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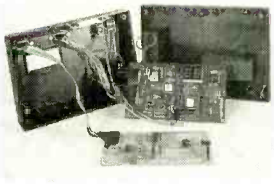

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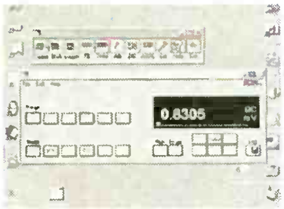

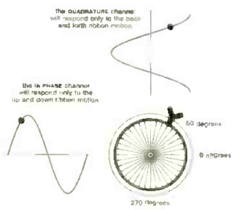

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EDITORIAL

Alphabet Soup

Last time we met, I spoke about the confusion the impending switch from NTSC TV broadcasting to digital TV (DTV) was causing broadcasters and manufacturers. Well, if these industry insiders are confused, how are ordinary consumers, even technically savvy ones, supposed to make sense out of the alphabet soup and multiple standards that the change is engendering?

Recognizing that, CEMA (the Consumer Electronics Manufacturers Association) announced at the just-concluded Winter Consumer Electronics Show (look for more coverage of that show in our next issue) an industry-standard set of definitions, and a logo that manufacturers can use to certify that a TV set or other device is capable of receiving and displaying all of the ATSC (Advanced Television Systems Committee) video formats. Here are the definitions:

DTV
ATSC CERTIFIED DIGITAL TELEVISION

Digital Television (DTV)—DTV is the umbrella term used to describe the new digital-television system adopted by the FCC in December 1996.

High-Definition Television (HDTV)—HDTV refers to a complete system or product with the following performance attributes:

- Resolution: A vertical display resolution of 720P (720 lines, progressive scan), 1080I (1080 lines, interlaced scan), or higher.
- Aspect Ratio: Capable of displaying a 16:9 image at the minimum resolution level.
- Audio: Receives, reproduces, and/or outputs Dolby digital audio.
- Receiver: Receives all ATSC Table-3 (digital) formats.

Standard-Definition Television (SDTV)—SDTV refers to a complete system or product with the following performance attributes:

- Resolution: A vertical display resolution lower than that of HDTV.
- Aspect Ratio: None specified.
- Audio: Produces useable audio.
- Receiver: Receives all ATSC Table-3 formats and produces a useable picture.

The road to digital TV has lots of bumps, twists, and turns. These standardized definitions and the certification program will certainly help make the trip over it at least a little smoother. But there is still so much more that needs to be done to minimize what's sure to be a period of great confusion among consumers.

Carl Laron

Carl Laron
Editor

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Seeing Red Over "Green" Cars

I read with interest your article, "Neighborhood Electric Vehicles" (**Electronics Now**, January 1998). It was well researched as far as the different options for locally operated vehicles are concerned, but I have a problem with the term "Zero Emission." The more accurate term would be "Transferred Emission." The Laws of Thermodynamics do not allow "something for nothing" as we all know; however, as long as we cling to the fallacy that these vehicles do not produce any emission, this problem will only get bigger.

As far as electrical vehicles are concerned, they rank as some of the most energy-wasting devices in use. The conversion of heat into electricity, at best, is 50% efficient at the plant. Assuming another 50% loss in transmission (some say 75%), this leaves only 25 units of energy out of 100 delivered to the charger. Given that at least 10–20% of the charger's energy is converted into heat and other losses for the high-current charging, that reduces the amount of delivered power to the battery at 20–22.5 units. Battery technology is such that, at best, brand new cells only deliver 40% of the energy put in. That leaves us with only 8–9 units actually delivered. This is a whopping 8–9% efficiency. Electric vehicles do get some of this back by dynamic braking, but the returns are minuscule.

The implications are that until there is a significant change in the technology, the conversion to electric cars will cause more pollution—not less. It will only change *where* the pollution is generated.

Also the introduction of a charger in every home will boost demand for elec-

(Continued on page 26)

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

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

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Push On, Push Off

Q *I'm building a project that requires power to toggle on and off with one pushbutton, like the on-off button of a pocket calculator. Is there a simple circuit that will do this without relays, using a 6-volt battery?*

Also, is there a single CMOS static-memory chip with 32K capacity in an SMT package? Last, I'm unable to locate a replacement part with imprints "Q576," "MEX," "H3," in a TO-220 case. I think it's a Triac. The tab is electrically isolated from all three pins. This is for a programmable digital timer I purchased from Canadian Tire.—M. K., Willowdale, Ont., Canada

A Taking your questions in reverse order, the ECG 5638 is a 400-volt, 8-ampere Triac with the tab isolated from all of the pins; it may fill the bill. (The gate is pin 3, the rightmost pin with the label facing you and pins pointing down.) If this seems consistent with the way your timer is wired, try an ECG 5638; it may work.

For a static memory, try the Cypress Semiconductor CY62256; documentation is on the Web at www.cypress.com.

Now for the pushbutton question. Calculators and electronic toys usually use a microcontroller that has a "sleep mode" in which it consumes very little power but can be awakened by a single pulse. Since your project apparently involves a microprocessor, you might go at it from that angle.

Otherwise, don't overlook the advantages of using a mechanical toggle switch; there are "push-on, push-off" switches that require no special circuitry.

But if you're stuck with a single SPST pushbutton, returned to ground, you can still use it as an on-off power control as shown in Fig. 1. Obviously, the switch operates a flip-flop. The catch is that before entering the flip-flop, the signal from the switch has to be debounced and then converted into a clean squarewave with a fast rise time. Debouncing is necessary because when you press a button, the switch "bounces" open and closed for a few milliseconds; a fast-rising square wave is needed to trigger a flip-flop properly.

The circuit in Fig. 1 solves the problem elegantly with one 4013 dual flip-flop chip. The first flip-flop is rewired as a Schmitt trigger to handle debouncing and to clean up the rise time. When you press the button, C1 discharges and the Schmitt trigger latches low; it goes high again when the capacitor recharges. Its output, at pin 2, is fed to the clock input of the second flip-flop, whose outputs swap states every time the button is pressed. The flip-flop operates an IRF510 switching MOSFET. Because the circuit is all MOS, it consumes less than 5 microamperes in the "off" state.

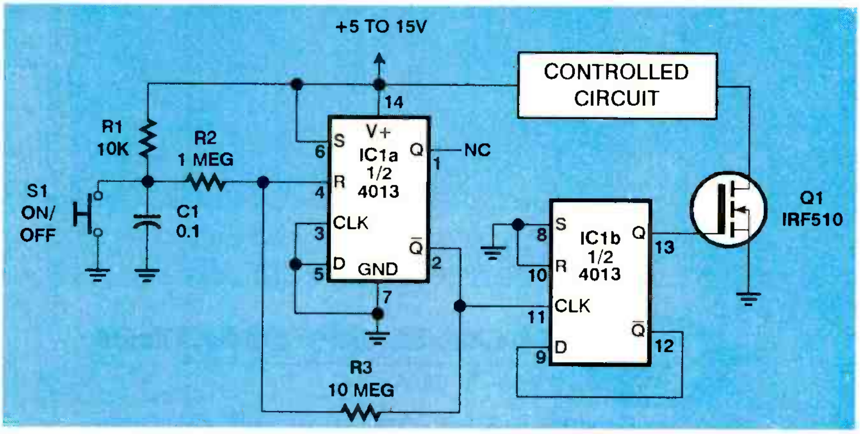


FIG. 1—A PUSH-ON, PUSH-OFF CIRCUIT. The first flip-flop is wired as a Schmitt trigger to debounce the signal from the button (S1); the second flip-flop receives a clean signal and toggles when the button is pushed.

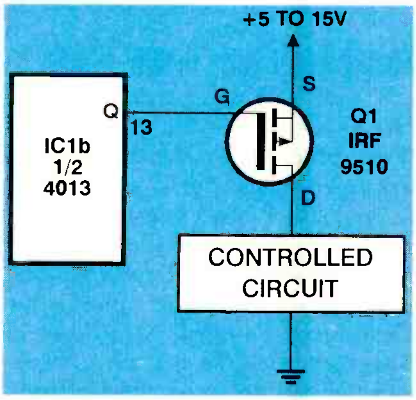


FIG. 2—IF THE CONTROLLED CIRCUIT and the controller must share the same ground, use "high-side switching" and a P-channel MOSFET.

If the controlled circuit has to share its ground (negative) supply line with the controller, you can use a P-channel MOSFET as shown in Fig. 2. This is called "high-side switching." Note that the MOSFET is wired upside down (source positive, drain negative).

A disadvantage of this circuit is that you can't predict the state of the flip-flop when power is first applied. That is, when you first connect the battery, the device may be either on or off. At worst, you'll have to press the button once after installing the batteries.

Tektronix Oracle

Q *In your December issue, a reader requested a manual for a Telequipment D53A oscilloscope. I've written to him and now I'll tell you what I have available. I supply manuals for all Tektronix and Telequipment products from 1945 to 1990, as well as for many older test instruments made by HP, Fluke, General Radio, DuMont, Hickock,* *Ballantine, and others. I prefer to supply manuals to the owners of the equipment for their own use.*

I worked for Tek for 41 years and collected manuals and parts, which were available through their company store. Now I spend hours on the phone helping people who come to me.—Deane Kidd, W7TYR, 27270 S.W. Ladd Hill Road, Sherwood, OR 97140.

A Thanks, Mr. Kidd. That reader (and his Tek 575 curve tracer) can personally attest to your helpfulness. Vintage Tektronix oscilloscopes are widely available at hamfests and are becoming collectors' items. Like Leica cameras or Zeiss microscopes, they're highly repairable, extraordinarily well-built, and capable of outstanding performance. If you can get tubes, they seem to last forever. Tektronix aficionados should also consult the book *Oscilloscopes: Selecting and Restoring a Classic* (which covers only Tek products), written and published by Stan Griffiths, W7NI, 18955 S.W. Blanton St., Aloha, OR 97007

Invisible Motorcycle?

Q *As a motorcycle rider, I find myself invisible to many car drivers. The requirement for keeping headlights on during the day was supposed to make us more conspicuous, but now many cars also drive with their headlights on and motorcycles no longer stand out.*

There is a headlight modulator legal in all 50 states that solves this problem; could you tell me how to build one? The requirement is to modulate the high beam (12-14 volts, 55 watts) 240 times a minute between full and 20% power.—R. A. H., Eugene, OR

A We'll have to take your word about the official specifications, but the circuit in Fig. 3 will probably do what you need. As Fig. 4 shows, it varies the brightness of the headlight by varying the duty cycle of a squarewave. That is, instead of consuming energy in a resistor, it switches the power on and off very fast. Since the power is always either on or off, little or no electricity is wasted, and because the switching rate is so high (5 kHz), the light-bulb filament remains at a constant temperature and doesn't suffer any extra wear.

You may have to experiment with component values to get the performance you need. Resistor R3 determines the brightness of the "dim" state; if you use a

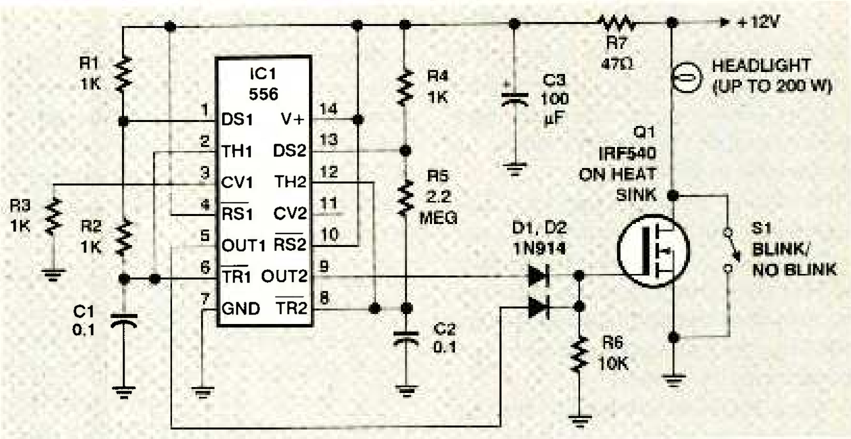


FIG. 3—THIS MODULATOR CIRCUIT makes a motorcycle headlight alternate between full and 20% power at a rate of four times a second.

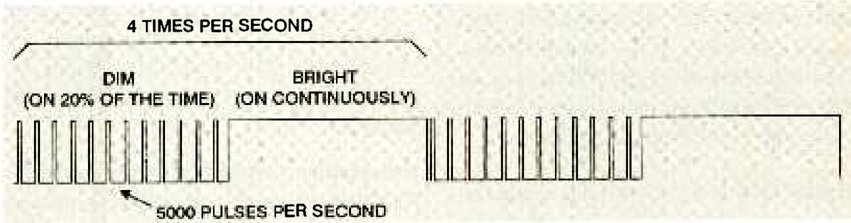


FIG. 4—THE MODULATOR IN FIG. 3 VARIES the brightness of the bulb by changing the duty cycle of a squarewave. The pulse rate in the dim state is so fast that the filament does not flicker.

CMOS 556 (such as 7556, TLC556, or LMC556), it will need to be much larger. The 4-Hz pulse rate is determined by R5 and C2. The purpose of R7 and C3 is to protect the 556 from voltage surges.

Darkroom Timer Wanted

Q *I have done photographic lab work both professionally and as a hobby, and for a long time I have wanted to build my own darkroom timer to suit my own needs. Now that electronics is a new hobby of mine, I am excited about the prospect of finally doing this.*

I would really like to build an LED timer including both minutes (up to 99) and seconds. I need it to count down from a preselected time and activate a relay to switch an AC load.

I'm aware of the "Time-Off" project in your sister magazine, ***Popular Electronics****, September, 1997. I can use it in some lab work, but it is not usable in the darkroom because of the LCD display.—G. A. P., Ft. Myers, FL*

A Red LEDs are indispensable in the darkroom because they're safe for black-and-white photographic paper and orthochromatic film. In fact, big arrays of LEDs make excellent safelights; there's no filter that can fade, and for physical reasons, all their light is confined to a narrow band of wavelengths.

You might be able to add a red LED to illuminate the Time-Off, or position neon lamp NE1 so that it illuminates the display. In that case, use a red-filtered neon pilot light (available at appliance-part stores).

What you really want, though, is a timer that was published in **Popular Electronics** back in August, 1992, pp. 53–58 and 91. It uses thumbwheel switches so you can select 0 to 99.9 or 0 to 999 seconds, and the display consists of red LEDs. Admittedly, it doesn't go up to 99 minutes, but 999 seconds are more than 16 minutes, long enough for most if not all steps in photographic processing. All of the parts are still widely available.

Plated-Through Holes

Q *How can I make plated-through holes on my two-sided printed-circuit boards so that I don't have to solder the same hole from both sides?—E. V., Toledo, OH*

A As far as we know, there is no easy way. Plated-through holes involve electrolysis plating with special chemi-

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at http://www.gernsback.com for information and files relating to our magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

To discuss electronics with your fellow enthusiasts, visit the newsgroups sci.electronics.repair, sci.electronics.components, sci.electronics.design, and rec.radio.amateur.homebrew. "For sale" messages are permitted only in rec.radio.swap and misc.industry.electronics.marketplace.

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 1993 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

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

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

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.

cals and equipment, followed by electroplating, and even the professionals consider the process difficult. But if a reader discovers an inexpensive way to make plated-through holes, we'd be glad to hear about it.

Converting Car to 12 Volts

Q *About your comments on converting a 6-volt positive-ground automobile to 12 volts, negative ground (Sept. 1997), I have a 1949 Ford truck on which I have done this. I removed the 6-volt generator and installed a 12-volt Delco alternator. The ammeter is a feed-through type and voltage doesn't matter. I installed dropping resistors in series with the gas, oil-pressure, and temperature gauges. I also installed resistors in series with the coils of the headlight and horn relays. I checked the accuracy of the oil-pressure gauge by temporarily connecting another pressure gauge.*

Of course, I changed all the light bulbs to 12 volts. I still use the 6-volt starter; it draws more power on 12 volts but still works as long as I don't crank too long at a time. I changed to a 12-volt ignition coil and installed a breaker-less ignition system. I'm almost 86 years old but still drive my truck every week.—R. E. Cook, Meridian, MS

A Thanks very much for sharing your results! The values of the dropping resistors will have to be determined experimentally, of course, but 10 ohms at 10 watts is a good starting point.

Emergency Alert System and SAME

Q *Years ago, I read an article, "Build a Low-Cost Emergency Broadcast System Monitor." The monitor would detect the 853- and 960-Hz tones and turn on an alarm. I built one and verified that it responded to the weekly tests. It was great for bad-weather warnings.*

Can you tell me about the new E.A.S. system? What frequency are the tones?—L. W., Mason, MI

A The Emergency Broadcast System (EBS) goes back to the 1950s and was originally intended to warn us of incoming nuclear bombs, but authorities have realized that it's also useful to warn people about tornadoes and the like, and that is now its main use. As you noted, EBS warnings are preceded by simultaneous 853- and 960-Hz tones. They're transmitted by ordinary radio and TV stations. Meanwhile, NOAA weather stations use a 1050-Hz tone to announce warnings, and you can buy radios that respond to the tone.

The new Emergency Alert System (EAS) has now replaced EBS, although the old tones are still transmitted for backward compatibility. NOAA's version of it is called SAME (Specific Area Message Encoding) because you can set your alarm to go off only when an announced warning pertains to your location.

EAS uses digital messages, not just analog tones. The audio encoding is similar to that used by modems, but the protocols are nonstandard (520.83 baud, 2083.3/1562.5-Hz FSK) to enhance security (the signals can't be faked with an ordinary modem). There is an elaborate code for the contents of the messages. To decode them, you need a computer (which can be built into a radio), not just a tone detector.

More information about EAS can be obtained from an article in *QST*, November, 1997, pp. 50-51 (published by the American Radio Relay League, Newington, CT 06111); from EAS (FCC, MS 1500C Room 736, Washington, DC 20554); and on the Web at www.fcc.gov/cib/eas.

Headphone Jack for TV

Q *I have a 13-inch color TV that has no headphone jack, and I want to put one in safely. How do I do it?—A. D. B., Pittsburgh, PA*

Q *I'm interested in taking the audio (mono) from my older TV and running it through my stereo amp and speaker system. Is there a way I can tap into the audio output stage of the TV, bypassing the speaker?—D. S. P., Sacramento, CA*

A Forty years ago, when all TVs had power transformers and audio-output transformers, this would have been an easy question—just replace the speaker with an 8-ohm, 2-watt resistor and take the audio signal across that.

Today, though, if you do that you may be risking your life. Some TVs have a "hot chassis" in which even the speaker is not isolated from the AC line. Although small audio transformers exist, they are not necessarily safe enough to use in this application. We consulted our TV-service expert, Sam Goldwasser, who told us that if the manufacturer has not already provided an audio output, it probably can't be done easily and safely. In any case, analysis of the circuit of your particular TV is required.

We have also found that the audio quality in cheap TVs is often dreadful, with plenty of hum, and connecting to a larger audio system only magnifies the defects!

Electricity and Water

Speaking of safety, we get lots of questions about electrically controlled sprinkler and pump systems, which we're usually reluctant to answer because water and electricity can be a dangerous combination, and also because we're not plumbers—water systems are outside our area of expertise.

Reader R. H. Hammett of Grandview, MO., writes to advise anyone experimenting with such systems to use low-voltage, line-isolated equipment for safety's sake. He recommends consulting the 400-page catalog of pumps, valves, and control components published by Aquatic Eco-Systems, Inc., 1767 Benbow Court, Apopka, FL 32703. As for us, we'll stick to electricity.

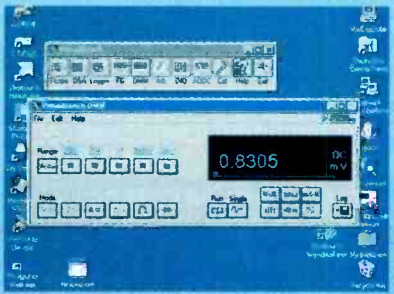
Writing to Q&A

That's all for this month. As always, we welcome your questions; please write to: "Q&A," **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication). *If you are asking about a circuit, please include a complete diagram.* Due to the volume of mail, we regret that we cannot give personal replies. EN

EQUIPMENT REPORT

NATIONAL INSTRUMENTS DAQMETER 4050 VIRTUAL DMM

Turn your computer into a full-function, digital multimeter with storage capabilities.



CIRCLE 15 ON FREE INFORMATION CARD

Notebook computers are becoming more powerful and more affordable almost every day. It seems likely that someday soon it'll be a coin toss as to whether you buy a portable TV set or just spend a few extra dollars to get a notebook computer that can not only act just like a portable TV, but also as a VCR, and much, much more.

That said, right now notebook computers are still a bit too expensive for most of us to purchase for such casual use. But for those who own or have access to a notebook computer, there are hardware and software applications available that can let you use that computer in a variety of ways you might not have thought possible. One such application that is sure to be of interest to readers of this magazine comes from National Instruments. It is the DAQMeter 4050 digital multimeter, which provides all the functions of a traditional DMM and adds the storage capacity and processing power of a computer.

The hardware part of the DAQMeter comes as a PC Card for notebook computers (it is also available as a PCI or ISA expansion card for desktop systems; while all three versions are said to function identically, only the PC-Card version is reviewed here). The system requirements are 16MB of memory and 20MB of free disk space. The DAQMeter package includes the PC-Card multimeter, test leads, "VirtualBench" software, drivers, documentation, and a nylon carrying bag; it sells for $695. The software is provided in Windows 3.1, 95, and NT versions.

Specifications

The DAQMeter 4050 is a 5½-digit virtual multimeter, or VMM, that can measure voltage, current, and resistance. You also get the power of data logging, time stamping, and recallable settings. Power consumption is about 45 mA, so it's not too hard on notebook-computer batteries. The package is ideal for making and logging remote measurements.

The DAQMeter 4050 works with AC or DC coupling and can measure AC and DC voltage in five ranges from 20 millivolts to 250 volts, AC and DC current in five ranges from 20 milliamps to 10 amps, and resistance in five ranges from 200 ohms to 20 megohms. The DAQMeter is auto-ranging with 10-, 50-, or 60-readings per second. AC measurements are true rms from 20 Hz to 25 kHz. The unit can also measure the forward voltage drop on diodes. Current can only be measured with an optional current-shunt module that converts the current into a voltage that the DAQMeter can measure when in its voltage mode. Software then automatically does the math and displays the result directly as current.

Setup and Use

Setting up the DAQMeter is very easy, once you know how it is done; a bit of background knowledge about the DAQ-Card product line goes a long way to making the installation painless. For example, none of the DAQ Cards are recognized by a notebook computer in the traditional way—where the computer sees the card and asks for a driver diskette. The cards will be recognized only after NI-DAQ, a comprehensive driver bundle, is installed from a CD-ROM. The single "driver" recognizes the entire line of DAQ Cards. Since we had already installed NI-DAQ when we reviewed the DAQScope (see **Electronics Now**, November 1997), no additional drivers needed to be loaded. In fact, no software at all had to be installed because VirtualBench was also already in place. A simple configuration utility informed VirtualBench about the capabilities of the card and DAQMeter hooked right up.

As you probably inferred from the above, VirtualBench can provide multiple functions other than the multimeter. The same software works with the oscilloscope card mentioned before and with many other products in the National lineup. However, only the multimeter function is "unlocked" by the serial number provided and when the DAQMeter card is installed. The VirtualBench-DMM software provides a "front-panel" display on your computer's screen that offers all of the controls found on a traditional DMM, but with hot-changing button labels and functions depending on operating mode.

Once set up, DAQMeter is easy to use. You simply insert the PC Card into a notebook-computer slot and connect the test leads. You then run VirtualBench and select the DMM function. A special cable that connects to the DMM card provides jacks for the test leads. The test probes are used with plastic covers placed over the ends to directly probe a circuit under test. With the covers off, the probes accept standard banana-jack accessories including spade lugs, alligator clips, and more.

For more information on the DAQMeter 4050, contact the manufacturer directly (National Instruments Corporation, 6504 Bridge Point Parkway, Austin, TX 78730, Tel: 512-794-0100; Fax: 512-794-8411), or circle 15 on the Free Information Card. EN

Prototype

New Technology for Finding Felons, Terrorists, and Evidence

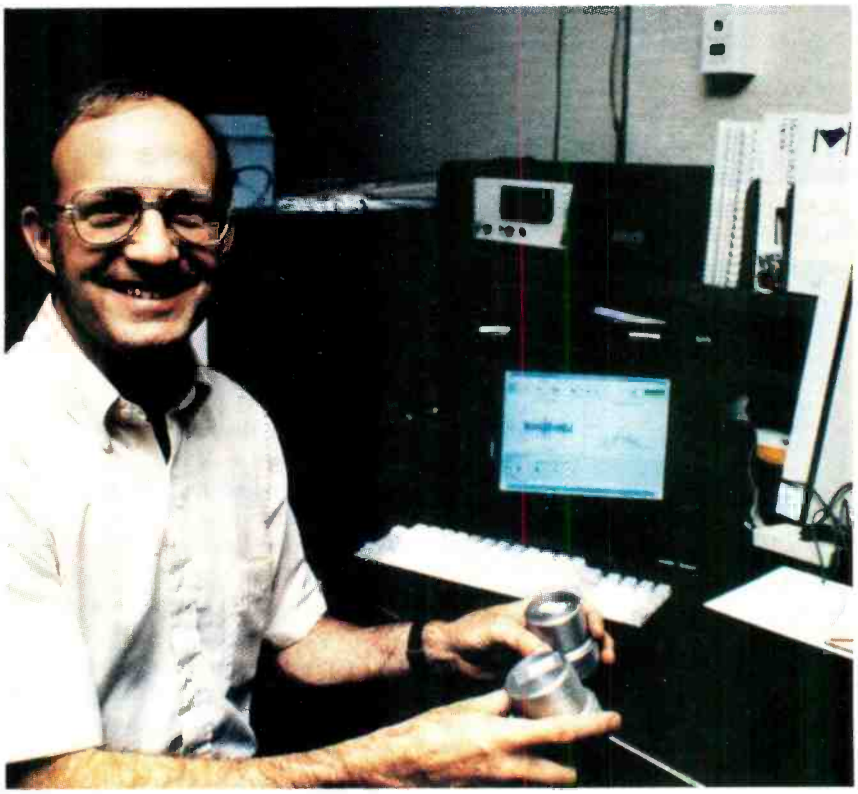
A convict tries to escape from prison by hiding in a secret compartment he built into a truck. He is quickly detected by guards using a device that detects his heartbeat. Airport security detains a terrorist bent on mayhem when he walks through a portal that detects explosives. Criminal investigators easily find all the evidence at the crime scene because it "blinks" when they wear special glasses. These very unique electronic technologies being developed for law enforcement could also find other applications.

Enclosed Space Detection System

The Enclosed Space Detection System (ESDS), developed by the Department of Energy's Oak Ridge National Laboratory (ORNL) and Lockheed Martin Energy Systems Inc., can "hear" the heartbeat of someone hiding in a car or truck. When the heart beats, it generates a small but measurable shock wave that travels through the body. That "ballistocardiac" wave is transferred to any surface or object in contact with the body. For instance, if somebody is hiding in a car trunk, the heart, being the strongest muscle in the body, actually moves the vehicle a few millionths of an inch at the same frequency as the heartbeat. That slight shockwave is quite detectable.

To detect a person hiding in a vehicle at a checkpoint, the engine is shut off, all legitimate occupants leave, and seismic geophones are placed at strategic locations on the vehicle. Computerized signal processing software filters out and discriminates between the unique beating of the human heart and other noise and vibration, such as fuel sloshing in the fuel tank or the contraction of the engine as it cools. The results of the "search" are displayed on the computer screen. The process takes about two minutes and has been shown to be 100% reliable, provided the vehicle is protected from moderate to high winds.

Recently, the Oak Ridge researchers have developed a system that uses microwave detectors mounted to a rigid structure, eliminating the need for the geophones to be placed on the vehicle. As a result, the ESDS will be even less intrusive and easier to use. A prototype ESDS was tested at California's Centinella Prison. When prison officials tried to smuggle someone past the ESDS, they



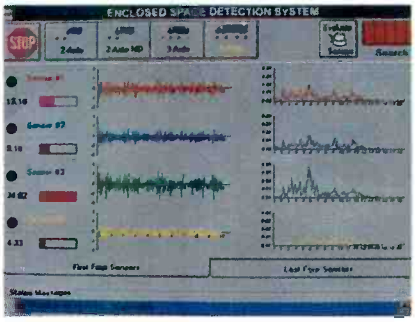
THE GEOPHONES AND PORTABLE COMPUTER used with the Enclosed Space Detection System (ESDS). (Oak Ridge National Laboratory)

FOR MORE INFORMATION

Oak Ridge National Laboratory
PO Box 2009, Bldg. 9113, MS 8206
Oak Ridge, TN 37831
Web: www.ornl.gov

Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185
Web: www.sandia.gov

COMPONENTS OF THE ESDS as installed on a system at the Wabash Valley Correctional Facility in Carlisle, IN. (ORNL)



THIS DISPLAY SHOWS that an intruder has been detected and a physical search is required. (ORNL)

were quickly discovered. Other systems are installed at the Riverbend Maximum Security Installation in Nashville, TN and the Wabash Valley Correctional Facility in Carlisle, IN. Geovox Security Systems of Houston, Texas is planning to market the ESDS commercially as the AVIAN for *A*dvanced *V*ehicle *I*nterrogation *A*nd *N*otification System.

Among other possible applications, the technology could be used to detect illegal immigrants being smuggled into the country or intruders trying to break into secured facilities. In the future, it could be used to search for vital signs of survivors after an earthquake or victims buried in an avalanche.

Explosives-Detection Portal

Terrorists carrying explosives have become an all too-real real threat at airports and in public buildings. A new explosives-detection system that is being developed by the Sandia National Laboratory for use by the Federal Aviation Administration (FAA) could greatly reduce that threat.

The explosive-detection sensors are located in a portal that looks much like metal detector that is now a familiar sight at airports. But rather than detecting metal, it will spot any individuals who have recently handled a wide variety of explosive chemicals. Ultimately, the explosives-detection system will probably be integrated with airport metal detectors to provide a single walk-through unit.

The explosives sensors depend on chemical preconcentrator technology developed as part of Sandia's mission to protect critical nuclear-weapons facilities from would-be saboteurs. The system is capable of detecting very small concentrations of all explosives of interest to the FAA.

The new portal sports vents and nozzles on its inside walls and ceiling. Persons being inspected stand inside the portal for a few seconds while the detector blows a quiet, gentle "puff" of air over them. An air sample is collected and passed through a commercial ion-mobility spectrometer. The system's software recognizes the chemical signatures of a variety of explosives.

If the system detects even a minute concentration of explosive residue on the skin or clothing, the quantity and type of chemical is displayed on an adjacent computer screen. People that show up positive for explosives would be further screened to see if there are any circumstances that might explain the reading. If suspicions remain after additional screening, airport security would be notified.

After three years of development, a prototype of the portal was recently installed at a main security checkpoint at the Albuquerque International Sunport. The portal is fully automated, providing instructions such as "enter the portal," "turn left," and "exit the portal"—in a friendly male voice.

Once the tests are complete, the FAA will use the results to determine the feasibility of licensing and manufacturing the explosives-detection portal technology for use at airports across the country, as well in public buildings such as government offices and courthouses. The basic technology could also be adapted to sniff for drugs.

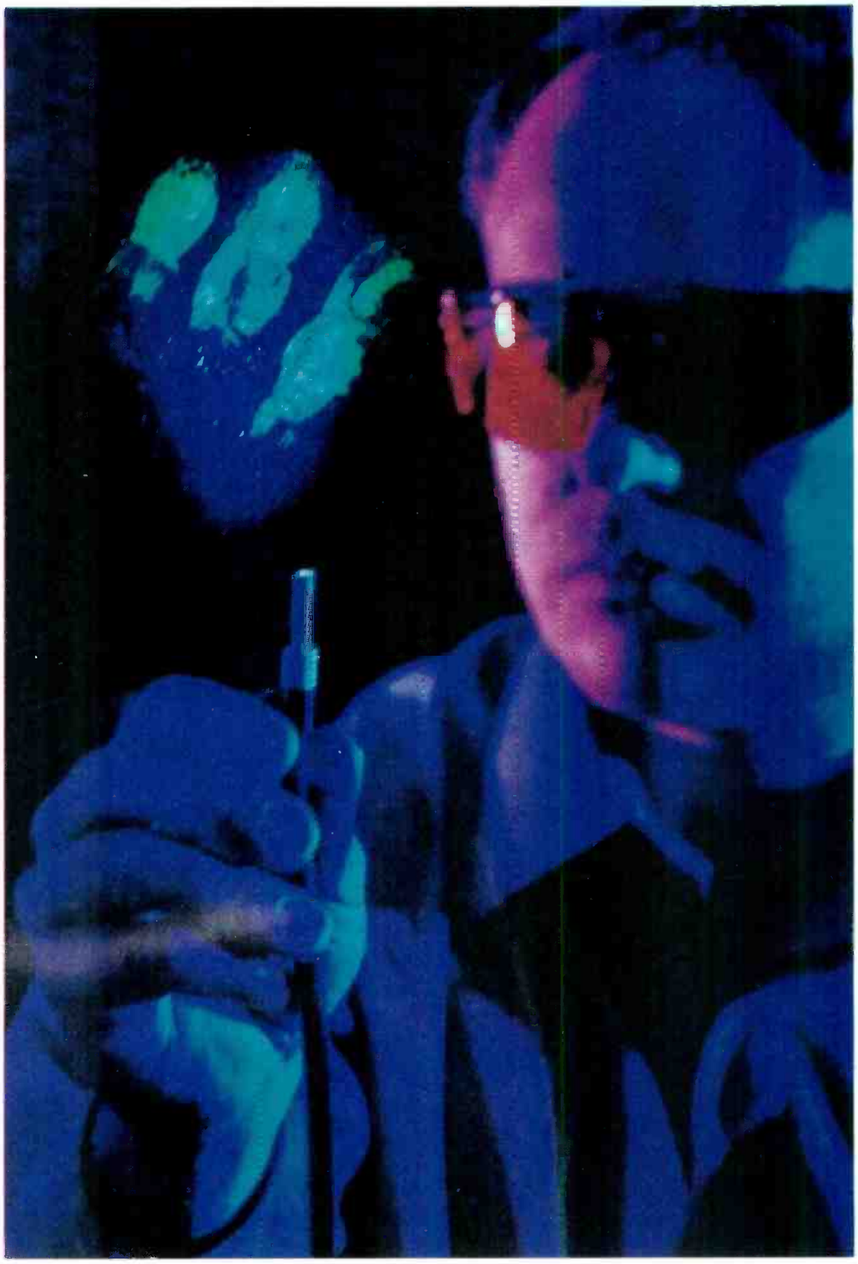
Evidence Detector

"Dusting" for fingerprints and finding urine and other organic evidence at a crime scene is not easy even for experienced criminal investigators. Sandia National Laboratories is now developing an evidence-detection technique whereby organic material would actually blink before the eyes of crime-scene investigators so they can locate potential evidence quickly, even in a well-lighted room.

Sandia's evidence detector uses the fact that all organic substances give off weak fluorescent emissions that are usually invisible to the naked eye due to interference from brighter lights. The system is based on a heterodyning effect; that is, the periodic dissonance between two signals at slightly different frequencies plus the human eye's natural affinity to see anything that moves or blinks.

The flashing lamp used in system is modulated at 100-times-per-second, which is much too fast for the eye to see. The shutters on a pair of modified glasses from a 3-D video game open and close at a slightly different frequency—102 times per second. That turns the glasses on and off at a rate that is also too fast to

IN THE EXPLOSIVES-DETECTION PORTAL, a "puff" of air is blown over a person and an air sample is collected and analyzed by a spectrometer. (Sandia National Laboratories)



IN SANDIA'S EVIDENCE DETECTOR, fingerprints and other organic evidence blink when special glasses are worn. (Sandia National Laboratories)

be detected by the human eye making the lenses appear transparent to the wearer. About twice a second, the glasses' shutter opens at the exact moment the lamp is on. Therefore, for a split second, most of the background light whose wavelengths are different than that of the lamp is drowned out. With the background light masked, the fluorescing organic evidence appears to flash so it is quite easily seen by the eye. Investigators wearing the special glasses see the room lighted normally, but more important, see any organic evidence flash a few times per second when illuminated by the lamp.

A prototype system will be tested by the Albuquerque Police Department's crime laboratory at actual crime scenes to work out any bugs in the technique. Testing will determine the type of evidence it can discover as well as verify that it can be practically used as a tool in criminal investigations. An important factor is that the system be affordable enough so it can used by just about any law enforcement agency's criminal investigation unit.

The technique could be especially useful for finding semen after sexual assault crimes because semen fluoresces much more brightly than the oils from fingertips. Researchers also hope to find out if fresh fingerprints fluoresce more brightly than "stale" organic materials. If so, the system could be effective in screening out evidence that is not part of a crime.

The bad guys can cover their tracks and stay out of sight, but thanks to these new technologies, it is getting ever more difficult to hide.—**BILL SIURU and ANDREA STEWART** PT

Camera on a Chip

An image sensor based on a complementary metal oxide semiconductor (CMOS) technology that could make the digital camera as inexpensive and as common as a computer mouse was recently announced by Sarnoff Corporation. The CMOS Active Pixel Sensor (APS) delivers nearly 100× the dynamic range of a standard Charge-Coupled Device (CCD) sensor, at comparable resolutions, for better shadow and highlight detail. It controls exposure without a mechanical iris, and its on-board electronics eliminate the need for external analog-to-digital converters and other circuitry required in CCD-based cameras.

"The CMOS APS is virtually a 'camera-on-a-chip,' and we believe it will revolutionize the way cameras are made and used," said Michael Ettenberg, Senior Vice President of Sarnoff's Solid State Division. "Not only can it replace CCDs in many current camera applications, it will create new applications. Its low cost allows engineers to add vision capability to products where it once would have been too expensive."

Sarnoff will license the technology to camera makers and provide engineering support. Two foundries to fabricate the chip have been approved, and the company will supply design tapes for manufacturers who wish to produce it in other foundries. Ettenberg foresees uses for the CMOS APS in such products as digital still cameras, PC-based video cameras, security and surveillance systems, videophones, even toys with built-in vision capabilities.

The Sarnoff design incorporates breakthrough technology that virtually eliminates the performance limitations associated with previous CMOS-based image sensors. Those sensors suffered from high levels of Fixed Pattern Noise (FPN), which gives an image a "dirty window" effect. In the Sarnoff design, internal circuitry reduces FPN to less than 0.01% of full signal, below the threshold of visibility.

Other features include full TV resolution, video output in both analog and 12-bit digital form, dynamic range over 110 dB to preserve image detail, low power consumption, and compatibility with color-filter technology. PT

Filtered Sunglasses

A modification in sunglass filters developed by NASA engineers may make our skies and roads safer by helping pilots and drivers see better. The filter—a low-cost, brownish, plastic material—was originally designed to help farmers identify diseased plants. The filter blocks much of the yellow and green light during daylight hours, enhancing the ability of the human eye to detect other colors in the visible spectrum, according to its developer Dr. Leonard Haslim, of NASA's Ames Research Center at Moffett Field, CA. This filter was modified by Optical Sales Corp., Portland, OR, and used in a new sunglass product now being marketed.

Stress in plants tends to be camouflaged by the plant's natural chlorophyll. As a result, many plant diseases cause irreversible damage by the time they become evident to the eye. In the past, it was necessary that highly-trained professionals examine plants to detect early signs of stress. "Now farmers can use goggles equipped with the special filter to locate diseased or stressed plants," said Haslim. "Sick leaves that appear just a bit yellow in normal light show up a much brighter yellow when viewed through the filter. Conversely, healthy leaves appear as a vivid green. If we diminish or block a lot of the yellow-green light that the eye normally sees, suddenly the other colors stand out in much greater relief."

The filter, called the passive chlorophyll detector, was invented by Haslim in 1991.The sunglass adaptation with the modified filter was first made commercially available in 1997. Government inventions, like the NASA filter, are often commercialized by the industry. According to Michael Weingarten, manager for business development (NASA, Washington, DC), "NASA invests more than $5 billion in technology development annually. It makes good economic sense to bring that state-of-the-art technology back to U.S. taxpayers when such a huge investment is being made." PT

Mother Earth Warms Up the Golden Arches

A McDonald's restaurant that opened in the Detroit area last December was one of the first in the chain to use the earth for its heating and cooling needs. A geothermal heat pump system, installed with the help of Detroit Edison and Electric Power Research Institute (EPRI), the science and technology organization of the electric power industry, will provide natural, environmentally safe energy at reduced cost. McDonald's will be monitoring the energy usage of the 3600 square-foot restaurant, evaluating results, and examining the potential of geothermal heat pump technology to save money.

Geothermal technology can economically and efficiently use solar energy naturally stored in the earth to heat water and to heat or cool buildings year-round. Geothermal heat pumps (also called ground source heat pumps) take advantage of the earth's stable temperature to help keep indoor temperatures comfortable. The system circulates water or other liquids through pipes buried horizontally or vertically underground.

In cold weather, geothermal heat-pumps transfer the earth's heat through the buried pipes into a circulating liquid, which transfers it into the building. In hot weather, the continually circulating fluid in the system's pipes cools the building by "picking up the heat" and transferring it into the cool earth. In cold climates, heat pumps offer an energy-efficient alternative to furnaces and air conditioning.

EPRI is working with member utilities and their customers to incorporate geothermal technology in many different national projects, including Wendy's in New York, a Texaco gas station/mini-mart and a Hardee's in Oklahoma, office buildings in Pennsylvania, and a country club in Georgia. This technology is also being used in historic sites such as Colonial Williamsburg.

"EPRI's demonstration projects provide valuable opportunities to transfer science and technology into practical solutions where we can learn how well the system's work under many different conditions. In the process, we will develop more reliable and cost-effective applications," explained Mukesh Khattar, Team Leader in EPRI's Customer Systems Group.

Geothermal systems reduce carbon-dioxide emissions that contribute to global warming. Benefits over other heating/cooling systems include being much quieter, and, with the heat exchange units inside the building and the buried pipes, greater reliability since the system is not exposed to weather conditions nor susceptible to vandalism.

The EPRI can be found on the Internet at www.epri.com. PT

BY SAM GOLDWASSER
SERVICE EDITOR

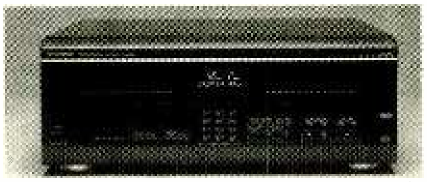
Cleaning a Disc, Repairing Scratched Discs, and More

WE'LL BEGIN THIS MONTH'S DISCUSSION OF CD-PLAYER/CD-ROM-DRIVE REPAIR BY LOOKING AT ONE OF THE MOST COMMON SOURCES OF PROBLEMS—THE DISCS THEMSELVES. THEN WE'LL LAY SOME OF THE GROUNDWORK WE'LL NEED TO get into theprocess of troubleshooting and repairing a defective player or drive.

Cleaning a CD is not a difficult chore, and you most certainly do not need a fancy CD-cleaning machine. Instead, just use a soft cloth, tissue, or paper towel moistened with water. Add a little mild detergent, if needed (Ivory soap works well). Wipe from the center of the disc out toward the edge—***not*** in the circular motion usually recommended for a vinyl LP. ***Never*** use any strong solvents. Even stubborn spots will eventually yield to your persistence. Washing under running water is fine as well.

Once done, gently dry with a lint-free cloth. Do not use a dry cloth as any dirt particles may cause scratches. The polycarbonate the CD is made of is tough, but don't expect it to survive everything. Very fine scratches are not usually a problem, but why press your luck?

Something that not everyone is aware of is the multilevel error handling technology in a CD player. Therefore, a dirty CD may not instantly produce obvious audio problems, but can nevertheless result in less-than-optimal audio performance. Very severe errors—long bursts—will result in audible degradation, including noise and/or muting of the sound. Even that might not always be detectable, depending on the musical content. Shorter runs of errors can result in the player interpolating between what it thinks are good samples. That process isn't perfect, but any inaccuracies probably will not be detected during casual listening. Errors within the correcting capability of the Cross Interleave Reed Soloman Code (CIRC), which is used to encode the data on a CD, will not be noticed at all. In principle, it should be possible to drill a 2.5mm-diameter hole in the discs (in fact, some test discs have such a hole), but not all players implement all of the possible error-handling strategies.



A DIRTY DISC OR LENS might cause even the best CD player to sound poor, but it is unlikely to cause damage to the unit itself.

Can Dirt Damage My Player?

One common thing you might hear from the man behind the counter in your local CD store is "Dirty CDs could do irreparable harm to your CD player, your stereo, your disposition, etc. Buy our $19.95 Super-Laseriffic CD Cleaning Kit." One claim I heard at a store that was part of a major chain was that dirt or dust on the laser lens would cause heat build-up that would burn out the mechanism. What he was promoting here was not a disc cleaner, but a little brush attached to a CD that brushed off the lens as it played.

This kind of stuff is total rubbish. The power of a CD laser is less than 1 mW, and it is not concentrated at the lens. And, those cleaning CDs with the little brush are almost useless on anything but the smallest amount of dry dust. If the lens or disc is dirty, the worst that can happen is that the CD will not play properly. There could be audible noise, or the disc might fail to track properly, abort at random times, or not even be recognized. However, the electronics will not melt down because of dirt on the disc or the laser lens.

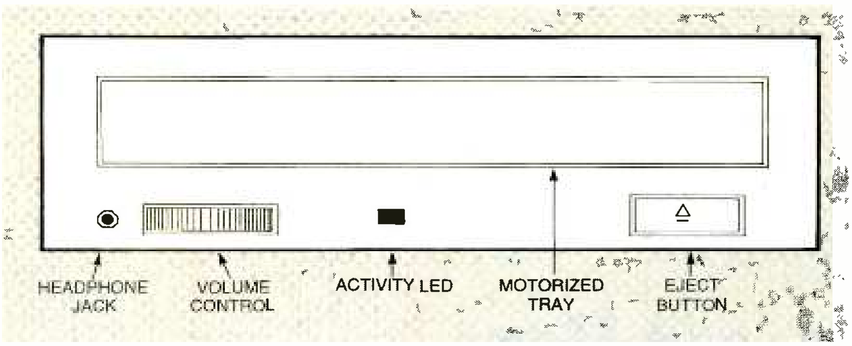
In short, it is just about impossible for a dirty CD to do any damage to the player, and a dirty lens will only result in disc recognition or play problems similar to those caused by a dirty CD; the laser will not catch on fire. About the only way damage could occur is if you loaded a cracked CD and the crack caught on the lens.

In any case, you do not need any fancy CD cleaners—soap or mild detergent, water, and a soft cloth will do the job. If the CD looks clean, it will probably be fine. If there are serious smudges or fingerprints, then cleaning could make a significant difference in performance.

Repairing a Scratched CD

So your favorite CD has turned up badly scratched (maybe your five-year-old decided that it would make a nice Frisbee), is there anything you can do? The answer is yes. There actually are three basic techniques for repairing scratches. They are: Mild Abrasives, Fillers, and Blowtorch.

• Mild abrasives: Use plastic or furniture polish, Brasso metal polish, or toothpaste to try and remove minor scratches. (Don't worry too much about causing damage; if the disc doesn't play, you can't



WHEN TROUBLESHOOTING A CD-ROM drive, the first step is to play an audio CD. If basic audio playback is fine, you can be reasonably certain that the optical pickup, the front-end electronics, and the servo systems are working correctly.

do any more harm.) When applying or rubbing any of these materials, wipe only from the center to the outside edge. A CD player can generally track across scratches that are perpendicular to its path reasonably well. It is the scratches that are parallel to the path that cause all the problems. If the scratch is minor, a mild abrasive may actually remove it completely. This is more effective when the surface has been scuffed or abraded rather than deeply scratched.

• Fillers: These include such typical items like car wax or furniture wax. Apply over the whole disc and buff out with a lint-free cloth. Filling larger scratches should be fairly effective, but be aware that the repaired disc will be more prone to damage in the future because of the soft wax filler. This technique works because the wax will fill in the space where the scratch is. Even deep scratches might give in to this approach.

• Blowtorch: A least one person who claims to have worked for several years in a used CD store swears by this technique. Supposedly, he uses a pencil-type pocket butane torch and with great dexterity fuses the surface layer of the readout side of the disc so that scratches and unsightly blemishes—well—melt away. Now there are obvious dangers in using fire on plastic and this is likely a last resort. I cannot tell you how many years of practice are required to get a CD-repair license. However, I am highly skeptical of this approach and suspect that destruction of the CD is the most likely outcome.

As an alternative to home repair, there are companies that actually specialize in fix ing damaged discs. A couple of these are Aural Tech CD (www.nsynch.com/~auraltech) and CD Repairman (www.cdrepairman.com). I have no experience with any of these companies, so I can't comment on their effectiveness or cost, but if you have an irreplaceable CD that has become damaged, they might be worth considering.

That concludes our discussion on the media itself. Assuming that cleaning of fixing a disc has not cleared up your problem, it will be necessary to deal with the CD player or CD-ROM drive itself. Let's begin that topic next with some preliminary information and tips.

Safety at All Times

While there are far fewer potential dangers involved in servicing a CD player compared to a TV, monitor, or microwave oven, some precautions are still required when working on a line-powered unit with its cover removed. There may be electrically live parts connected to the power line, usually around the power cord entrance to the chassis, the power transformer, and the on/off switch. If there are, tape them over or cover them somehow so you need not be concerned with a shock. Unless you are troubleshooting a primary-side power-supply problem, there should be no need for you to go near the AC line. For portable players, the internal voltages are all quite low, so shock is less of a concern than accidental damage to the equipment due to carelessness.

The laser in a CD player is infra-red. It usually operates at 780 nm—while that wavelength is at the edge of the visible range, for all intents and purposes, the beam is invisible. Note that the beam is very low power (under 1 mW), and coupled with the optics, presents very little danger. Nonetheless, don't go out of your way to look closely into the lens while the unit is on!

Note: With most CD-type lasers, if the lens is viewed from an oblique angle, you'll usually see a deep-red spot, about the size of a period. This emission appears to be low intensity, and might be a spurious emission in the red part of the spectrum or just your eye's response to the near IR energy of the main beam. In any case, do not be misled into thinking that the laser beam is weak. The main beam is up to 10,000-times more intense! Take care. However, the red dot is an excellent indication that the laser is being powered and is probably functioning. To be sure, you need an IR detector to confirm the existence of the laser beam. A circuit for testing IR remote controls, like the one presented in the June 1997 installment of "Service Clinic," could also be used for this purpose.

Troubleshooting Tips

As in all electronics troubleshooting, many problems have simple solutions. Don't immediately assume that the problem you are looking at is some combination of esoteric, complex, convoluted failures. For a CD player, it may just be a bad belt or a dirty lens. Try to remember that the problems with the most catastrophic impact on operation (a CD player that will not play past track 6) usually have the simplest solutions (the gears that move the optical pickup need lubrication). The kinds of problems we would like to avoid at all costs are the ones that are intermittent or difficult to reproduce: the occasional audio noise or skipping, or a CD player that refused to play classical CDs of music composed between 1840 and 1910. (If you come across a player that won't play heavy-metal rock, send it to me—please.)

When attempting to diagnose problems with a computer's CD-ROM drive, start by trying to get it to play an audio CD. Data read-back is more critical since the error correction needs to be perfect. But if the audio playback works, you know that the optical pickup and most of the servo systems and front-end electronics must be working. A CD-ROM drive that won't play a music CD has no chance of loading Windows 95

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around inside your head will lead to a different, more-successful approach or solution. Don't work when you are really tired—it is dangerous and mostly non-productive.

Whenever you work on precision equipment, make copious notes and diagrams. You will be eternally grateful that you did when the time comes to put the

(Coninued on page 26)

BY JEFF HOLTZMAN
COMPUTER EDITOR

Stayin' Alive: The Great Pilot Plot

SURPRISE, SURPRISE: READING CHARACTERS ONE AT A TIME FROM A SERIAL PORT IS A HIGH-OVERHEAD, SLOW PROCESS. READING CHARACTERS IN BLOCKS RUNS MUCH FASTER, ALMOST ACCEPTABLY SO.

To back up a step, we've been working the past few months on a chart-recorder application for the 3Com PalmPilot. The application is called HiLo. The purpose of HiLo is to read data in byte-sized chunks as it comes in an RS-232 serial port, maintain statistics about the data—minimum value, maximum value, and average (mean) value—and display the data in a scrolling format like a chart recorder. Our progress to date is shown in Fig. 1. This months' code is available at the Ingeneering web site, www.ingeninc.com. Look for a file named hilo2.zip.

Looking at Fig. 1, note that there is a new edit field, labeled *Scale*, on the screen. To its left is a field labeled *Last*. Last displays the actual value of the last item received. Scale displays the value scaled to fit the 90 × 100 plot area. The Scale value is approximately 35% of the received value (in pixels).

The central portion of the display functions as the chart recorder. Data points are displayed right to left in the order in which they are received. The display function is smart enough not to scroll the display point by point. Rather, when it receives a block of points (as many as 100 in the current implementation), it scrolls the chart recorder portion of the display by as many pixels (leftward) as points received. Then it draws the points one by one, right to left. The right-most point always represents the most recently received value.

Implementation Notes

The overall structure of HiLo remains the same. Four major changes have occurred:

1) I replaced the deadly slow AddPoint routine with a much faster AddPoints routine, shown in Listing 1.

2) The old AddPoint also performed the display function. Now there is a separate routine, DisplayChart, shown in Listing 2. As mentioned above, DisplayChart is not completely brain-dead, although there is certainly room for improvement.

3) I added a John Travolta "Stayin' Alive" call to the operating system so that the Pilot won't "go to sleep" (enter a low-power mode in which it doesn't respond to serial-port activity) while HiLo is running.

4) Miscellaneous new and improved #defines and the like were added, as was a new debug routine for displaying a string and number in a dialog box at run-time.

Listing 1 shows the new multi-byte read routine, AddPoints. (AddPoints is called by SerIOReceive, discussed in an earlier article.) AddPoints is pretty simple, although there is one trick. The calling routine passes four things to AddPoints: a pointer to an input buffer (where the OS has stashed the data), a pointer to an output buffer (where we save the data), a count (number of bytes received), and a position (where in the output buffer the next byte is stored).

The output buffer is defined to be 100 bytes long. So what happens when we receive data byte 101? The output buffer is actually implemented as what is called a *ring buffer*. Imagine a ring with 100 slots. When the 100th slot is filled,

LISTING 1—ADDPOINTS

```
static void AddPoints (UInt pos, ULong cnt, Byte *ib, Byte *ob) {
  SerIOCnt += cnt;
  while (cnt > 0) {
        // get input char, put in buffer
        SerIOCur = *ib;
        ob[pos] = SerIOCur;

        // update stats
        SerIOSum += SerIOCur;
        SerIOMin = (SerIOCur < SerIOMin) ? SerIOCur : SerIOMin;
        SerIOMax = (SerIOCur > SerIOMax) ? SerIOCur : SerIOMax;

        // update pointers, counters
        cnt--;
        ib++;
        pos = (pos + 1) % MAX_DATA_POINTS;
  }
  // update stats
  SerIOAvg = SerIOSum / SerIOCnt;
  SerIOSca = (int) (SerIOCur * VERT_SCALE);
}
```

the next byte "wraps around" and is stored in the first slot, overwriting the original contents. The slots are actually numbered 0 to 99. The wrapping behavior is obtained using C's modulus function using the following line of code.

```
pos = (pos + 1) % MAX_DATA_POINTS;
```

Listing 2 show the display routine, DisplayChart. It gets a pointer to the display buffer, a count of bytes to be displayed, and the position of the ring pointer. First DisplayChart scrolls the display rectangle left by the number of pixels specified by the count parameter. Then the area where the new points are to be plotted is erased. Last, points are extracted from the data buffer, scaled to fit the display, and plotted one by one.

For plotting, I used the WinDrawGrayLine function. The name is something of a misnomer, as the Palm OS supports only 1-bit (monochrome) graphics. It simulates gray by drawing every other pixel. The routine is somewhat intelligent, but has some bugs. For example, if you send it a series of bytes of equal value, you expect to see stripes—alternating bands of black and white. It turns out that if you send data slowly, a byte at a time, such as by pressing a key on a keyboard about once per second, you get stripes. However, if you hold the key down, you get an alternating pattern, in which the blacks and whites are offset by 1 pixel.

Either way, though, the display is not always consistent; sometimes it switches modes, seemingly arbitrarily. Also, line length may be off by one, because in the process of eliminating pixels to simulate the gray effect, the end may be eliminated. Those are not major issues, but they are limitations that need to be understood. For comparison purposes, the code also has a "commented-out" line to draw solid lines, using WinDrawLine.

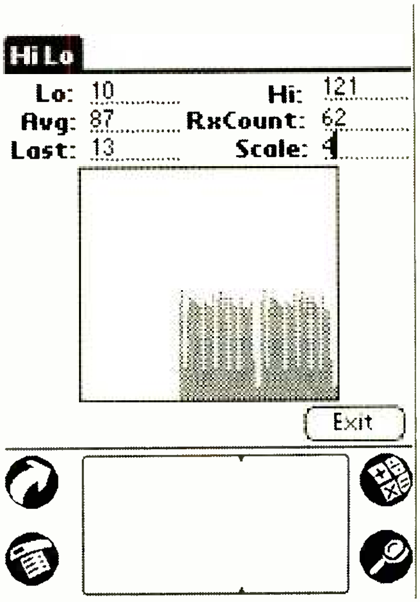


FIG. 1—THIS MONTH we implement a real scrolling chart-recorder display.

Listing 3 shows another point of interest. As discussed in preceding articles, the Palm OS is event driven. In the absence of "real" events, the OS pumps nil events through the system to give various processes a chance to do something. HiLo watches for nil events, and when it receives one, checks the serial port for data. If any is pending, it is retrieved, and then displayed. Note that DisplayChart is only called if the Receive Count is greater than zero.

At the top of that routine, but not shown here, is the following call:

```
EvtResetAutoOffTimer();
```

That forces the Pilot to stay alive as long as HiLo is running.

Limitations, Optimizations, and Improvements

This version of HiLo is *much* better than the previous one. However, it still has some problems. For example, although it's much more responsive now, you can still swamp it by sending too much data too fast. If that happens, a dialog pops up, warning you of an error. You must click OK to dismiss that dialog, and you may have to click in one of the edit fields or the system will block (not receive any more characters).

The main problem there is the lack of intelligence in the Display routine, the

(Continued on page 26)

LISTING 2—DISPLAYCHART

```
static void DisplayChart(Byte *buf, UInt bufHd, ULong cnt) {
  Short              xPos;
  RectangleType  r;
  Short              ScrollSize = 0;

  // scroll the window, erase any leavings
  cnt = (cnt > MAX_DATA_POINTS) ? MAX_DATA_POINTS : cnt;
  if (cnt < MAX_DATA_POINTS) {
        WinScrollRectangle (&ChartRecRect, left, cnt, &r);
        WinEraseRectangle(&r, 0);
  }
  else
        WinEraseRectangle(&ChartRecRect, 0);

  // draw the last point received, right-most, and work backward
  xPos = POS_X;
  while (cnt > 0) {
        bufHd—;
        bufHd = (bufHd >= MAX_DATA_POINTS) ? MAX_DATA_POINTS - 1 : bufHd;

        SerlOCur = buf[bufHd];
        SerlOSca = (int) (SerlOCur * VERT_SCALE);

        WinDrawGrayLine(xPos, POS_Y, xPos, POS_Y - SerlOSca);
        //WinDrawLine(xPos, POS_Y, xPos, POS_Y - SerlOSca);

        xPos—;
        cnt—;
  }
}
```

LISTING 3—MAIN FORM EVENT LOOP

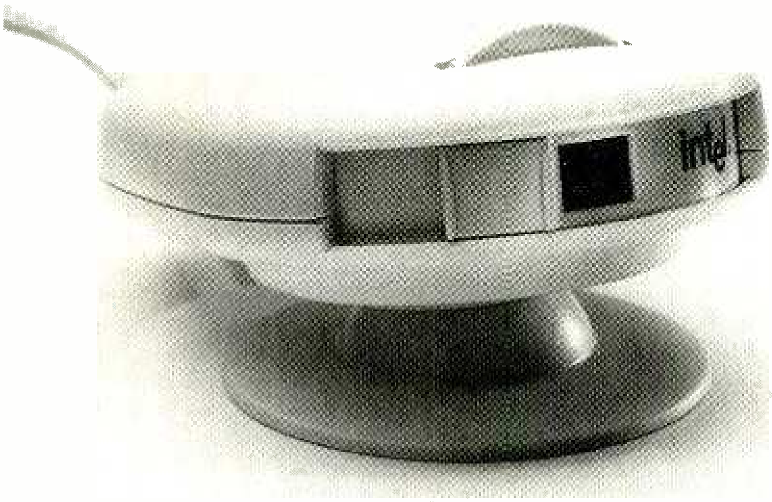
```
...
  else if (event->eType == nilEvent) {
        RcvCount  = 0;
        SerlOReceive ();
        if (RcvCount > 0)
                DisplayChart(Data, BufHead, RcvCount);

        handled = true;
  }
...
```

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

PC Camera Pack

PC USERS CAN NOW EXPERIence a communications, photography, and photo-editing package in one product that plugs into Pentium processor-based PCs. The easy-to-use Create & Share Camera Pack includes an Intel PC camera, hardware, and an integrated suite of communications and image-editing software. The software suite enables consumers to make, enhance, and organize snapshots and videos that can be passed along to others in print, on screen, and on the Web. The camera pack also includes the necessary ingredients for making video phone calls over the web as well as over regular phone lines. An Intel PC camera sits on top of the PC's monitor and serves as the center of the Create & Share software suite.



CIRCLE 20 ON FREE INFORMATION CARD

The software suite includes all of the following applications: The Guided Tour introduces the capabilities of the camera pack. The Launcher and The Gallery make it easy to organize snapshots and videos made with the camera pack and to subsequently drag and drop those images into editing applications. The Scene Recorder is an easy way to record a short video or take an instant snapshot with just a few mouse clicks—snapshots that can personalize Christmas cards or calendars. PhotoEnhancer quickly and easily enhances images captured from the PC camera. NetCard enables postcards with pictures and sound to be e-mailed. Other applications permit morphing, stretching, and shrinking images.

The Intel Camera Packs are available for systems with a Pentium-processor-based PC running at 90 MHz and higher; Windows 95; 16 MB RAM; an 800 × 600 display; 16-bit color; 16-bit SoundBlaster-compatible sound system with microphone and speakers; a 4× CD-ROM drive; approximately 75MB free hard disk space; an Internet service Provider that supports TCP/IP; and a 28.8 K (or faster) modem.

Three versions of the camera pack are available: The USB version retails for $199; the PCI version sells for $299; and the PCI Modem version retails for $399.

Intel Corporation
2200 Mission College Blvd.
P.O. Box 58119
Santa Clara, CA 95052-8119
Web: www.intel.com

Automotive Tester

ADVANCED FUNCTIONS AND features in demand for diagnosing and troubleshooting auto and truck problems are available in the Model 488 Digital Multimeter. The handheld meter (measuring $8^1/_2 \times 4^1/_4 \times 2$ inches and weighing under 21 ounces) tests and measures AC/DC volts, amps, and ohms under the hood or under the dash. With the inductive pick-up probe attached, it performs rpm/tach readings for both vehicles with or without distributors. In addition, the frequency function tests engine sensors, ABS, and other automotive systems. The temperature reading function gives readings in Celsius and Fahrenheit, making

CIRCLE 21 ON FREE INFORMATION CARD

conversion charts unnecessary when servicing foreign autos.

The easy-to-read LCD display provides a $3^3/_4$-digit, 3200-count readout, and the Data-Hold function freezes readings for future reference. Continuity, diode test, duty cycle, and dwell measurements are standard features. The D-488 also tests and measures ignition and engine systems; sensors, solenoids, and components; coils, diodes, and alternators; charging systems; and cooling, heating, and lighting systems. An "auto-power-off" feature extends battery life.

The Model D-488 digital multimeter comes complete with test leads, alligator clips, temperature probe, rpm pick-up, battery, manual, rubber holster, and carrying case. It retails for $179.

HC Protek
154 Veterans Drive
Northvale, NJ 07647
Tel: 201-767-7242
Fax: 201-767-7343

Data Radio

THE MFJ-8631 IS A DEDICATED data transceiver for the 220-MHz band that operates on a factory-installed frequency 223.700 MHz. It has all the features of the 2-meter version and provides up to 3-watts output. This transceiver allows users to get away from the crowded 2-meter band and opens up the 220-MHz band for high-performance packet use. All data rates from 1200 to 9600 baud can be run directly out of the box.

CIRCLE 22 ON FREE INFORMATION CARD

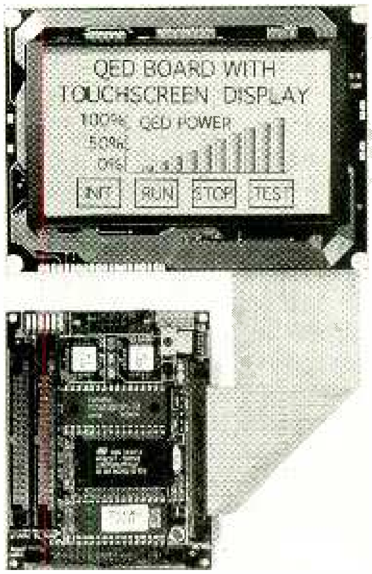
Compatible with all TNCs having hardware DCDs as well as with most that have software DCDs, the MFJ-8631 is ready to use as soon as an appropriate TNC cable and 12-VDC is plugged in, and the antenna is set up. Its five-watt output covers your operating area without disrupting distant nodes.

Features include ultra-fast PIN-diode switching, instantaneous changeover between transmit and receive, a dual-conversion receiver, 0.25 µV low-noise preamp, and a double-tuned front-end. The narrow 10.7 MHz IF filter and special full data-bandwidth IF filter provides an optimum passband and steep skirts for error-free data reception. Unsquelched audio feeds directly to the TNC for lightning-fast DCD response. Plug-in crystals for other frequencies and pre-wired cables are available as add-ons.

The tiny MFJ-8631 (5- × 5- × $1^1/_2$-inches) draws just 15 mA on receive and less than 1 amp on transmit on 12-VDC, and it retails for $139.95.

MFJ Enterprises, Inc.
300 Industrial Park Road
Starkville, MS 39759
Tel: 800-647-1800 or 601-323-5869
Fax: 601-323-6551

Embedded Controller Board



CIRCLE 23 ON FREE INFORMATION CARD

PACKING DATA ACQUISITION, control, and a touch-screen-user interface on a palm-sized surface-mount board, the QED board is easily programmable in C, Forth, or Assembly using any PC. Built-in programming tools include an interactive debugger, multitasking, executive and comprehensive libraries of device-driver functions—including drawing and plotting functions for the 128 × 240 pixel touch-screen/graphics display with which the board directly interfaces.

The QED board is ideal for a wide range of applications, including machine automation, data acquisition, industrial control, robotics, and scientific instrumentation. Because of its small size,

(Continued on page 31)

SERVICE CLINIC

continued from page 18

unit back together. Most connectors are keyed against incorrect insertion or unintentional interchange of cables, but that's not always the case. Apparently identical screws might have different lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Try using pill bottles, 35mm film canisters, and plastic ice-cube trays to sort and store screws and other small parts.

Another consideration is ESD—Electro-Static Discharge. Some of the electronic components in CD players, CD-ROM drives, and similar devices, are vulnerable to ESD. There is no need to go overboard, but taking reasonable precautions like not wearing clothing made of wool, which tends to generate static, is a good idea. When working on component CD and laserdisc players, get into the habit of touching a ground, like the metal chassis, before touching any circuit components. An anti-static wrist strap is another good idea.

A basic set of precision hand tools should be all that you will need to disassemble a CD player and perform most adjustments. Needed tools include a selection of Philips and straight-blade screwdrivers, needle-nose pliers, wire cutters, tweezers, and dental picks. A jeweler's screwdriver set is a must, especially if you plan to work on a portable unit. For adjustments, a miniature (1/16-inch blade) screwdriver with a non-metallic tip is desirable (the non-metallic tip prevents the screwdriver from detuning the circuit as you make your adjustments).

Unless you get into optical alignment of the laser assembly, no special tools will be needed, and the service manual will indicate what you do need if you are faced with that kind of repair. A low-wattage fine-tip soldering iron and fine rosin-core solder will handle any soldering or desoldering that needs to be done along the way.

For thermal or warm-up problems, a can of "cold spray" or "circuit chiller," and a heat gun or blow drier can come in handy. Use them to locate thermally sensitive parts that are causing problems. Use the extension tube of the spray can and make a cardboard nozzle for the heat source to provide precise control of which components you are affecting.

That wraps it up for this time. Until next month, if you have any specific problems or questions, you can reach me by e-mail at sam@stdavids.picker.com. For general information on electronics troubleshooting and repair visit my Web site at www.repairfaq.org. EN

LETTERS

continued from page 5

tricity beyond the abilities of the grid, and power-plant construction will have to mushroom to keep up. I know there are other ways to generate electricity that are non-, or at least not as polluting, but they are dwindling and not expanding. No new nuclear reactors have been commissioned for over a decade, the hydroelectric situation is even worse, solar is not an option due to poor efficiency, and geothermal cannot supply enough to handle even a fraction of the added load.

The one solution to this problem is the Hybrid Vehicle, in which the size of the internal combustion engine is reduced and attached to a generator. The batteries are used for acceleration and hill-climbing assistance. The emissions of this type of vehicle are greatly reduced by increasing efficiency and not overpowering the power plant to accelerate the car. Most charging would be handled by the motor/generator combination, thus only using the grid for light charging and not for a deep charge. The battery weight could also be reduced, since it is in a supporting role only.

Thanks for your time and your ear, and by the way, I do like your magazine very much!

RICHARD PERCIFIELD
Tonganoxie, KS

Editorial Approval

Regarding the recent dialog between yourself and your readers, I thought you might want to know that , in my opinion, your editorials about the Internet are right on target. While I agree that the signal-to-noise problem on the Net/Web is a bad one, my entire research agenda is being immeasurably helped by data and contacts that I have been able to make using that valuable resource.

Keep up the good work.

FOREST M. MIMS III
via e-mail EN

COMPUTER CONNECTIONS

continued from page 23

PILOT DEVELOPER RESOURCES

www.wademan.com/Pilot/Program/FAQ.htm
www.massena.com/darrin/pilot/index.html
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www.metrowerks.com/db/updates.qry?function=list&sw=CWPP3 (patches)
www.ingeninc.com

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routine that calls it, or both. The way it works now, if lots of data is streaming in, we get 100 bytes, and display 100 bytes. A more sensible solution would decrease the amount of display processing when there is lots of activity.

Related is the fact that the current routine simply copies input data from one buffer (the system's) to another (ours). If we set the system buffer to be our buffer, we could eliminate that overhead. I have resisted doing so, because I don't think there will be that much performance gain, and because we're going to end up copying data anyway to deal with the next item.

HiLo currently has no ability to store data for subsequent retrieval, analysis, and display. Dealing with the operating system's concept of databases brings a whole new layer of complexity to the application, and will undoubtedly have significant performance ramifications as well. With persistent storage in place, it might be interesting to implement live scrolling.

A limitation (that purposely hasn't been dealt with yet) is that there is no user interface for the serial port settings; 9600, 8N1 is hard-coded into the program. Not critical, but interesting is the concept of responding to serial I/O from sleep mode. There is no documented, simple way to do so. Hmmm . . . .

That's all for now. Stay in touch via e-mail; (jeff@ingeninc. com) EN

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Master Catalog—1997/1998

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Fax: 800-366-9662 or 602-438-1690
Web: www.jensentools.com
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CIRCLE 338 ON FREE INFORMATION CARD

Featuring 300 pages of items essential to electronics and other related industries, this latest catalog is filled with tool kits for the installation, maintenance and repair of electronic equipment. Several newly developed kits, including the JTK-3100 Aircraft Pre-Flight/Preventive Maintenance Kit, the JTK-2001 PC Workstation Plus Kit, and the JTK-2900 Network Support Kit, are introduced. Products offered for the first time are a number of test instruments, specialty tools, testers, and probes, among which are Fluke's DSP-2000 Cable Analyzer, an insulation-piercing electronics probe, a mini-flip circuit-board holding fixture from FIL, and B&K Precision's NTSC TV generator.

A special 8-page section is devoted to Hewlett-Packard products, such as state-of-the-art electronic measuring devices, including an assortment of oscilloscopes, logic analyzers, function generators, and universal counters.

Practical RF Design Manual

by Doug DeMaw W1FB
MFJ Publishing
300 Industrial Park Road
Starkville, MS 39759
Tel: 800-647-1800 or 601-323-5869
Fax: 601-323-6551
Web: http://mfjenterprises.com
$19.95

CIRCLE 339 ON FREE INFORMATION CARD

Engineers, designers, technicians, amateur radio operators, and students will find a wealth of information here about transmitter and receiver fundamentals, mixers, balanced modulators, detectors, IF amplifiers, filters, AGC systems, frequency-control systems, small-signal RF amplifiers, large-signal amplifiers, and frequency multipliers.

The scores of useful circuit diagrams in this book are founded on practical laboratory experience. Although these circuits are not intended for exact duplication, they will function well if they are built. Many of them can be used as building blocks for composite systems in the RF-communications industry.

The reader will find no theoretical circuit examples, and there is little reference to circuits that have appeared in trade journals and manufacturer's application notes. This book is written in easy-to-understand language, without "talking down" to the reader. Equations are used only where necessary to demonstrate a particular design approach. Approximations are used where acceptable, owing to the non-uniformity found in semiconductors that are not graded for a tight set of parameters. Usually the designer has to do some finalizing of a circuit to compensate for the differences in performance of ICs or transistors that have the same part number.

QuickCross 6.0

NTE Electronics, Inc.
44 Farrand Street
Bloomfield, NJ 07003
Tel: 800-631-1250 or 201-748-5089
Fax: 800-683-3338
Web: www.nteinc.come
Free


CIRCLE 340 ON FREE INFORMATION CARD

QuickCross is a software cross-reference to the NTE line of industry-standard replacement components and is available in Windows and DOS formats. In addition to containing replacements for over 260,000 semiconductors, 41,000 relays, and 1386 flyback transformers, this edition includes surface-mount resistor and capacitor selector guides.

Version 6.0 provides users with one of the most comprehensive and easy-to-use cross references of electronics components. It allows distributors, technicians, and hobbyists to easily access NTE's full line of products. To use QuickCross, the searcher simply keys in any industry device number—U.S., Japanese, or European—and in less than a second, the NTE equivalent is displayed.

QuickCross can be downloaded free from their Web site; it also can be purchased from NTE distributors for $12. rugged surface-mount construction, and low power requirement, it is extremely useful in many handheld applications as well.

The embedded controller provides up to 512K on-board memory and 60 I/O lines including keypad and graphic-display interfaces, time-controlled I/O, 16 analog inputs, 8 analog outputs, quad high-current drivers, and dual serial ports. Battery-backed write-protectable RAM eliminates the need for PROM burning. It is priced at $495 in single quantities.

Mosaic Industries, Inc.
5437 Central Avenue #1
Newark, CA 94560
Tel: 510-790-1255
Fax: 510-790-0925
E-mail: info@mosaic-industries.com
Web: www.mosaic-industries.com

1998 Publications Catalog

Prompt Publications
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Indianapolis, IN 46214-2041
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Fax: 317-298-5604
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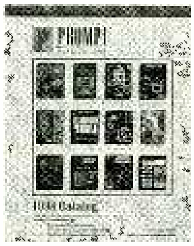
Free


CIRCLE 341 ON FREE INFORMATION CARD

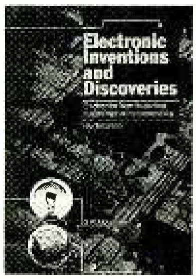
Aimed at hobbyists, students, and professional technicians, the catalog presents hundreds of best-selling titles from Prompt Publications, Butterworth-Heinemann, Macmillan Computer Publishing, and UCANDO Educational Videos. Along with many new books, there are updated editions—second editions of *Real-World Interfacing with Your PC* and of *Power Supplies*, as well as the sixth edition of *Modern Dictionary of Electronics*.

Concentrating on technical books for both the novice and the experienced electronics technician, Prompt has published more than 100 books in its first seven years, and has another 30 scheduled for 1998. Prompt's Web site provides complete book summaries, new release dates, and other information.

Some of the new publications coming out in 1998 are *Complete Guide to Audio* from Prompt; *Laser Technology*, an educational video from UCANDO; *Surface Mount Technology Terms & Concepts* from Butterworth-Heinemann; and the eighth edition of Macmillan's *Upgrading and Repairing PCs*.

Electronic Inventions and Discoveries: Electronics From Its Earliest Beginnings to the Present Day

by G.W.A. Dummer
Institute of Physics Publishing
The Public Ledger Building (U.S. Office)
Suite 1035
150 South Independence Mall West
Philadelphia, PA 19016
Web: www.iop.org
$40



CIRCLE 342 ON FREE INFORMATION CARD

In a remarkably short time, electronics has penetrated almost every aspect of modern life. The pace shows no sign of slackening. Spanning two and a half centuries, this book traces electronics from its earliest beginnings to the present day. It is a mini-encyclopedia full of valuable information on practically all inventions in electronics, as well as an up-to-date systematic review of the major developments in the field.

This book is an essential reference for engineers wishing to broaden their knowledge, and provides a sound background for students, hobbyists, and general science readers. The first section presents concise but comprehensive histories of developments in the major areas of electronics: transistors, audio and sound, radio, television, computers, robotics, and in business applications. Inventions are categorized both by subject and chronologically, with concise descriptions of over 1000 key inventions.

Acronyms and abbreviations are explained, and there are complete bibliographies of books on inventors and inventions.

Analog Dialogue: Volume 31-1

Analog Devices, Inc.
Ray Stata Technology Center
804 Woburn Street
Wilmington, MA 01887
Tel: 800-ANALOGD or 617-937-1428
Fax: 617-821-4273
Web: http://www.analogcom/publications/magazines/Dialogue/dialog.html

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CIRCLE 343 ON FREE INFORMATION CARD

Analog Dialogue is a forum for the exchange of information on circuits, systems, and software for real-world signal processing. Feature articles include "DSP101"—Part One of a multi-part introductory series on DSP system design, "Selecting Mixed-Signal Components in Digital Communication Systems," and "Build a Smart Analog Process-Instrument Transmitter."

In other articles, recently-released amplifiers, buffered switches and multiplexers, A/D and D/A converters, and power-management supervisory circuits are described; and sources of information for further information are suggested, such as data sheets, newsletters, and application notes. EN

NEW PRODUCTS

continued from page 25

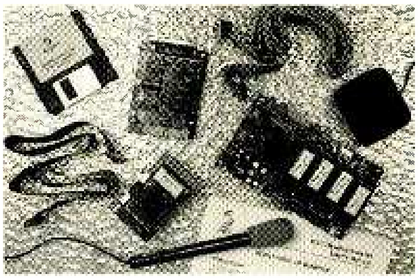
rugged surface-mount construction, and low power requirement, it is extremely useful in many handheld applications as well.

The embedded controller provides up to 512K on-board memory and 60 I/O lines including keypad and graphic-display interfaces, time-controlled I/O, 16 analog inputs, 8 analog outputs, quad high-current drivers, and dual serial ports. Battery-backed write-protectable RAM eliminates the need for PROM burning. It is priced at $495 in single quantities.

Mosaic Industries, Inc.
5437 Central Avenue #1
Newark, CA 94560
Tel: 510-790-1255
Fax: 510-790-0925
E-mail: info@mosaic-industries.com
Web: www.mosaic-industries.com

Speech Recognition Kits

TWO SPEECH RECOGNITION kits from Sensory, the RSC Development Kit 2.2 and the Interactive Speech Demonstration Unit, allow designers to integrate speech recognition into consumer telephony and electronic applications.



CIRCLE 24 ON FREE INFORMATION CARD

The RSC Development Kit 2.2 contains a complete package of hardware and software tools, including a development board, an in-circuit emulator, and a memory board. It gives designers unlimited access to Sensory's speech and audio-technology libraries so they can develop custom programs using the company's RSC-164 and RSC-164i Interactive Speech Chips

The Interactive Speech Demonstration Unit is intended to showcase Sensory's speech recognition and audio capabilities through a series of interactive demonstrations. The unit comes complete with all necessary hardware components and pre-programmed ROMs to provide real-life demonstrations of low-cost speech recognition, including voice dialing, voice password, and speaker-dependent and speaker-independent applications.

The development and demonstration kits have several new speech-technology capabilities, including higher accuracy and enhanced filtering software. The continuous listening feature allows compete hands-free and eyes-free product operation. A product will continuously listen for pre-programmed command words and carry out the associated tasks upon recognition. The kits also feature consecutive-digit speech recognition for speaker-dependent and speaker-independent technologies. Enhanced noise-filtering software improves recognition rates by over 97%.

The RSC Development Kit sells for $3200, and includes all the necessary hardware and software to integrate an RSC chip into a product or project. The Interactive Speech Demonstration Unit sells for $300. Current owners of earlier versions of the kits can purchase upgrades for $50 and $30 respectively.

Sensory, Inc.
521 East Weddell Drive
Sunnyvale, CA 94089
Tel: 408-744-9000
Fax: 408-744-1299
Web: www.SensoryInc.com EN

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Sacramento, CA 95814

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Sacramento, CA 95841

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Gateway Electronics of CO
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Denver, CO 80211

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

Connecticut

Cables & Connectors
2198 Berlin Turnpike
Newington, CT 06111

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

Georgia

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Chamblee, GA 30341

Illinois

Tri State Elex
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Mt. Prospect, IL 60056

Kansas

Electronic Hobby Shop
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Maryland

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5015 Herzel Place
Beltsville, MD 20705

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Baltimore, MD 21211

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

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Norwest Electronics
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Livonia, MI 48150

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Elec. Parts Specialists
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Flint, MI 48506

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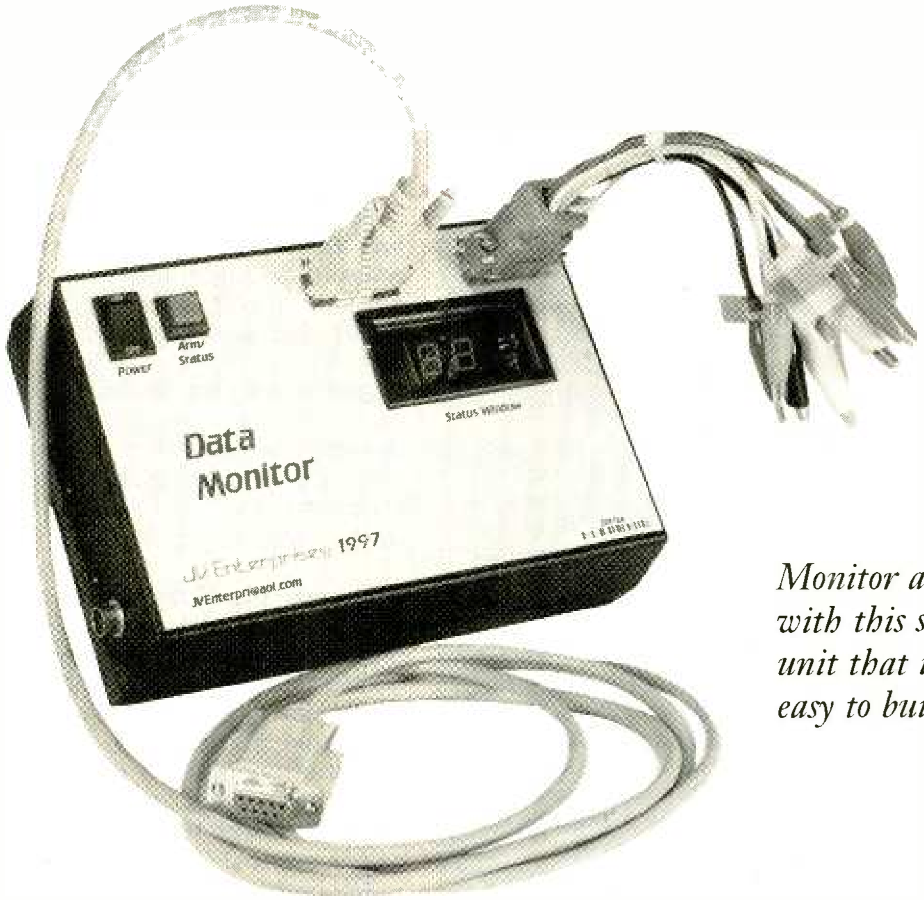

BUILD THE DATA MONITOR

Monitor and record events with this sophisticated unit that is both easy to build and use.

JON VARTERESIAN

Imagine how useful it would be to be able to monitor and record information about your environment for extended periods of time without having to be physically there. With a variety of input sensors, you could analyze the temperature of your attic to see if you really needed those ridge vents. You could count the number of people that came in and out of your store, and when each one entered and left, for weeks at a time. You could monitor the relative humidity or pressure of your lab or home. You could monitor the voltage and current output of your latest solar-cell project. You could even count the squirrels opening your squirrel feeder. The uses for such a monitoring device are only limited by the imagination. Now imagine how useful such a device would be if it could be run from either battery or AC power and didn't need to be tied to a PC to store information.

The Data Monitor described in this article is just such an instrument. It is highly configurable, low in cost, and easy to use. It can monitor and store up to four analog and four digital inputs at the same time. The sampling rate can be set anywhere from 30 milliseconds to more than 49 days. There is also an eight-term complex trigger that can include up to four digital and four analog inputs. All of the information is recorded in an electrically-erasable programmable read-only memory module (EEPROM) that has a capacity of 2048 words. The EEPROM is extremely error tolerant and can hold onto any data that has been stored in it even if the power is turned off or lost. Each sample has a time and date stamp included in order to protect the integrity of the data. That makes it easy to analyze any data that has been stored over a long period of time.

The Data Monitor is set up using an easy-to-use Windows-based program. Once it has been set up, the Data Monitor runs by itself. When the sample and store process is complete, the same program is then used to retrieve all of the data that has been collected. The only computer requirements for using the Data Monitor is a PC that is running either Windows 3.1 or Windows 95 and has an available COM1 or COM2 serial port.

The Data Monitor's hardware can monitor and record almost any electronic or electrical circuit through the use of plug-in personality modules. An accompanying article details the building of a general-purpose personality module that includes four digital and three analog inputs. Also included is a temperature sensor that uses the Data Monitor's fourth analog input. Although not needed to test the Data Monitor, building that personality module is a good idea and is very handy for testing the various functions of the Data Monitor.

How it Works. The heart of the Data Monitor is a PIC16C74 microcontroller, which controls all of the functions of the unit. That particular

PARTS LIST FOR THE DATA MONITOR

SEMICONDUCTORS

IC1—PIC16C74 microcontroller, programmed (Microchip)
IC2—24LC16B/P 16K serial EEPROM, integrated circuit (Microchip)
IC3—MAX232CPE RS-232 converter. integrated circuit (Maxim)
IC4, IC5—Not used
IC6—LM340T 5-volt regulator, integrated circuit
D1, D2—1N4001 silicon diode
Q1, Q2—FMMT3904 NPN transistor, SOT-23 package

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R3, R17–R20, R25, R26—10,000-ohm
R2—10-ohm
R4—not used
R5—12,100-ohm, 1%, metal-film
R6—4020-ohm, 1%, metal-film
R7, R8—not used
R9–16—91-ohm
R21–R24—not used

CAPACITORS

C1, C2—15-pF, axial ceramic
C3, C6, C7, C10—0.1-µF, axial ceramic
C4, C5, C8, C9—1-µF, 63-WVDC, electrolytic
C11—0.22-µF, axial ceramic
C12—10-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

DISP1—LN524 2-digit 7-segment light-emitting diode display, common cathode (Digi-Key P355-ND or similar)
J1, J4, J5—Square-post connector strip, right-angle, male
J2, J3—Square-post connector strip, straight, male
XTAL1—4-MHz oscillator (CTX006-4MHZ or similar)

Case, 9-volt battery, 9-volt battery connector, 9-volt wall adapter, square-post female sockets, 9-pin D-subminiature male, connector, 9-pin D-subminiature female connector, 44-pin PLCC socket, toggle switch, normally-open momentary switch, wall-adapter connector, RS-232 data cable, hardware, wire, etc.

Note: The following items are available from: JV Enterprises, PO Box 370, Hubbardston, MA, 01452. E-mail: JVEnterpri@aol.com: Complete kit of all items including programmed IC1 with source code, manuals and documentation, Windows software with source code, unlimited technical support, $249.00; assembled and tested unit, $299.00; programmed PIC16C74 with assembly source code, $20.00; complete printed documentation package, including Users Guide, Technical Reference Manual, Assembly Manual, schematics, foil patterns, and assembly drawing, $9.00; Enclosure with 9-volt battery compartment and drilling template, $20.00: PC board with silk-screen, plated holes, and solder mask, $13.50; Windows software with source code. $29.00. Please add $7.00 shipping and handling for complete kit and assembled unit; $5.00 for all other orders. Massachusetts residents must add 5% sales tax. Check or money order only.

member of the PIC microcontroller family has several features built into it that make it particularly attractive for use in the Data Monitor. Two of the features that help reduce the number of components in the circuit are a serial-interface controller and an 8-channel 8-bit analog-to-digital converter.

As mentioned above, analog and digital inputs are supplied to the unit through a plug-in "personality module." That module contains circuitry that can interface, buffer, or modify any input signals before they are passed to the Data Monitor itself. Although the design and construction of a personality module will not be discussed here, the article "Build this I/O-Temperature Personality Module" found elsewhere in this issue of **Electronics Now** describes a general-purpose personality module that will get you started with the Data Monitor. That add-on device will provide four digital inputs, three analog inputs, and one temperature-measurement input.

Data is stored and retrieved from the EEPROM using a two-wire technique called the *Inter-I* C (or IIC) protocol. That method was developed by Philips and Signetics. Although an "enhanced" specification that allows data transfers at a rate of 400,000 bits per second is supported by the EEPROM, the Data Monitor follows the 100,000 bits-per-second rate that was established by the original specification. See the sidebar for a technical overview of the IIC protocol.

Status for the Data Monitor is shown on a 2-digit 7-segment LED. The PIC drives those digits directly. A momentary push-button switch is used to enable the LED display. That switch also "arms" the Data Monitor, telling it when to begin sampling and storing the inputs.

Serial communications between the Data Monitor and a PC is done with an RS-232 interface. The data rate of the serial port is 19,200 bits-per-second with eight data bits, one stop bit, and no parity bit. No flow-control signals are used during communications. The power supply regulates and conditions the 9-volt battery or the 9-volt DC power supply down to the 5-volt level needed by the circuit.

Software. The Data Monitor uses two types of software: the programming in the PIC chip and the control software on the PC. The PIC programming can be broken into two main components: a main loop that handles the non-timing-critical events, and an interrupt-service routine that handles the time-critical events.

When power is first applied to the Data Monitor, the PIC program initializes all of its internal variables and waits for configuration information to be sent through the RS-232 port from the PC. While waiting, the Data Monitor's system voltage is monitored. That lets the battery voltage be checked at any time. Once the configuration data is sent to the Data Monitor, it is written to the EEPROM. When the arm switch is pressed, the Data Monitor begins sampling and storing data based on the user-supplied parameters. Once sampling has begun, the percentage that the EEPROM is full is also calculated. Any information that needs to be sent over the RS-232 link to the PC is also done.

The interrupt-service routine does two functions. The first function is to run the PIC's internal clock. Each "tick" of the clock is one millisecond. That means that anything that the interrupt-service routine is doing must be finished in less than one millisecond, or the next tick will be missed, messing up the Data Monitor's real-time clock. The other section services the RS-232's receive interrupt. That section takes care of all of the data that is received from the PC.

The Data Monitor is controlled by a Microsoft Windows program. With it, the Data Monitor is prepared for sampling, and the stored information is retrieved. When configuring the Data Monitor, you can say what combination of analog and digital inputs are to be stored, whether to average the analog samples or not, how many samples to include in any averaging, set the rate that the Data Monitor takes samples, what type of trigger mode to use, and define the eight-term trigger equation.

Most of the controls are self-explanatory. However, the trigger equation can become complex so some explanation is in order. Depending on your needs, the trigger equation can be used to set up any type of triggering condition from the very simple to the extremely complex. The format of the trigger equation is as follows:

(Trigger_1 & Trigger_2 & Trigger_3) # (Trigger_4 & Trigger_5 & Trigger_6) # (Trigger_7 & Trigger_8)

The "&" is a logical AND and the "#" is a logical OR. Each of the eight trigger terms can be linked to any one of the analog or digital inputs, along with one or more trigger modes. With a digital input, the trigger can become active when the input is rising, falling, or at the same level it was before the overall trig-

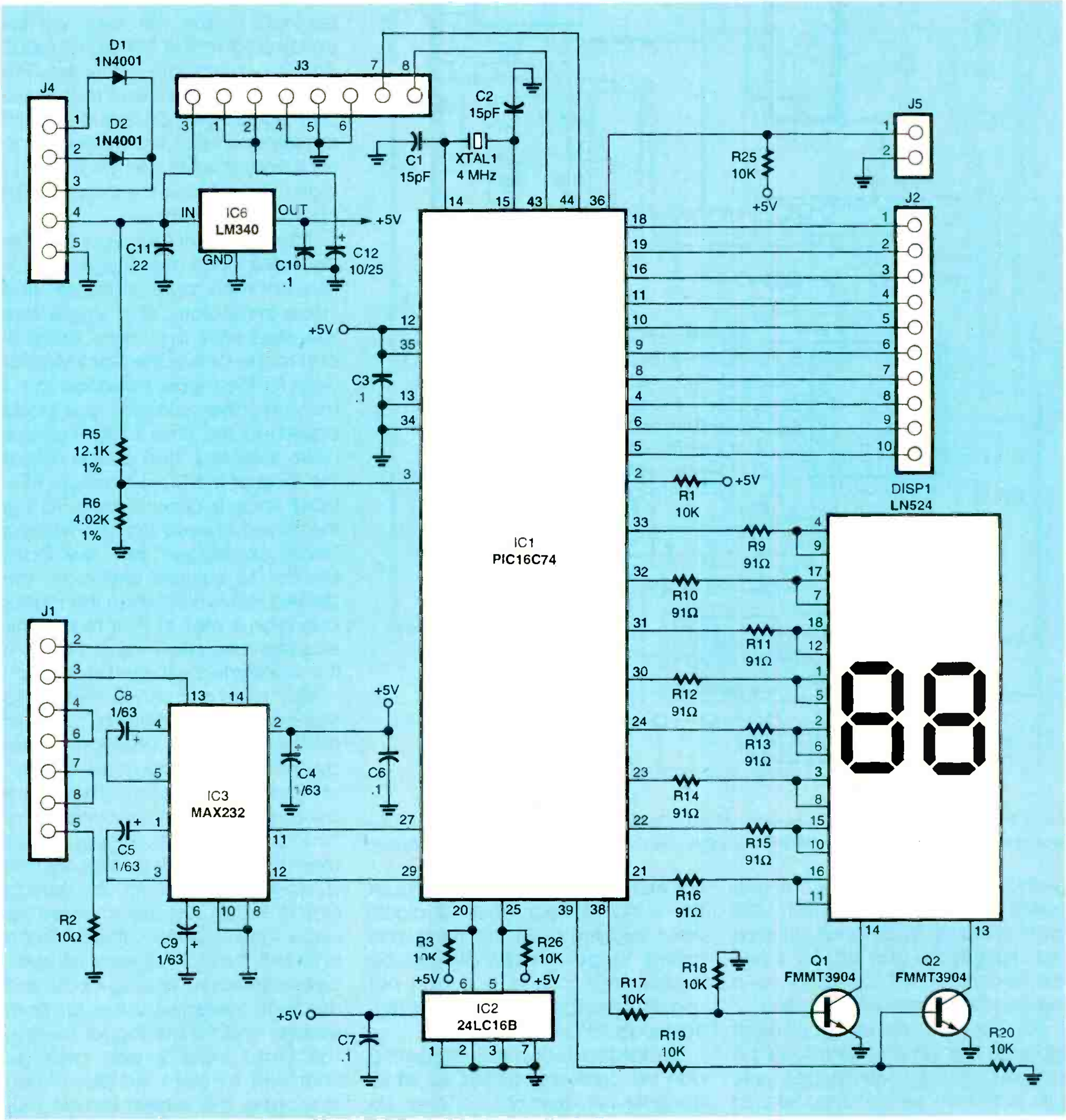

Fig. 1. The Data Monitor is built around a PIC16C74 microcontroller chip. It is easily powered by a wall transformer or a 9-volt battery.

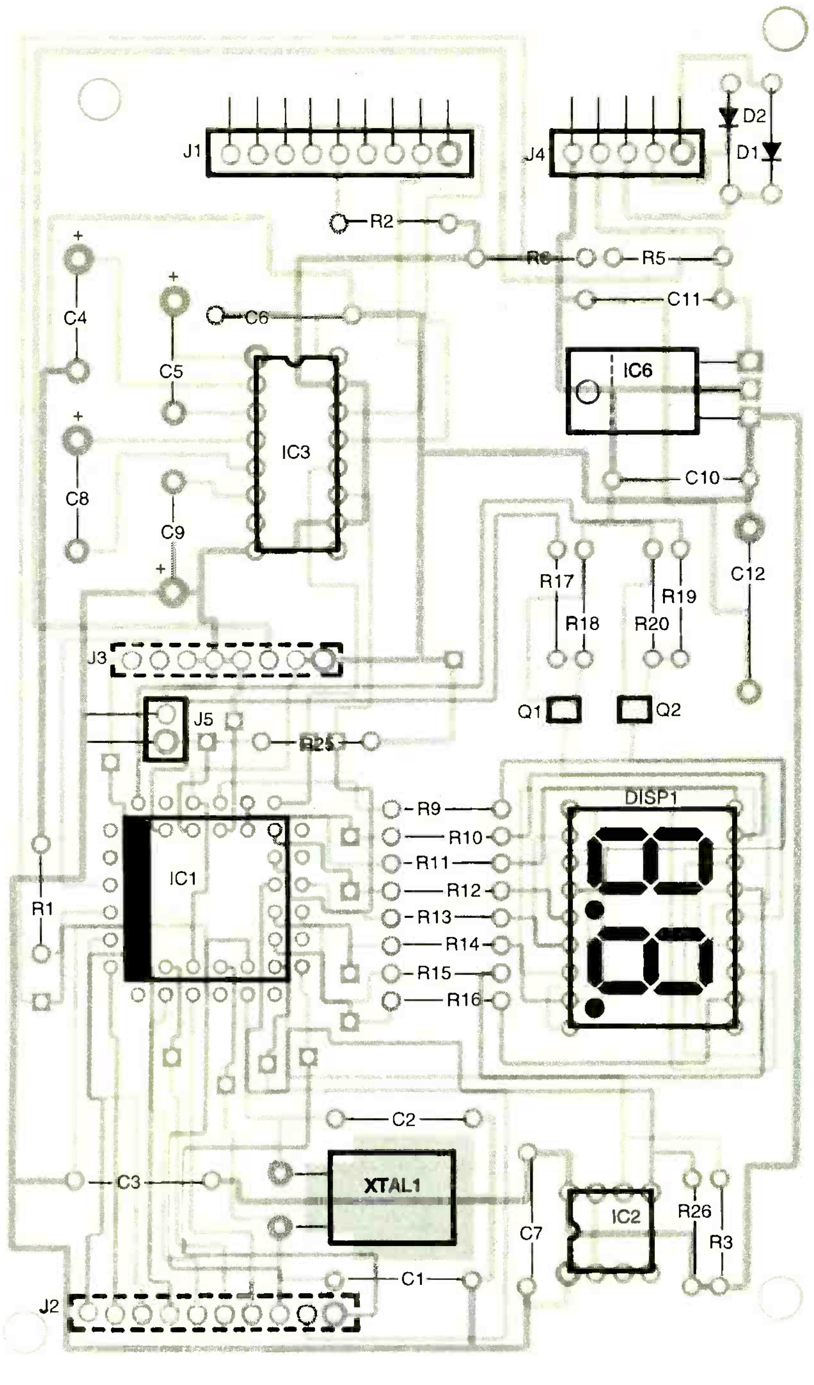

Fig. 2. When building the Data Monitor, solder J2 and J3 to the solder side of the board. Those connectors will hold a Personality Module that passes the signals to be monitored to the Data Monitor.

gering condition was met. Similar conditions are available with the analog inputs. Since analog inputs are digitized to one of 256 levels, the level that will be used as a threshold must also be specified.

You do not have to use all eight triggers; any unused terms will be ignored. For any given trigger type, you can also select one, two, or even all three of the trigger modes that are linked to a particular input.

For example, if you want to trigger the Data Monitor when a digital input toggles, both the rising and falling trigger modes should be enabled. Of course, you can not specify analog trigger terms for digital inputs, and *vice versa*.

Understandably, the triggering can be confusing at first, so let us consider an example. Let's set up the Data Monitor to store the ambient temperature from a sensor connected to analog-input 1 whenever any of the following conditions are met: digital-input 1 rises or digital-input 2 toggles while digital-input 3 is high. We'll use trigger terms 1, 4, and 5. Remember, terms 1, 2, and 3 are linked together according to the logic formula given above. Similarly, terms 4, 5, and 6 are also linked together. Note that all other trigger terms are left unused so that they will be ignored.

The Data Monitor will only store the information coming from analog-input 1. The first term will be connected to the first digital input, and it will activate on a rise. The fourth term will be linked to the second digital input. On that one, both the rise and fall states will be selected. Finally, the fifth term is linked to digital-input 3, and the steady-state choice is selected.

There are also two ways to store the data once the trigger conditions are met: "store on trigger" and "store immediate." If a trigger was specified with the "store immediate" mode active, the Data Monitor waits for the trigger condition to be met, and then samples and stores based on the time base that has been selected. That mode makes the most of the Data Monitor's EEPROM since it doesn't have to log the time between stores. Selecting "store on trigger" tells the Data Monitor to sample and store the desired inputs only when the trigger condition is met. In that mode, the elapsed time since the Data Monitor was started will also be stored.

You can also have the Data Monitor perform different levels of averaging on the analog samples by checking the "average enable" check box in the setup screen. Data averaging is used to average or "smooth out" the analog inputs used for storage or for triggers. The averaging applies to all analog inputs; it can not be enabled for some and not for others. Once enabled, the Data Monitor will average all selected analog inputs and use that averaged value for both storage and for the trigger modes. The Data Monitor can average from one to eight samples. When averaging, the current sample plus the last several samples are used. For example, if eight samples are to

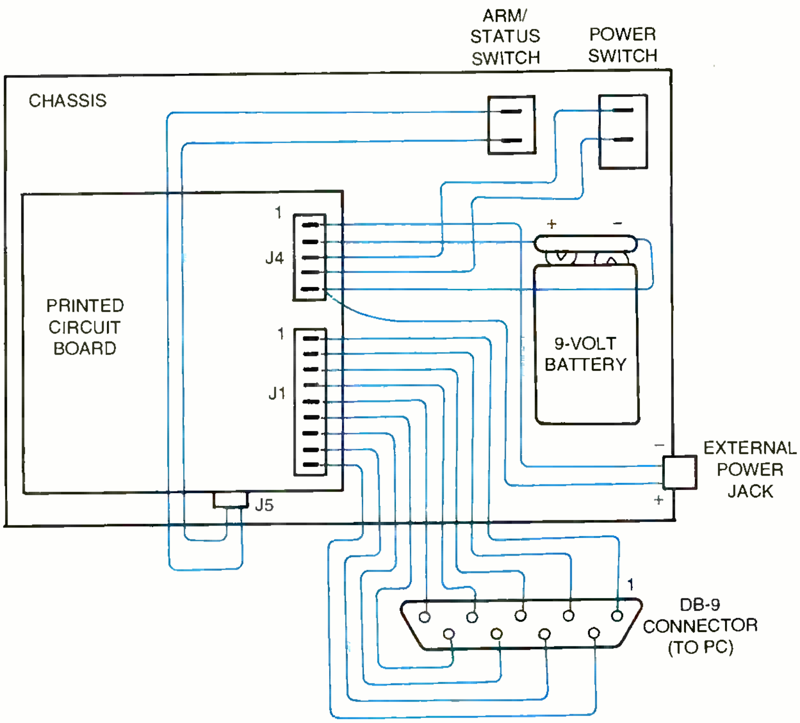

Fig. 3. Use extra care when wiring the Data Monitor's power connector. A mistake here can destroy the unit when power is applied.

TABLE 1

Sample No.	Input Value	Output (Averaging=2)	Output (No Averaging)
1	0	([0]+0)÷2=0	0
2	130	(0+130)÷2=65	130
3	128	(65+128)÷2=96	128
4	133	(96+133)÷2=114	133
5	130	(114+130)÷2=122	130
6	128	(122+128)÷2=125	128
7	128	(125+128)÷2=126	128
8	128	(126+128)÷2=127	128
9	128	(127+128)÷2=127	128
10	128	(127+128)÷2=127	128
11	128	(127+128)÷2=127	128

be averaged, the current sample plus the last seven samples are used. An example of the effects of averaging is shown in Table 1. In that example, an averaging of 2 is used to show the difference between averaging the data and storing the straight values.

Once all of the configuration information has been entered, the data is then sent to the Data Monitor over the RS-232 cable. Once that is done, the Data Monitor is then ready to be armed. It can be disconnected from the PC at this time and placed wherever it needs to be. Pressing the Arm/Status switch will arm the Data Monitor, and begin the sample and store process. You will see two three-bar characters on the display, showing that the sample and store process has begun. Pressing the Arm/Status switch will display the percentage that the EEPROM is full.

When the EEPROM is full, or you have collected enough data, you can download the information recorded in the Data Monitor to the PC for analysis. The same program is used to download the stored information. Type in the name of the file that you wish to save the data in and select a directory in which to store it. Press the OK button, and the software will download the collected data and place it in an ASCII text file with the name that you gave. The download process can take up to 5 seconds. The downloaded file can be opened by any standard text editor or word processor. You can also use a spreadsheet in order to analyze and chart the information from the Data Monitor.

Circuit Description. The schematic diagram in Fig. 1 shows that the Data Monitor is built around IC1, a PIC microcontroller. The circuit needs a DC power source between 7 and 12 volts that can supply 200 milliamps. That power is fed through J4. Both a 9-volt battery and a wall-mounted 9- to 12-volt DC adapter are connected through pins 1 and 2 of J4, with pin 5 serving as the ground. Each power source is isolated from each other by D1 and D2. The power is then routed through an on-off switch that is connected between pins 3 and 4 of J4. The power is regulated down to 5 volts by IC6 and filtered by C10–C12.

The rest of the circuitry supports IC1. Translating IC1's serial transmit and receive lines between TTL and RS-232 voltage levels is done by IC3. Through that chip and J1, the Data Monitor connects to a PC. The pinout on J1 is designed to match the pinout used on the 9-pin serial ports commonly found on PCs. An unusual feature of the serial-interface circuit is R2, which gives a small measure of short-circuit current protection for the RS-232 connection. Any power-supply noise that might disturb the operation of IC3 is decoupled by C6.

The Data Monitor's status is displayed on DISP1, a 2-digit 7-segment LED display. The display is a common-cathode type—all of the cathodes in each individual LED are tied together, with the anodes separated. The anodes of each digit are driven from IC1 directly through current-limiting resistors R9–R16. In order to minimize the number of pins needed for IC1 to control the dis-

LISTING 1

Data Monitor Download Data (V1.0) -- JV Enterprises

Storage Mode :: Immediate
Trigger Mode :: None
Average Off ::----
Time Stamp :: 20:50:22.070
Date Stamp :: 01\02\97
User Time Scale :: 30 MilliSeconds

Time	Dg1	Dg2	Dg3	Dg4	An1	An2	An3	An4
20:50:25.297	0	0	0	0	88	0	0	0
20:50:25.327	0	0	0	0	88	0	0	0
20:50:25.357	0	0	0	0	88	0	0	0
20:50:25.387	0	0	0	0	88	0	0	0
20:50:25.417	0	0	0	0	88	0	0	0

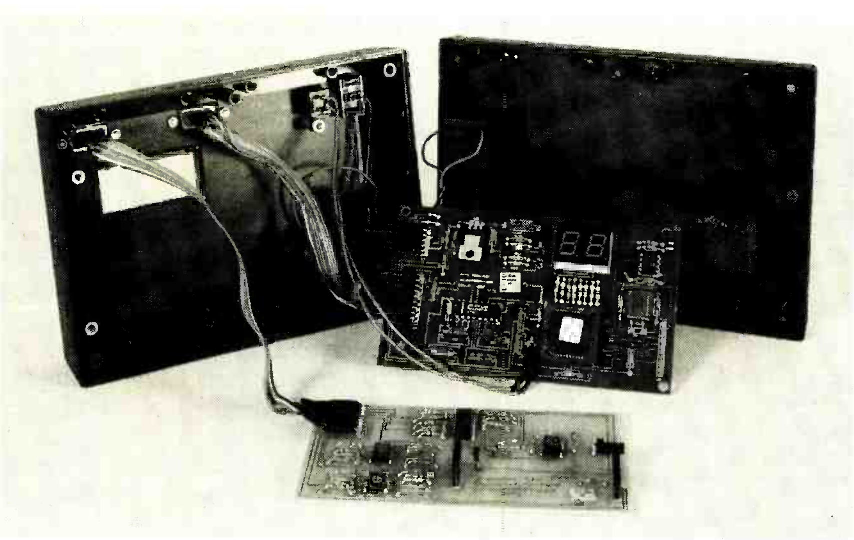

Fig. 4. When your Data Monitor is ready to be closed up, it should look something like this. The additional PC board in the foreground is a general-purpose I/O-temperature sensor Personality Module that is described in an accompanying article in this issue. You will need some type of Personality Module to use the Data Monitor. You can design your own if you want.

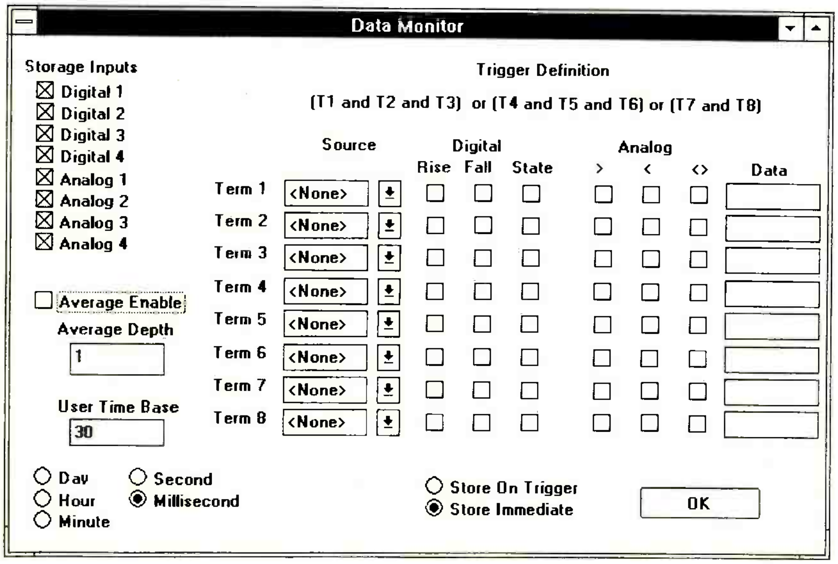

Fig. 5. Programming the Data Monitor is a snap with this Windows-based program. Selecting the various features and options is as easy as pointing and clicking with a mouse.

play, the data to each digit is multiplexed. In that way, the data for the first digit is sent through the resistors while Q1 is turned on and Q2 is turned off. Then the data for the second digit is sent through the resistors while Q1 is turned off and Q2 is turned on. The process is repeated every eight milliseconds. At that rate, the human eye cannot tell that the display digits are alternating on and off—the display appears to be on continuously.

A momentary pushbutton is wired across J5. That button is used to arm the Data Monitor and to activate the display. Normally, the display is off, helping conserve battery power. Also, the display will not update while the button is pressed, making it a little easier to read.

Connectors J2 and J3 provide the connections to the Data Monitor's Personality Module. The use of each pin is shown in Table 2. The analog- and digital-input signals are applied to those pins. The analog inputs are connected to the PIC's A/D converter. Two additional pins are used to let the Data Monitor know what type of Personality Module is connected to it. The voltage from a voltage divider made up of R5 and R6 is applied to one of the unused analog inputs of IC1. That way, the Data Monitor can also watch the unregulated voltage level of its own power supply, and take appropriate action if the batteries (if used) get too weak.

Building the Data Monitor. Although the Data Monitor is a sophisticated information-gathering device, its construction is quite straightforward. If you decide to etch and drill your own board, foil patterns are provided. As an alternative, an etched and drilled PC board can be purchased from the source given in the Parts List. Since the Data Monitor PC board is double-sided, you should make sure that all connections on both sides of the board are properly soldered if you make your own board. A purchased board will have all of the component and via holes plated, making assembly much easier.

Microcontroller IC1 must also be programmed with the instructions needed to run the Data Monitor.

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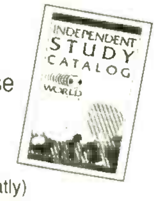

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Again, a pre-programmed part is available from the source given in the Parts List. Blank chips can also be programmed. The programming information, along with the computer-interface program, is available at the Gernsback FTP site (ftp://ftp.gernsback.com/pub/EN/datamon.zip).

Once you buy or etch your board, use the parts-placement diagram in Fig. 2 for the proper location of the components. Pay particular attention to the orientation of any polarized components. If a part is soldered onto the board backwards, removing it will be much more difficult due to the double-sided traces.

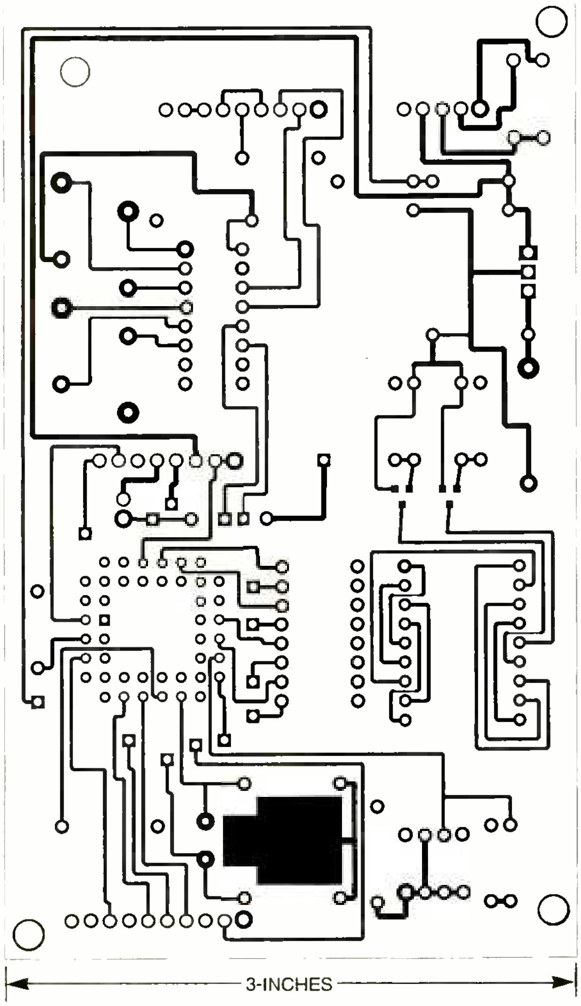
Start assembly by mounting all of the resistors and capacitors. A socket will also be needed for IC1. Sockets may also be used for the other ICs, but that is not necessary. Doing so, however, will make troubleshooting and repair of the Data Monitor much easier. Connectors J1–J5 should also be mounted. Note that J2 and J3 are mounted on the *solder* side of the board. The other connectors are right-angle types; their pins should point to the closest edge of the board.

The first semiconductor to be mounted is IC6. It should be mounted flat to the board with the metal tab facing *away* from the PC board and the plastic front *against* the board—opposite from the normal way to mount such a component. Before going any further, the board should be tested to see that the proper voltages appear at the various locations of the other semiconductors. If there is a problem or mistake in the board, it is easier (and less expensive) to correct the problem now rather than destroying several ICs. Set up a bench-type power supply for 9 volts DC. If you do not have a bench supply, a 9-volt battery can be used instead. Connect the positive terminal of the supply to pin 1 of J4 and the negative (ground) terminal of the supply to pin 5. The output voltage of IC6 should be 5 volts. That voltage should also appear at the several power-supply pins on the rest of the IC locations. Use the schematic diagram in Fig. 1 as a guide as to which pins should be checked. As a final test, pin 3 of IC1 should be about 3 volts. Once the board checks out, the rest of the semiconductors and DISP1 can be mounted. Double-check the orientation of the devices against Fig 2. as you mount them.

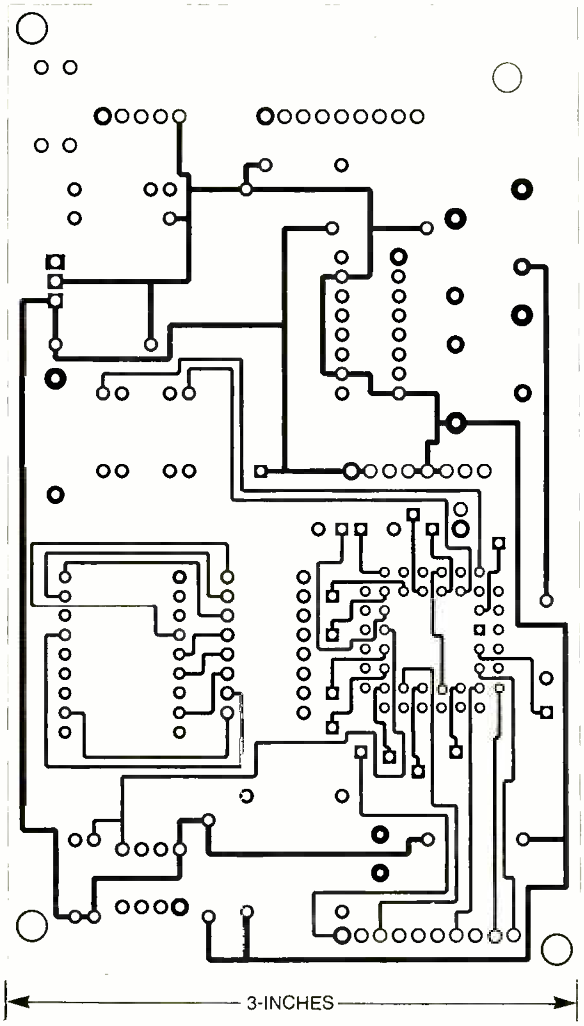
Prepare a suitably-sized enclosure by drilling and cutting holes for the power switch, status switch, and power connector. Four holes will be needed for mounting the PC board to the front panel. A cutout for viewing DISP1 is also needed in the front panel. In addition, two 9-pin connectors will be used for both the serial interface to the computer and to connect the monitored circuits to the Data Monitor's personality module.

The various connectors and switches are wired as shown in Fig. 3. Use suitable connectors for attaching the wires to J1, J4, and J5. The status switch simply connects across J5. The computer interface is wired to J1 connecting pin 1 to pin 1, pin 2 to pin 2, and so on. Pay special attention to the wiring of J4. That connector brings the 9-volt battery, the external DC wall adapter, and the Data Monitor's power switch together. Do not mis-wire J4, or the unit will be destroyed the first time power is applied. Wiring the input connector to the Personality Module will depend upon what type of connector and Personality Module you will be using.

Once all of the wires are attached to the various connectors, mount the connectors and switches to the enclosure. Attach the connectors at the other ends of the wires to J1, J4, and J5. If you are using the Personality Module described in the accompanying article, the unit should look similar to Fig. 4. Simply



Here is the foil pattern for the component side of the Data Monitor PC board.



Here is the foil pattern for the solder side of the Data Monitor PC board. If you etch and drill your own board, don't forget to connect any foil connections that pass from one side of the board to the other.

TABLE 2

PINOUT FOR J2	
Pin No.	**Signal**
1	Digital Input 1
2	Digital Input 2
3	Power On/Off Control
4	Personality ID 2
5	Personality ID1
6	Personality 0
7	Analog Input 4
8	Analog Input 3
9	Analog Input 2
10	Analog Input 1
PINOUT FOR J3	
Pin No.	**Signal**
1	5-volt regulated supply
2	5-volt regulated supply
3	9-volt unregulated supply
4	Ground
5	Ground
6	Ground
7	Digital Input 4
8	Digital Input 3

screw the PC board onto the spacers mounted on the front panel, mount the Personality Module onto J2 and J3, and close up the case. The Data Monitor is now ready for testing.

Testing. Now that you have fully completed assembling the Data Monitor, you must test it to make sure it is fully functional. Insert a fresh 9-volt battery or attach a 9-volt DC wall adapter to the Data Monitor. Turn on the power switch and press the Arm/Status button. Two single bars should be seen in DISP1. That means that the Data Monitor is ready for communications with the host computer.

Connect the serial cable from the Data Monitor to the PC and run the Data Monitor software. Click on the "Configure" pull-down menu and select "Comport." Choose the serial port that the Data Monitor is attached to. Now select "Setup" from the "Configure" pull-down menu and set the Data Monitor's options to record all of the digital and analog inputs. You can leave all other options at their defaults. With the Data Monitor storing information at 30-millisecond intervals, the setup screen should look like the example shown in Fig. 5.

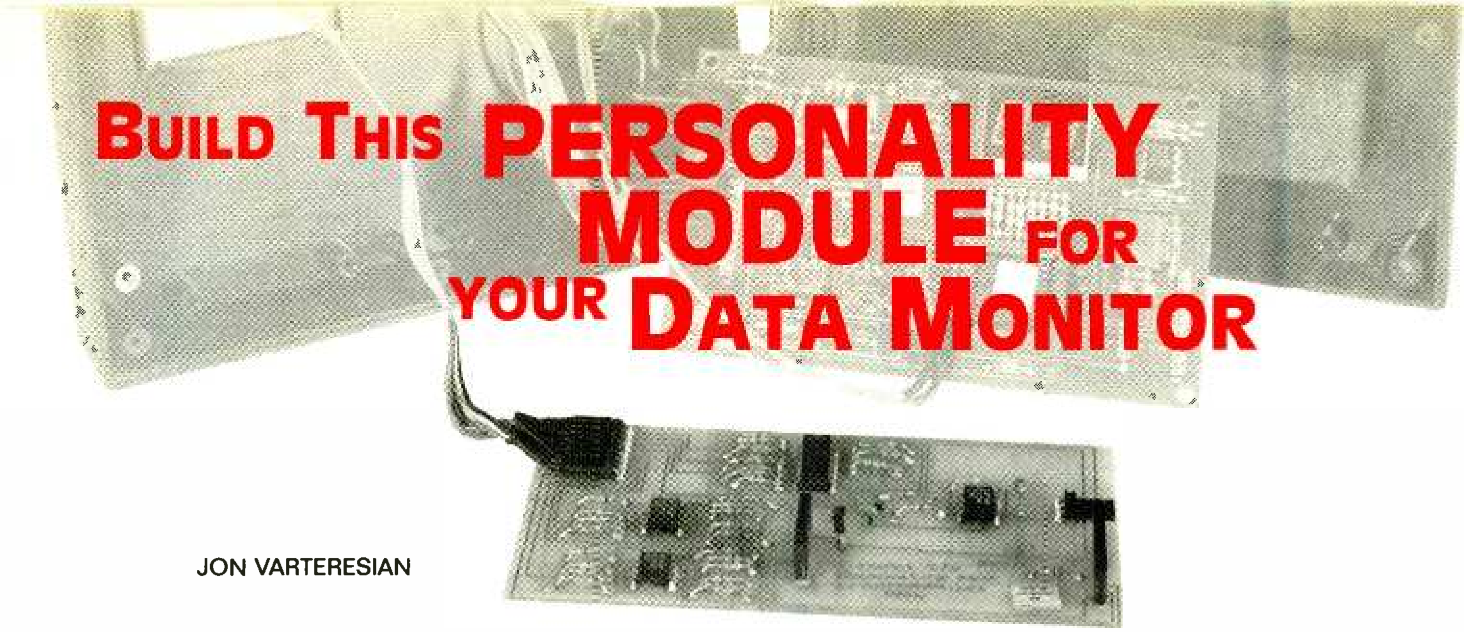
Send the setup information to the Data Monitor by selecting "Initialize" from the "Configure" pull-down menu. You should see a "Data Monitor initialized" information box if everything went OK. If not, check both the internal and external cables and connections. Make sure that you haven't plugged some of the internal cables on backwards.

Now press and hold the Arm/Status button. You should see two three-bar characters on DISP1. Release the button. The Data Monitor is now sampling and storing the data from the analog and digital inputs. The complete cycle should take less than a minute. Let the Data Monitor run until it is full. You can check on the progress of the cycle by pressing the Arm/Status button. When pressed, DISP1 will display how full the EEPROM is as a percentage. The status will not update while you hold the button. To update the display, let go of the button and press it again. When the status window shows "00.," the Data Monitor is finished and ready for downloading to the host. The dot to the right of the zeros shows that the Data Monitor is full. You do not need to wait for the EEPROM to fill completely before downloading; you can download at any time.

Select the "Download" pull-down menu and pick "Download." A pop-up menu will appear. Choose a directory and filename for the downloaded data. Press the "OK" button, and the software will download the Data Monitor and place the data in a text format in the loca-

(Continued on page 48)

BUILD THIS PERSONALITY MODULE FOR YOUR DATA MONITOR



JON VARTERESIAN

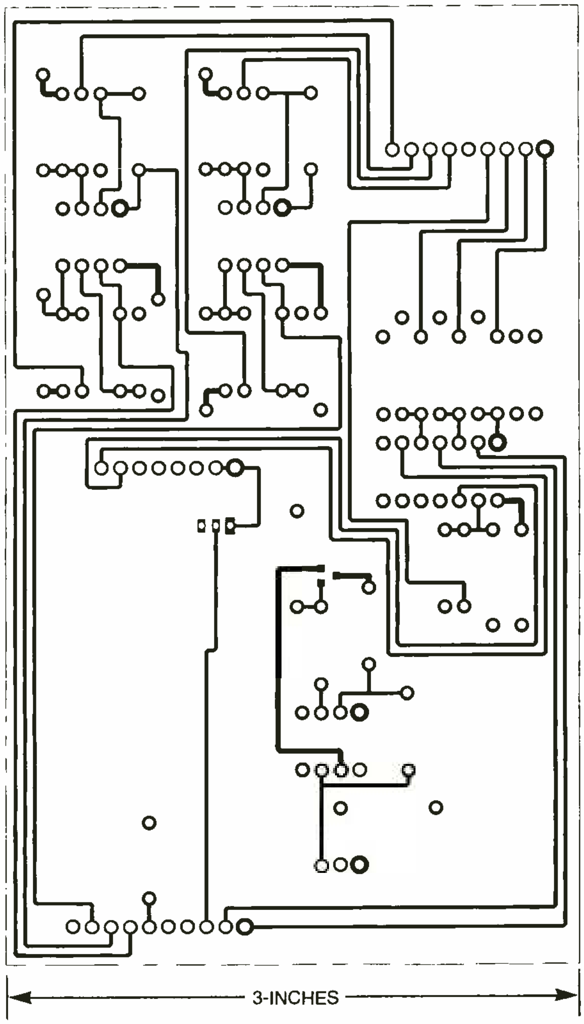
A Personality Module for the Data Monitor will get you started with monitoring digital and analog inputs. You can even track the temperature at the same time!

By now, you've probably studied the Data Monitor described elsewhere in this issue. You probably have some ideas as to where such a useful device can be used. You're ready to roll up your sleeves and dive right into the construction, but that article says that you need a Personality Module to connect the Data Monitor to the outside world. You might not have the patience or expertise to design your own, but you'd still like to use the Data Monitor. It seems like you'll never be able to use the Data Monitor.

Enter the General-Purpose I/O-Temperature Personality Module! This add-in circuit board for the Data Monitor will let you get started with using the Data Monitor, and just might be all that you need for all of your data sampling and event recording.

How it Works. In order to use different sensors for unique monitoring applications as well as to protect the internal circuitry from surges and possible electrical damage, the Data Monitor is designed to use what is called a Personality Module. A Personality Module connects to the Data Monitor's main circuit board through a 10-pin and an 8-pin connector.

This Personality Module is a very simple design. It has buffer circuits



Here is the foil pattern for the component side of the Personality Module.

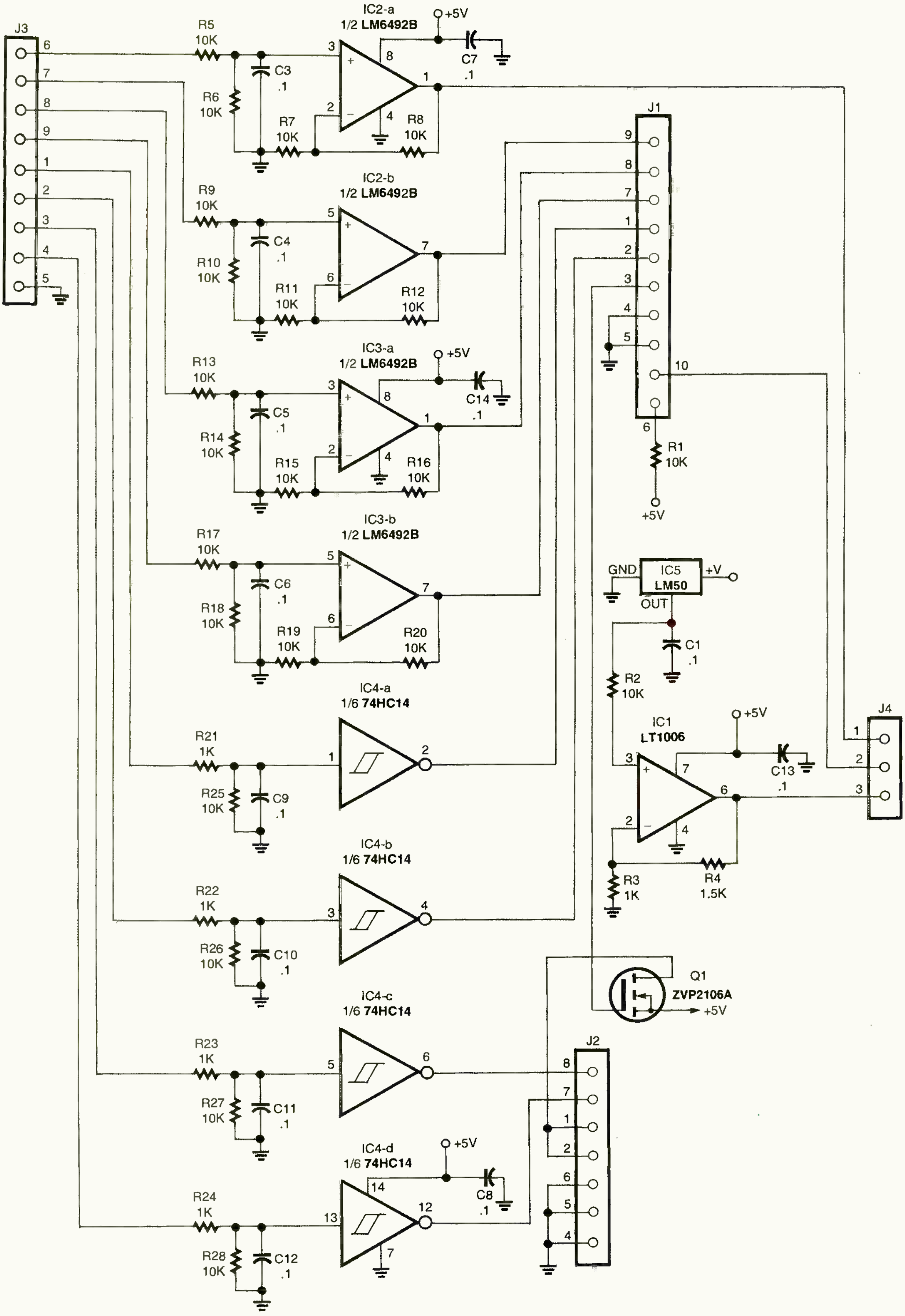


Fig. 1. The Personality Module is a set of simple analog and digital buffers that protect the Data Monitor's sensitive circuitry. Analog-input 1 can also be used to measure temperature.

for both the digital and analog inputs, as well as an on-board temperature sensor. The temperature sensor is designed to connect to the Data Monitor through analog-input 1. If you need all four analog inputs, or you just need to use the first analog input for whatever reason, a movable jumper block on the Personality Module lets you bypass the output of the temperature sensor. That way, the first analog input has the same buffering circuit that the other analog inputs have.

Power for the Personality Module comes from the Data Monitor itself. An on-off control transistor is included for future compatibility; future versions of the Data Monitor software will let the Data Monitor power down the Personality Module circuitry in order to conserve battery power if the Data Monitor is going to be used in the field where a wall adapter cannot be used for extended periods of time.

Circuit Description. The schematic diagram for the General-Purpose I/O-Temperature Personality Module is shown in Fig. 1. The buffering circuits for the digital and analog inputs are the same buffer circuit duplicated for each channel. Only one of each type of channel will be described. The other three channels of each type will work the same way.

In the analog channel, the input signal is buffered by IC2-a, an LM6492 CMOS rail-to-rail op-amp. Resistors R5 and R6 form a voltage divider on the input signal. With a value of 10,000 ohms, the input signal is attenuated by a factor of 2 for a gain of ½. Those values also present an input impedance of about 20,000 ohms to the source of the signal. The op-amp is used as a non-inverting voltage follower. The gain of IC2-a is set by R7 and R8. With those resistors at 10,000 ohms, IC2-a has a gain of 2. Capacitor C3 along with R5 and R6 form a low-pass filter that has a cutoff frequency of about 500 Hz with the values shown. A gain of ½ followed by a gain of 2 will have an effective gain of 1 for the analog buffer circuit.

The digital buffer is built around IC4, a 74HC14 inverting Schmitt trigger. Using a Schmitt trigger helps clean up any slow-rising digital signals and prevents any jitters if the input does not change cleanly from one state to the other. A low-pass filter is formed by R21, R25, and C9. With the values shown, the cutoff frequency is about 910 Hz. Resistor R25 does extra duty by holding a valid logic level on the inputs of IC4-a if the input is not being used. Without it, the input of IC4-a will act like an antenna, picking up stray noise that will cause problems with the other gates in IC4. The input impedance that the external digital signals will see from the input buffer is about 11,000 ohms.

Temperature sensing is done by IC5, a National Semiconductor LM50. That sensor is capable of detecting temperatures between -10 and +50°C. It has a very linear output over the full range of temperatures. The output voltage of the LM50 for any particular temperature can be found by using the formula:

Output Voltage=0.5 volts+(0.01 volts × °C)

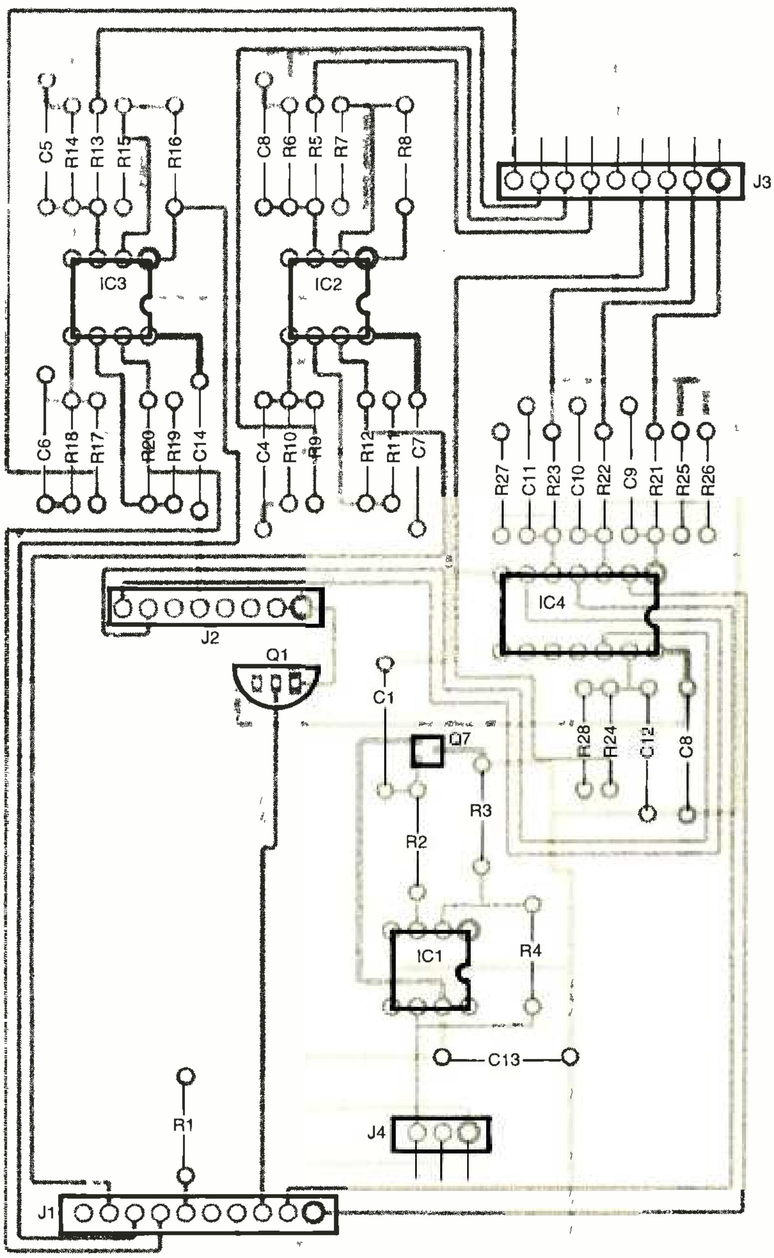
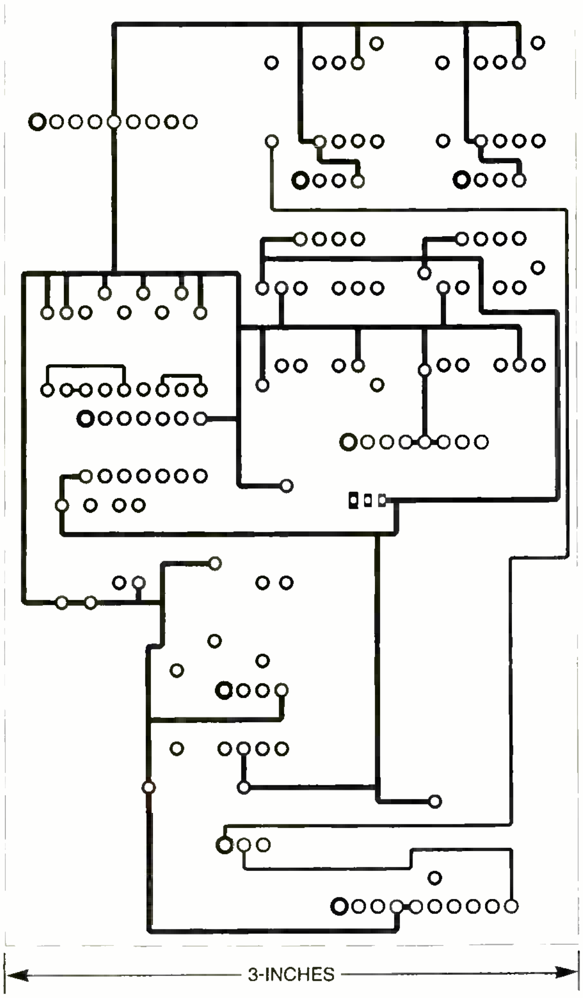


Fig. 2. When building the Personality Module, be careful of the orientation of the polarized parts. Some of the semiconductors are sensitive to ESD, especially Q1.



Here is the foil pattern for the solder side of the Personality Module.

For example, a temperature of 20° C would yield an output voltage of 0.5 + (.01×20), or 0.7 volts.

The output of the temperature sensor is then amplified by IC1, a non-inverting op-amp with a gain of 2.5. That gain increases the voltage range of IC5 so that it will cover the full range of the Data Monitor's analog-to-digital converter. The reference voltage for the A/D converter inside the Data Monitor is 5.0 volts. Since the converter is an 8-bit device, the digital value reported by the Data Monitor is represented by the following formula:

Reported value=(Input voltage/5) × 255

A temperature of 20° C produces an output of 0.7 x 2.5, or 1.75 volts. The Data Monitor's A/D converter would output a value of 89.

The input to the first analog input can be switched between the temperature sensor and the usual analog input voltage by shorting the appropriate pins on J4 with a jumper block. With the jumper in place between pins 1 and 2, analog input will be routed to the Data Monitor. If you want to read the temperature sensor, place the jumper on pins 2 and 3.

The Personality Module also contains Q1, a P-channel MOSFET, in order to control the power consumed by the Personality Module. The current version of the Data Monitor PIC program leaves Q1 always on, so that the Personality Module is always powered up. As previously mentioned, future versions of the Data Monitor software will be able to turn the Personality Module on only when data sampling is to take place. That technique will help conserve power when the unit is operating from a 9-volt battery.

Connections for the digital and analog inputs are made through J3, with J1 and J2 being used to mount the Personality Module onto the back of the Data Monitor's main board.

Building the Personality Module. The Personality Module is a simple double-sided PC board. Foil patterns are included if you wish to etch and drill your own board. As an alternative, you can purchase one from the source given in the Parts List. In either case, the parts-placement diagram in Fig. 2 shows where the various components are to be located.

All of the components are located on the component side of the board. If you are using a board that you etched yourself, keep in mind that you will have to solder connections on both sides of the board if you did not plate the holes beforehand. It is easiest to begin by mounting the smallest parts first. Start with the resistors and capacitors. Follow them with the connectors. Once all of the passive components have been soldered to the board, install the ICs. The temperature sensor, IC5, should be the second-to-last component installed. Finish the board by installing Q1. Be careful when installing Q1, as it is very sensitive to electrostatic discharge. The jumper on J4 should be installed depending on whether you want to use the Personality Module's temperature-sensing capability. Placing the jumper on pins 2 and 3 of J4 will select the on-board temperature sensor.

When the Personality Module is finished, inspect it carefully for poor solder joints, solder bridges, incorrectly-installed components, and other similar errors in workmanship. Once you are satisfied with your work, the Personality Module can be installed in the Data Monitor by simply inserting J2 and J3 into the connectors on the back of the Data Monitor's main board.

If you want, you can mount an additional 9-pin connector onto the Data Monitor's case and connect it to J3 of the Personality Module. That way, you will have a convenient way to connect the Data Monitor to whatever devices you wish to monitor. You may use any pin numbers

PARTS LIST FOR THE GENERAL I/O - TEMPERATURE MODULE

SEMICONDUCTORS

IC1—LT1006CN8 op-amp, integrated circuit (Linear Technologies)
IC2, IC3—LM6492BEN op-amp, rail-to-rail, integrated circuit
IC4—74HC14 hex Schmitt trigger, integrated circuit
IC5—LM50 temperature sensor, integrated circuit (National Semiconductor)
Q1—ZVP2106A P-channel MOSFET transistor (Zetex)

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R2, R5–R20, R25–R28—10,000-ohm
R3, R21–R24—1000-ohm
R4—1500-ohm

ADDITIONAL PARTS AND MATERIALS

C1, C3–C14—0.1-mF, axial-ceramic capacitor
C2—Not used
J1, J2—Square-post connector, straight, female
J3, J4—Square-post connector, right angle, male
Jumper block, hardware, etc.

Note: The following item is available from: JV Enterprises, PO Box 370, Hubbardston, MA, 01452. E-mail: JVEnterpri@aol.com: PC board with silk-screen, plated holes, and solder mask, $13.50. Please add $5.00 shipping and handling. Massachusetts residents must add 5% sales tax. Check or money order only.

you wish for the 9-pin connector; just make a careful note of which pins are connected to which input channels. If you are going to use the temperature sensor, you should drill several holes in the Data Monitor's case so that the air around the Data Monitor will be able to reach IC5.

Circuit Modifications. You can change the values of the resistors on the input-buffer circuits if you need different levels of amplification or attenuation. On the analog input circuit, the gain of the input resistors is:

$$R5/(R5+R6)$$

The overall gain of the buffer is the resistor gain times the op-amp gain. To adjust the op-amp gain, use the following formula:

$$(R7+R8)/R7$$

The cutoff frequency of the low-pass filter on either type of buffer is found by:

$$1/(R5+R6) \times C3$$

Naturally, each buffer can be modified individually to suit your needs. You could even build several Personality Modules with different characteristics. That way, changing the design of the Data Monitor's input circuits is as simple as opening the case and replacing the Personality Module. Ω

DATA MONITOR

(continued from page 43)

The Inter-IC Protocol

The IIC interface uses a protocol that ensures reliable transmission and reception of data between devices. When transmitting data, one device is the "master" that generates a clock pulse, while the other device(s) acts as a "slave." In the Data Monitor, the PIC is always the master device, always in control of all data transfers. The EEPROM is always the slave device, responding to the PIC's commands.

In the IIC interface protocol, each device has an address. When a master wishes to start a data transfer, it first transmits the address of the device that it wants to "talk" to. All of the devices on the IIC bus listen to see if the address being sent is their address; only the target device responds. Within the address field, one bit specifies whether the master wishes to read or write to the target device. In the Data Monitor, IC2 (the EEPROM) has a fixed constant in the address field because it is the only slave device on the IIC interface bus, so it does not need an address. In any case, the master device generates the clock for the data transfer. In the Data Monitor, the clock is transmitted on pin 20 of IC1, and the data is transmitted and received on pin 25. For more detailed information, Microchip's databooks are excellent sources for their devices (the PIC and the EEPROM). The original specification from Philips and Signetics, "The IIC Bus and How to Use It" is also an excellent source of information.

tion and under the name that you chose.

Open the download file with any text-viewing program. Because all of the Data Monitors inputs were left unconnected, all of the digital and analog inputs should report "0." If you happen to be using the I/O-Temperature Module described in the accompanying article, analog-channel 1 should be reporting the current temperature. See that article for a detailed description of how to interpret the values. A typical download file should look similar to Listing 1.

Connect a 4½-5-volt source to the first digital channel. Repeat the above procedure: configure the Data Monitor, collect the data samples, and download the new data to the PC. If you want, you can use the same file name as before. The contents of the data file should be the same as before except for the first digital channel, which should report "1" instead of "0."

Repeat the above steps three more times for each of the other digital inputs. Verify that the Data Monitor reports the correct logic state for each of the tests. At this point all of the digital inputs are verified and operational. If any test failed, check all the connections and correct any mistakes.

The analog channels will be tested next. Attach a 2½-volt bench-type power supply to the second analog input and the Data Monitor's ground. Configure, initialize, arm, and download information from the Data Monitor as before. You should see that the second analog channel has a value of about 128±1. As with the digital channels, test each analog channel in the same way.

The Data Monitor is now fully operational and needs only the addition of a personality module to be ready for use. Details on a suitable module can be found beginning on page 44. Congratulations and happy monitoring! Ω

Explore the mysteries of human perception, or just impress your friends with a piece of workbench "magic."

DAVE SWEENEY

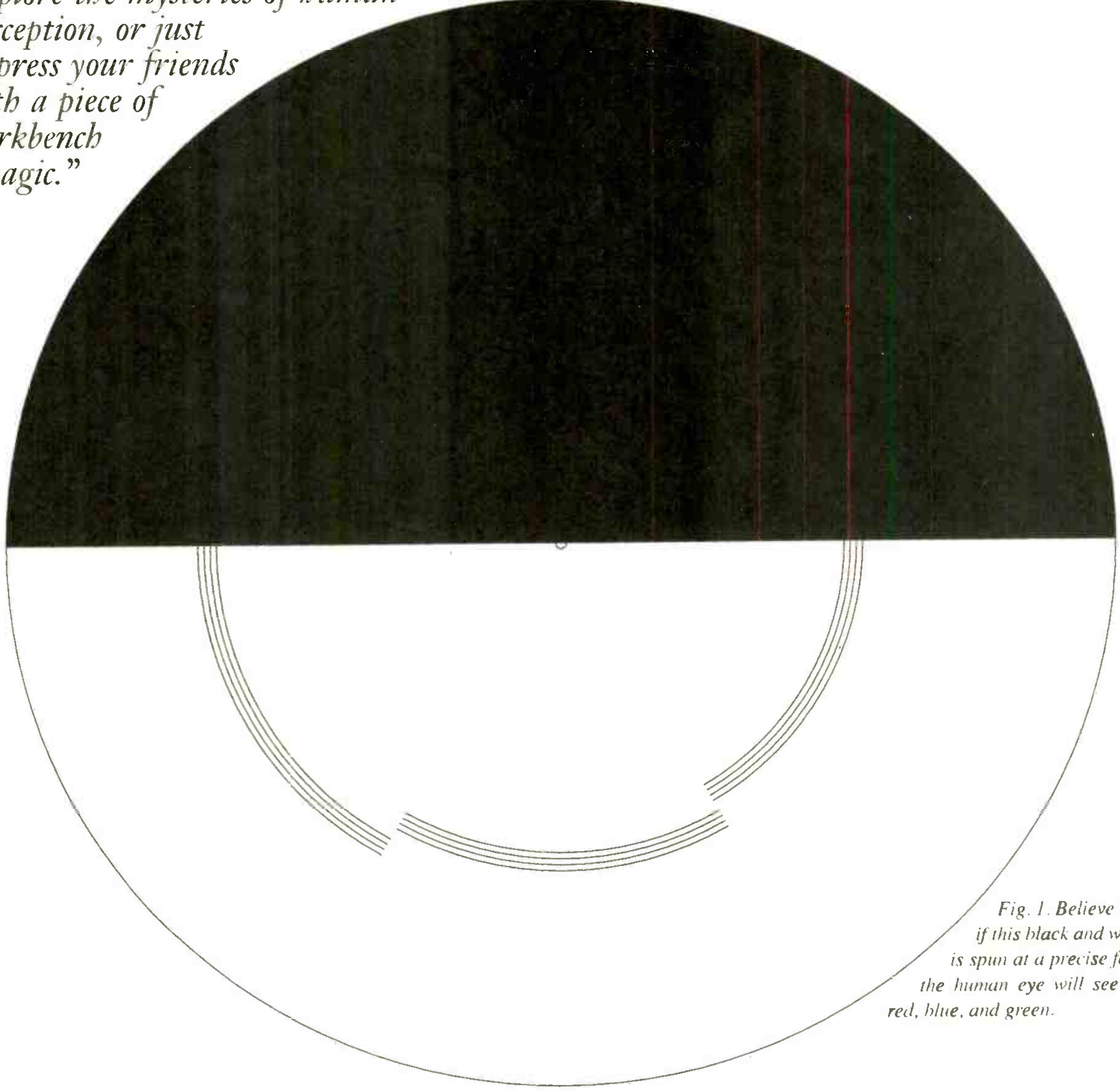


Fig. 1. Believe it or not, if this black and white disc is spun at a precise four rpm, the human eye will see lines of red, blue, and green.

EXPERIENCE THE FECHNER PHENOMENON

How would you like to enjoy some workbench entertainment, and, at the same time, explore the basics of human perception? You can do that by creating a "Fechner" Disc, which, for those unfamiliar with it, is simply a piece of paper containing a circular black and white pattern. When you spin the disc at a precise four rotations-per-second, the black lines in the pattern suddenly take on vivid colors. Spin the disc clockwise and the outer lines become red, the middle lines green, and the inner lines blue. Reverse the spin direction, and the color order reverses.

Setting up the demonstration is easily done using the disc presented in Fig. 1 and parts that are found around most electronics workbenches. First, cut out the disc pattern and mount it on a matching piece of light cardboard to give it strength. Next, attach the disc to the shaft end of an electric motor mounted in a vise. Power the motor through a speed-control circuit and get the disc spinning at just the right speed. When you see the colors, invite friends and family for a demonstration of something important. Ask them to observe the colors.

LISTING 1

```
%!PS-Adobe-1.0
%% Fechner Disc Image
.5 setlinewidth
0 setgray
%All structures define arcs as follows: center x, center y, radius, start angle, end angle

% The perimeter circle
270 350 250 0 360 arc
stroke

% The half black circle
270 350 250 0 180 arc
fill
stroke

%The inside line segments
 newpath
270 350 122 180 240  arc
stroke
newpath
270 350 125 180 240  arc
stroke
newpath
270 350 128 180 240  arc
stroke

%The middle line segments
 newpath
270 350 131 240 300 arc
stroke
newpath
270 350 134 240 300 arc
stroke
newpath
270 350 137 240 300 arc
stroke

%The outer line segments
newpath
270 350 140 300 360 arc
stroke
newpath
270 350 143 300 360 arc
stroke
newpath
270 350 147 300 360 arc
stroke

showpage

%%Trailer
%%Pages: 1
%%EOF
```

Mention the rings and point out the locations of the red, green, and blue. When they agree that they see the colors, have them focus on the disc as you cut power to the motor. The disc stops rotating and, presto, there's no more color. Your astounded subjects will stand in awe and might be heard to mutter: "Cool."

Gustav Fechner. The optical effect discussed above is called the Fechner Phenomenon and is named after Gustav Fechner (1801-1887), who studied mental perception and developed early theories of psychophysics. Born in Gross-Sächen, Prussia, Fechner received a medical degree at the University of Leipzig, then studied physics and mathematics. In 1834, he was appointed Professor of Physics at Leipzig.

Although he was essentially a physicist, he turned to the problems of philosophy and concentrated on the entire spectrum of perception. Considering the interaction of the mind with matter, he developed his theories of psychophysics. Other scientists have examined his theories and have written about them. More information about Fechner can be found by searching the World Wide Web, as well as by visiting your local library.

Color Perception and The Fechner Disc. The basic workings of the human eye are well understood: Focused by the lens with brightness limited by the pupil, light stimulates the retina and sends visual information along the optic nerve. Our brain detects that information, and based upon signals from different elements within the retina, defines a visual image. The retina contains photoreceptor cells called rods and cones, and it's the cones that specialize in daylight and color vision (see Fig. 2).

So, then, how does a spinning black-and-white disc trick the human mind into seeing color? While the complete mechanism is not totally understood, it is believed that while viewing the spinning disc, the signals transmitted along the optic nerve probably contain some of the same frequencies and the same waveshape as cone signals from actual color content in a viewed object or scene. It is important to remember that color is simply the human mind's interpretation of transmitted and reflected electromagnetic radiation of a particular frequency, that color perception can vary among individuals, and that image perception can depend greatly on the surrounding background. Interestingly, a monochrome videotape of a Fechner Disc image played back on a raster scan, monochrome television generates the same color effect as a "live" Fechner-Disc demonstration.

Speed Controller for the DC Motor. While there are many educational and philosophical aspects to the Fechner Disc demonstration, you'll probably want to do it just for the fun factor. The good news is that you'll not have to spend a lot of time or money on building the setup.

The most important component is, of course, the motor. An inexpen-

PARTS LIST FOR THE MOTOR-SPEED CONTROLLER

SEMICONDUCTORS

IC1—555 timer IC, integrated circuit
IC2—LM317T voltage regulator, integrated circuit
Q1—2N3904 NPN transistor

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—4700-ohm
R2—10,000-ohm, potentiometer
R3, R8—270-ohm
R4–R6—1000-ohm
R7—4700-ohm
R9—10-ohm, 5-watt

CAPACITORS

C1—20-µF, 15-WVDC, electrolytic
C2—0.02-µF, 15-WVDC, electrolytic
C3—10-µF, 15-WVDC, electrolytic

ADDITONAL PARTS AND MATERIALS

MOT1—Hobby motor, RadioShack 273-231 or similar
Fechner Disc (see text), perf board, wire, solder, etc.

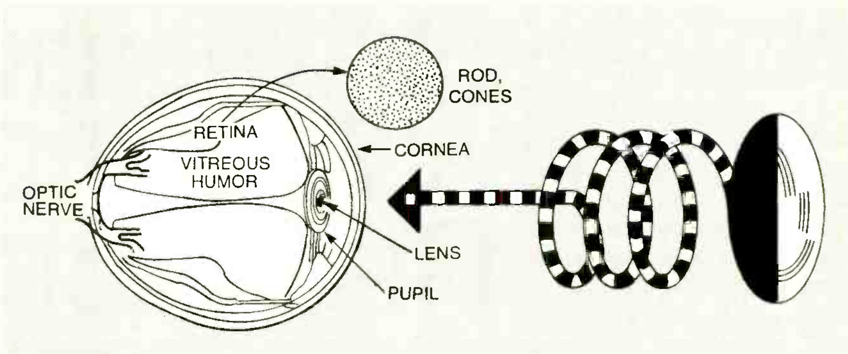


Fig. 2. Light from the spinning Fechner disc enters the eye through the pupil, stimulates the rods and cones of the retina, and is passed by the optic nerve to the brain.

sive hobby motor will work fine as long as it is reversible, but there is another important requirement: It must be capable or turning at a relatively low rate of four to five rotations-per-second. Since that rate is very slow for your typical hobby motor (most spin at thousands of rpm at their rated operating voltage), we need some way to reduce that speed. One approach is to place a potentiometer in series with the motor. Unfortunately, that won't work well with most motors. That's because most motors will simply stop once the applied voltage is significantly below the rated operating voltage. Besides, we need a way to precisely control the rate of revolution, and it is nearly impossible to achieve the needed precision using just a potentiometer.

Instead, we will use the approach shown in Fig. 3, which illustrates a concept for using a variable voltage regulator to run a small motor. In its normal configuration, pin 3 of the voltage regulator connects to a potentiometer, which controls the output voltage. However, for our motor-control circuit the potentiometer is replaced by a pulse generator, which means that the output to the motor takes the form of a train of pulses. The amplitude of the pulses is sufficient to move the rotor; however, the average power varies with pulse frequency and the motor speed varies with the average power. As a result, controlling the pulse frequency provides the motor-speed control we need.

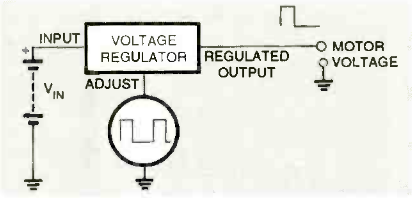


Fig. 3. In its normal configuration, the output of a motor-control circuit like this one is varied using a potentiometer connected to the regulator's ADJUST pin, but in our circuit the potentiometer will be replaced with a pulse generator.

Figure 4 provides the circuit details for our controller. The speed of motor MOT1 varies with the output frequency of IC1, a 555 timer wired as a pulse generator. Pulses applied to the base of Q1 turn it on, which in turn modulate the ADJ pin (pin 3) of the LM317T regulator, IC2. The resulting pulsed power to the hobby motor provides a voltage that is sufficient for starting the motor, yet provides a low average power, and thus low speed. In the circuit shown, resistor R2 and capacitor C1 determine the pulse rate. By adjusting R2, you control the pulse frequency applied to the base of Q1, and thus the running speed of the motor.

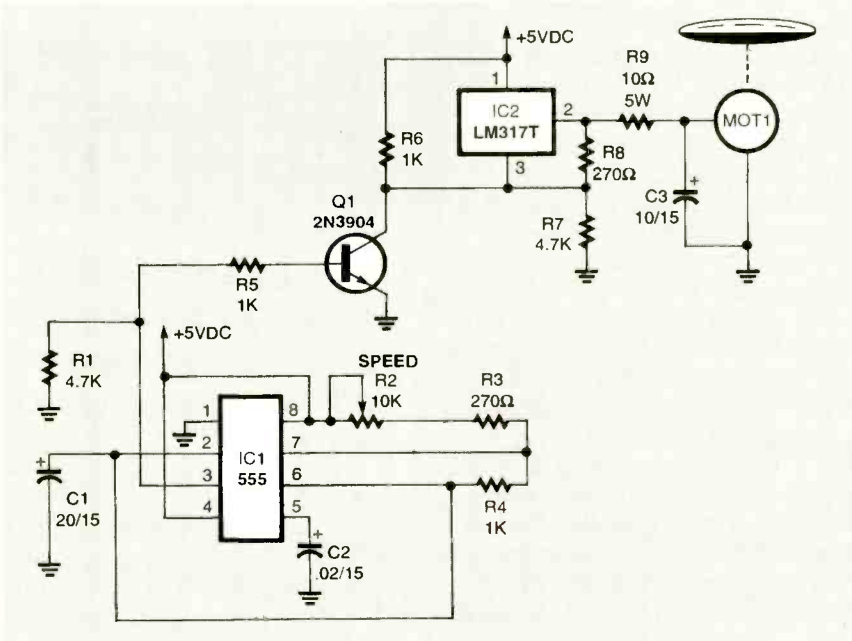


Fig. 4. Here's the schematic diagram for our motor-control circuit. It allows a standard hobby motor to turn at a precise four rpm.

There is one drawback to the use

(Continued on page 64)

RESTORING A "REEL" RECORDER

This month we look at the final steps in bringing your vintage open-reel recorder back to its original glory.

PHIL VAN PRAAG

Now that all of the preliminary steps described last month have been satisfactorily completed, you should have a "functioning" tape recorder. This month, we'll find out just how well your tape recorder is functioning. Assuming you find it is not entirely up to factory specs, you will need to determine whether the reasons for this are simply a matter of adjustment, or require component replacement. Finally, we'll describe critical alignment steps needed to bring out the best possible performance from your vintage audio recorder.

We're going to start with the tape recorder's mechanical section. We already know the basic electronic functions are at least working at some minimum performance level, and that will be adequate for the "ultimate" mechanical test—wow and flutter (W/F). Conversely, however, if the mechanical adjustments and alignments are not all "up to snuff", you cannot accurately perform the electronic specification checks and adjustments.

Okay, let's begin. Now you could jump ahead to the W/F spec measurement and try to get a "bottom-line" idea about the mechanical section before (or presumably in lieu of) performing the following tests, but I don't recommend it. These tests will give you an excellent portrait of the condition of your machine. Remember we're doing a restoration here, not a repair. Further, they will alert you to wear or misadjustment conditions that may be masked during the W/F test, but nonetheless are crying for attention.

Tensions. First, let's check the take-up and supply reel tensions. Please recognize that we can only provide general guidelines here, with "ball-park" specs. The actual specs are those originally provided by the manufacturer of your machine. Regarding those tensions, however, the ballpark numbers will probably suffice for your model as well. Remember how we did a crude form of this test with our finger during the preliminary test. Well, now we'll actually measure the tensions.

To do this, you will need an empty reel, some string, and a spring tension gauge capable of reading up to 10 or 15 ounces. Fasten one end of the string to the hub of the reel and place it on the take-up turntable. Now manually wind the string onto the reel clockwise a couple of revolutions. Fasten the other end of the string to the gauge. Now, with the recorder in play mode, and with the motor shutoff defeated (as in the preliminary test), allow the string to continue winding onto the reel while ensuring that the string is not binding against either reel flange and that the spring gauge is held parallel to the string. Read the tension as the string is slowly winding; it should be about three to five ounces.

If it's much less than three ounces, it could cause the tape to wind too "loosely" onto the reel; that could cause "bunching up" on the reel when it is subjected to the high tension encountered during the start of rewind mode. It can also result in a sudden jerking of the tape a second or two after the start of play mode if tape slack is formed as play is initiated. On the other hand, if the take-up tension exceeds about seven or eight ounces, that could cause the tape to be "yanked" (how's that for a technical term!) through the capstan/pinch-roller area, resulting in uneven tape speed, high W/F, and perhaps even tape stretching.

A similar test should be performed on the supply side (except, of course, winding the string counter-clockwise instead of clockwise). Supply-reel play-mode tension is often somewhat less than on the take-up side, with normal readings at about two to four ounces.

The adjustment for play-mode reel tension is either rather easy, or rather difficult, depending on whether this is a three-motor or a single-motor machine. If it's a three-motor machine, an adjustment can usually be made via slide rings on large power resistors connected to the supply and take-up motors. Hopefully, you have located a schematic diagram of your recorder, or at least an adjustment pictorial, to help find the appropriate resistor(s). If not, you might be able to visually (or through the use of an ohmmeter) trace down to the proper component.

If you have a single-motor ma-

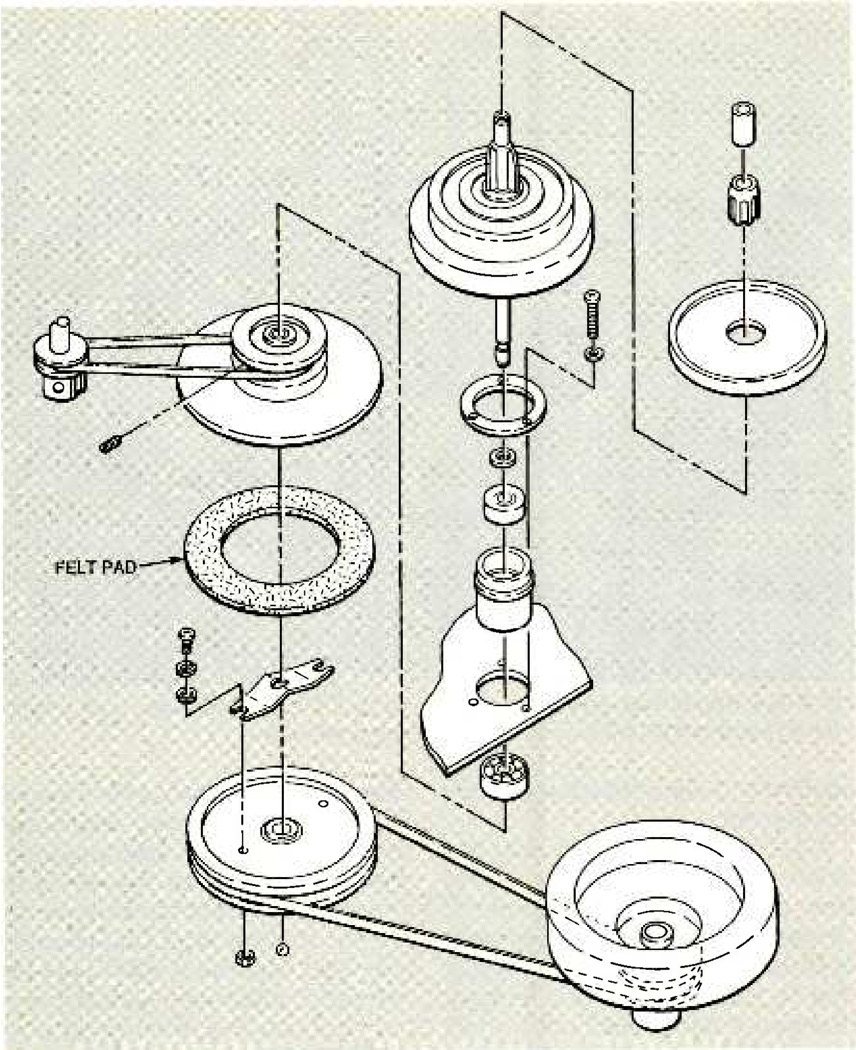


Fig. 1. A typical take-up turntable-clutch assembly from a single-motor recorder. The felt pad is used as a "slip clutch," transferring rotational force on an as-needed basis to ensure smooth winding of tape onto the take-up reel. Great care must be used to avoid oil or grease contamination of either the felt or its mating surface.

chine, chances are the supply and take-up tensions are created through the use of a "slip/clutch" contraption, usually formed by a cotton/felt pad slipping on a smooth nylon plate or plastic film washer. Figure 1 shows a typical take-up turntable clutch assembly. Driving force is transferred to this assembly from the motor via a belt or rubber idler. Therefore, the cause of tension problems can be from any or all of the above items. Belts should be soft and supple, and still possess sufficient tension to adequately drive all associated pulleys. If cloth belts were used, check for excessive fraying, or general decomposition, as well as tensioning and free rolling of the spring-tensioning pulley. Idler rubber must be soft enough, and free of flat spots or gouges, to evenly and reliably drive their associated pulleys.

Perhaps the most likely culprit in single-motor tensioning problems, however, is the slip clutches themselves. Occasionally, reconditioning is possible; but the majority of cases require the replacement of both the felt material and the nylon/plastic surface. In any event, the entire turntable assembly must be disassembled to gain access to those parts. That is often a difficult task for the uninitiated; so, if you don't feel up to it, this may be the time to call for professional help. If you do attempt this repair, be sure to take careful note of all the little washers, clips, and other hardware that will need to be removed along the way. Also note the sequence of removal, as that will need to be precisely reversed when re-assembling.

Once you have gotten to the slip clutch, inspect it for obvious damage. Usually, you will find that the felt has compressed somewhat because of the tension against it for many years. If it is not shiny, however, and if the compression has not resulted in a loss of reel height (as would be evidenced by the tape scraping on the upper reel flange), then it may still be serviceable. Now look at the nylon/plastic surface. It must not have any abrasions, deposits, or any other surface roughness of any kind. If it does, ordinarily it should be immediately replaced. Unfortunately, that is often not possible; in that case your next line of attack is to attempt refinishing via very light scraping and/or polishing of the surface. That will sometimes work; unfortunately, the only way to find out is to completely re-assemble the turntable assembly and see what happens. That can be one of the more frustrating aspects of the restoration process; but hang in there, eventually you will get it right!

Though of somewhat less concern, the other reel tensions to consider are the brake tensions. We can't get as specific here because of the wide variance in the brake methods used over the years, as well as the means of measurement and adjustment. The good news is that as long as the tape is not being unduly stressed or slackened, after the brakes are applied, and as long as you are satisfied with the amount of time it takes for the reels to stop (once again, specs vary widely here), then you are okay. After all, the brakes are totally out of the picture during play or record (actually, even here there are a few exceptions).

If you have access to the original factory specs, or if tape damage could occur if something isn't done, go ahead and check out and/or make some adjustments. If you have a three-motor machine, the most common adjustment is at one end of the brake band. A typical brake band configuration for three-motor designs is shown in Fig. 2. Sometimes the adjustment takes the form of moving to a different spring stop along a tab at the end of the band; other times it's a matter of bending the tab slightly, relative to a stop post. In single-motor machines, perhaps it's a heavier tension applied to the same slip clutch used to create play-mode back tension. If that is the case, the repair you performed to correct play-mode problems might also take care of the brake issue.

Note that there are two different brake specs for each turntable; one for each direction of travel. The tension spec for one direction will be perhaps as much as double that of the other direction. To give you at least some point of reference, the three-motor Ampex Model 350 has specs of 7 and 14 ounces at each turntable, using the string measurement method described above (this time with the transport in stop mode), but based on a $10^1/_2$-inch reel instead of a 7-inch reel. It's important to note the type of reel used in conjunction with the specification, since different reel sizes will have different hub diameters.

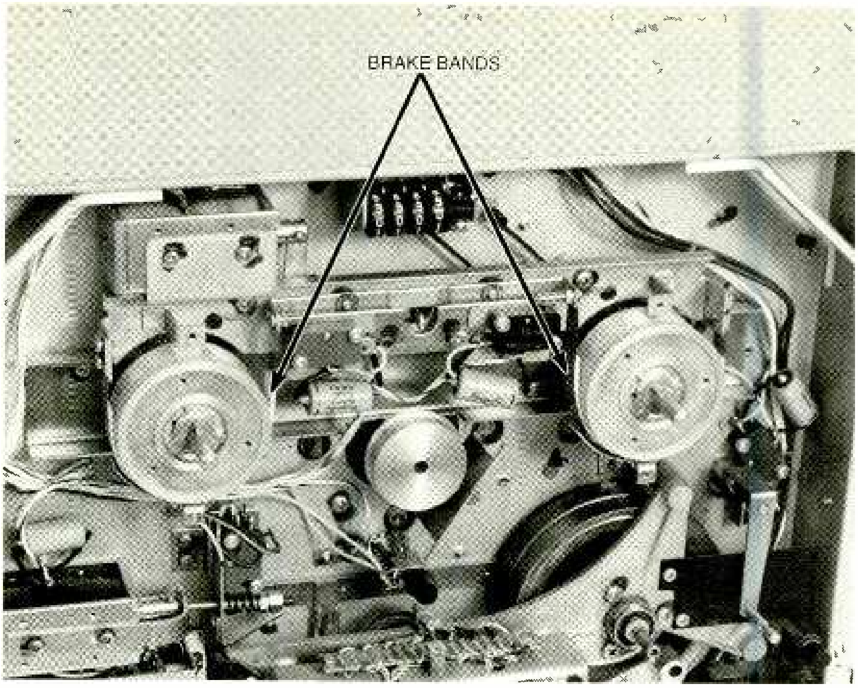


Fig. 2. Typical brake bands found on three motor recorders. The same precautions apply with the felt band linings—do not moisten and avoid oil or grease contamination.

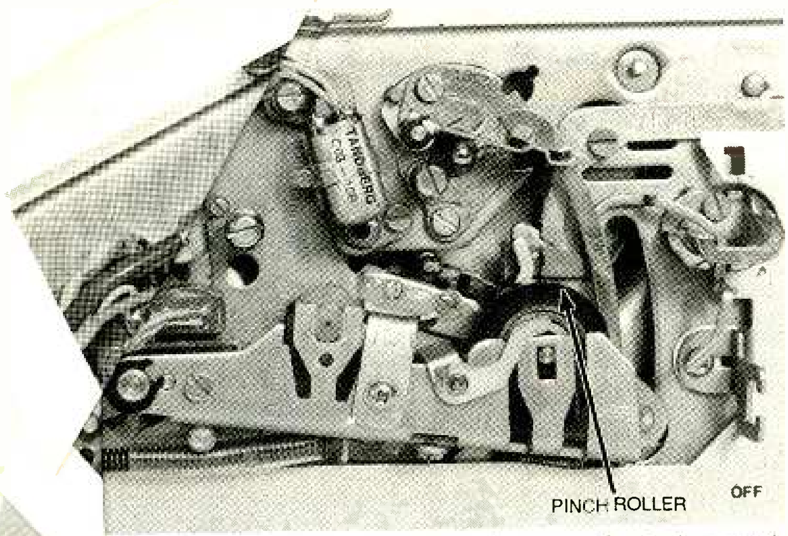
Pinch Roller. Let's spend a few moments discussing the pinch roller and its contact with the capstan shaft. First, having gone through all the preliminary cleaning and lubrication, the pinch roller should spin free, exhibiting no sluggishness. If it is sluggish, remove it from its shaft and clean both the shaft and the inside of the pinch-roller wheel again. Then apply a couple drops of oil and re-assemble. Now, with the recorder power off, push the roller very lightly against the capstan shaft (depending on the mechanics, you might have to move the operating lever into play mode in order to do this—as is the case with the Tandberg 3000X shown in Fig. 3). With your head at capstan level and one eye closed, sight down the area at which the pinch roller is making contact with the capstan. With just very light pressure, ensure that the edge of the pinch roller is perfectly parallel to the capstan. As you ease the pressure on the pinch roller, check that the amount of clearance between the two as the pinch roller is moved away is identical top and bottom. That is important as the tape will tend to skew upward or downward if the two are not parallel.

Contact pressure between the pinch roller and capstan during play or record is also important. Obviously, it needs to be sufficient to drive the tape without slippage due to take-up-reel back tension. However, it also should not be too great, otherwise it could exert undue strain on the upper capstan bearing. Unfortunately, most manufacturers do not have a spec on this; so you are left to your own judgment as to whether the force you observe and feel is sufficient, but not excessive. Another factor in the amount of contact pressure required is whether the pinch roller has hardened, or whether the capstan shaft has become too smooth as a result of wear. (You will note that the capstan shaft usually has a satiny finish when it comes from the factory. I have seen capstan shafts with lots of wear that have mirror finishes over the ¼-inch tape-contact area.)

Just to provide a ballpark number here, the Crown SX822 (a three-motor machine with a solenoid-actuated pinch roller) calls for a 10- to 12-pound pressure, measured by pulling straight down on the bar to which the pinch roller is mounted. The end of the bar is located at about the outer circumference of the roller. The adjustment was made, as was common for solenoid-operated pinch rollers, by tightening or loosening an adjustment nut located on a spring arm. Non-solenoid operated assemblies often had no means for adjustment here. If that is the case with your machine, double check all of the other possible causes of slippage mentioned above; if that still doesn't do it, then consider replacing the spring that holds the pinch roller against the capstan.

Before proceeding with the W/F measurement, take a final look at any roller-style tape guides. Those rollers (many of which have ball-bearing race assemblies) should spin freely, with no visible signs of embedded dirt still lurking in the corners or edges. It's a good idea to just disassemble these roller guides, clean them thoroughly, and lubricate as you put it all back together.

Wow/Flutter Measurement. Finally, let's go ahead and perform the W/F measurement. By this time, you should have taken care of all major mechanical subsystems, so I would expect decent results. However, don't be surprised if it doesn't quite meet spec the first time. While there are many factors that we have already checked, there are proba-



…chines, such as this Tandberg Model 3000X, the transport function lever must be …lay position in order to check that the tape-contact surface of the pinch roller is … the capstan shaft.

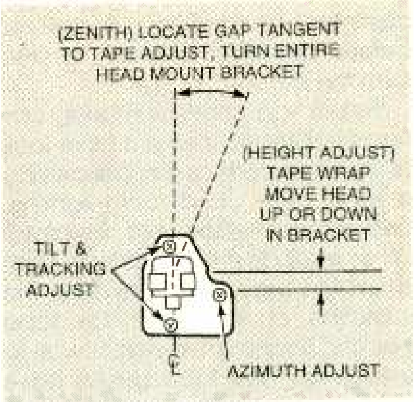


Fig. 4. The various adjustments needed to bring tape heads into proper alignment.

…others that we haven't; …which really can't be …d, from a practical stand… without replacing suspected …ponents and comparing the …sults.

If you have a pre-recorded W/F tape, thread it up, set the appropriate tape speed, connect the recorder's playback pre-amp output to your W/F meter, and "let 'er rip." If you don't have a prerecorded W/F tape, don't worry about it. You can record the flutter test frequency directly onto the machine you're restoring (unless, of course, it's a "play-only" machine) and then simply play it back. The latter method does, technically, allow errors to creep in due to alternate reinforcement and canceling of the flutter components upon subsequent playback. However, the results obtained using this technique will be close enough.

Just take the time to record a sufficient length of tape, and then study the meter when playing back. Look at the dips and peaks for about a minute. This should allow you to observe the "usual" peak and average levels, as opposed to the "occasional" peaks and averages. The reading of W/F is always somewhat subjective; not using a prerecorded tape simply makes it a bit more subjective. Some W/F-meter manufacturers recommend making several test recordings, and use the "average of the peaks" as the "official" W/F number.

Several methods have been used by manufacturers to express their W/F specs. Sometimes they will not state whether the published number is "peak" or "rms;" other times they will state "average peak" or "average rms;" still other times they will not stipulate whether the number is "weighted" or "unweighted". But, at least by now you will know the W/F of your machine; and, if you happen to own more than one, it can be a point of relative comparison between them.

If your reading is obviously out of spec, then I would recommend the following sequence: First, double check all of the mechanical work you have done thus far. Next, review your log of this machine, looking back to the very first cleaning-related observations. Are there any clues there that might lead to a cause for this condition? If neither of those steps help, then you will need to explore new ground.

It is always possible that a bad bearing somewhere is causing the problem. Listen very carefully to the sounds emanating from the mechanics as you play a tape. Are there any grinding, or raspy sounds? Sometimes, with the W/F meter still connected, you can simultaneously see and hear abnormal fluctuations in sight and sound, synchronized so as to point out the source. You might try replacing the capstan-motor capacitor (often somewhere between 2 and 4 mF, at about 350 volts).

If any of the above doesn't resolve the problem, at this point tracking down its source becomes more difficult. At the factory, or at a field service center, the technician would most likely start swapping out major parts, like capstan motors, to try to isolate the source. Obviously, that is even more difficult today, owing to a lack of replacement parts. If you happen to own two identical machines, then this is the time to drag out the other one and swap parts, one at a time. It's not pretty, but eventually you will find the problem this way; unless, of course, the second machine has the same problem. This does happen, when you consider that high wear items—or really any weaknesses—can easily be the same for identical model machines.

Now that we've gotten the mechanics "beaten into shape," let's move on to the electronics.

Tape Path Alignment. First, we're going to tackle tape-path and head alignment. If things here are not perfectly aligned, the electronic performance of your recorder will suffer. During a restoration, proper alignment should be assured before making any other electronic adjustments. That alignment includes vertical height, wrap, tilt, zenith, and azimuth.

A primary issue here might be wear: if the tape path is well worn (*e.g.*, substantial grooves worn into the head faces), then it might be best not to attempt any tape-path alignments. If that is the situation with your machine, then be especially careful to read the following alignment information in its entirety before deciding whether to perform this step.

Before you consider making any head adjustments, take a close look at the tape path as you are playing a tape. With good room lighting, and perhaps enlisting the assistance of a small flashlight, closely sight down the tape path, watching the reflection of light from the tape backing. That is an excellent way to ensure that the tape guides have not become bent or misadjusted. If, for example, you see one edge of the tape crimped against a particular guide, that could be an indication of trouble. However, be extremely careful before adjusting anything. Take careful notes of all abnormalities; and, if you do make any adjustments, be sure to note the extent of the adjustment. It might subsequently turn out that that was not the source of the problem. If so, you will want to return the adjustment to its original setting.

Make sure that alignment tools to be used in the head area are all demagnetized or non-metallic before you begin. Also, take a look at Fig. 4, which will familiarize you with the various head-adjustment parameters along with the common adjustment-screw locations. Note that these adjustments may or may not be located just as shown; and in some cases, not all of these adjustments may be present.

Figure 5 shows the proper track spacing for most ¼-inch open-reel tape standards. While track spacing relative to the tape edge is obviously very important, it's not something you can do much about during a restoration process, unless, of course, you need to replace a head. The reason is that many "used" machines have developed a wear groove across their front face as a result of tape friction. If, for some reason, vertical head positioning has gotten out of alignment (it's unlikely this happened at the factory), the odds are that the wear groove reflects that condition. If so, and if you were to readjust the vertical position to conform with Fig. 5, it would create an "overlap" condition over one edge of the groove. That would most likely mean the creation of an air gap between the head and the tape at one side. The result of this could be vertical tape skew, increased tape wear, poor high-frequency response, and reduced S/N on the track(s) closest to the air gap. The bottom line here is that it's not a good idea to mess with the vertical head alignment on used machines whenever a wear groove is present.

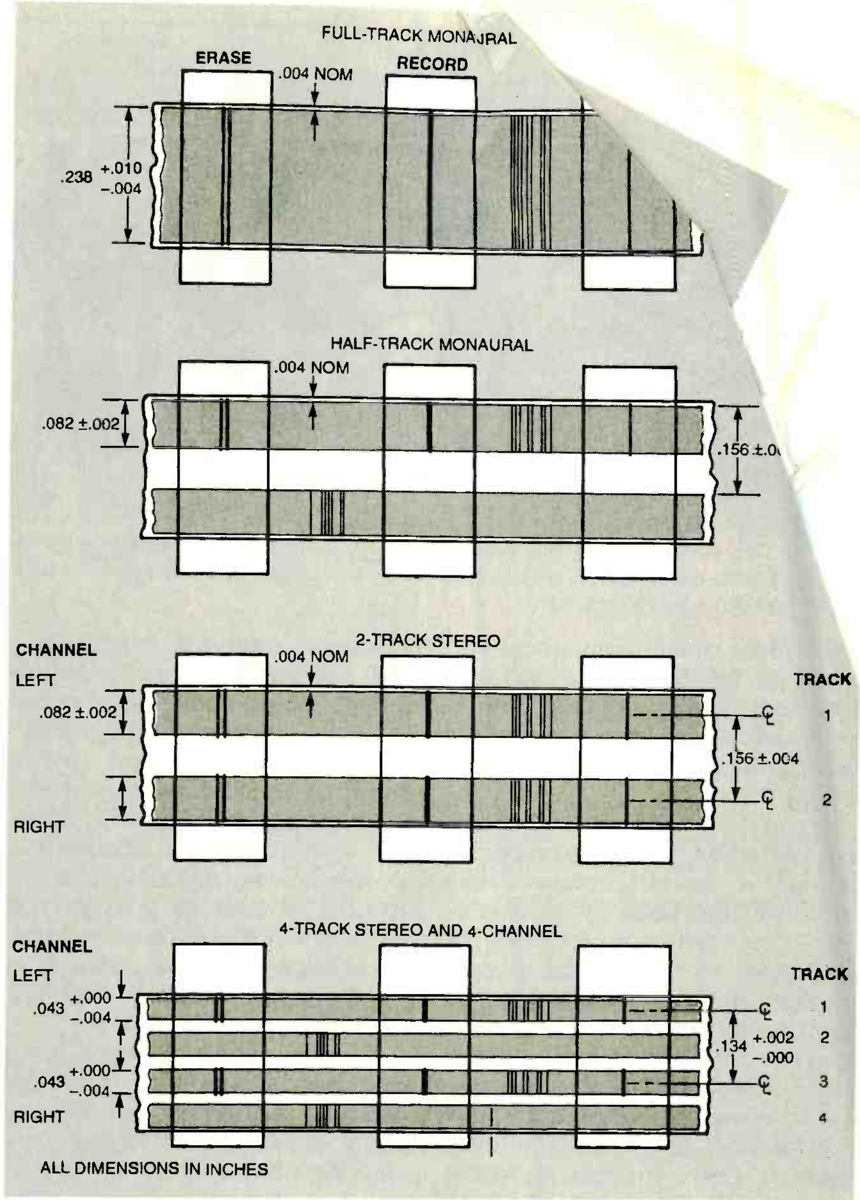


Fig. 5. Track spacing standards for popular ¼-inch tape audio recorders.

If you have a four-track machine, and do not hear any crosstalk (from alternate tracks) when playing commercial prerecorded tapes, then the odds are that your play head is in proper vertical alignment. With a two-track machine, you will have to rely on careful visual observation.

The erase-head gap is typically slightly longer than that of the record head, so erase-head height is usually not an issue. However, that can be easily verified, and you don't even need instruments to read the result. Simply record a 1-kHz peak signal; then rewind and place the machine in record again, this time with no input signal, and while monitoring the output by ear. If you don't hear any trace of the 1-kHz tone, the erase-head height is okay. Note, however, that even if you do still hear the tone faintly, it doesn't necessarily mean that erase-head height is to blame. It could also be inadequate current flowing to the erase head, perhaps due to weak

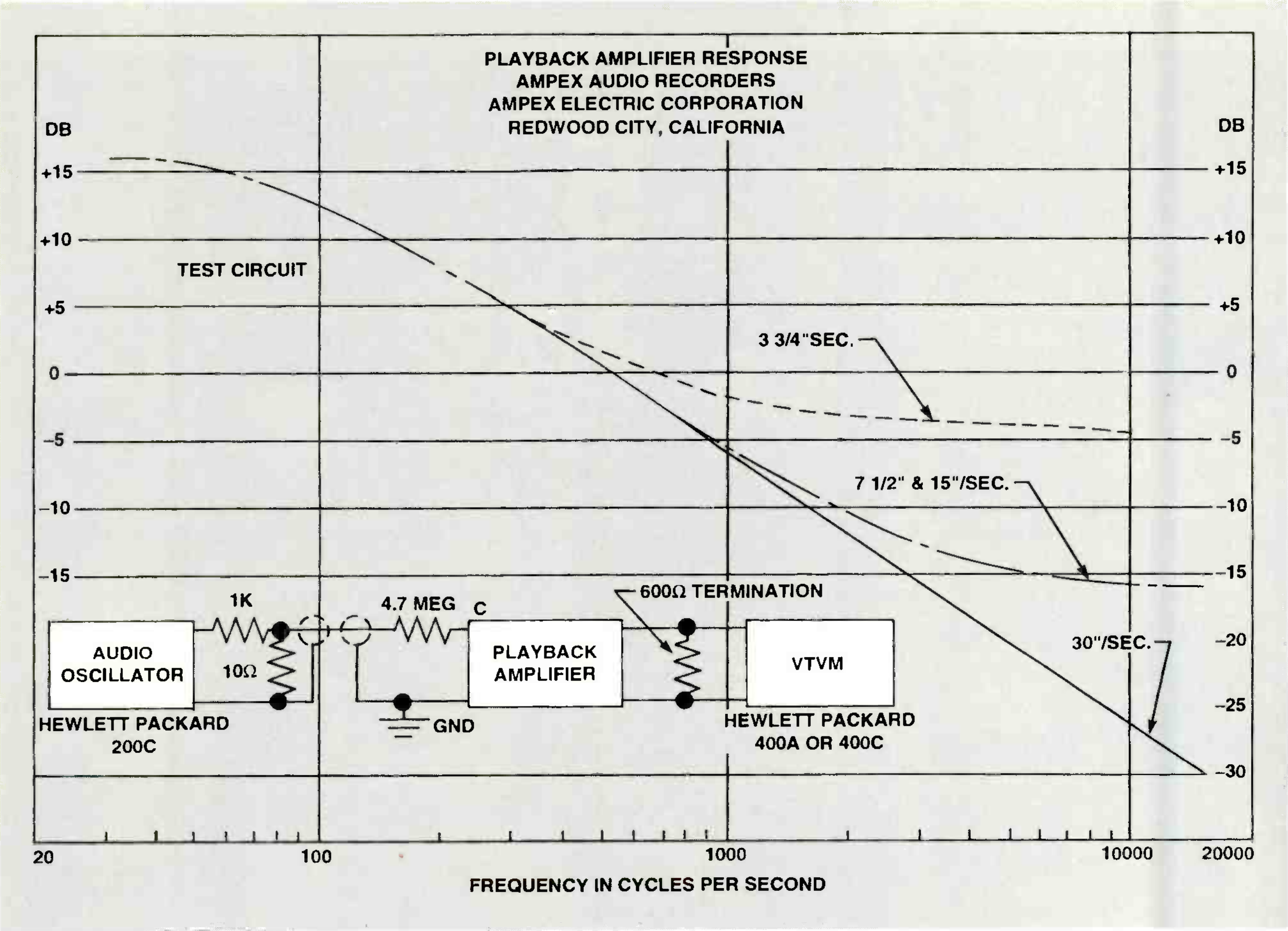


Fig. 6. Typical playback-amplifier equalization curves.

emission of the bias/erase oscillator tube, or a leaky oscillator capacitor. If you have a schematic diagram of the electronics, check to see if a current or voltage specification is given for the erase signal.

Tape wrap has to do with the extent of tape contact across the head, and is a function both of the shape of the front of the head (which, obviously, you can't control—but remember this if you replace a head with a non-identical substitute), and the "penetration" the head makes into the line of the tape path. Penetration is sometimes adjustable, usually by moving the platform onto which the head is mounted forward or backward. Excessive penetration might be, for example, where the head pushes the tape far enough forward to where it is lifted from the adjacent guides, or another head. Insufficient penetration would be where the head barely touches the tape. There's no mathematical precision here; just look at how the heads are situated relative to the penetration issue. For example, often the record and play heads have similar geometry, and so one might expect a similar tape wrap. Another clue is to look very closely at the groove worn into the head face. If the tape wrap is such that it's not covering a portion of the wear area, that could be an indication that tape wrap is now insufficient.

A related adjustment (called "zenith") ensures that the head gap is centered within the portion of the tape that is in contact with the head. If a significant wear groove is present, however, it might be better to leave this adjustment alone.

The "tilt" alignment ensures that the "front-to-back" angle of the heads is correct with respect to the tape. If it is off, the tape will have more head contact on one side than on the other. One way to observe that is to look at the wear pattern on the head. If it is in the shape of a trapezoid instead of a rectangle, you likely have a poor tilt adjustment. As with head height, it's not a real good idea to go making changes if this situation has been around long enough to create a significant trapezoidal groove. However, if the tape wrap is fairly extensive, it might be okay to make a small correction here. You might be best off to just note the problem, and then see how successful the rest of the electrical spec checks and adjustments are before changing the tilt settings. If all else comes back to spec, and the "dropout" level (instability in playback level) is tolerable, then leave it alone.

Next, we'll tackle azimuth adjustments, which will ensure that the record- and play-head gaps are perpendicular to the length of the tape. The first check should be made on the play head, and you will need a standard alignment tape to accomplish this. Typically these tapes will have a number of recorded passages, often with a voice lead-in to identify the next passage. (If you have need for an

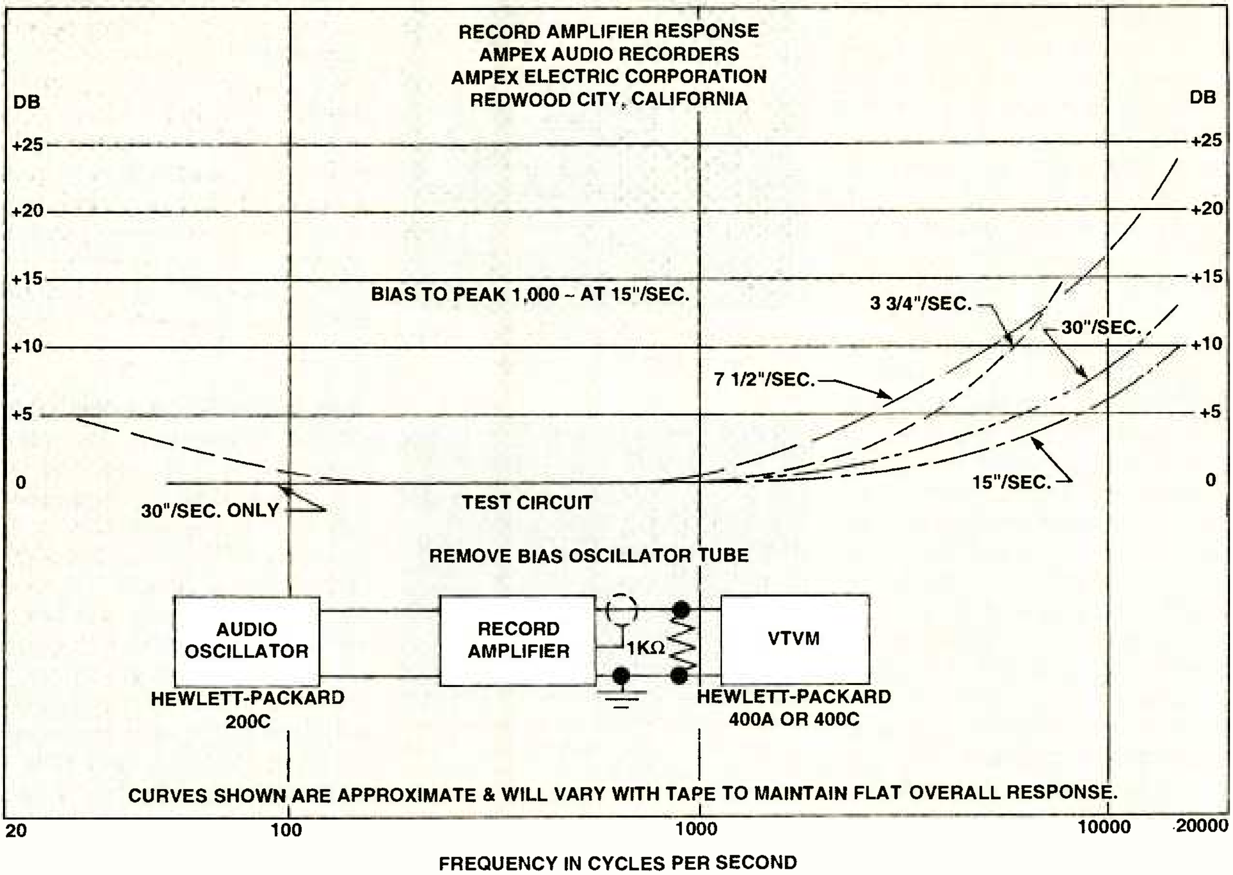


Fig. 7. Typical record-amplifier equalization curves.

alignment tape, you may contact the author c/o EC Designs at the address given in the "For More Information" box for suggestions.) The passage of interest here is a high frequency tone (often 10 kHz). Before playing it, identify which screw on the play-head platform influences the azimuth angle, and clean off any locking paint as necessary. Adjust for a peak level while watching an output meter, then take careful note of the extent of adjustment (just in case you need to reset it later).

Now let's align the record-head azimuth. (If your machine has a combination record/play head, you're done; just go to the next adjustment.) Set up the machine to record a 10-kHz tone onto a blank tape, at a level of about -15 dB. While watching the simultaneous play-head output on a meter, adjust the record-head azimuth very slowly for a peak reading (note that there is a delay between the time you make the adjustment and the time that portion of the passage reaches the play head). Again, write down the amount of adjustment needed.

That completes the head-alignment process. Before we leave the subject of heads, and get into frequency response, it's probably worthwhile to spend a moment on head wear. While all tape heads wear out eventually, they do last a long time. Typical head life from an early 1970s machine, using premium tapes, could be 4,000 hours or more. There's no sudden, magic point where the heads become useless. Rather, the wear process is gradual, eventually affecting the electrical specifications. Further, different model heads have different head-gap depths and are composed of different materials with still different wear characteristics. What I'm saying here is to not rule out a set of heads just on the basis of the size of the wear groove. Check the electrical specs first. See what effect bias and level adjustments might have. You might discover that there are still hundreds of hours of life remaining!

On the other hand, improper cleaning of the tape path very often spells premature doom for the tape heads—if not in the form of poor frequency response, then perhaps in the form of excessive dropouts (maybe as a result of "craters" formed on a head face due to a glob of oxide stuck there for a long time). While it certainly pays to carefully note those issues when evaluating a machine for potential purchase, once again don't categorically rule it out on the basis of improper wear; just be cautious.

General Adjustments. Now that we've gotten the mechanics back to spec, and we're confident that the tape heads are aligned properly, what's left is a number of general electronic checks and adjustments. Please note that the following procedure is very general in nature. Tape recorder electronic designs vary widely; and, as such, you are always better off if you have the manufacturer's alignment instructions. If you do, then follow those instructions in lieu of the following. If you do not, then proceed with the following instructions, but bear in mind that this might not be the optimum way to set up your machine. While this procedure will work, a few things might get overlooked, and other things may have to be done twice due to interacting controls.

The approach we're going to take is to first make a few assumptions. If true, we can streamline the remaining electronics alignment. (If they are not true, we'll find that out anyway, in the process of the tests we perform.) These assumptions are based on the electronic alignment controls still appearing to be at (or near) their original factory settings, and on the overall condition of the electronics appearing to be excellent (and/or you have already replaced any "suspect" components—leaky wax/paper capacitors, weak tubes, etc.). If these assumptions are correct, then it's a good bet that the equalization and approximate record- and play-level calibrations are close to spec.

Frequency-Response/Bias Adjustment. Let's take a look at the frequency response. To do this, connect your audio oscillator and THD analyzer (assuming that it also houses an audio voltmeter), and thread a blank tape of the formulation you will be using on this recorder. If the machine has separate record and play heads, this process will proceed much faster as that will allow simultaneous playback monitoring as you adjust the bias. (We'll assume this configuration for the following adjustments. If you do not have playback capability during record, you will have to alternately record, then play back several times to find the optimum settings.)

Initially, set the oscillator to 1 kHz and a level of 0 VU on the recorder meter. Now, reduce the oscillator level by 20 dB, and, while monitoring the source with the external voltmeter, set the voltmeter pointer (achievable if your instrument has a "set level" mode) to a 0 VU meter reading. Now place the machine into record mode (let's start at the

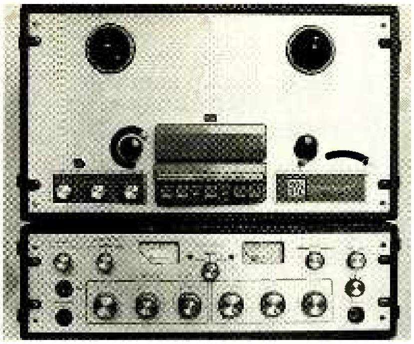


Fig. 8. Magnecord Model 1024 deck. Another "big iron" machine from the 1960s.

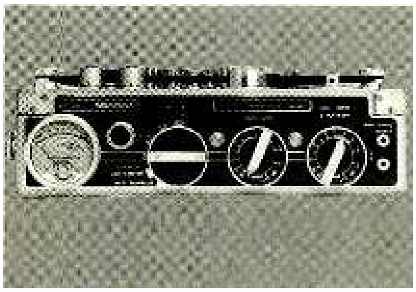


Fig. 9. Nagra Model III recorder. This was a professional portable machine, popular with the motion-picture industry.

fastest tape speed on your recorder), and switch the output to "playback" monitoring. The tape output level at this point might, or might not, be at 0 VU. Don't worry about that right now; just note the level relative to the 0 VU setting you had when looking at the record preamp.

Now switch the oscillator to 10 kHz (while maintaining the same oscillator level). Ideally, the 10-kHz output level should be at 0 VU, but a level within + 3 dB or so is often still within factory spec. If it's much higher than that, try increasing the bias-level control to bring the 10-kHz response into that range. Now, increase the oscillator frequency, and note the point where the response trails off to - 3 dB. If the frequency is less than the high-frequency-response spec, and if the 10-kHz response was identical to that at 1 kHz, then you might try going back to 10 kHz, decreasing the bias a bit to increase the 10-kHz level to, say + 2 dB, and then check the 3 dB drop-off point again.

If you are unable to achieve the factory frequency-response specs, something is obviously wrong. This could be due to worn heads, improper equalization (either record or play), or a faulty preamp component (again either record or play). The frequency-response portion of a standard alignment tape could be used to rule out the play head and play-preamp/-equalization circuitry. If that's okay, then the record circuitry should be considered suspect. If you have an oscilloscope, and are adept at such things, you might find a faulty component in a preamp section.

Total Harmonic Distortion (THD). If, on the other hand, the machine now meets the high-frequency spec, the next step is to measure the THD at 0 VU. Simply make a 1-kHz recording at 0 VU (on the recorder meter) for a couple of minutes; then, while playing it back, "set level" at 0 VU on the THD meter, then switch to "distortion" mode, and adjust frequency and balance for a null. If the THD is what you want it to be for a 0-VU recording level, then proceed to the S/N test, coming up next. If the distortion is greater than what you want it to be at 0 VU, then you can try to go back and increase the bias a bit more. While that will bring down the distortion, it will also decrease the high frequency response. So, if that is not to your liking, you can try the THD test again, this time at, say -3 dB.

If the THD is to your liking, the next step is to re-calibrate the record preamp "VU meter record level" to read 0 VU for that signal level going to the head. (This is another area where you must be careful if you do not have a schematic. Some recorder designs do not have a separate VU-meter calibration pot. Therefore, the only record-level adjust is sometimes an overall record level, acting on both the VU meter and the signal going to the head. If that is the case, it will be apparent when you try to adjust it; just be sure to watch for it.)

If your machine has separate bias controls for each speed, go ahead at this point and complete the bias adjustments, along with THD checks.

Signal-to-Noise Ratio (S/N). Assuming frequency response and THD is now acceptable, the next step is to measure S/N. If you wish to measure S/N relative to 0 VU, simply make another recording at 0 VU for about 20 seconds (otherwise, if measuring relative to 3 % THD, first determine the "head room," then set the VU level for that peak reading. You may need to use an external meter for this if the recorder meter is above full scale); then, while still in record, turn off the oscillator—or turn the record level control down to zero—and continue recording for another 30 seconds. Play back that same section of tape, quickly "setting level" on the audio meter to 0 VU and then, when the level drops, measure the decade drops and residual meter reading to determine the S/N. If it meets spec, congratulations! If it doesn't, then—once again—you've got some work to do.

Some common causes for poor S/N, beyond what we've already covered, are noisy transistors or tubes, faulty capacitors, and sometimes (although much less often) even resistors. This can be a very time-consuming investigative process. An oscilloscope may be very helpful here to spot the "corrupt creature."

It's worth mentioning again that we have really simplified the alignment process described above. It may, or may not, be totally adequate for your machine. If you have a "professional" machine, for example, then you should pay more attention to "standard" levels. Use the alignment tapes, along with the manufacturer's instructions, to set up your recorder.

Equalization. Finally, let's cover equalization. So far, we've been assuming that record and play equalization is probably okay. If you need to check it out, however (or, are simply curious), let's take a look at what's involved.

Figure 6 shows the playback equalization published by Ampex for their recorders back in 1953. These curves are similar to those for many other recorders, representing an approximate doubling in signal amplitude with a doubling of frequency (an increase of 6 dB per octave). This has to do with the physics of magnetic recording,

Fig. 10. Acme Model 1500 recorder. A modest 3-inch reel machine, using "rim drive" and a swing-out permanent magnet to erase previous recordings when in the record mode.

and, in theory at least, will be the same for all machines. This curve "levels off" at the higher frequencies due to natural losses.

If you have a standard alignment tape for this purpose, that would be the quickest means to check conformance with the curves at each speed on your recorder. If not, then a setup similar to the one shown in Fig. 6 can be used to directly inject the test frequencies. One frequency representing each of the low-, mid-, and high-frequency points should be adequate (*e.g.*, 30 Hz, 1 kHz, 10 kHz). Recorders differ as to the adjustments available: from none at all (fixed equalization), to a single control (usually influencing the high-end response), to multiple controls (high- and low-frequency adjustments, sometimes with one set for each machine speed).

Figure 7 shows some record-equalization curves, published for the early Ampex professional machines. Before checking or adjusting record equalization, be sure that play equalization has been set properly, as the measuring of record equalization uses the play preamp as well to ensure overall flat response. Unlike play equalization, record equalization may have to be reset for significantly different tape formulations; particularly, for example, if converting from a typical 1950s formulation (such as Scotch 150) to a premium 1970s low noise tape (such as Maxell UD35).

Note the test circuit shown in Fig. 7, which is to be used if you want to measure the actual signal being applied to the head. Also note the recommendation that the bias oscillator tube be removed during the measurements; that's done to eliminate any bias component from influencing the readings. If your recorder is transistorized, you would need to carefully select a test point at which to insert the VTVM; it should be after the equalization boost and before mixing with the bias signal (just before delivery to the record head). Then, make sure to check for presence of the bias signal, after you have set up your audio oscillator, by temporarily removing the audio frequency and ensuring that any bias component is minimal.

Perhaps a simpler method, however, is just to read the overall response throughout the recorder, exploiting the fact that we now know that the play equalization is correctly adjusted. We also know that the bias has already been optimized for the desired tape formulation. Therefore, if we simply connect an audio oscillator to the record input jacks, thread the desired tape, enter record mode, set the input level to -20 dB, and then monitor tape output with our trusty audio meter, we should be able to sweep through the frequency range and see a reasonably flat response (depending on the manufacturer's frequency response spec).

If the response is not flat, then carefully adjust the record equalization. Note, however, that you will then have to go back and reset bias, and also re-check THD. It shouldn't take more than two "equalization-bias" adjustment cycles to get a feel for the capabilities of your machine and thus choose an optimum setting. If the response will not smooth out, and you have confirmed proper operation in all of the previous steps, then you must suspect the equalization circuit components.

Believe it or not, if you have successfully made it through to this point, you should now have a tape recorder capable of virtually the same performance as when new. As a matter of fact, the existence of modern premium tapes could mean even better specs than when new if your machine is more than 25 years old.

Completing the Restoration Process. What remains in the restoration process is all the cosmetic stuff;

FOR MORE INFORMATION

This article is based on the new book, *Evolution of the Audio Recorder* by the author, Phil Van Praag. It contains over 500 pages of history, evolution, restoration, photos, and a price guide. It's available at $39.95, postpaid, from EC Designs, P.O. Box 33, Genesee Depot, WI 53127.

everything from re-gluing and pinning cracked or broken cabinet joints, to buffing front panels, to restoring worn lettering, to replacing hardened rubber feet, and on and on. The list is long, but the additional work is necessary if the restoration is to be complete.

I sincerely wish you the best of luck in these pursuits. Whether your machine is a "big iron" Magnecord 1024 (Fig. 8), a professional Nagra III (Fig. 9), or a modest Acme 1500 (Fig. 10), it will be well worth the effort. If you 'stick it out' to a successful completion, I'm sure you'll derive much more satisfaction and enjoyment from the subsequent use of your "like new" tape recorder. Ω

FECHNER PHENOMENON

(continued from page 51)

of pulse-width modulation to control a DC motor: It tends to make them run hotter than they would if you simply cut off the voltage. Inexpensive motors could easily burn out if run continuously for prolonged periods of time. In short, don't run the demonstration for hours on end without some type of heatsink or another cooling arrangement, or, at the very least, shut things down and let the motor's insides cool off at regular, reasonable intervals.

PostScript for the Fechner Disc. As stated earlier, the image shown in Fig. 1 can be photocopied and attached to a motor shaft for a quick look at the Fechner Phenomenon. However, you may want to explore the way that perceived colors vary with arc segment length and with changes to the black field. To do that you could try to re-create the disc in a graphics application, but due to the pattern's need for precisely positioned, perfectly circular arcs as well as the pattern's lack of symmetry, you will benefit greatly if you write PostScript code instead. Then, by editing the PostScript text, you could create a disc of any size as well as explore the relationship between image segments and color effects.

If you read this magazine often, especially Don Lancaster's "Tech Musings" column, you are no doubt aware of PostScript, which is an object-oriented page-description language. The page-description programs are generated by software applications, transferred to a PostScript printer, and interpreted to produce a printed page. The language has an extensive array of commands and operators to facilitate the creation and placement of precise and often complex figures and graphics. Compared to PostScript's capability, our Fechner Disc is quite simple. To get you started, Listing 1 contains the PostScript code that generated the Fechner Disc in Fig. 1. Note that the image comprises a set of arc segments. An outer circle is defined as an arc segment from 0 to 360 degrees. The half black segment is defined as an arc from 0 to 180 degrees; the "fill" statement defines it as a black area.

All of the arcs have the same center coordinates, (270, 350) and various start and end angles. The remarks in the listing identify the function of each of the code statements, and show the parameter values for the image generation. To produce the image, you need to store the PostScript code as a text file and send it to a PostScript printer under an operating system command that tells the printer to process the image, not print the text. Under DOS, for example, use the COPY command with the PostScript text file as the file to copied and the PostScript printer as the destination. Ω

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BY DON LANCASTER

All About Quadrature, and More

MOST SCIENCE STUDENTS AND ENGINEERS SHOULD LEARN AND APPLY THIS ESSENTIAL RULE: AN HOUR SPENT IN THE LIBRARY IS WORTH A MONTH IN THE LAB. SAME GOES FOR ENGINEERS. THAT'S BECAUSE THERE'S NOT MUCH POINT in doing any personal lab work or any product development when someone else has long ago clearly created something much better, or has found all of the hidden insider "gotchas" that are flat out going to prevent you from getting where you think you are headed. Let's begin this month with a topic that starts off with a lot more library than lab time.

Understanding Quadrature

I've often been accused of heading off at right angles to everyone else. It turns out that there often is a darn good reason for doing so.

Take a bicycle wheel. Tie a ribbon on its rim. Spin it on a north-south axis as illustrated in Fig. 1. When viewed "axle-on" from the south, you will see the ribbon going round and round, spending time east, west, up, and down from the axle.

When viewed from the west, you should see a ribbon bouncing up and down. Rapidly changing in mid-path, but spending "dwell time" near its upper and lower travel limits. The west-viewed waveform traced out by the ribbon is often called a sinusoid or simply a sinewave.

Now view the wheel from the top. You'll again see the ribbon bouncing back and forth, but this is different somehow. It is still sort of a sinewave, although this particular "sinewave" responds to the east and west ribbon motion rather than the up and down motions of the previous one. By itself, the shape does seem sinusoidal. But compared to the up and down viewing, we have a cosine. Such a cosine wave will be phase shifted by precisely 90 degrees from its sinewave counterpart.

Note particularly that the side view ignores any and all back and forth ribbon motion, while your top view will ignore any and all up and down ribbon motion. The information content on the one channel is invisible to that of the other!

The two waveforms are said to be either orthogonal or in quadrature. Quadrature waveforms do occur over and over again in electronics.

For instance, your ribbon position could define a vector from your axle, expressed in polar coordinates. Our vector has a length and a direction. In a math space, your angle will be in degrees counterclockwise from east. Alternately, in a geographical space, the degrees are clockwise from north. Obviously, you should pick one or the other and stick with it.

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Electronic stuff almost always uses math-space degrees. The west-view sinewave and the top-view cosine wave instead define your ribbon position with two scalar quantities, or a pair of single values. Often, quadrature measurements or waveforms can be used to convert between a vector and its two scalar components. Such separated parts are said to be in rectangular or Cartesian coordinates.

For example, say you have a 20-inch bike wheel with a 10-inch radius, and say the ribbon happens to slant +60 degrees in math space. The top viewed east to west, or the cosine component, should be +5.0 inches, because the trigonometric cosine of 60 degrees is 0.5000. The side viewed up-down or sine component will be +8.660 inches, because the trigonometric sine of 60 degrees is calculated as 0.8660.

Such trig values are easily found in math tables, in scientific calculators, and even slide rules. They also could be created by a series approximation algorithm or whatever.

The side or sine view is sometimes called the real or the I (in-phase) component; the top or cosine view is sometimes called the imaginary or the Q or (quadrature) component. The letter j is often used to denote an electronic imaginary axis (it seems that current had first dibs on the more obvious i variable).

Neat Quadrature Tricks

One remarkable property is that all quadrature channels of information can be independent of each other. If you try multiplying any sine times a cosine over precisely one cycle, you will get a zero result.

That happens because your cross products change for each quadrant.

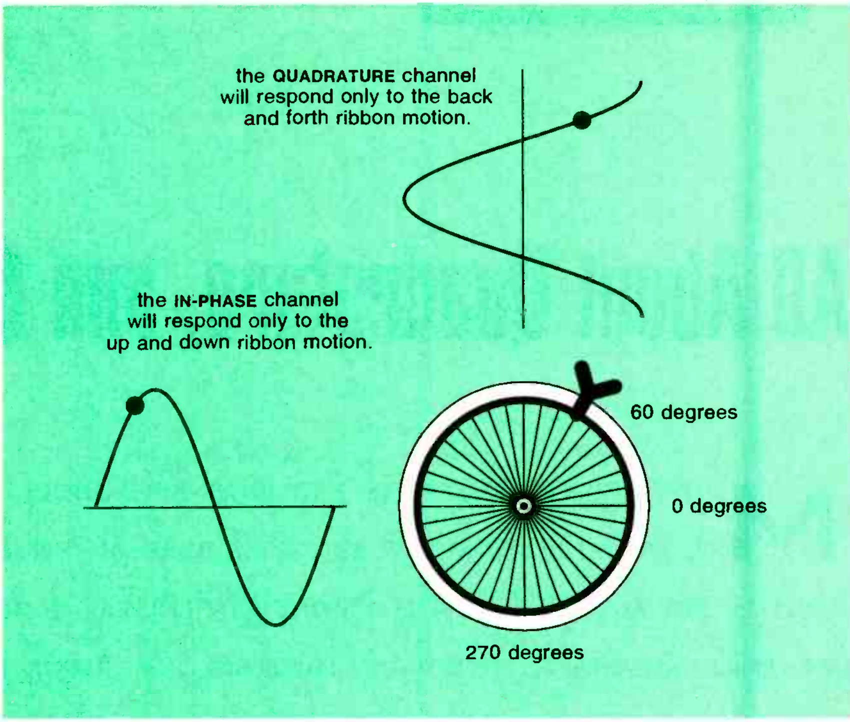

FIG. 1—QUADRATURE WAVEFORMS are mechanically or electrically shifted by precisely 90 degrees from each other. They have many uses.

Algebraic signs are both positive in quadrant I and are both negative in quadrant III. But they are opposites in quadrants II and IV.

Yet another group of remarkable properties is that the slope for any cosine is a quadrature sinewave! And the slope of a sinewave is a negative quadrature cosine wave. A different name for "slope" is the derivative.

Further, the accumulated area you should find under any sinewave is a quadrature cosine wave. And the accumulated area under the cosine wave is a negative quadrature cosine. Another name for "accumulated area" or any "area under the curve" is the mathematical integral.

As with trig values, integrals and derivatives are found in books of math tables, or can be generated by finding slopes or by adding up cumulative areas. See any introductory calculus book for all the gory details.

In fact, you could build a dandy oscillator simply by cascading two integrators and a sign changer. That circuit "solves" the fundamental differential equation relating sines and cosines, and thus simply has to create them. Such an oscillator can simultaneously provide you with a pair of quadrature sine and cosine wave outputs.

A lossy variation on cascaded sine and cosine integrators is known as a state-variable active filter, which can offer you a stable high Q. One obscure use for such a circuit is quadrature art where psychedelic audio color patterns are displayed on an oscilloscope or a computer screen. More details on state variable filters and quadrature art applications can be found in my *Active Filter Cookbook*.

Although the sine values and the cosine values can end up completely independent of each other, together they should define a unique ribbon position or phase on the wheel. That suggests that we can place two totally different channels of information on a rotating vector or a similar carrier, which lets us put twice as much stuff in a given bandwidth than we might have thought we could.

Those channels might be called an "I" (for in phase) and the "Q" (for quadrature) channel. They become quite important in cellular communications and wireless modems. One older example of I and Q channel use is color TV where the chroma information is set by a pair of color difference values.

Generating Quadrature Signals

One really big use for quadrature signals can involve single-sideband communications. Figure 2 shows how a broadband quadrature phase-shift network can be used to create SSB transmissions. For those unfamiliar with it, SSB gives us compelling advantages over earlier AM or amplitude modulation in that only half the bandwidth is needed and no raw

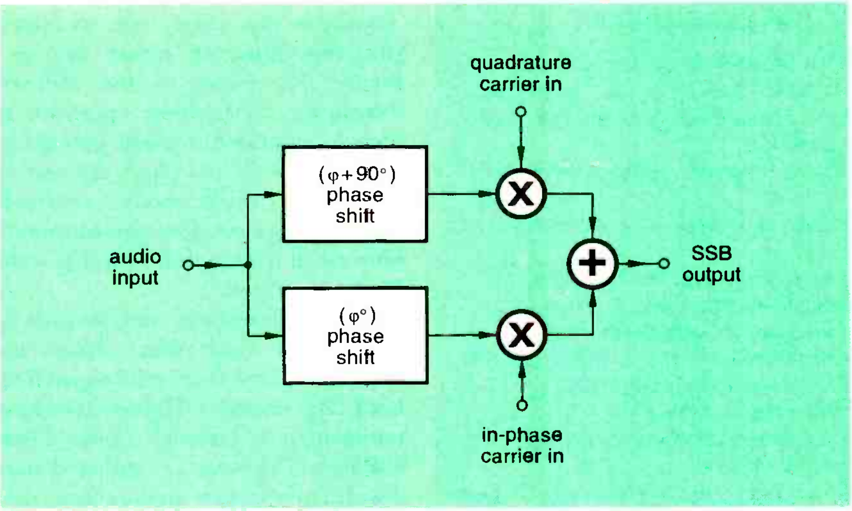

FIG. 2—ONE POPULAR METHOD of single-sideband generation uses a broadband audio quadrature phase shifter.

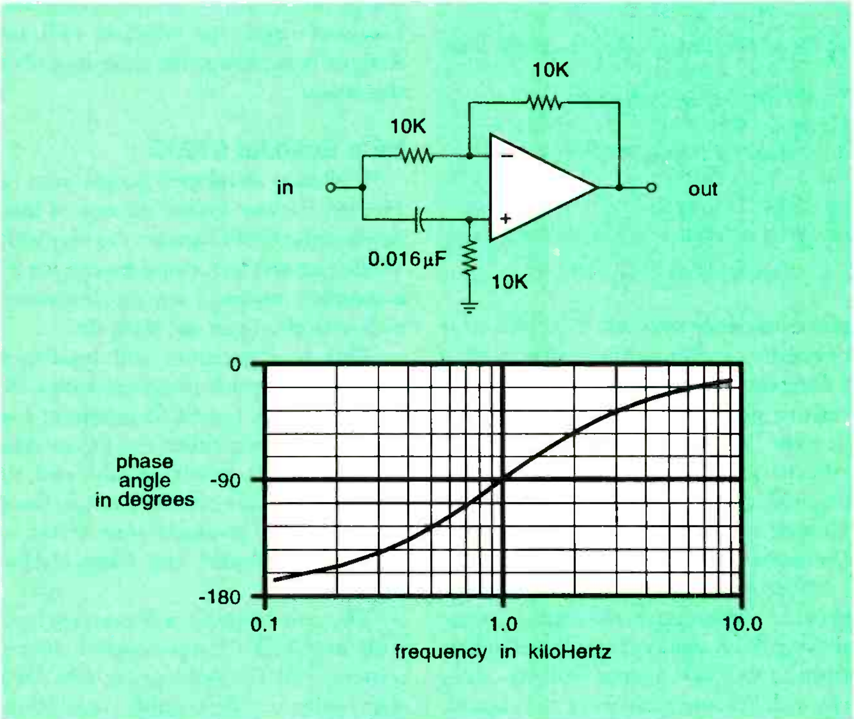

FIG. 3—A FIRST-ORDER ALL-PASS active filter can be used as an equalizer, cranking out phase as fast as some other circuit cranks it in.

carrier power needs to be transmitted or otherwise wasted.

Generating a quadrature signal at a single frequency is no big deal. We have seen that changing a physical point of view by 90 degrees does it. You also can simply stall or delay for a quarter cycle.

For instance, a 1-kHz audio sinewave has a time period of one millisecond. To generate a quadrature signal, any fixed delay of a quarter millisecond should suffice. At 100 MHz, a quarter wavelength or 90 degrees will be slightly over two feet. Thus, the time delay from any short piece of coax or other line can be used as a single-frequency quadrature phase shifter. There even used to be trombone lines found in VHF phase-shifting lab work just for this.

For useful SSB or modem communication, though, you will need to quadrature delay a band of frequencies. Sadly, what was your 90-degree fixed delay phase shift at 1000 Hz becomes a 135-degree phase shift at 1500 Hz and a 180 degree phase shift up at 2000 Hz. Instead, what you will want is a linear phase system that advances phase exactly by 90 degrees as you advance your frequency.

Nearly any analog low-pass circuit using either capacitors or inductors inherently has to provide more delay than a linear phase for the simple reason that capacitors and inductors are causal, meaning that they can "remember" what went on in the past but have no means of foretelling the future. Thus, higher-frequency parts of waveforms tend to get further and further behind. That is known as the group-delay problem, and is it ever a problem.

For example, if the ones of an older modem were at one frequency and the zeros were at another, with bad group delay in a filter, you will get times when you have a one, a zero, neither, or both at the output! Obviously "neither" or "both" are not very good.

So, you'll have to get real fancy if you decide to build up a wideband quadrature network. In fact, it turns out there is no perfect way known to do so. Amplitude or phase lumps are certain to crop up, as is limited bandwidth. But there might be some useful approaches you could try. However, we are getting ahead of ourselves; first we need to pick up some details on a circuit we might find useful.

An All-Pass Equalizer

To work around all of the inherent excess phase shifting problems with traditional inductors and capacitors, an equalizer can sometimes be used. An equalizer is simply a circuit that tries to crank out excess phase as fast as the problem circuit cranks it in.

A simple first-order all-pass section and its response appears in Fig. 3. That circuit has the property that all reasonable frequencies will be passed with unity gain.

To analyze the circuit, note that the gain of the op-amp will be -1 to an input on the left side of the left resistor on the inverting (-) input; and +2 to a signal applied directly to the non-inverting (+) input. At the lowest of frequencies, the capacitor will seem to be nearly an open circuit, and the gain will be -1 for a phase advance of 180 degrees. At very high frequencies, the capacitor will be nearly a short circuit, and the gain will be -1 + 2 = +1 for a phase shift of 0 degrees. Whenever your capacitive reactance matches your resistance, the combined phase shifts and gains on the op-amp inputs will still give you a unity gain output, but at a phase advance of 90 degrees.

Thus, unlike any typical low-pass filter circuit, phase is retarded as frequency increases. That retardation can be used to

BROADBAND QUADRATURE RESOURCES

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offset excess phase in whatever your new all-pass equalizer is trying to equalize.

You can also have fancier second-order equalizer circuits that let you crank phase in and out faster with more control. Higher order all-pass networks are also possible, but they are usually implemented using cascades of first-order and second-order all-pass sections grouped together.

Broadband Quadrature Networks

How can you generate a broadband quadrature phase shift? Three schemes are shown in Fig. 4. Our first scheme (Fig. 4A) is called the phase-difference method. In it, you set up two cascaded chains of first-order all pass circuits; one for I, one for Q.

By carefully specifying the phase advance of each circuit, you can get a 90-degree differential delay between the two channels over a chosen wide bandwidth. Those differential delays typically can be +45 degrees and -45 degrees with respect to the input. The amplitude is reasonably smooth, but there will be lumps in the phase. An original phase-difference paper by Bedrosian appears in the June 1960 *IRE Transactions on Circuit Theory*.

The second route (Fig. 4B) uses the phase-sequence network. The fixed array of resistors and capacitors is driven off of a differential pair of audio sources, giving relative phases of 0, 90, 180, and 270 degrees. This phase sequence method is covered in *The Art of Electronics*. One original phase sequence paper is by Gingell and published in *Electrical Communication*, v48-1.

Note that these analog circuits only provide differential 90-degree phase shifting. Both output channels will inherently be "behind" the real world in-phase channel, because a capacitor can causally react only to events that have already happened.

Digital filters, however, have a stunningly interesting property. They can look "forward" as well as "backward" in time simply by checking earlier or later taps in a time storage history. Thus, digital filters can be non-causal and hence "distortionless." It's quite easy to build a linear-phase, sharp-cutoff, digital filter. We looked at these techniques a while back (see MUSE105.PDF through MUSE107.PDF on my www.tinaja.com Web site.)

In fact, digital filters can easily do all sorts of things that are difficult or impossible with analog. There is a piece of black magic math known as a Hilbert Transform that simply tells us "phase shift everything by ninety degrees." Figure 4C shows us the Hilbert-Transform digital-filter approach to broadband quadrature phase generation. Note that while the phase can end up exact, there will be modest amplitude ripple in your needed approximations. One useful ploy to deal with that is the Ramez algorithm.

Hilbert Transforms can be built up with all the usual adders, delays, and DSP multipliers. One useful digital filter book that includes Hilbert-Transform information is Jackson's *Digital Filters and Signal Processing*. I've gathered more detailed information on the above-mentioned and other references on broadband quadrature networks together for you as this month's "Resource Sidebar." Loads of thanks to Winfield Hill and Rodger Rosenbaum for their inputs on this topic.

HP's ScanJet 6100C

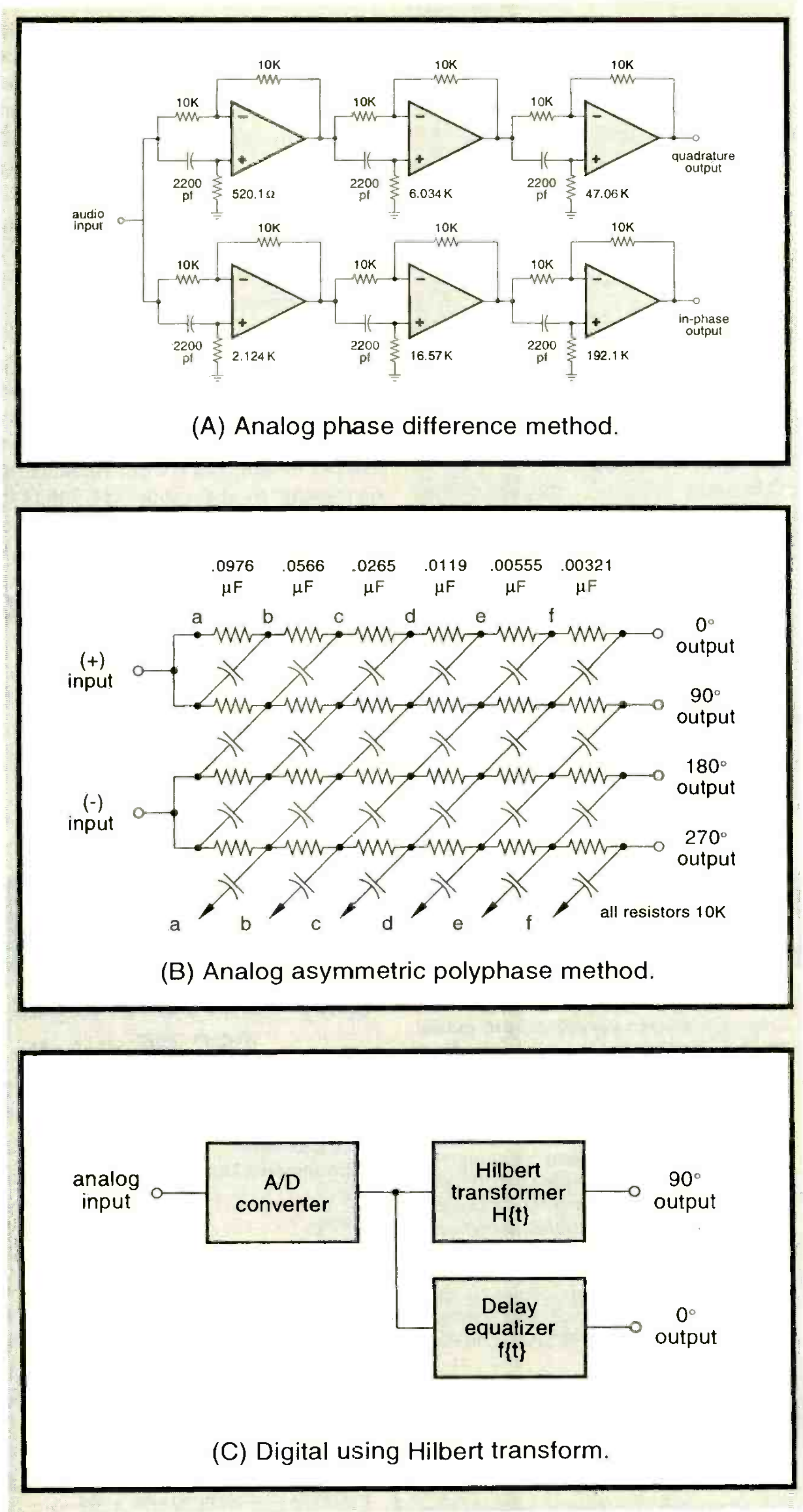
The nice developer people over at Hewlett Packard loaned me one of their new ScanJet 6100C scanners to play with. While I haven't had it long enough yet for a complete review, I am very impressed with what this beast can really do.

This is a premium and legal-sized flatbed scanner that interfaces with a PC host through a fast SCSI interface. List price is $921 for either the PC or Mac version. Street prices should end up somewhere around the $620 range. Good pricing on HP products often shows up in *Computer Reseller* and *Comp-U-Mart* magazines.

The unit combines a fluorescent light with its CCD (charge-coupled device) sensor. Optical resolution is 600 DPI, with software deliverable resolutions ranging from 12 to 2550 DPI. Cropping is a snap and scaling can go from 3 to 400 percent.

Color or black and white is done in a wide variety of formats, including a self-optimizing 10-bit gray and 24-bit full color. Fancy image processing options include dithering, filtering, thresholding, interpolation, a gamma adjustment, inversion, scaling, color correction, and mirroring. There is even an optional 35 MM slide scanner accessory.

My main interest in a scanner is to capture all of my older books for my Web site and CD-ROM publishing ventures. The HP scanner interfaces beautifully with Acrobat Capture for extraction of both the text and the layout. Bee is



(A) Analog phase difference method.

(B) Analog asymmetric polyphase method.

(C) Digital using Hilbert transform.

FIG. 4—THREE APPROACHES to broadband quadrature phase shifting.

going bonkers over this machine, scanning all sorts of stuff for textile teaching, crafts, and her co-op food newsletters.

There's also a copier mode that sure is handy. It works with your laser printer and gives you all sorts of size, quantity, quality, shading, and enlargement options. Compared to a "real" copier, the 6100C ends up somewhat slower using its highest quality mode, but normally produces much-better looking results. This is a really great machine.

New Tech Lit

From Texas Instruments comes CD-ROMs on Logic and 1394 Solutions. From AKM Semiconductor, there's a new *Audio & Multimedia Data Book*. And from Raychem, there's the revised *Circuit Protection Databook*.

From Atmel, comes a *AVR Risc Microcontroller* data book. For those unfamiliar with it, the AVR seems to me to be cheaper and faster than a PIC, but a lot less elegant. Their instruction set is very much 6502 like, (yea, team), but typically should execute in single machine cycles. Even their smallest units include a fast multiplier and an analog comparator. Both external and internal interrupts are supported.

Landsat MSS image data is newly available on CD ROM by way of Tom Oliver. His prices start at $13 per CD. Broad coverage in several spectral bands is available. Amazingly cheap aerial photos with surprisingly high resolution are separately offered by several advertisers in *Earth Observer Monthly* (EOM). Information on microwave and RF heating ideas can be found at the International Microwave Power Institute at www.impiweb.org.

We have bunches of worthwhile books this month. Let's start with *Inside Intel*, which is an unflattering look at this industry giant. I don't care for either the title or the really awful fonts in *Web Psychos, Stalkers, & Pranksters*, but the book nicely reveals solid information on hiding and un-hiding web addresses and steps you can take towards your own web security. For guidance on where the web seems to be taking us, read *Growing Up Digital: The Rise of the Net Generation*. Check out my www.tinaja.com/amlink01.html for more details on these titles.

From Lindsay, his latest new-old book is *Popular Mechanics 1919 Shop Notes*. The hydraulic ram on page 2971 sure is a cute and "free" way to pump water uphill.

A great and free master industry-wide electronic search service is now up at www.questlink.com.

While not obvious, PostScript can elegantly (though not instantly) get tricked into painting with translucent ink! It can also be used to create "alpha" channel overlay effects and even blue screens. Further details can be found in ALPHADEM.PDF on my www.tinaja.com. Also

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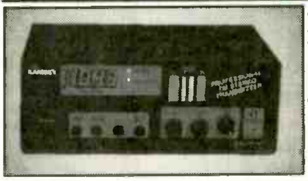

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We also offer a high power export version of the FM-100 that's fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported.

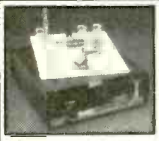
FM-100, Professional FM Stereo Transmitter Kit $299.95
FM-100WT, Fully Wired High Power FM-100. . . . . $429.95

Synthesized FM Stereo Transmitter

Microprocessor controlled for easy frequency programming using DIP switches, no drift, your signal is rock solid all the time - just like the commercial stations. Audio quality is excellent, connect to the line output of any CD player, tape deck or mike mixer and you're on-the-air. Foreign buyers will appreciate the high power output capability of the FM-25; many Caribbean folks use a single FM-25 to cover the whole island! New, improved, clean and hum-free runs on either 12 VDC or 120 VAC. Kit comes complete with case set, whip antenna, 120 VAC power adapter - easy one evening assembly.

FM-25, Synthesized FM Stereo Transmitter Kit $129.95

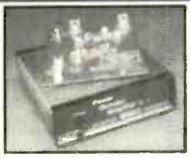
Tunable FM Stereo Transmitter



A lower cost alternative to our high performance transmitters. Offers great value, tunable over the 88-108 MHz FM broadcast band, plenty of power and our manual goes into great detail outlining aspects of antennas, transmitting range and the FCC rules and regulations. Connects to any cassette deck, CD player or mixer and you're on-the-air, you'll be amazed at the exceptional audio quality! Runs on internal 9V battery or external power from 5 to 15 VDC, or optional 120 VAC adapter. Add our matching case and whip antenna set for a nice finished look.

FM-10A, Tunable FM Stereo Transmitter Kit. $34.95
CFM, Matching Case and Antenna Set. $14.95

RF Power Booster Amplifier



Add some serious muscle to your signal, boost power up to 1 watt over a frequency range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM Stereo transmitters, providing radio service through an entire town. Power required: 12 to 15 volts DC at 250mA, gain of 38dB at 10 MHz, 10 dB at 1000 MHz. For a neat, professionally finished look, add the optional matching case set.

LPA-1, Power Booster Amplifier Kit $39.95
CLPA, Matching Case Set for LPA-1 Kit. $14.95
LPA-1WT, Fully Wired LPA-1 with Case $99.95

Micro FM Wireless Mike

World's smallest FM transmitter. Size of a sugar cube! Uses SMT (Surface Mount Technology) devices and mini electret condenser microphone, even the battery is included. We give you two complete sets of SMT parts to allow for any errors or mishaps-build it carefully and you've got extra SMT parts to build another! Audio quality and pick-up is unbelievable, transmission range up to 300 feet, tunable to anywhere in standard FM band 88 to108 MHz. 7/8"w x 3/8"h x 3/4"h.

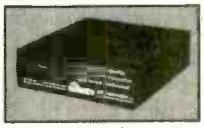
FM-5 Micro FM Wireless Mike Kit $19.95

Crystal Controlled Wireless Mike

Super stable, drift free, not affected by temperature, metal or your body! Frequency is set by a crystal in the 2 meter Ham band of 146.535 MHz, easily picked up on any scanner radio or 2 meter rig. Changing the crystal to put frequency anywhere in the 140 to 160 MHz range-crystals cost only five or six dollars. Sensitive electret condensor mike picks up whispers anywhere in a room and transmit up to 1/4 mile. Powered by 3 volt Lithium or pair of watch batteries which are included. Uses the latest in SMT surface mount parts and we even include a few extras in case you sneeze and loose a part!

FM-6, Crystal Controlled FM Wireless Mike Kit $39.95
FM-6WT Fully Wired FM-6 . . . . $69.95

AM Band Radio Transmitter



Ramsey AM radio transmitters operate in the standard AM broadcast band and are easily set to any clear channel in your area. Our AM-25, 'pro' version, fully synthesized transmitter features easy frequency setting DIP switches for stable, no-drift frequency control, while being jumper setable for higher power output where regulations allow. The entry-level AM-1 uses a tunable transmit oscillator and runs the maximum 100 milliwatts of power. No FCC license is required, expected range is up to 1/4 mile depending upon antenna and conditions. Transmitters accept standard line-level inputs from tape decks, CD players or mike mixers, and run on 12 volts DC. The Pro AM-25 comes complete with AC power adapter, matching case set and bottom loaded wire antenna. Our entry-level AM-1 has an available matching case and knob set for a finished, professional look.

AM-25 Professional AM Transmitter Kit....................$129.95
AM-1 Entry level AM Radio Transmitter Kit....................$29.95
Cam Matching Case Set for AM-1....................$14.95

Tone-Grabber Touch Tone Decoder / Reader

Dialed phone numbers, repeater codes, control codes, anywhere touch-tones are used, your TG-1 will decode and store any number it hears. A simple hook-up to any radio speaker or phone line is all that is required, and since the TG-1 uses a central office quality decoder and microprocessor, it will decode digits at virtually any speed! A 256 digit non-volatile memory stores numbers for 100 years - even with the power turned off, and an 8 digit LED display allows you to scroll through anywhere in memory. To make it easy to pick out numbers and codes, a dash is inserted between any group or set of numbers that were decoded more than 2 seconds apart. The TG-1 runs from any 7 to 15 volt DC power source and is both voltage regulated and crystal controlled for the ultimate in stability. For stand-alone use add our matching case set for a clean, professionally finished project. We have a TG-1 connected up here at the Ramsey factory on the FM radio. It's fun to see the phone numbers that are dialed on the morning radio show! Although the TG-1 requires less than an evening to assemble (and is fun to build, too!), we offer the TG-1 fully wired and tested in matching case for a special price.

TG-1, Tone Grabber Kit. $99.95
CTG, Matching Case Set for TG-1 Kit. $14.95
TG-1WT, Fully Wired Tone Grabber with Case. $149.95
AC12-5, 12 Volt DC Wall Plug Adapter $9.95

The Cube World's Smallest TV Transmitter

Perfect video transmission from a transmitter you can hide under a quarter and only as thick as a stack of four pennies- that's a nickel in the picture! Transmits color or B&W up to 150' to any TV tuned to cable channel 59 with a solid 20 mW of power. Crystal controlled for no frequency drift with performance that equals law enforcement models that cost hundreds more! Deluxe model includes sound using a sensitive built-in mike that will hear a whisper 15 feet away! Units run on 9 volts and hook-up to most any CCD camera. Our cameras shown below have been tested to mate perfectly with The Cube and work great. Fully assembled.

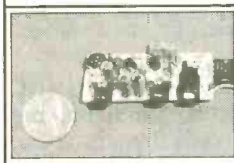
C-2000 Video Transmitter Cube....................$89.95
C-3000 Video and Audio Transmitter Cube....................$149.95

CCD Video Cameras

If you're looking for a good quality CCD board camera, stop right here! Our cameras use top quality Japanese Class 'A' CCD arrays, not the off-spec arrays that are found on many other cameras. You see, the Japanese suppliers grade the CCDs at manufacture and some manufacturers end up with the off-grade chips due to either cost constraints or lack of buying 'clout'. These cameras have nice clean fields and excellent light sensitivity, you'll really see the difference, and if you want to see in the dark, these are super IR (Infra-Red) sensitive! Available with Wide-angle (80°) or super slim Pin-hole style lens. Both run on 9 VDC and produce standard 1 volt p-p video. Add one of our transmitter units for wireless transmission to any TV set, or add our Interface board (below) for Audio sound pick-up and direct wire connection to any Video monitor or TV video/audio input jacks. Fully assembled.

CCDWA-2 CCD Camera, wide-angle lens....................$99.95
CCDPH-2 CCD Camera, slim fit pin-hole lens....................$99.95
IR-1 IR Illuminator Kit....................$24.95

CCD Camera Interface Board



Here's a nifty little kit that eases hook-up of your CCD camera module to any video monitor, VCR or video input TV set. The board provides a voltage regulated and filtered source to power the camera (CCD Cameras require a stable source of power for best operation), sensitive electret condensor mike for great sound pick-up and RCA Phono jacks for both audio and video outputs. Runs on 11 - 20 VDC.

IB-1 Interface Board Kit....................$14.95

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Check Out What We Have To Offer:

Fantastic DMM Offer!!!

Don't let the price fool you. This meter is a digital multimeter designed for engineers and hobbyists. Equipped with 5 functions and 19 ranges. Each test position is quickly and easily selected with a simple turn of the FUNCTION/RANGE selector rotary switch.

General ***Rubber Boot Included***

Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity

Overrange Indication: 3 Least Significant Digits Blank

Temperature for Guaranteed Accuracy: 23 C 5 C RH<75%

Temperature Ranges:
Operating: 0 C to 40 C (32 F to 104 F)
Storage: -10 C to 50 C (14 F to 122 F)

Power: 9V Alkaline or Carbon-Zinc Battery(NEDA1604)

Low Battery Indication: BAT on Left of LCD Display

*Dimensions:*188mm long x 87mm wide x 33mm thick

Net Weight: 400g

$19.00 any qty

DC Voltage (DCV)

Range:	Resolution:	Accuracy:
200mV	100 V	
2000mV	1mV	(1%rdg+2dgts)
20V	10mV	
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	Resolution:	Accuracy:
200 A	100nA	
2000 A	1 A	(1.2%rdg+2dgts)
20mA	10 A	
200mA	100 A	(1.2%rdg+2dgts)
10A	10mA	

Overload Protection: mA Input. 2A/250V fuse.

Resistance (Ω)

Range:	Resolution:	Accuracy:
200Ω	100mΩ	
2000Ω	1Ω	
20KΩ	10Ω	(1.2%rdg+2dgts)
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	(2%rdg+10dgts)

Maximum Open Circuit Voltage: 2.8V

Diode Test

Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

ohFE Test

Measures transistor hFE.

Frequency Range: 45Hz-450Hz

Maximum Allowable Input: 750V rms

Response: Average Responding. Calibrated in rms of a Sine Wave.

AC Voltage (ACV)

Range:	Resolution:	Accuracy:
200V	100mV	(1.2%rdg+10dgts)
750V	1V	

CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

20 AMP Switching Power Supply

$99.00 any qty

A very special Circuit Specialists offer. This 20 amp continuous switching power supply is available at this fantastic low price!

Specifications
Input Voltage: AC 110V +/- 15%, 50Hz/60Hz
Output Voltage: DC9V 15V variable
Polarity: Negative ground
Current (13.8v): 25A peak, 20A continuous
Overvoltage Protection
Cooling fan inside chassis

CAT NO	DESCRIPTION	PRICE
SPS-1020G	20 Amp Switching Power Supply	$99.00

Developer

This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

Etching Chemicals/Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3	Makes 1 pint	$3.50	$2.75

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 165mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10
PP1212	305mm x 305mm/12" x 12"	12.78	10.65	8.52

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114	114mm x 165mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80
GS1212	305mm x 305mm/12" x 12"	18.88	15.73	12.59

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 165mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30
GD1212	305mm x 305mm/12" x 12"	22.09	18.35	14.68

Etching Tank

This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

REDUCES ETCHING TIME!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

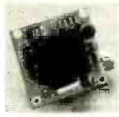
1/3" CCD Board Cameras

Available with **PINHOLE LENS** with **AUDIO**; **STANDARD LENS** with **AUDIO**; and **STANDARD LENS** with **INFRA-RED**. These are the world's smallest commercially available CCD board cameras!

World's Smallest B&W Board Cameras

Specifications

Image Pick-Up Device	1/3" CCD area Sensor
Picture Elements	EIA=512(H) x 492(V)
Pixel Pitch	EIA=9.6UM (H) x 7.5UM (V)
Scanning System	2 : 1 Interlace
Scanning Frequency	EIA=525 lines, 60 field/sec (II) 15.750 KHz x 60 HK
Resolution	430 Lines
Minimum Illumination	0.03 LUX
S/N Ratio	45DB
Lens Mounting	4.3mm standard, 5mm pinhole
Video Output	1.0 VP-P/750OHM composite signal
Power Requirement	8-12 VDC (9VDC standard)
Power Consumption	100mA
Operating Temperature	-20C -+ 70 C RH 95% Max
Storage Temperature	-40C -= 85 C RH 95% Max
Audio Pick-Up Sensitivity	-60 DB (0DB = 1B/UBAR, 1KNZ)
Audio Frequency Range	20 Hz to 20KHz
Audio S/N Ratio	More than 35DB
Audio Output Level	1VP-P/600 OHM



WDP-2000

WDS-2005

WDI-4000

Dimensions

WDP-2000	30mm (H) x 30mm (W)
WDS-2005	30mm (H) x 30mm (W)
WDI-4000	44mm (H) x 30mm (W)

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDP-2000	1/3" B&W Pinhole Lens with Audio	$89.00	$77.00
WDS-2005	1/3" B&W Standard Lens with Audio	89.00	77.00
WDI-4000	1/3" B&W Infra-RED (no audio)	89.00	77.00
WDPH-55BW	Plastic Housing Option for B&W Board Cameras (WDP-2000 & WDS-2005 ONLY)	13.00	12.00

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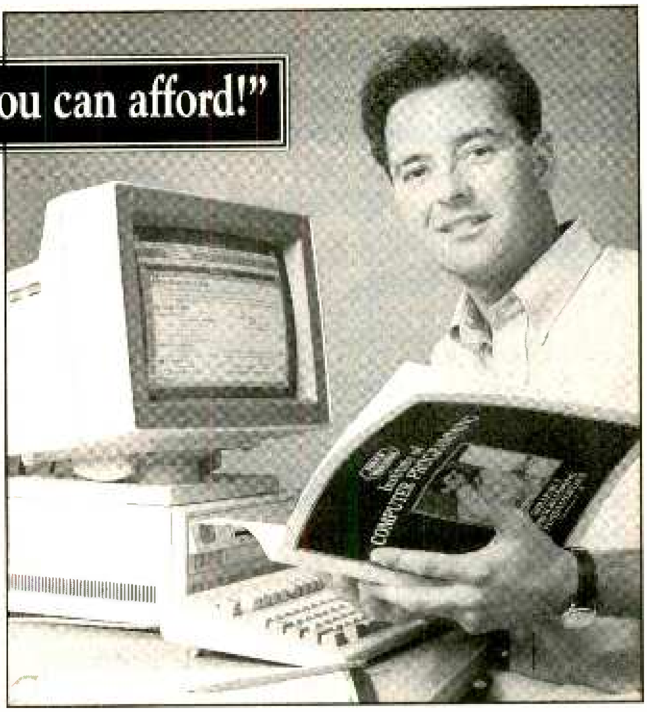

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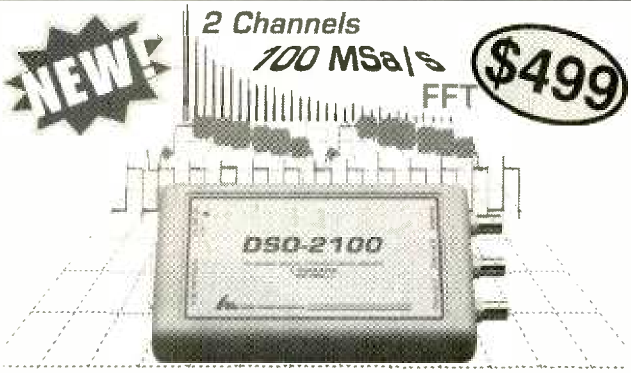

- **2 Ch.** Digital Oscilloscope
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For **$499** you get the model **DSO-2102S Oscilloscope**, Probes, Interface Cable, Power Adapter, and Windows and DOS Software.
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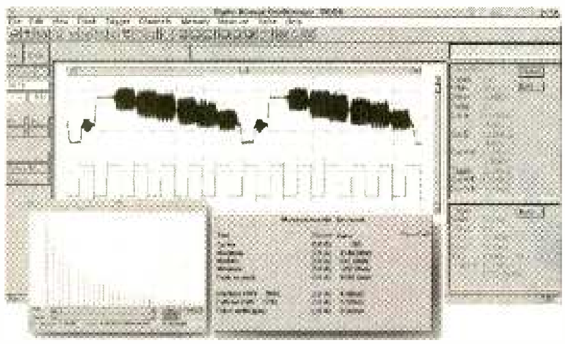
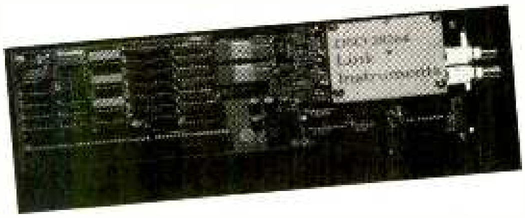


DSO w/Logic Analyzer (ISA based)



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- **2** Oscilloscope Channels
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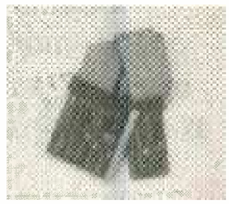

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COMPARE:	16C54	MV1200
OEM (1K) PRICE	$2.57	$1.99
RS232 PROGRAM DOWNLOAD	NO	YES
SINGLE CHIP OPERATION	NO	YES
BUILT-IN BASIC	NO	YES
EEPROM DATA MEMORY	NONE	64
PROGRAM MEMORY	768 OTP	1K FLASH
MATH REGISTERS	1	32
MAX INSTRUCTIONS / SEC	5M	20M
MAX COUNTER 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

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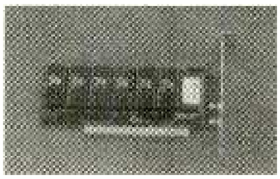

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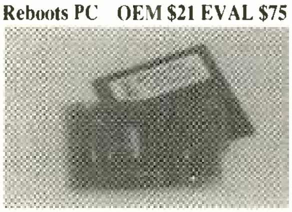

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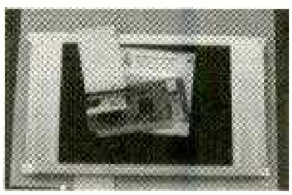

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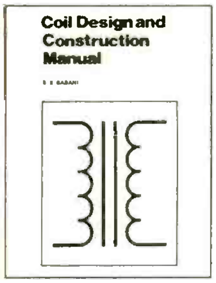

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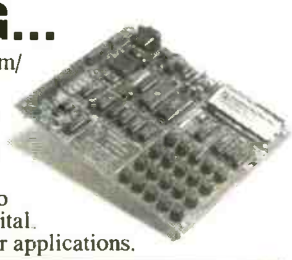

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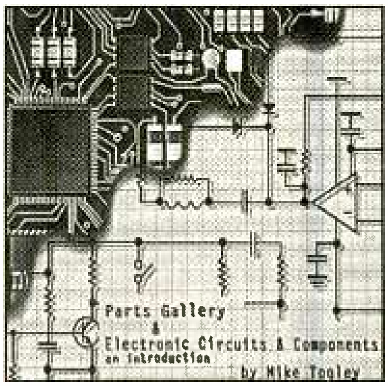

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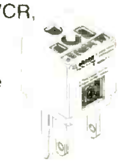

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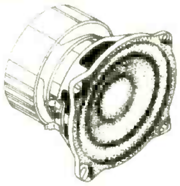

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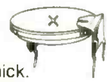

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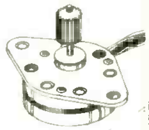

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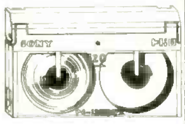

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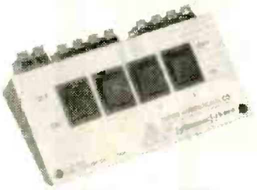

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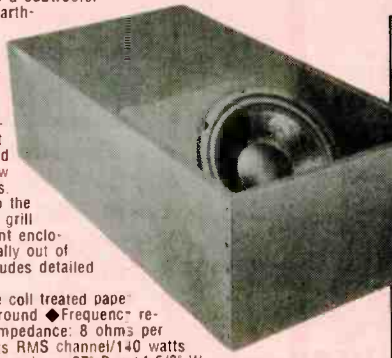

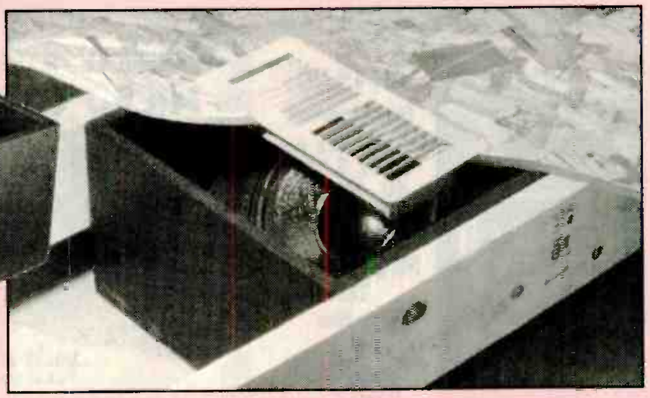

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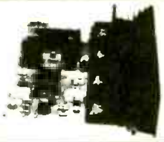

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Kit: $ 67.92 Asmb.$ 86.95

Power Output: 120W into 4 ohms RMS. 72W into 8 ohms RMS. Frequency Response: 10 - 20 KHZ. THD: < 0.01%. Tone Control: Bass ±12dB, Mid ±8dB, Treble ±8dB. Sensitivity: Phono Input, 3mV into 47K. Line, 0.3V into 47K. Signal to Noise Ratio: 86dB. Power Requirement: 40V DC @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Metal Cabinet Model LG-1924.

80W + 80W Pure DC Stereo Main Power Amplifier TA-802 (4 lbs.) ▲▲

Kit: $ 49.94
Asmb.$ 69.94

Power Output: 80W per channel into 8 ohms. THD: < 0.05%. Frequency Response: DC to 200 KHZ, -0 dB, -3dB @ 1W. Power Requirement: 30V AC X 2 @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Capacitor 8,200uf 50V Model 017. Suggested Metal Cabinet LG-1924

60+60W Stereo Power Amp. ▲▲

SM-302 (11 lbs.)

Kit:$ 85.00

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30W + 30W Pre & Main Stereo Amplifier TA-323A (1 lb.) ▲

Kit: $ 32.50 Asmb.$ 50.50

Power Output: 30W into 8 ohms RMS per channel. THD: < 0.1% from 100 HZ to 10 KHZ. Sensitivity: Phono 3mV @ 47K. Tuner, Tape 130mV @47K. Signal to Noise ratio: 80dB. Power Requirement: 22 to 36V AC, 3A. May use Mark V Model 002 Transformer. Suggested Cabinet LG-1684.

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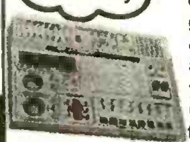

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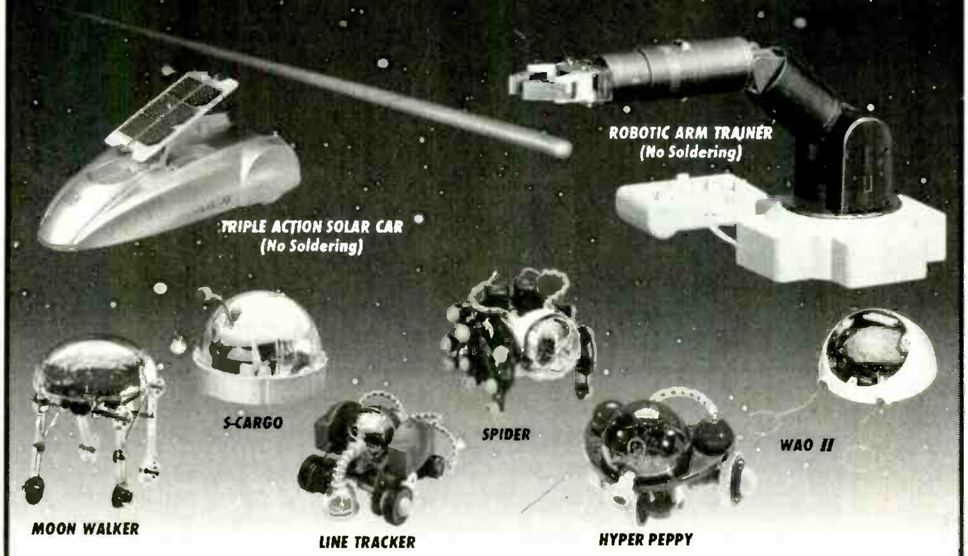

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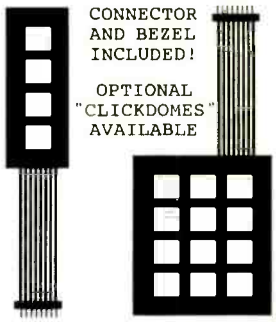

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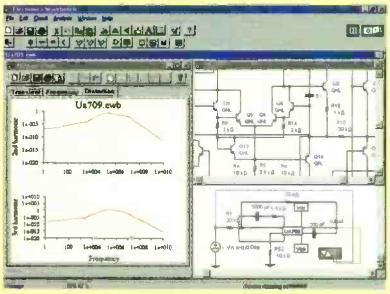

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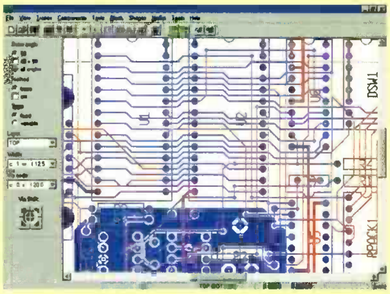

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