 for $72.00

S-VHS Tape (Used)

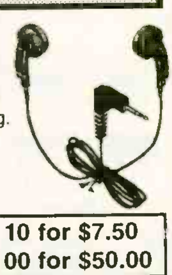


Super VHS tape users! Save a bundle on name-brand S-VHS, T-120 tapes. These tapes were used for a brief period, then bulk erased. The record-protect tabs have been broken out, so you will have to cover the notch with a piece of tape, but they work great and cost a fraction of the "new" price. Try some, you'll be back for more.

CAT #S-VHS **$3.00 each**

10 for $28.00 • 100 for $250.00

Great Price! "EAR BUD" STEREO EARPHONES



Miniature "in-ear" earphones for use with most portable CD, radio and tape players. Gold-plated 3.5 mm stereo phone plug. 32 ohm impedance.

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CAT #HP-6

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LIQUID CRYSTAL DISPLAYS

240x64 dot LCD with built-in controller.

AND 4021ST-EO. *Unit is EL back-lit.* $59.00 or 2 for $109.00 *or*
OPTREX. DMF5005 *(non back-lit)* $49.00 or 2 for $89.00

20 character x 8 line 7¼L x 2¼H *The built-in controller allows you to do text and graphics.*

Alphanumeric—parallel interface

16x1	$7.00	20x2	$10.00	32x2	$8.00
16x1 (lg. char.)	$10.00	20x4	$15.00	40x1	$8.00
16x2	$7.00	20x4 (lg. char.)	$10.00	40x2	2 for $20.00
16x2 (lg. char.)	$10.00	24x2	$10.00	40x4	$20.00
16x4	$15.00	32x4	$10.00	4x2	$5.00

5V power required • Built-in C-MOS LCD driver & controller • Easy "microprocessor" interface • 98 ASCII character generator • *Certain models are backlit, call for more info.*

Graphics and alphanumeric—serial interface

size	Mfr.	price	size	Mfr.	price
640x480 (backlit)	Epson	$25.00	480x128	Hitachi	$10.00
640x400 (backlit)	Panasonic	$20.00	256x128	Epson	$20.00
640x200	Toshiba	$15.00	240x128 (backlit)	Optrex	$20.00
480x128 (backlit)	ALPS	$10.00	240x64	Epson	$15.00
			160x128	Optrex	$15.00

6" VGA LCD 640X480, Sanyo LMDK55-22 $25.00

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Non-Enclosed TTL

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• Open Frame Construction • Standard Interface Connector • Degaussing Coil included • *Mfr. Samtron*

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POS & BAR CODE

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Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.

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SONY Miniature Color LCD Display (LCX005BKB) $29.99

• 1.4 CM (0.55 inch) Diagonal Full Color Display • Built In Horizontal and Vertical Drivers • Delta Dot Pattern for High Picture Quality - 537 dots (H) x 222 dots (V) • Compatible with NTSC & PAL Format and Sync Inputs • 12 VDC Operation with -1 to +17 V RGB Signal and Driver Input Voltage • Excellent Display for Virtual Reality Projects, Viewfinders, and Miniature Test Equipment Displays • Pin Outs and Specification Included • Unit Requires Clock, Synchronization and Video

CELL SITE TRANSCEIVER $49.00 2 for $89.00

These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 HMz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other Interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer. tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

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The ProxLink Radio Module is a small communication device which replaces cables between RS-232 devices with wireless RF (Radio Frequency) technology. Attaching a pair of ProxLinks to any two devices with three wire asynchronous RS-232 ports allows wireless data transmittal at rates up to 19.2 Kbaud (full duplex) over a range of 500 - 800 feet. Modules use 900 MZ spread spectrum radio for communication which does not require an FCC site license. A variety of configuration information (radio channel, baud rate, serial port configuration, etc.) can be programmed into module's non-volatile memory by host PC to provide compatibility and avoid overlapping systems. Configuration changes are supported by menu driven, on-board software. Commonly used Terminal Emulation software and transfer protocols can be used for configuring modules and transferring data between computers. ProxLinks require only 6-9 VDC (350 mA), RS-232 (9 pin sub - D) interface, and small (~ 4") whip antenna for operation. Unit size is 4.0" x 6.5" x 0.75". Installation schematics and application details available. These are 100 Mw power.

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GM412, less lens..$119, GM410, less lens..$169

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NEW MICRO CAMERA, w/audio 1/3" CCD, 410

Lines Res., 0.3 Lux sens., AGC, Auto Shutter. Pwr. from 9 to 12VDC @100mA, 250k PIXELS, Std. model, 3.6mm, 92° FOV lens, Pinhole, 90° FOV. A real glass lens. Both focus from 10mm to infinity. Std. NTSC video out. 1/2 once! SENSITIVE to IR. Size Std: 1.25"sq. x 1"d. PH is 0.6"d, Both with 6" leads. WARNING: Don't confuse these models with LOW RESOLUTION, HIGH LUX C-MOS CAMERAS.

GM-1000A-STD.............$79	**GM-1000A-STD/Audio.....$84**
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Micro Lenses for GM1000 series

2.5mm, 150°............$22	8.0mm, f2.0.............$22
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6.0mm, f2.0.............$22	5mm, 70°PH............$22

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This system offers 4 or 8 camera inputs. Full screen image, single or dual-page REAL TIME quad display, super resolution: 960 x480, Independent brightness adj. for each chan. Alarm time (1-20 sec.) Auto Sequencing w ith adj. dwell:1-4 sec. User-friendly.

Quality video processing at a remarkable price. • 8 video inputs. •1 monitor out & 1 quad out.• Single page or dual page switch. • 8 alarm inputs • Buzzer • 2 Alarm Out • Dim: 239 x166 x55 mm. ***SPECIAL! GM8-BQ....$299ea.***

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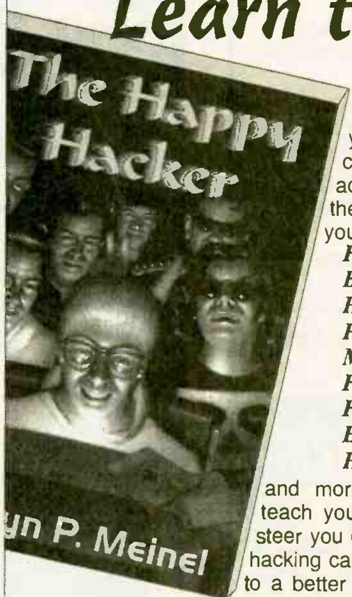

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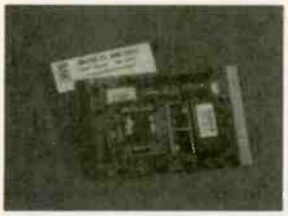

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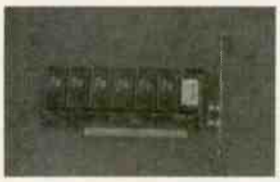
MAX INSTRUCTIONS / SEC	5M	20M
MAX COUNTER BITS	16	18
INPUT / OUTPUT BITS	12	15
A TO D COMPARATOR	NO	YES
HARDWARE INTERRUPTS	NONE	3

PINOUT:

RESET	1	20	VCC
PD0	2	19	PB7
PD1	3	18	PB6
XOUT	4	17	PB5
XIN	5	16	PB4
PD2/INT	6	15	PB3
PD3	7	14	PB2
PD4/TMR	8	13	PB1/AD1
PD5	9	12	PB0/AD0
GND	10	11	PD6

- LONG WORD INSTRUCTION - FRIENDLY SYMMETRIC ARCHITECTURE -



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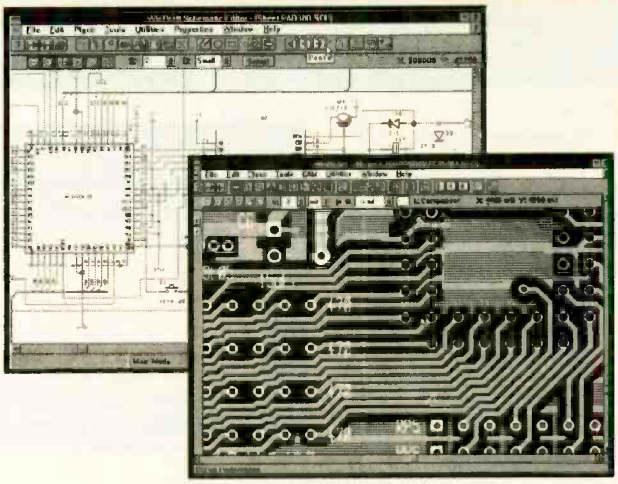

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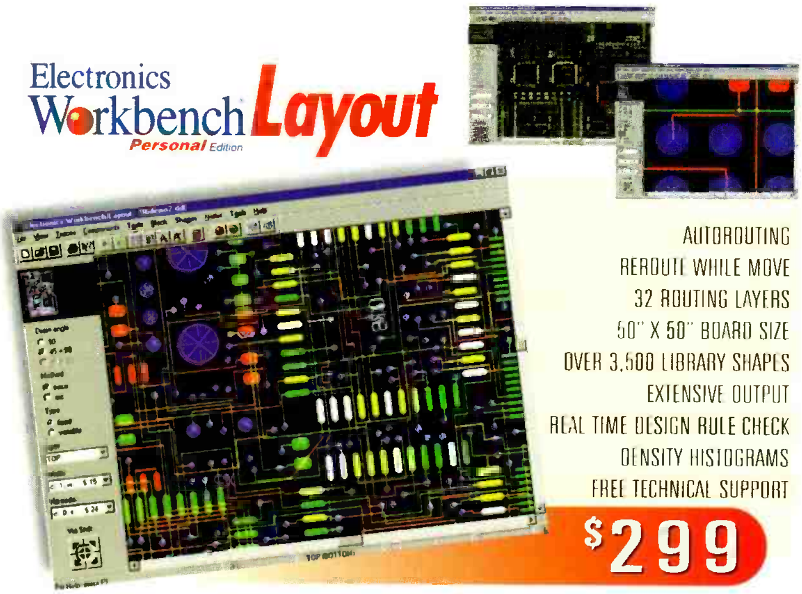

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