PC-BASED TEST EQUIPMENT

OCTOBER 1996

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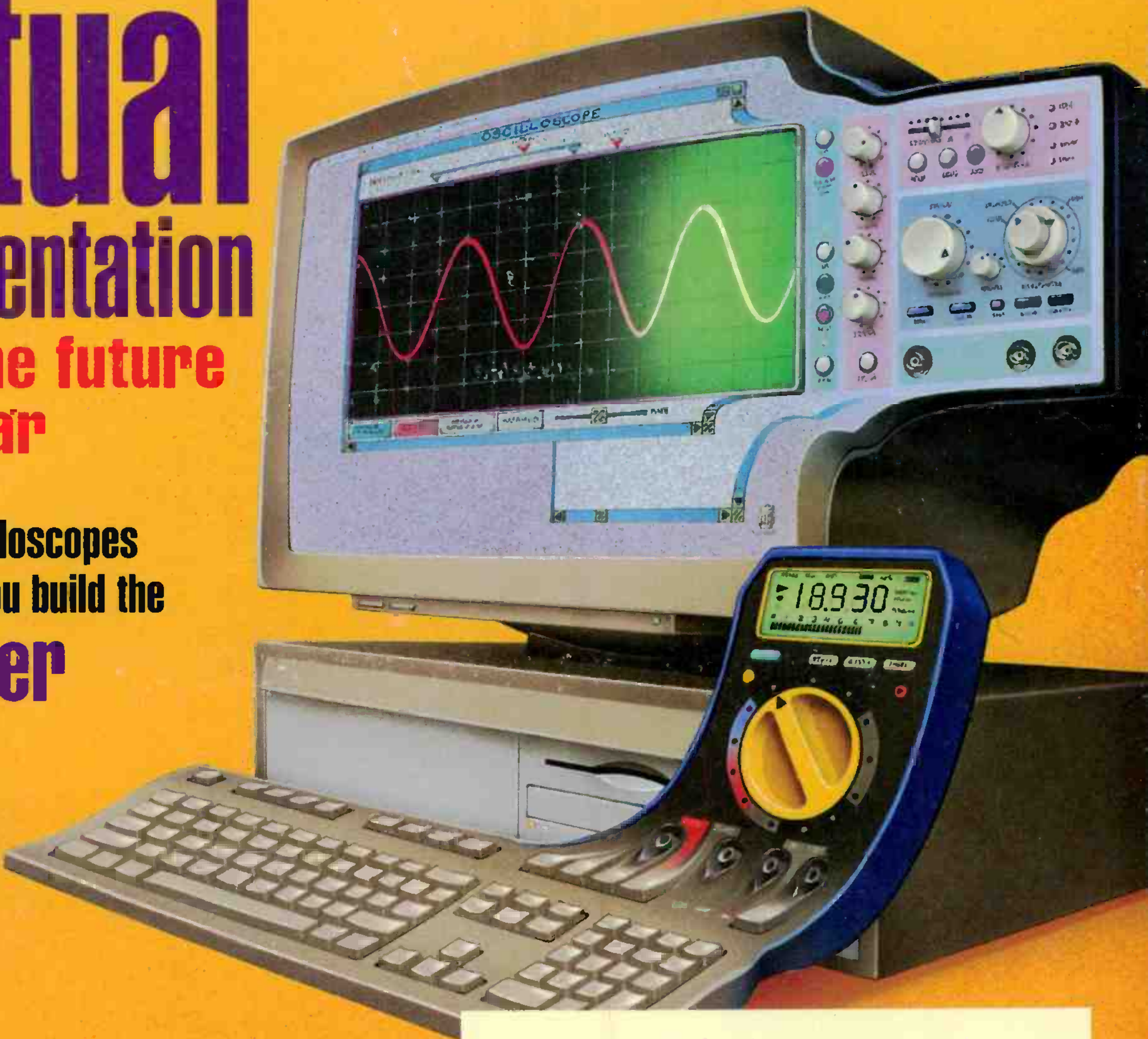
Take a visit to Virtual Instrumentation and see the future of test gear



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Electronics NOW®

Vol. 67 No. 10

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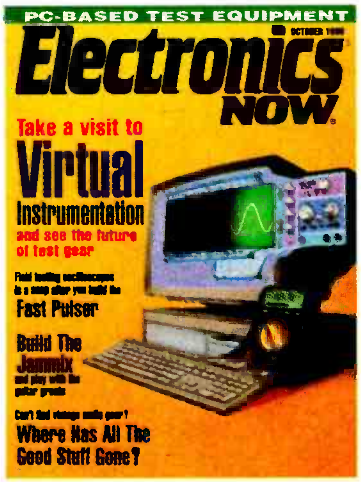

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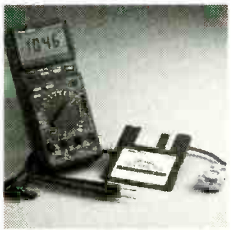
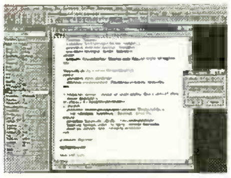
OCTOBER 1996

TECHNOLOGY

DEPARTMENTS





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EDITORIAL

The Future of Test Equipment

Since its birth in the mid 1970s, the personal computer—and the microprocessor inside it—has changed and shaped our lives in countless ways. Nowhere is that more true than in electronics.

For example, buckets full of components can now be replaced by a single microprocessor or microcontroller and some lines of code. Engineers no longer need to breadboard countless circuit variations to see if a particular design is valid. Today's circuit-design software lets you create a schematic, and then input a signal and examine the circuit's behavior at nearly any point.

But what about on the test bench? Sure, much modern test gear now has a microprocessor as its heart and brains. And PCs are used to store and analyze information gathered by traditional test gear or PC-based test cards. But, until recently, the controlling software was limited in its scope and versatility.

That is all changing. Modern testing peripherals and graphical-programming techniques are turning the personal computer into the test gear itself. But it is test gear unlike anything we've seen to date. It is test gear that can adapt itself to virtually any task at hand. At one moment it might be a DMM; at the next, an oscilloscope; and later on, a signal generator. Or, it might be all of those, and more, at the same time.

What's the secret that makes it work? The answer is "Virtual Instrumentation," and the technology behind it is likely to change the nature of the electronics test bench forever. To learn more about it, turn to our article, "A Visit to Virtual Instrumentation." The future of test equipment begins on page 33.

Carl Laron
Editor

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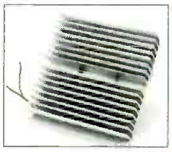
Thermoelectric Cooler with Heat Sink



- Transfers heat from one side of the pump to the other resulting in a hot and cold side with differences up to 60°C
- Pumps 50 watts continous @ 6 amps
- Size: Heat sink: 5.0"L x 5.0"W x 1.3"H
  Pump: 2.7"L x 1.8"W x 1.2"H

Part No.	Description	1-4	5-9
131975	Thermoelect. cooler	$29.95	$26.95

WAHL® FingerTip® Soldering Iron

Model #7495

The FingerTip® soldering iron fits right on your finger allowing your hands to hold more, with less effort.

- Variable temperature: 425°F–900°F
- Includes FingerTip® iron, power supply, 1/2 mil pitch tip, fine tip, micro tip, and wiping sponge

Part No.	Description	1-4	5-9
132791	FingerTip solder iron NEW		$139.95

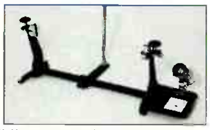
XYTRONIC Analog Display Soldering Station

SPECIAL

- Electronic temperature control from 200°F to 878°F
- Zero-voltage thyristor switching protects voltage and current sensitive devices such as CMOS ICs against voltage spikes
- Includes one P/N 35115, 1/16" tip

Part No.	Description	1-4	5-9
114569	Analog disp. station Special		$89.95

Benchtop PC Board Solder Station



- Holds PC boards up to 13" wide.
- Can be adjusted by using press release and sliding support arm to hold desired size board
- Right hand soldering iron holder
- Size: 19.5"W x 8.8"D x 8.8"H

Part No.	Description	1-4	5-9
133065	PC board solder stat. SALE		$49.95

REVEAL 4X Multimedia Bundle

The Mozart quad speed, Windows® compatible kit has everything you need to install and be up and running in minutes!

- Quad speed internal drive
- Mozart 16-bit sound card
- 20 watt shielded speakers with volume control
- Includes CD data and audio cables

Complete Upgrade Kit!

Part No.	Description	1-4	5-9
132062	4X multimedia kit SALE		$139.95

LOGICAL DEVICES INC. CUPL Software

CUPL Software is one of the world's most popular and comprehensive PLD/FPGA design software systems, with over 20,000 users. CUPL is a very versatile and powerful logic compiler that can be used to create simple or even very sophisticated logic designs for PLD's and FPGA's. CUPL runs either in DOS or in a DOS prompt within the Microsoft® Windows® environment.

132871 132880

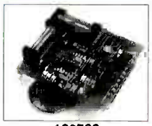
132871: CUPL Starter Kit
Supports 10 of the most popular PAL & GAL architectures.

132880: PAL Expert
Supports 75 of the most popular PAL, GAL and PROM architectures.

SPECIAL

Part No.	Description	1-4	5-9
132871	CUPL starter kit Special		$89.95
132880	PAL expert Special		249.95

PRECISION NAVIGATION, INC. Vector 2X Compass Modules



- Applications: vehicle mapping and tracking, robotics, HAM radios, camera positioning
- Power supply: single 5 volt 126703
- P/N 132901 is a mechanically gimbaled version of the Vector 2XT (P/N 126703), designed for tilt compensation

Part No.	Description	1-4	5-9
126703	Vector 2X module	$49.95	$44.95
132901	Vector 2XT module	99.95	89.95

Jameco 26 Pc. Hobby Tool Set

- 6 screwdrivers (Phillips #0, #1, slotted 0.05", 0.08", 0.09", 0.12")
- 10 bits: 5, 6mm, #No.1, #No.2, No.1, No.2, T-10, T-15, T-20, socket adapter
- Handle • Stainless steel tweezers
- Extension bar • Sockets: 5, 6, 8, 10mm
- 4" long nose plier • 4" side cutter

Part No.	Description	1-4	5-9
99629	26 pc. tool set	$19.95	$17.95

SL WABER Surge Protectors

SurgeSentry 6 outlet

- Ultimate 3-stage protection
- No limit connected equipment guarantee
- 62,525 amp spike suppression; 880 joules

133090

DataGard 7 Outlet

- $1000 connected equipment guarantee
- Standard 1-stage protection 133081
- 13,000 amp spike suppression; 520 joules

Part No.	Description	1-4	5-9
133090	SurgeSentry 6-outlet SALE		$29.95
133081	DataGard 7-outlet SALE		12.95

JAMECO 3½-Digit Pocket Multimeter

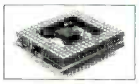
SPECIAL

- Measures: AC/DC voltage, A DC, HFE and resistance
- DC voltage: 200mV, 2V, 20V, 200V, 1000V
- AC voltage: 200V, 750V
- Resistance: 200Ω, 2kΩ, 20kΩ, 200kΩ, 2MΩ
- DC current: 200mA, 2mA, 20mA, 200mA, 10A • Diode test • Transistor HFE
- Removable test leads

Part No.	Description	1-9	10-24
119212	Pocket meter w/ test Special		$17.95

Power Leap Upgrade Adapter

For 486SX/DX/DX2 to 586-100/120



- Supports 5V 486 motherboards
- 586-XXX chip not included
- Supports 64-bit X86 compatible processor with 16KB write-back cache
- 100 and 120MHz core speeds with 33, 40 and 50MHz bus options (BIOS written before 1995, will only work with AMD CPUs)
- Includes manual and 3.5" utility/test disk

Part No.	Description	1-4	5-9
131941	Upgrade adapter SALE		$49.95

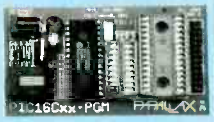
Jameco E(E)PROM Programmers

Part No.	Description	1-4	5-9
101400	1 socket 16Kbits-512Kbits E(E)PROM prog.	$129.95	$119.95
78465	4 socket 16Kbits-2Mbits E(E)PROM prog. Closeout		229.95
78457	1 socket 16Kbits-2Mbits E(E)PROM prog.	199.95	179.95

7400 Series Integrated Circuits

Part No.	Product No.	1-9	10-99	100
48979	7400	$.49	$.45	$.39
49015	7402	.39	.35	.29
49040	7404	.49	.45	.39
49091	7406	.45	.39	.35
49120	7407	.45	.39	.35
49146	7408	.49	.45	.39
50235	7432	.49	.45	.39
50374	7442	.59	.55	.49
50403	7445	1.19	1.09	.99
50420	7447	1.19	1.09	.99
50454	7448	3.95	3.49	2.95
50551	7474	.49	.45	.39
50577	7475	.89	.79	.69
50593	7476	1.09	.99	.89
50631	7483	.99	.89	.79
50665	7486	.69	.59	.49
50681	7489	3.95	3.49	2.95
50690	7490	.99	.89	.79
50745	7493	.89	.79	.69
49322	74121	1.09	.99	.89
49357	74123	1.19	1.09	.99
49373	74125	1.29	1.19	1.09
49488	74147	4.95	4.75	4.45
49509	74150	1.95	1.75	1.55
49568	74154	2.95	2.75	2.49
49621	74159	1.75	1.55	1.35
49891	74190	2.95	2.75	2.49
49912	74192	1.75	1.55	1.35
49939	74193	1.75	1.55	1.35
49955	74194	1.75	1.55	1.35

PARALLAX PIC16C5x/xx Programmer Pack



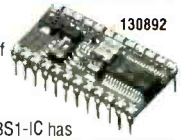
Programs, reads & verifies PIC16C5x/xx devices!

- Supports PICs: 54, 55, 56, 57, 58, 620, 621, 622, 61, 62*, 63*, 64*, 65*, 71, 72*, 73*, 74* and 84
  *Requires 40-pin ZIF adapter ($49.95)
- Requires IBM PC or compatible with parallel port, DOS 2.0 or better
- Includes programmer, 8051-like assembler, software simulator and application notes

SPECIAL

Part No.	Description	1-4	5-9
132898	PIC prog. pack Special		$99.95

PARALLAX Basic Stamps



130892

Basic Stamps are small computers using a variation of Basic, called PBASIC to control execution of many applications. The BS1-IC has 8 I/O lines, while the BS2-IC has 16 I/O lines.

Specifications:

	BS1-IC	BS2-IC
EEPROM	256 bytes	2048 bytes
RAM	14 bytes	26 bytes
Max. prog. length	80 instructions	500 instructions
Clock speed	4MHz	20MHz
Program speed	2000/sec.	4000/sec.
Max I/O speed	2400 baud	50K byte
Package	14-pin SIP	24-pin DIP
PC Interface	Parallel	Serial
Size	1.4"L x 0.4"W	1.2"L x 0.6"W

Part No.	Description	1-4	5-9
127693	BS1-IC SALE		$34.95
130892	BS2-IC SALE		49.95

Resistor Assortments

Part No.	Description	1-9	10-24
107836	1/2W carbon film 5 each 70 values (from standard 161 values, every other value from R10Ω-R5.6MΩ) 350 pcs.	$12.95	$11.49
107861	1/2W carbon film resistors 100 each standard 161 values (16,100 pcs.)	179.95	161.95
10719	1/4W carbon film 5 each 70 values (from standard 161 values, every other value from R10Ω-R5.6MΩ) 350 pcs.	9.95	8.95
10655	1/4W carbon film resistors 100 each standard 161 values (16,100 pcs.)	119.95	107.95
108281	1/8W carbon film 5 each 70 values (from standard 161 values, every other value from R10Ω-R5.6MΩ) 350 pcs.	10.95	9.95
108311	1/8W carbon film resistors 100 each standard 161 values (16,100 pcs.)	149.95	134.95

Jameco Solderless Breadboards

20773

- Low static plastic body – CMOS safe
- Nickel plated clips designed to withstand up to 5,000 insertion cycles

Part Number	Contact Points	Size L x W	Pricing 1-9	10-49
94457	100	6.5 x 0.4	$2.49	$2.25
20343	200	6.5 x 0.8	3.95	3.49
20600	400	3.3 x 2.1	4.95	4.49
20669	630	6.5 x 1.4	4.95	4.49
20722	830	6.5 x 2.1	6.95	6.25
20757	1,360	6.5 x 3.1	SALE	11.49
20773	1,660	6.5 x 4.3	16.95	14.95
20790	2,390	6.9 x 5.8	SALE	19.95
20811	3,220	7.3 x 7.5	29.95	27.95

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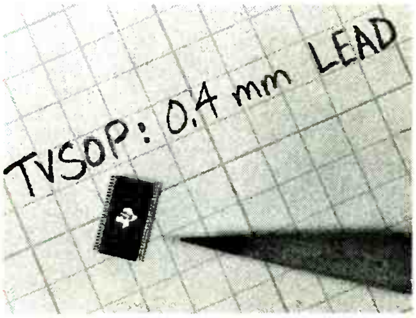
WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

Smallest Dual-in-Line Packages

A family of semiconductor packages developed by Texas Instruments (Dallas, TX) requires approximately 40% to 60% less board space than comparable, previous-generation SSOPs (Shrink Small Outline Packages). The new Thin Very Small Outline Packages (TVSOPs) will allow designers of portable computer and communications products to create smaller systems with improved performance.

TVSOPs feature a lead pitch of 0.4mm and meet the 1.2mm height restriction of the PCMCIA (Personal Computer Memory Card International Association) standard for credit-card-size add-on modules for notebook and



TEXAS INSTRUMENTS' THIN VERY SMALL OUTLINE PACKAGES (TVSOPs), which require about half the board space of Shrink Small Outline Packages (SSOPs), will allow engineers to design smaller, higher performance portable computers.

laptop computers. They are made using TI's multi-layer palladium lead-plating process, which assures the most consistent soldering and manufacturing performances. The TVSOP family features packages with 14, 16, 20, 24, 48, 56, 80, and 100 pins. TVSOPs with 14 to 56 pins have lower inductance than TSSOPs (Thin Small Outline Packages) and SSOPs. Devices placed in the packages with lower inductance will achieve greater speeds and improved performance.

The first TVSOP devices, which will be made by TI's Advanced Systems Logic group, will include high-performance 5-volt (ABT and AHC) and 3.3-volt (ALVC and LVC) logic families.

Super-CAD Car Design

Ford Motor Company (Dearborn, MI) will use the world's most powerful supercomputer—an IBM RS/6000 SP—to reduce the time it takes to bring new cars to market. The computer is located at the Cornell Theory Center (CTC) in Ithaca, New York. Ford is a new member of CTC's Corporate Partnership Program.

The physical prototyping of automotive parts and components is not only time-consuming and expensive, but also limits the number and accuracy of the scenarios that engineers can initiate. High-performance computing (HPC) replaces physical parts prototyping with numerical simulations.

"We're eager to scale up the numerical simulations to help system design," explained George Shih, a supervisor in Ford's Advanced Vehicle Technology group. "HPC will help us reduce the time from initial design to a new car rolling off the assembly line." Streamlining the design process is crucial to ensure U.S. auto industry competitiveness in a global market.

"Our 512-node IBM RS/6000 SP and new high-performance storage system offer the industry a unique, scalable environment to develop and test solutions to complex engineering problems ranging from computational fluid dynamics to crash simulations," said Malvin H. Kalos, CTC's director.

Ford's simulations will include under-body, under-hood, power trains, and exteriors. Software will be tested for scalability and performance.

New Jersey Research Center

Last spring in Lyndhurst, New Jersey, Daewoo Electronics Company, Ltd. (Seoul, Korea) established an advanced research center for the development of next-generation non-memory semiconductors, digital-broadcasting systems, multimedia software and hardware, and futuristic consumer-electronics products such as high-definition and digital VCRs. The company plans to invest a total of $30 million over a five-year period in Daewoo Electronics Research Center in America (DERCA), which is expected to employ 60 local researchers this year and increase that number to 100 in 1997.

Daewoo's Technical Center in Korea and the new U.S. research center will work in cooperation with the David Sarnoff Research Center on the development of non-memory chips. DERCA will also work with Daewoo's local sales subsidiary in New Jersey and its production plants in Mexico to form the first stage of a pan-American network of research, production, and sales facilities.

Lassie, Come Home

The HomeAgain Animal-Companion Retrieval system uses microchips implanted into dogs and cats to provide permanent identification for recovering lost or stolen animals. The microchip is part of a 24-hour, nationwide system that already includes an estimated 61,000 animals and has been responsible for some 620 recoveries since it was launched a little over a year ago. The American Kennel Club (AKC) manages the retrieval system database.

A rice-sized transponder is injected into the scruff of the animals neck. Available through veterinarians, the microchip is programmed with a unique code that is displayed when read by a hand-held scanner. The system can be

used in dogs of all ages and cats that are at least six months old.

Speeding Up World's Fastest Web Site

Walnut Creek CD-ROM's Web site, the largest and most active Internet site, has been upgraded with a 100-megabit link—making it the site with highest bandwidth as well. The server is a 150-MHz Pentium-Pro computer running FreeBSD Unix, a high-performance multitasking operating system designed for internet users.

The site provides free access to more than 72 gigabytes of high-quality software, shareware, and information. During the first three months of 1996, more than 300,000 downloaded a total of 29 million files—more than six trillion bytes of information. The site is home to the Simtel collections of Windows and MS-DOS software, the Slackware Linux project, the Blackhawk Windows 95 collection, and the NewT Windows NT archive. It also contains collections of Unix programs, images, and technical documents. Walnut Creek CD-ROM's Web site can be reached at http://www.cdrom.com or ftp.cdrom.com.

Computerworld Smithsonian Award to General Motors

The 1996 Computerworld Smithsonian Award (CSWA) for technology innovation in transportation went to General Motors (Troy, MI) for its OnStar vehicle integrated service system. The award cites OnStar for "its innovative application of technology for the auto industry which is destined to change our driving experience forever."

OnStar, which will be available on most 1997 Cadillac models, uses three technologies to provide several safety, security, and convenience features. Global Positioning System (GPS) satellite technology provides vehicle location; a hands-free, voice activated cellular phone transfers voice and data between the car and the 24-hour OnStar Center; and an integrated vehicle system built into the car links OnStar to all of the car's on-board computers, allowing the system to remotely unlock doors, detect when an airbag deploys, and report when a car is being stolen.

The OnStar technology will be included in "The Information Age: People, Information and Technology," a permanent exhibit at the Smithsonian Institution that has been visited by more than 3 million people. OnStar will also have a page on the Innovative Network (http://innovate.si.edu), the CWSA Web site.

Alliance for Internet-Ready Products

National Semiconductor Corporation (Santa Clara, CA) is using technology from Sun Microsystem's (Mountain View, CA) JavaSoft business unit to provide a new generation of Internet-enabled products that will combine JavaOS with National's embedded processor and analog mixed-signal technologies. The result will be products with built-in connectivity, such as the iPhone, a full-featured telephone with built-in Internet access, which National is developing with recent spinoff InfoGear Technology Corporation (Redwood City, CA).

"We believe that the market for consumer information appliances is huge, said Robert Marshall, CEO of InfoGear. "Bringing Java to the embedded world will provide the iPhone with a rich and growing software development base. Together, [our three companies] combine the consumer device with software and silicon solutions that will quickly bring the iPhone to the marketplace and stimulate volume production."

The potential ramifications of this technology are embedded systems designs that allow large-scale functionality and connectivity. The technology will address the changing needs of OEM customers who want to build a new generation of products that can be controlled, monitored, and reprogrammed via networks. Applications include consumer products, wide area networks, remote access, and multifunctional office equipment.

Added Support For CompactFlash

As of June 10, 21 new members had joined the CompactFlash Association (CFA), bringing the total number of members to 44. The CFA promotes the adoption of CompactFlash as a new industry standard for removable digital storage. The new members are prominent companies in the computing, semiconductor, connector, component, imaging, communications, and consumer-electronics fields, including major players such as Konica, MCCI, Mitsubishi, Psion, Sanyo, Siemens Nixdorf, and TDK. They join CFA founders Apple Computer Inc., Canon, Eastman Kodak Company, Hewlett-Packard, LG Semicon, Matsushita, Motorola, NEC, Polaroid, SanDisk, Seagate, and Seiko Epson.

The CompactFlash storage card is a tiny, removable data-storage system introduced in October 1994 by SanDisk. It meets all PCMCIA standards, and can be easily slipped into a low-cost, passive Type II adapter card that then can be used to move digital data, images, and audio to any standard PC card slot in computers, printers, set-top boxes, and other electronics platforms. CompactFlash provides the lowest cost flash storage solution for capacities of 2MB and above, and can operate at either 3.3 or 5 volts. EN

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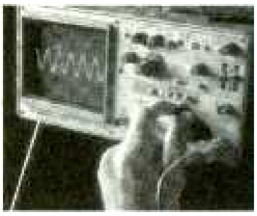

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VIDEO NEWS

WHATS NEW IN THE FAST-CHANGING VIDEO INDUSTRY

BY DAVID LACHENBRUCH

HDTV Chipset

Two semiconductor manufacturers have announced the joint development of a five-chip set that they say could make possible mass production of digital HDTV in 1998—and at a reasonable price. Mitsubishi in Japan and Lucent in the U.S. made the announcement. Lucent is the former manufacturing and R&D arm of AT&T, and its chips have been developed by its Bell Laboratories operation. Bell Labs made major contributions to the establishment of the original U.S. standards for monochrome and color TV.

The chips are designed to "perform all the functions needed for next-generation high definition TV sets for the U.S. market," the companies said. Both plan to sell chips to receiver makers, and Mitsubishi has already announced its first customer: its own TV-manufacturing operation. The chips will combine some 10-million transistors and associated circuits. The first samples are due in early 1998, and production quantities later that year.

The chipset will consist of: (1) a demodulator to separate digital signals from the analog carrier; (2) a demultiplexer to separate audio from video signals; (3) an image encoder to decompress the encoded video signal; (4) an audio decoder to accomplish the same function with the audio signal; and (5) a display processor to transform the video signals to the proper format for the display used (CRT, projection system, plasma display, etc.).

The chips are designed for the Grand Alliance system—the digital HDTV system developed jointly by broadcasters, manufacturers, and research companies, and the subject of widespread tests. At our deadline, strong pressures were being exerted to derail the system. One group in Congress is demanding that the FCC abandon any effort to set standards for HDTV, on the grounds that any standard would freeze technology at today's standards.

A group representing some computer manufacturers is insisting that the FCC reject the Grand Alliance's provision for both progressive and interlaced scanning and permit progressive scanning only, on the grounds that interlaced scanning isn't compatible with computers. TV broadcasters and manufacturers argue that if the FCC doesn't set a standard, it will kill HDTV forever, and that abandoning interlaced broadcasting will make it difficult to manufacture inexpensive TV sets (such as small-screen models). They add that progressive scan also would be used to feed better pictures to higher-priced sets.

Sony's Video Eyeglasses

Sony has introduced a "personal head-mounted LCD monitor" in Japan for viewing images from a VCR, TV, or video CD. The "Glasstron" is priced at the equivalent of about $800. It contains two 0.7-inch color LCDs, each with 180-pixel resolution, which Sony says provides the equivalent of a 52-inch monitor viewed from six feet. A "see-through" function electrically changes the degree of transparency of the LCD to produce the illusion of watching an image hanging in mid-air. The system incorporates a stereo headset. A companion portable video CD player costs around $300. Sony says that it has no plans to offer Glasstron in the U.S.

Two-Way Wireless Cable

"Wireless cable," or multiple microwave distribution systems (MMDS), by definition, would seem to be a one-way medium. However, American Telecasting has completed a test in Lakeland, Florida, of a system that delivers two-way, high-speed data service and Internet access using cable modems. The system used Zenith cable modems, at 500 kbps, and proved that wireless cable can operate at the same speeds as the fastest wired cable modems, the company says.

The tests used $20 antennas and off-the-shelf transceivers. Subscribers in various sectors use two different transmitter frequencies, with both channels reused 24 times, each feeding a small arc. If transmitting arcs are as small as 7.5 degrees, each wireless cable system can handle up to 100,000 customers with just two transmitting frequencies, American Telecasting estimates.

"Micromirror" Projection TV

The magic word in the world of projection video these days is "Micromirror." More than a dozen projectors have been displayed that use Texas Instruments' Digital Micromirror Device (DMD) for ultra-bright digital pictures. The first projectors are designed for industrial use, but consumer models are on the way.

Projectors using TI's DMD chips are identified by the trademark and logo "DLP" (for Digital Light Processing). DMD chips are made on standard semiconductor manufacturing equipment. Each one contains about 500,000 hinged microscopic mirrors that can be activated mechanically to reflect light into a lens by the application of a voltage. The most impressive DMD projector is the one about to be marketed by Digital Projection Company, using three chips and producing a theater-sized picture with brightness and resolution rivaling that of 35mm film. Sony and Electrohome have also shown 3-chip systems.

Portable projectors using single-chip systems have been demonstrated by ten other manufacturers, principally for display of computer data, and several are now on the market. Runco and Vidikron both plan systems for high-end home-theater installations, at just under

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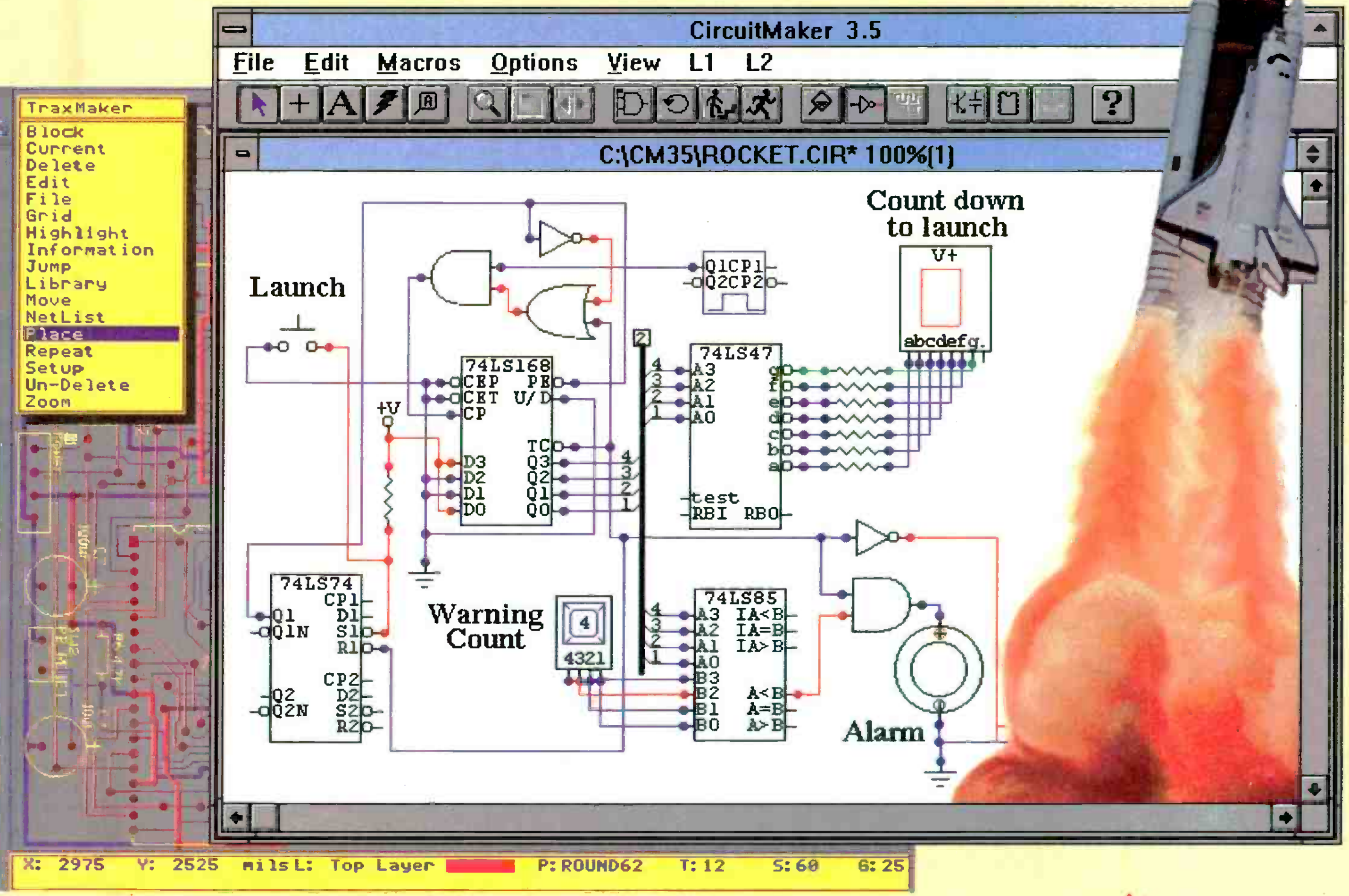

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$10,000. The first two-chip system is being demonstrated by Projectavision, whose Digital Home Theater, slated to sell at $7000 to $9000, is convertible from rear to front projection by removing the portable projector from its cabinet and changing the lens.

There are indications that TI won't be alone for long in the microscopic mirror semiconductor business. Japan's Hitachi and America's Raychem have joined forces to develop a mirror semiconductor, but unlike TI's moving mirrors, theirs are fixed. Their reflectability is determined by applications of modulating voltages rather than physically tilting the mirrors. Raychem says that assures the brightest possible, least expensive display.

Another microscopic mirror semiconductor has been developed by California-based Aura Systems and licensed to Korea's Daewoo Electronics. Its Actuated Mirror Array (AMA), like the other two systems, consists of tiny mirrors mounted on a semiconductor. Unlike TI's DMD mirrors, which must be either on or off, Aura says that AMA's mirrors can be varied in light intensity by changing the tilt angle of each mirror. The result, Aura claims, will be better brightness at lower cost. EN

Q & A

READERS QUESTIONS, EDITORS ANSWERS

Detecting Cut Phone Line

Q *Would you please design a simple circuit to sound an alarm if my phone line is cut? It should switch a relay to trigger an alarm if the phone line voltage suddenly goes to zero. —J. H. G., Falmouth, MA*

A Detecting a cut phone line can be an important function of an electronic security system. It's not uncommon for burglars to start their work by cutting the telephone line so that no one can summon help.

Unfortunately, detecting a cut phone line isn't easy because the voltages on a normal phone line vary so much. The voltage is typically 48-volts DC when the telephone is on the hook, 2- to 15-volts DC during a conversation, 90-volts AC during ringing, and 200-volts DC when the telephone company is testing the line. Brief moments of 0 volts are common; what you really want to detect is a voltage that goes to zero and stays there.

A second restriction is that the cut-phone-line detector can't draw any appreciable current. Its impedance has to be higher than 50 megohms, or the telephone company will think it's a leaky cable.

Figure 1 shows a circuit you can try. It uses two transistors in a Sziklai (complementary Darlington) configuration to detect currents as small as 0.05 microampere. Be sure to use transistors that are in good condition and free of leakage.

Components R1, R2, R3, and C1 smooth out momentary variations in voltage so the alarm doesn't trigger every time the telephone rings. If the voltage stays at zero for thirty seconds or more, the alarm should trigger. The load can be a piezo buzzer, an optocoupler, or a small relay.

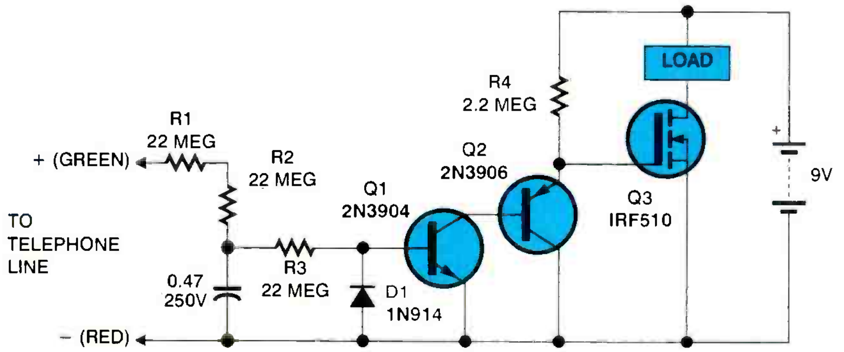

FIG. 1—THIS CUT-PHONE-LINE-ALARM energizes if the line voltage drops to zero for more than a few seconds

Because of the tiny currents it must detect, this circuit should be powered by its own 9-volt battery, with no direct connection to the rest of the burglar alarm. Otherwise a slight difference in ground potentials might cause the circuit to perform somewhat erratically.

Printer Port Input?

Q *I have a program that uses bit 2 of the printer port to clock in data. How are they doing this? Are there other ways of inputting from the port? Is there some reference on the hardware? — M. S., Columbus, NE*

A The parallel printer port of a PC works a lot like the bus of an 8-bit microprocessor. It uses 5-volt TTL logic levels and can interface to all sorts of microprocessor peripherals.

Most newer printer ports are bidirectional, which means that the 8 data lines can be used for input as well as output. Even the older unidirectional ports have several input lines for checking the printer status.

There are various DOS and BIOS services for printing, but the simplest way to access the printer port is to write data to its port address (hex 3BC, 378, or 278) and read status bits from the next higher address (3BD, 379, or 279 respectively). The OUT command and INP(...) function in BASIC and the port[...] array in Turbo Pascal accomplish that. Each of them transmits a byte at a time.

Many newer ICs don't need all eight data lines; they use a serial interface requiring just three wires—clock, data, and ground. To receive data, the PC sends pulses to the clock pin, and then, immediately after each pulse, looks for data on the data pin, as shown in Fig. 2. Three-wire serial interfaces are widely used with analog-

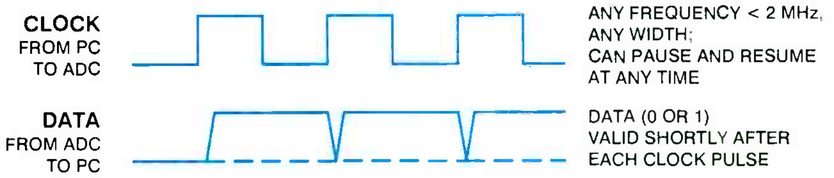

FIG. 2—THE TIMING DIAGRAM for a 3-wire serial communications port. The clock pulses tell the ADC when to deliver each bit of data. The third wire is ground.

to-digital converters (ADCs) and serial EEPROMs.

Unlike RS-232 serial ports, three-wire serial interfaces do not have a fixed baud rate; each pulse can be any length (above a certain minimum) and the computer can pause at any time. Thus, nothing goes wrong if a multitasking computer has to turn its attention to something else for a moment.

A working circuit that uses a PC parallel port to receive data from a 10-bit analog-to-digital converter (Texas Instruments TLV1549) is shown in Fig. 3; it uses the program in Fig. 4. Besides the three wires already mentioned, we use a fourth wire for reset (chip select) and a fifth one as a source of power. That's right—the TLV1549 uses so little current that it can be powered from a logic-level signal. In fact, if your printer port produces 5 volts (not all do), you can use the more common TLC1549. Resistor R1 reduces transmission errors by isolating the ADC from the cable capacitance; it may be unnecessary if the cable is short.

More information about parallel ports is available on Jan Axelson's web pages at *http://www.lvr.com*, which also includes code to do port I/O under Windows. See also *MicroComputer Journal*, May 1994, pp. 14–26; July 1994, pp. 69–78; September 1994, pp. 65–76; and Nov. 1995, pp. 32–35. Those articles are not available from us, since it's not our magazine, but your public library should be able to obtain copies. For still more sources of information, see the next question.

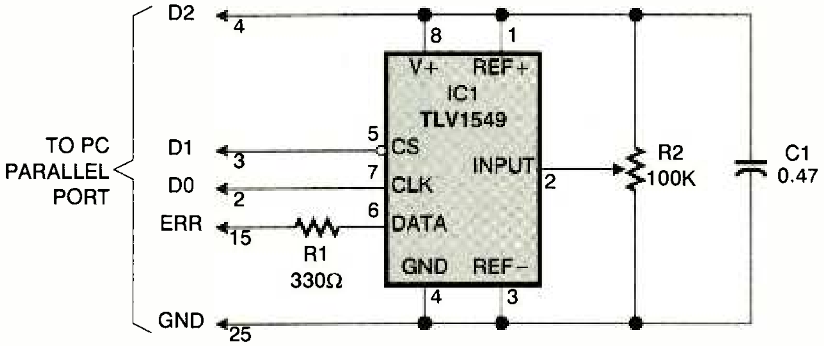

FIG. 3—THIS ANALOG-TO-DIGITAL CONVERTER transmits 10 bits of data to the PC through the PC's printer port, which also powers it.

PC Pinouts and Technical Data

Q *Where can I obtain pinouts and signal specifications for the connectors used on personal computers, such as VGA, SVGA, RS-232, RS-422, RS-485, Centronics (printer), IDE (hard drives), AT and PS/2 keyboards, mice, and the TV standard for video and sound? – J. K., Beloit, WI*

A Most bookstores have a few books on repairing PCs, but we assume you want to go deeper. One book you will find indispensable is *Pocket PCRef*, by T. J. Glover and M. M. Young (Sequoia Publishing, 1994). It gives most of those pinouts, along with memory and port maps, error codes, switch settings, and a huge table of hard disks by make and model with their parameters and settings.

To learn how a PC actually works, read *The Personal Computer from the Inside Out*, by M. Sargent and R. L. Shoemaker (Addison-Wesley). That is an update of a classic book from the 1980s. And for an electronic engineer's view of the PC, see the computer chapter in *The Art of Electronics*, by Horowitz and Hill (Cambridge University Press). Any good bookstore should be able to order those books.

IBM technical manuals are a valuable but often-overlooked source of information; after all, IBM invented the PC. You can get a catalog of available manuals by calling 1-800-879-2755 or viewing IBM's web page, *http://www.pcco.ibm.com/desktop/pcdcat.html*. If you find an original blue-covered PC XT or AT *Technical Reference* at a swap meet, snap it up; it's still the best source for some kinds of information. The original PC manual even included schematics.

Finally, note that most computer

```
' QBASIC program to read data from TLV1549 ADC

CLS
port = &H378    ' or 3BC or 278

' Initialize the TLV1549

OUT port, 6   ' binary 110: pwr on, CS high, CLK low
OUT port, 4   ' binary 100: pwr on, CS low,  CLK low

' Take readings until the user presses a key

again:
  ' Clock in 10 bits, assemble into a binary number
  ' Note: First reading after initialization is invalid.
  result = 0
  FOR i = 1 TO 10
    bit = (INP(port + 1) AND 8) / 8
    result = 2 * result + bit
    OUT port, 5     ' Take CLK high and then
    OUT port, 4     ' low, to request next bit
  NEXT i

PRINT result
IF INKEY$ = "" GOTO again

OUT port, 0   ' turn it all off
END
```

FIG. 4—THE QBASIC PROGRAM in this listing reads the data from the circuit in Fig. 3.

manufacturers have web sites with information available. For example, *www.maxtor.com* gives up-to-the-minute information about Maxtor hard disks.

One at a Time?

Q *I have call waiting and would like to receive incoming calls without losing my modem connection. Is that possible? — A. G. H., Lexington, KY*

A Only by modifying the modems on both ends, not just your modem. When two modems are connected together, each of them transmits a continuous carrier tone which is phase-modulated with data. If the carrier goes away, the modem assumes it has lost its connection and hangs up. That is desirable, because modems *do* lose their connections, by accident, fairly often.

Call waiting notifies you of an incoming call by interrupting your connection for a moment and sounding a beep. When it does so, the modems can't hear each other's carriers, and they hang up. You could modify them to wait patiently during the beeps, and then resend whatever data was being sent. This would require changes to both modems and the communication protocol. Actually, Windows 95 Dial-Up Networking *will* redial if it loses its connection and pick up right where it left off. Other protocols may do the same.

But even then, you wouldn't be able to talk on the phone while transferring data by modem. The reason is that a modem uses the full information-carrying capacity of the phone line, and so does a normal voice conversation. If the line had the bandwidth to carry two conversations, the telephone company would install multiplexing equipment themselves and sell it as two lines, not one. You can use it for voice or data, but not both at the same time.

Seeking Prescaler

Q *I have been searching without success for an IC that can be configured as a divide-by-100 prescaler and can accept inputs up to 2 GHz or higher. Can you help? — T. E. P., Gadsden, AL.*

A A prescaler is used in front of a frequency counter to divide the frequency so that the rest of the counter doesn't have to count so fast. For example, a 10-MHz counter with a divide-by-100 prescaler will go up to 1 GHz.

Try the GEC Plessey SP8904B, an ECL prescaler that divides by 10 and goes up to 7 GHz. To divide by 100, use two of them in a row. Plessey can be reached at 408 438-2900.

HOW TO GET INFORMATION ABOUT ELECTRONICS

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, Tel: 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 1991 only) are available from 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 (Tel: 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, Box 637, Spanaway, WA 98387.

Replacement transistors, ICs, and other semiconductors: Replacement components for a wide variety of popular devices is marketed by Philips ECG, NTE, and Thomson (SK) and 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; therefore, 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.

Internet: On the internet, electronics is discussed in Usenet newsgroups such as *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 now 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.

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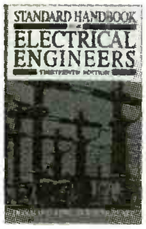

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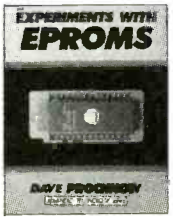

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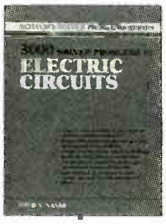

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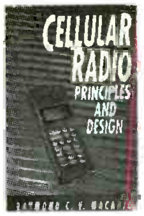

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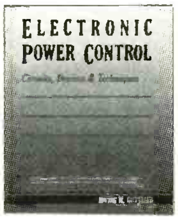

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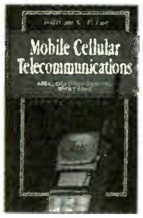

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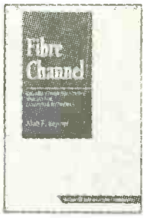

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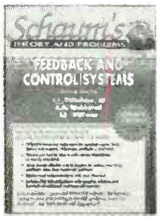

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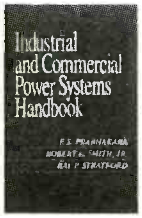

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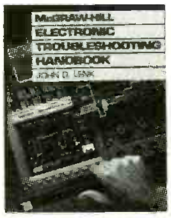

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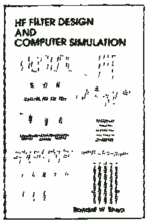

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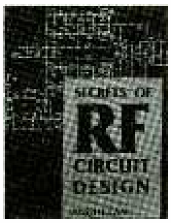

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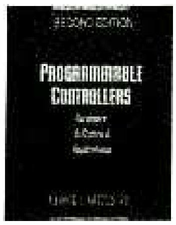

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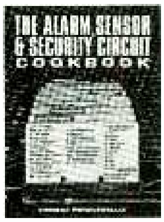

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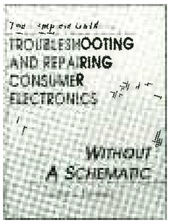

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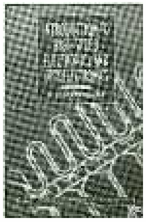

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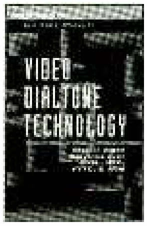

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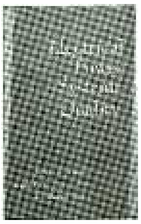

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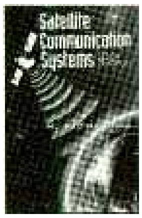

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LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Oops!

Due to a printing error, the author's byline did not appear in the September, 1996 installment of "Servicing." The column was written that month by Dick LaJeunesse of Tektronix, Inc. We apologize to Dick and our readers for that omission—Editor.

Corrections To Power Factor Correction

Don Lancaster's article on power factor correction ("Hardware Hacker," **Electronics Now**, June 1996) is apt to cause more confusion than he attempted to alleviate. It contained several misstatements that were either potentially misleading or outright wrong. I shall attempt to correct some of them.

First, his definition of a linear component as one whose operation does not change with time is, in fact, a statement of the property of "time-invariance" and not linearity. Linearity requires two conditions to be true. The first is that the output (voltage, current, etc.) must scale in direct proportion with the input (i.e., if the input is doubled, the output will double). For most devices, some limit will be reached where that will no longer hold true. When that happens, you are said to have "exceeded the linear region of operation" of the device. Condition two states that the output due to the sum of one or more simultaneous inputs must be identical to the sum of the individual outputs produced by each input acting alone. Together, those conditions imply that the circuit/system/component is operating in its "linear region" and that "superposition" applies.

More to the point of the article, a voltage sinewave applied to an inductor will produce a "negative" cosine current waveform, not a current waveform as stated. That must be true if the current is to lag the voltage by 90 degrees. In the case of a capacitor, the applied voltage sinewave will produce a "positive" cosine current waveform, and the current will lead the voltage by 90 degrees.

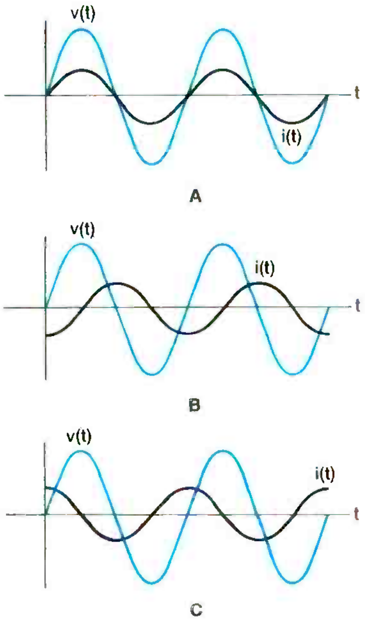

FIG. 1—VOLTAGE CURRENT WAVEFORMS FOR (A) a purely resistive load (current and voltage are in phase); (B) a purely inductive load (current lags the voltage by 90 degrees; and (C) a purely capacitive load (current leads the voltage by 90 degrees).

The lag/lead wording in "Hardware Hacker" was correct, but the positive/negative statements were reversed. In addition, while the diagrams in the article's Fig. 1 were correct, they were also, unfortunately, unlabeled. The Fig. 1 that accompanies this letter and shown here indicates the relationship between the current and voltage time waveforms for purely resistive, inductive, and capacitive loads.

Another, more serious error occurred in Mr. Lancaster's definition of power factor (PF) as the ratio of real power to reactive power. If that was true, a resistor would have a PF of infinity instead of 1 as (correctly) stated.

Power factor is actually the ratio of real power to another quantity called the "apparent power," which is itself the product of the RMS voltage and the RMS current for any given load. That is equal to the cosine of the angle between the voltage and the current waveforms (which was correctly stated). Just as an interesting point, that angle is also the angle of the complex impedance of the load when expressed in polar form.

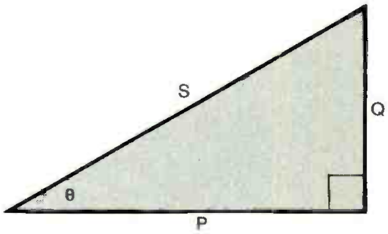

FIG. 2—POWER TRIANGLE FOR a predominantly inductive load.

The usual way to depict all of those powers is with the "power triangle" shown here in Fig. 2 for a predominantly inductive load and in Fig. 3 for a predominantly capacitive load. In both figures, S equals the "apparent" power, P equals the "true/real/average" power, and Q equals the "reactive or quadrature" power. Note that S-squared = P-squared = Q-squared because the

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triangle is a right one. Now it can be seen that if the load is purely resistive, Q = 0, which forces the indicated angle to zero. Therefore, S now equals P, and the power factor is unity as required. For a purely reactive (inductive or capacitive) load, the indicated angle will equal ±90° and the power factor will be zero.

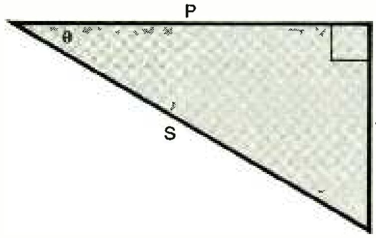

FIG. 3—POWER TRIANGLE FOR a predominantly capacitive load.

For companies with a lot of inductive loads (drills, lathes, mills, etc.) the angle can be quite large. The apparent power as well as the current will then be high. That costs the company money both in power-company bills and in equipment damage due to wire and cable heating, insulation breakdown, accelerated aging, etc. "Power-factor correction" is a method to reduce those problems by adding parallel capacitance to the loads. Because it is in parallel, the additional capacitance will not affect the operation of the load but will act to reduce the angle and increase the power factor back toward unity. The net effect is to make the load "look resistive" to the power company by forcing the voltage and current waveforms back into phase.

That so-called "ancient" electrical engineering concept is still very important and should be given careful consideration. More information on circuit theory can be found in most electrical engineering textbooks.

JAY RABKIN
Pasadena, CA

Tesla Defended

When Don Lancaster discussed Nikola Tesla and Tesla coils in his "Hardware Hacker" column (**Electronics Now,** July 1996), he advised readers to limit their research to books written by Tesla rather than "the errant ramblings" about him being circulated by new-age publications. That's good advice, and Mr. Lancaster would do well to follow his own suggestions. His references to Tesla in past columns have on some occasions been nothing more than errant ramblings.

I agree with Mr. Lancaster's views on "free energy" in that over unity in energy output has not yet been substantiated. Tesla believed that the universe was a vast reservoir of energy and proposed that mankind might someday attach its wheels of industry to it. Perhaps that is the root of all the myths regarding so-called free energy. But why berate Tesla for coming up with such a worthwhile objective?

We know from Tesla's writings that he accomplished an amazing over unity in power output. His Colorado Springs Magnifier achieved power levels of 120,000 horsepower at 280 times per second. That feat makes our modern marvels of electrical engineering appear tame in comparison. Most produce powers on an order of magnitude less than the Colorado Springs device. The highest potentials that can be maintained at a repetitious rate rarely reach 70% of Tesla's 1899 apparatus. Tesla's unfinished Long Island plant was designed to produce 30,000,000 volts.

Incidentally, Tesla coils are not just for entertaining or frightening visitors to science centers. They are legitimate scientific instruments that continue to be used in various industries that need a source of RF power.

HARRY GOLDMAN
Tesla Coil Builder's Association
Queensbury, NY

EN

EQUIPMENT REPORTS

RADIOSHACK DMM WITH COMPUTER INTERFACE

A quality, extra-feature digital multimeter becomes an advanced data-acquisition system when you connect it to your PC.

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When asked to review a digital-multimeter, I yawned. However, my eyes opened wide when I began reading the manual for the Radio Shack LCD Digital Multimeter, Model 22-168A. Like most other quality DMM's, it is a portable, 3½-digit, hand-held, test instrument for use in the field, lab, shop, and home. A bit more than a fist full in size, the DMM is 7¼-inches long × 3¼-inches wide × 1½-inches high and has a 2½×1¼-inch, full-function LCD display. Its most significant feature is that the DMM can be connected to a desktop or laptop PC to store measurement data. A diskette packaged with the DMM provides MS-DOS and Microsoft Windows software that interfaces the DMM with the computer to log and graph measurements.

Initial Checkout

The initial inspection of the DMM checked how it functioned as a *standard*, stand-alone, digital multimeter. The DMM's ability to measure accurately AC/DC voltages, AC/DC current, capacitance, resistance, and frequency was on par with the current stand of quality DMMs of equal or greater price. The same was true for the DMM's ability to check continuity, and diodes, transistors, as well as logic states. What makes this DMM a real winner is its many other special functions.

Auto-hold feature. When the DMM is first turned on, "A-H" appears in the upper left comer of the LCD display to indicate that the auto-hold feature is on and secondary display shows the reading taken four seconds earlier.

Compare function. The user can rapidly compare measurements to stored high- and low-reference values. If the measured value is between the reference values, the meter's secondary display shows "PASS". If the measured value is above the upper reference voltage or below the lower reference value, the meter displays "HIGH" or "LOW", respectively. The reviewer found it handy for selecting matched resistors to within 1% of value.

Data-hold feature. The DMM stores a voltage or current reading on the secondary display. The main display continues to track the present measurement.

Minimum feature. The DMM lets the user measure the minimum value of a changing reading. When the FUNCTION button causes "MIN" to appear at the top of the display, both the main and secondary displays show the current reading. Press the SET/RESET button to activate the minimum feature. The secondary display only updates when the present reading is lower than the previously held reading.

Maximum feature. This feature is the opposite of the minimum feature. The secondary display only updates when the current reading is higher than the previously held reading. The main display continues to track the current measurement.

Relative-measurement feature. The DMM measures values relative to a reference value that is pre-set. For example, in an audio amplifier you might have an 18-volt power bus to the final audio-amplifier stage. You could monitor the voltage as it decreases on the bus as the unit's volume control is raised for the purpose of evaluating the power-regulation performance.

Interfacing with a Computer

The DMM connects to a computer using the supplied RS-232C cable between the meter's and the computer's serial ports. The communication parameters are: 1200 baud, 7-bit ASCII, no parity, and 2 stop bits. The data format consists of 14 bytes.

Two programs are supplied on a diskette with the DMM—one for MS-DOS and the other Windows 3.1 or better. They are used to log and display data collected from the DMM. The MS-DOS program is called RS, and is in the GRAPH/C subdirectory. That software requires a VGA monitor. The Windows program is called Scopeview, and is in the SCOPE directory. That software requires a VGA or EGA monitor.

It is best to run the programs from your PC's hard drive; however, you could copy the diskette and run the programs from the diskette in your A or B drive if you wish. In any event, you don't have to be a computer buff to load and run the programs. By following the instructions in the manual and on-screen directions, you become an expert after the first go-around! The supplied programs let you sort and print out a recorded log of measurements and even graphs.

For those who know BASIC, you can create your own software to go beyond that or to create customized applications. The manual provides a simple program that you can build on to get you started.

Wrap Up

Can we cover it all in this limited space? No! What was not covered in

continued on page 80

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Three new features minimize user setup and operating errors. First, a graphical display of the waveform up to 50 MHz shows the triggering conditions for the counter, ensuring the user of a correct count based on valid trigger points. The LCD also displays a shaded hysteresis band to eliminate false counts, and the peak-to-peak voltage. Second, the multi-measurement readout can display up to ten voltage and time measurements simultaneously, (unlike traditional counters, whose displays show the result of only one selected measurement). Third, the Models 163 and 164 feature uncluttered front panels and a simple menu system. The user determines the type of measurement required, selects it, presses "autoset," and the counter takes care of the rest.

In addition to the values and waveform display modes, the Model 164 has a statistics mode that provides deeper insight into signal behavior and shows underlying trends that no single measurement reading could possibly reveal. The unit's statistics mode displays parameters such as the mean value, standard deviation, and maximum/minimum values.

The Model 163 has a base price of $1495. The Model 164 starts at $1895; with the temperature-compensated crystal oscillator and 1.3-GHz option it costs $2395; with the high-stability, ovenized oscillator and 1.3-GHZ input it costs $2795.

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Spectrum Analyzer Scope Adapter

GLOBAL SPECIALTIES MODEL GSA-1000 converts any conventional oscilloscope into a highly-accurate, cost-effective 1-GHz spectrum analyzer. When connected to an oscilloscope via two BNC cables, the spectrum-analyzer adapter provides a frequency range of 400 kHz to 1 GHz and a bandwidth of 150 kHz. The center frequency can be adjusted over the full frequency range with direct frequency readout on a large LCD. Both scan width and scan rate are fully adjustable.

The Model GSA-1000 can be used in research and development, servicing, and education. Specific applications include estimating spurious emissions

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from equipment; checking oscillator and transmitter harmonics, output levels, and antenna efficiencies; tracing RF signals through signal paths; and making rapid comparisons between good and faulty equipment. As an educational tool, it can be used to demonstrate components in waveforms and show the effects of mixing and intermodulation.

The Model GSA-1000 spectrum-analyzer oscilloscope adapter costs $1050.

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Designed to be used in the family room, the Print-It measures a compact 10 × 12 × 13 inches. It uses Fujifilm's Thermo-Autochrome technology, which requires no inks, toners, or ribbons. As in conventional photography, the paper contains the dye, which gives the prints real photo-like quality, with even the finest details sharply rendered. The paper tray holds up to 20 sheets.

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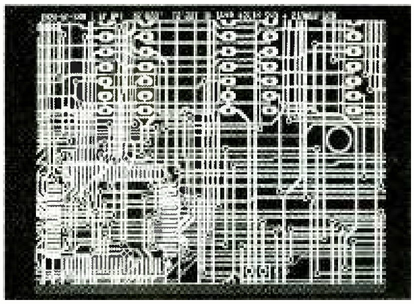

Gridless routing makes it easy to handle difficult components, such as D connectors and surface-mount packages, getting the maximum use of available space. The routing algorithm is based on shape—the only constraints are the design rule clearances and track-width limit. As each net is routed, existing tracks are shoved aside to make room. If all routes appear to be blocked, the MultiRouter will rip up and retry problem areas until a solution is found.

When all the nets are routed, the MultiRouter can also be used to fatten the tracks, miter corners, and eliminate unnecessary track segments and vias. The router will complete most designs in minutes, saving days of layout design time.

The MultiRouter and EASY-PC Professional XM software costs $575 and $475, respectively. Prices include airmail shipping.

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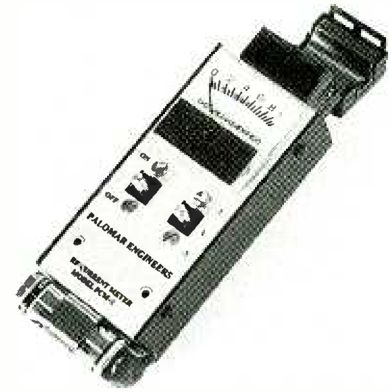

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The PCM-1 clamp-on RF current meter costs $125 plus $6 shipping (to the U.S. and Canada).

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continued on page 80

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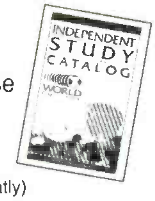

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A Visit To Virtual Instrumentation

See how your PC can be used to take the place of an entire workbench full of top-notch test and measurement gear.

Regardless of your involvement in electronics, at some point you are going to need some type of test or measurement gear. That's true if you are a hobbyist tinkering around in your workshop on the weekend, a design engineer trying to develop a sophisticated new circuit, or a manufacturing engineer monitoring production processes in a factory.

Until recently, electronic test instruments were very defined in scope and purpose—most had their one or two applications where nothing else would do. Now, that's all changing. Many of today's test instruments are computer based, and the range of their duties often vary widely from one situation to another. Key to the success of these new test instruments is a new technology called *Virtual Instrumentation*. Here's its story.

Traditional Test Equipment. The traditional test instrument is a self-contained box that performs a very defined procedure, like measuring a voltage or displaying a waveform. On the front panel there typically is an array of knobs, pushbuttons, and switches that you use to configure the input/output capabilities of the instrument. On the back are connectors and possibly other switching devices.

Generally, several different measuring devices are needed, some of which may have to be cabled together, to acquire all the parameters you need for a given test. And it's not unusual for the unit-under-test to require more than one test configuration, which means you have to rearrange the instrument cluster or, at the least, twist knobs and/or press buttons each time you want to change your testing profile.

The problem with that process is it requires you to buy a wide assortment of test instruments to have a fully equipped workbench that can handle any situation you might encounter. That's because the vendor defines the instrument's functionality, and no single instrument can cover all possible scenarios. For example, you might need a low-distortion audio generator for one test and a fast digital-pulse generator for another.

PC-Based Test Instruments. The trend today is toward PC-based test instruments that use the power of the computer to serve as the engine for instrumentation. Those instruments, which are beginning to share the benchtop with stand-alone instruments, are controlled by software rather than knobs and dials; that feature makes them more flexible.

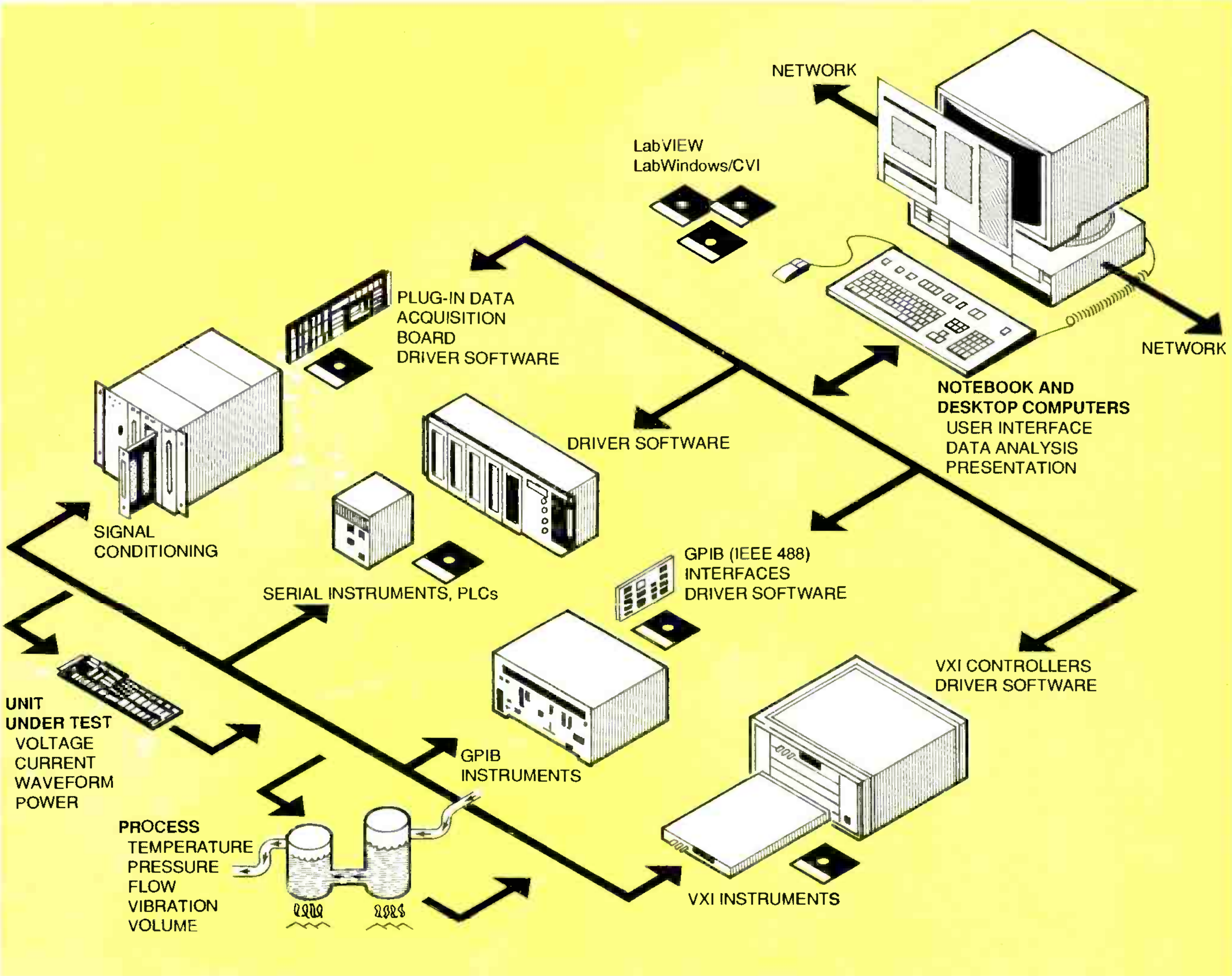


Fig. 1. Virtual instrumentation lets you build your own test and measurement instrumentation systems using standard computers and off-the-shelf hardware.

Fig. 2. Our benchmark test bench is built around a Leader Model LFG-1300S sweep/function generator and a Leader Model 8020 dual-channel oscilloscope.

PC-based test instruments can be either benchtop units like a GPIB instrument (see the Glossary, located elsewhere in this article) or, more popularly, adapter boards that plug into an IBM PC or compatible computer. The two can be mixed and matched (see Fig. 1), so you're not limited to one type or the other. However, the board instruments have an advantage in that it's easier to share resources and communicate information between them via the PC's expansion bus. Plug-in adapters are generally faster than their external counterparts, too.

Until recently, though, the software used to control those instruments was limited, to say the least. Early instrument-control software, which appeared in the mid 1980s, came in two basic forms. The first consisted of routines dedicated to a particular instrument, like a Hewlett-Packard data acquisition (DAQ) controller. That software was device specific, and not portable to other instruments, even those made by HP. The other type of software consisted of very generic routines, generally written in C language. While it could be used to control any instrument, many of the routines were basic system management and scheduling tasks.

Virtual Instrumentation. It wasn't until the late 1980s that we first saw software packages that provided a graphical representation on a computer screen that resembled real-world instrumentation front panels. The early pioneers were Hewlett-Packard and National Instruments.

The dominance of Microsoft Windows has completely changed how PC users interact with their computers. Programming tools, too, have evolved rapidly from cryptic text-based code to visual programming. So, even though National Instruments' LabVIEW was introduced in 1986, it wasn't until 1991, when LabVIEW was upgraded to the Windows platform, that it caught the attention of most virtual-instrumentation programmers. At about the same time, Hewlett-Packard decided to pursue virtual-instrument programming for the UNIX platform. And so was born virtual instrumentation. Today those two giants offer virtual-instrumentation packages for DOS, Windows, Unix, and Macintosh.

So, what exactly is a virtual instrument? In short, it is a collection of hardware and software components working together with your computer in a measurement/monitoring environment. Note carefully that the key word here is software. The famous World-War II poet/pilot John Gillespie Magee, Jr. once wrote, "I have slipped the surly bonds of earth . . . and touched the face of God." Similarly, virtual instrumentation lets you slip free from the bonds of restricted test methods and touch that which exists only in another dimension. In other words, like any technology that succumbs to the lure of the PC, virtual instrumentation lives in an almost surreal world of unlimited possibilities.

The best way to illustrate how real instrumentation and virtual instrumentation compare is by example. Let's say you have a low-frequency audio bandpass filter that you want to test for peak response and attenuation. The following scenarios show three ways to handle the situation.

Benchtop Instruments. Traditionally, the testing described above is done using a sweep generator and an analog oscilloscope. So for the benchtop example we selected a bench-test setup that included a Leader Model LFG-1300S sweep/function generator and a Leader Model 8020 dual-channel oscilloscope (see Fig. 2).

To perform this test, we first set the amplitude and frequency sweep limits of the function generator, using a handful of knobs and slide switches, then proceeded to adjust the oscilloscope for a stable trace by trimming the trigger and timing controls. We now had a picture of the filter's frequency response, but only on the screen of the oscilloscope. To record the results we had to bring up the graticule, eyeball the trace's cross points, and chart the numbers on a piece of paper.

Virtual Instruments 1. We next duplicated the test bench using virtual test instruments. The signal source was a PC-based Keithley MetraByte SM1010 arbitrary-function-generator

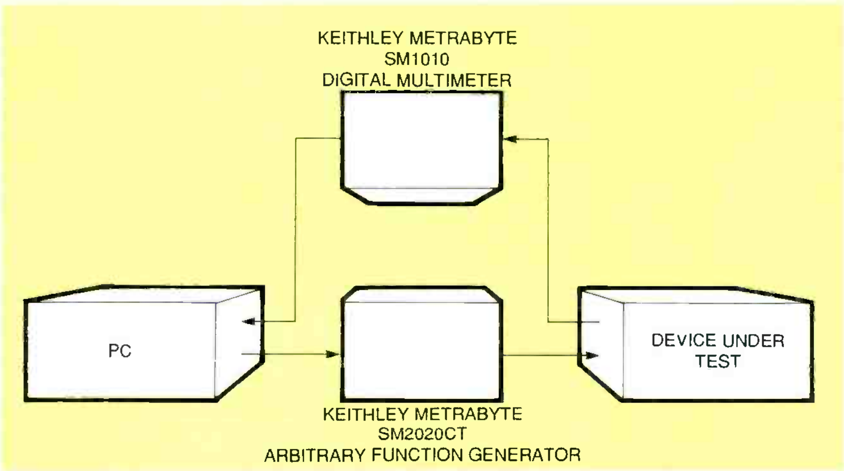


Fig. 3. In the first virtual-instrumentation example, we used a Keithley MetraByte SM2020CT arbitrary function generator and an SM1010 DMM to measure the frequency response of the device under test.

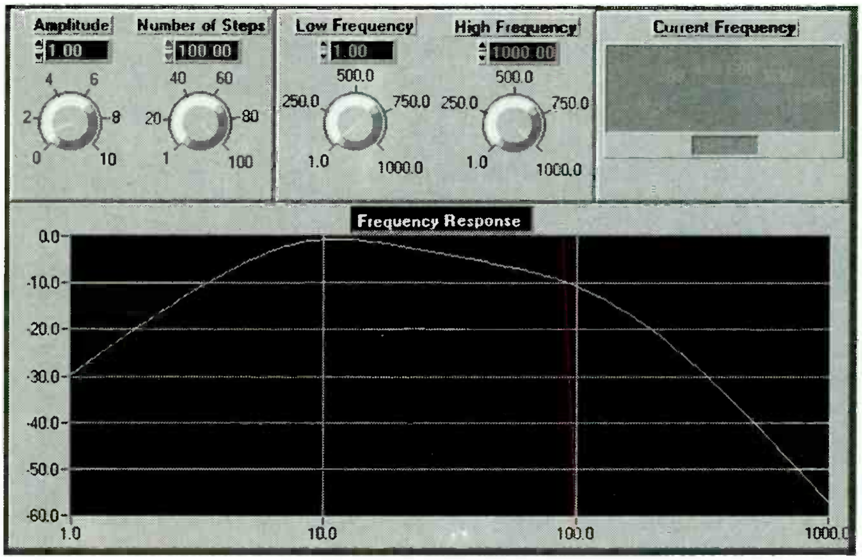


Fig. 4. We created the virtual instrument for the first virtual-instrumentation example using National Instruments' LabVIEW programming software.

Graphical Programming

Initially introduced as a way for department managers to create custom database applications, graphical programming is making inroads into the scientific and instrumentation communities. A graphical programming application is one that solves the problem of having to learn a traditional programming language, like C or Basic, by implementing the process of writing code in the shape of icons.

In its purist form, you write programs simply by connecting or wiring icons together without having to know anything about the code it generates. LabVIEW, from National Instruments, is typical of today's graphical programming for virtual instrumentation. With LabVIEW, you build your instrument by selecting icons from a library and connecting them together in much the same way you'd construct a flow chart. Icons exist for both buried mathematical functions and visible front-panel controls. The graphical compiler converts the LabVIEW block-diagram source code directly into machine code.

For users who need access to the code to write special routines or to create new icons, there are programs like LabWindows/CVI. LabWindows is a different approach to C programming, one that lets you experiment with library functions and learn how they work before you ever write a line of code. Like LabVIEW, you interactively build the function call by specifying the values of the controls on a function panel. Ω

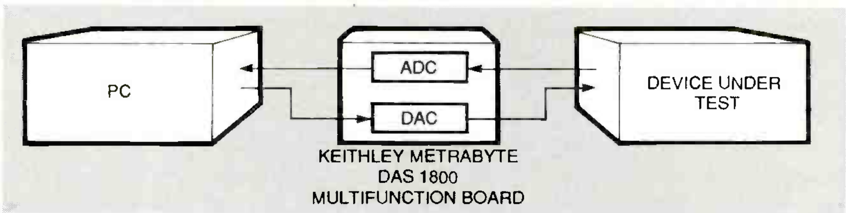


Fig. 5. In virtual-instrumentation example 2, we used a Keithley MetraByte DAS 1800 multifunction board to measure the frequency response of the device under test.

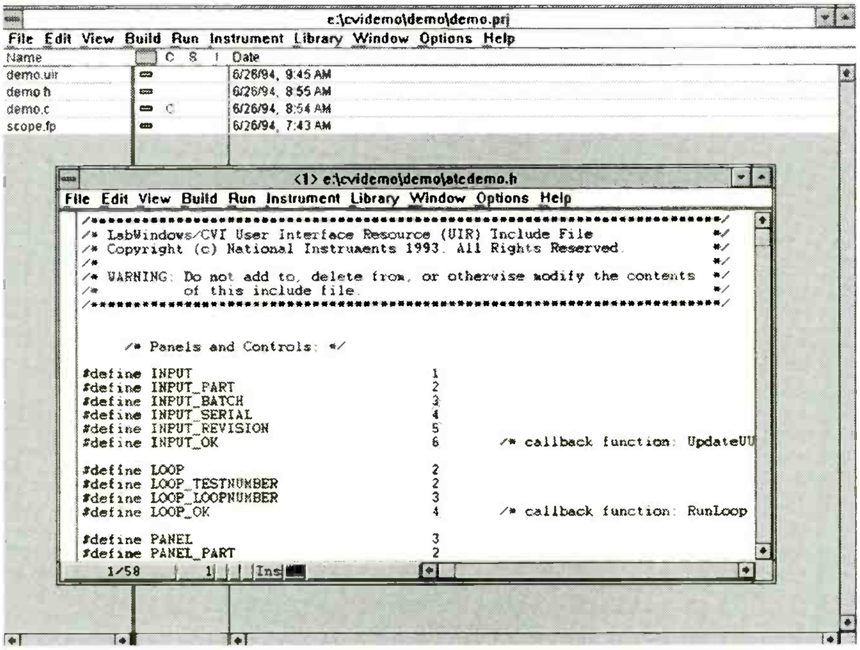


Fig. 6. We created the virtual instrument for the second virtual-instrumentation example using National Instruments' LabWindows/CVI C compiler programming software.

adapter card and the monitor was a Keithley MetraByte SM2020CT digital-multimeter card (see Fig. 3).

That done, it was time to choose the instrumentation software. While Keithley MetraByte has a virtual instrumentation software package called VTX ($450), it requires Visual Basic and only works with select Keithley MetraByte products. Given those restrictions, we opted for National Instruments' LabVIEW graphical programming software.

We then created the virtual instruments. Notice that we substituted a digital multimeter for the oscilloscope, yet we have what looks like a scope screen on our front panel (see Fig. 4). Herein lies the strength of virtual instrumentation.

If you look at the requirements of the test, you see that all you actually need is an AC voltmeter and a variable-frequency audio generator. By advancing the frequency from 1 Hz to 1000 Hz in increments of whatever, and taking a voltage reading at each step of the way, you can plot the frequency response of the filter. That is what we told LabVIEW to do (notice that the number of steps is a knob adjustment). While there are oscilloscope cards on the market that we could have used for this application, they're more expensive and overkill for this project.

Virtual Instruments 2. Finally, we decided to demonstrate the versatility of virtual instrumentation by downsizing the hardware to its basic components using a Keithley MetraByte DAS 1800 multifunction board. Among other functions, that board contains two 12-bit digital-to-analog converters (DAC), one of which we used for the signal source, and a 12-bit analog-to-digital converter (ADC) that we configured as a voltmeter (see Fig. 5).

For this test setup we used National Instruments' LabWindows/CVI virtual instrumentation software (see Fig. 6). LabWindows is a visual programming tool that uses library functions to generate compiled C code. In addition to providing programming icon libraries that automatically generate code, LabWindows gives you access to the code itself to write special functions or to modify an existing routine.

First we programmed the DAC to behave like a sinewave generator. Basically, a DAC looks at a binary number and converts it into an analog-voltage representation of the number. Let's assume the output range of the DAC is 10 volts. If we input the number 4096, the output voltage will be 10 volts. If we input the number 2048, the output voltage is 2.5 volts. A 0 input results in a 0-volt output.

Glossary

DAQ—An acronym for Data Acquisition cards; adapter boards that plug into a PC slot.

EPP—Enhanced Parallel Port. A type of parallel port capable of sending and receiving data at speeds up to 800 MB per second.

GPIB—Developed by Hewlett-Packard in 1965 under the name of HP-IB (Hewlett-Packard Interface Bus), the GPIB (General Purpose Interface Bus) is the premier parallel communications protocol for desktop test instruments that link with the PC.

IEEE 488—In 1965, Hewlett-Packard developed the Hewlett-Packard Interface Bus (HP-IB) to connect their line of programmable instruments to their dedicated controllers. In 1975, that interface protocol was adopted by the IEEE Committee and designated the IEEE 488 Standard. The term is synonymous with GPIB.

PC Card—The industry name for any device—memory card, modem, etc.—that plugs into a PCMCIA expansion slot.

PCMCIA—Short for Personal Computer Memory Card International Association. See PC Card.

Plug and Play (PnP)—A standard developed by Microsoft, Intel, and others that lets you plug in a PC adapter board without having to set switches or jumpers.

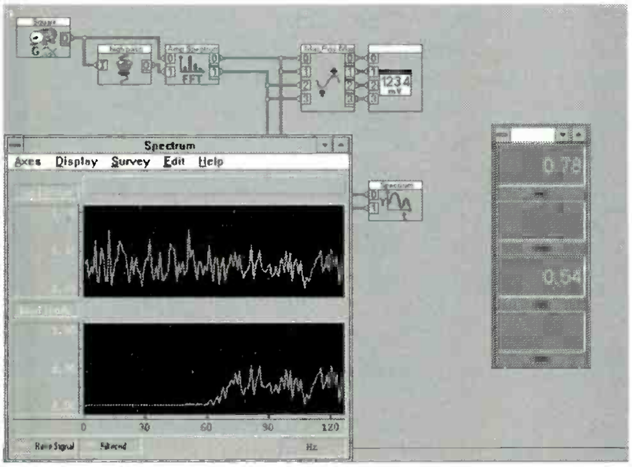
RS-232C—The official specification (developed by the Electronics Industry Association, EIA) on which standard PC serial ports are based.

VI—An acronym, coined by National Instruments, that stands for Virtual Instrumentation.

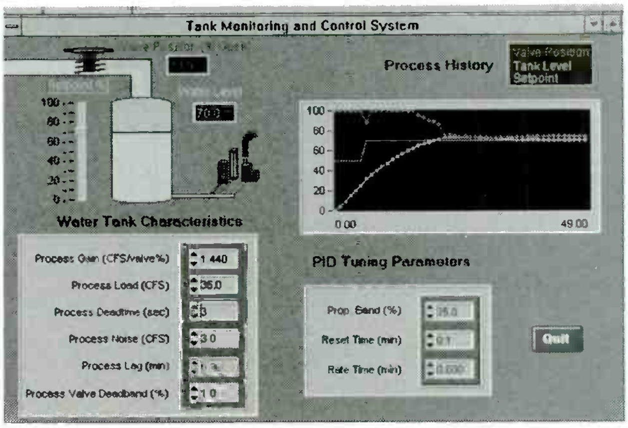
VXI—A technology that uses a mainframe chassis with a maximum of 13 slots to hold modular instruments on plug-in boards; not compatible with PC boards.

The Many Faces of Virtual Instrumentation

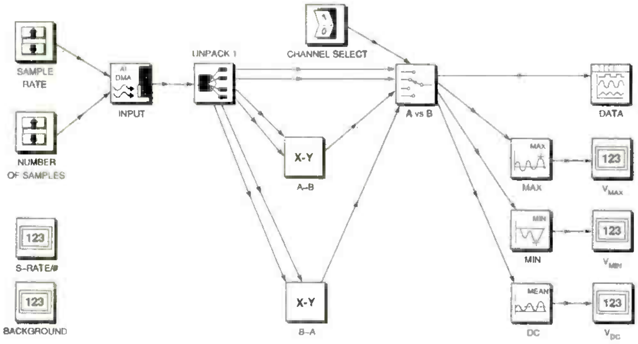
While the goal of virtual instrumentation is to portray the test instrument as a physical device, it seems everybody has a different opinion of what those devices should look like. Here's how some of the popular programs think a virtual test bench instrument should appear.



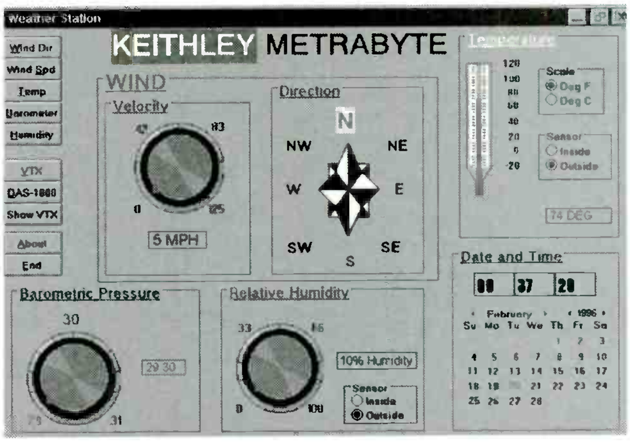
Dasylab is a popular virtual-instrumentation program that shows instruments in their simplest form—as data displays with the logic diagram in the background. Dasylab is available from Dasytec and other vendors, including IOtech, Microstar Laboratories, and Strawberry Tree.



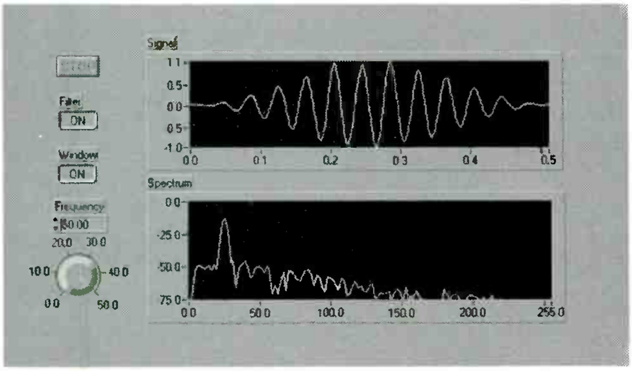
While National Instruments' LabWindows/CVI screen can be made to look like LabVIEW, it's frequently used in production testing where macro models, like the water tank above, are often the preferred choice.



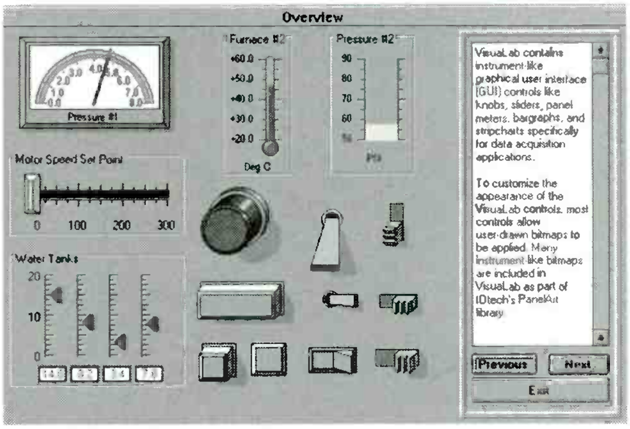
This is how Visual Designer, from Intelligent Instrumentation, symbolizes a dual-channel oscilloscope with digital display. The digital voltmeters (on the right) show the maximum, minimum, and average voltage values.



Visual Test Extensions, VTX, from Keithley MetraByte is a Windows extension application that works under Microsoft's Visual Basic program.



LabVIEW, from National Instruments, does the best job of duplicating the look and feel of a benchtop test instrument, with knobs and buttons that really work.



VisuaLab, from IOtech, does an excellent job of mimicking switches and gauges. Like Keithley MetraByte's VTX, it requires Microsoft Visual Basic.

Through careful ordering of the numbers, we can create an output signal that mimics the undulations of a sinewave. The frequency of the signal is determined by the rate at which we step through the conversions.

An ADC is the mirror image of a DAC: It converts analog voltages into binary numbers. To make the ADC behave like an AC voltmeter, though, we need to condition the input signal. We do that by taking voltage samples over several waveforms, then mathematically processing the numbers to arrive at a result in volts rms. Those rms numbers are then plotted on the screen to produce a frequency-response curve.

Comparing the Options. Of the three above examples, the first, using benchtop instruments, is the least flexible. It's also the hardest to use, due largely to the lack of a permanent recording feature, and it takes up a lot of bench space. On the other hand, it's the least expensive, checking in at just $1200.

Virtual Instruments 1 is the most expensive approach, costing you a cool $1680 for the two boards specified. While there are cheaper alternatives to the ones mentioned, they'll still cost you more than $1200, and that doesn't include LabVIEW, which is a one-time expense of $995. However, it's the easiest configuration to setup and modify, and is an excellent choice for a test lab where the test requirements change constantly, because changes to it can be make quickly and effortlessly.

Virtual Instruments 2 is the most adaptable of the lot because it uses very fundamental building blocks that can be configured to meet a wide variety of situations. It's faster and cheaper ($1499, not including LabWindows) than virtual-instrumentation example 1, and is the easiest to use once set up. While you don't have to be a rocket scientist to set up this arrangement, you will need a working knowledge of C+. That approach to designing virtual instruments is ideal for production testing where the test specifications hardly ever change, and price and test speed are important factors. It's also the most conducive to automatic testing (ATE).

I know what some of you are thinking: We're comparing apples to oranges. In the first instance we used an oscilloscope, in the next we used a multimeter, and in the last it's an ADC. But that's the beauty of virtual instrumentation—there are no constraints with virtual instrumentation.

Virtual Beginnings. Up to now there's been a distinct line between real test instruments and virtual test instruments. But that distinction is likely to blur as virtual instruments improve in performance and life-like appearance. We can imagine a time when 3D graphics and touch screens will give a virtual instrument the actual look and feel of a benchtop instrument. But whatever shape they eventually take, virtual instruments are here to stay. Ω

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Marlboro, MA 01752-1192
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National Instruments
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160 South Wolfe Rd.
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BUILD THE FAST PULSER SCOPE CALIBRATOR

You're looking for a used oscilloscope at a ham fair and wonder if that $150 gem is really as good as the person at the table says it is. The trace lights up and the seller assures you it is "like new." What you need is something that will allow you to do a quick check of amplitude accuracy, sweep accuracy, and bandwidth. The Fast Pulser Scope Calibrator described here is a small, portable, battery-powered scope calibrator that meets those needs perfectly and costs less than one bad deal.

Testing a scope. Amplitude accuracy and calibration are both relatively simple to test. Any signal of a known amplitude will work well, including something as unsophisticated as a battery. Just apply the signal to the scope and count the number of divisions. If you have a way to generate one, a squarewave is even more useful as you get a direct indication of peak-to-peak amplitude that allows testing of AC-coupled circuits.

Time (or sweep) accuracy is easily tested by using a signal derived from a crystal oscillator, which will give better than 0.1% resolution and typically closer to 0.01%, depending on the crystal.

The most difficult parameter to measure is bandwidth. If you had a variable-frequency generator with a calibrated output, you could measure bandwidth by sweeping the input frequency until you reached the –3-dB point. Unfortunately, those instruments are not very portable. However, there is an easier way to determine bandwidth that is close enough for most purposes: apply a fast rise time pulse to the oscilloscope and observe the rise time of the displayed waveform.

To see how that works, let's say that a scope under test has the response curve of Fig. 1-a. Figure 1-b is a simple resistor-capacitor circuit that models that response curve.

If V_{in} is a fast pulse, V_{out} can be found with:

$$V_{out} = V_{in}(1 - e^{-t/RC})$$

where e is the exponential function, R is the resistance in ohms, C is the capacitance in farads, and t is the time in seconds after the pulse is applied. That output looks like the curve shown

Psst! Wanna buy a used oscilloscope? Checking out that bargin before you buy is now a snap with this handy, portable device.

STEVEN D. SWIFT

in Fig. 2. Figures 1-a and 2 were calculated using values of R and C to simulate an oscilloscope with a –3-dB rolloff at 100 MHz.

Rise time is the time for a signal to go from 10% of its final value to 90% of its final value. Those points are labeled as 10% and 90% in Fig. 2, with the final value of V_{in} normalized to one.

We need to find the rise time, so by using:

$$0.1 = (1 - e^{-t_{10}/RC})$$
$$\text{and } 0.9 = (1 - e^{-t_{90}/RC})$$

we solve for t_{10} and t_{90} using:

$$t_{10} = 0.1054\ RC$$
$$\text{and } t_{90} = 2.303\ RC$$

The final formula for the rise time becomes:

$$t_r = t_{90} - t_{10} = 2.198\ RC$$

Since the –3-dB bandwidth (BW) of a simple RC circuit is given by:

$$BW = 1/(2\pi RC)$$
$$\text{or } RC = 2\pi BW$$

With $\pi = 3.1416$, we substitute into the formula for t_r:

$$t_r = 0.35/BW$$
$$\text{or } BW = 0.35/t_r$$

That formula can also be used to approximate other circuits with a smooth rolloff that are more than just the simple RC type, as long as they do not suffer from excess peaking, which causes ringing. Figure 3 is a plot of the bandwidth versus rise time using that formula.

If the rise time of the pulse is not fast compared to the rise time of the oscilloscope being tested, the scope's true rise time can be calculated by:

$$t_r(\text{scope}) = \sqrt{t_r(\text{observed})^2 - t_r(\text{pulse})^2}$$

For bandwidths up to 250 MHz, a pulse with a rise time t_r of < 640 picoseconds (0.64 nanoseconds) will cause less than a 10% error in the scope's bandwidth prediction. Figure 4 shows observed rise times on the scope's display versus actual rise times of the scope's circuitry as a function of the output rise time of the applied pulse.

Those calculations and figures apply to oscilloscopes with well-behaved responses as in Fig. 1-a. Poorly designed, misadjusted, or defective oscilloscopes will have overshoot,

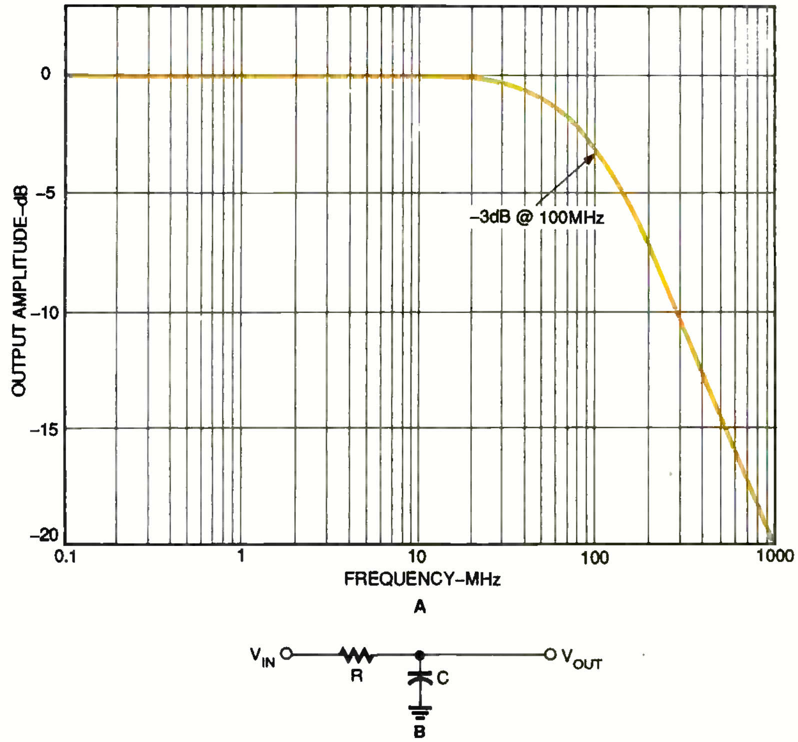


Fig. 1. The response curve of a typical oscilloscope (a) and a simple R-C circuit that simulates that response (b).

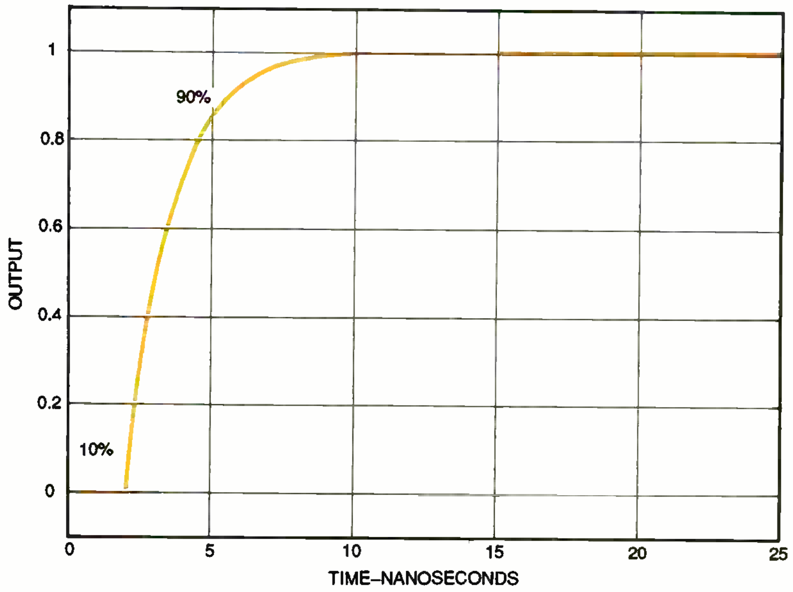


Fig. 2. The output of the R-C circuit when a fast pulse is applied to its input. Like oscilloscopes, a lower bandwidth will take longer for the output to reach 100%.

ringing, or undershoot. If overshoot or ringing is present and is, for example, greater than 15% of the final value, the apparent bandwidth will be incorrect. That is generally a sign of a peaked response and indicates an oscilloscope that may have some problems or be unsuitable for precision work.

Circuit design. With that background information, we can now design a circuit that will give us the correct signal to measure the amplitude, frequency, and bandwidth of an oscilloscope. We also want a unit that is small, battery-powered, and portable.

Since the bandwidth specification is going to be the most challenging, let's start there. We need to generate a fast pulse. In the past, the fastest devices available were tunnel diodes. Tektronix at one time made many different tunnel-diode pulsers, but those diodes are almost impossible to find. Fortunately, the need for high-speed digital circuitry has forced semiconductor manufacturers to generate special fast-logic families. One of those is Motorola's ECLips (*E*mitter *C*oupled *L*ogic *i*n *p*icoseconds). The devices specified have a maximum output rise time of 350 ps (0.35 ns): more than adequate for our purposes. We'll choose one of those devices for the fast part of the circuit.

A crystal-oscillator circuit ensures frequency accuracy, while the amplitude is set by choosing a version of the

PARTS LIST FOR THE FAST

RESISTORS

(All resistors are 1/10-watt, 1%, metal film, type 0805 surface mount, unless otherwise noted.)
R1, R2—82.5-ohm
R3, R4, R5, R9—124.0-ohm
R6, R7, R14—681.0-ohm
R8—1-megohm
R10, R11—100-ohms, 1 turn variable, surface mount (Panasonic EVM-1GSX30BXX or similar)
R12, R15, R18—27.4-ohm
R13—63.4-ohm
R16—49.9-ohm
R17, R19—0.0-ohm

CAPACITORS

C1, C2, C3, C4, C14, C16—10-µF, 6.3WVDC, tantalum, surface mount (3216 SM)
C5, C6, C7—.022-pF ceramic, surface mount (0805 SM)
C8, C9—470-µF, 6.3WVDC, high-frequency aluminum electrolytic (Panasonic ECA-0JFQ471 or similar)
C10, C11, C13, C15—22-pF ceramic, surface mount (0805 SM)
C12—220-pF ceramic, surface mount (0805 SM)

SEMICONDUCTORS

IC1—74HC4060M HCMOS oscillator/divider, SO-16 integrated circuit
IC2—MC100EL32D ECLips divide-by-2, SO-8 integrated circuit (Motorola)
IC3—MAX777CSA switching regulator, SO-8 integrated circuit (Maxim)
LED1—High brightness light-emitting diode, red

device for the fast part of the circuit whose output levels are both temperature and power-supply stable. The final overall block diagram is shown in Fig. 5.

Design details. Figure 6 shows the complete schematic. Refer to it and the block diagram during the discussion that follows.

A 74HC4060 HCMOS oscillator/divider integrated circuit (IC1) was chosen for generating the master clock because it includes the oscillator circuitry and dividers necessary for a precision crystal-controlled clock with a minimum of external components. Choosing that part lets us use an inexpensive 4-MHz crystal rather than a larger and more costly low-frequency crystal.

The divide-by-16 output of IC1, at 250 kHz, is applied to a Motorola MC100EL32 divide-by-2 ECLips flip-flop (IC2), through level-shift and decoupling components C7, C15, and R6. Resistor R3 sets the input impedance seen by IC2 and divides the amplitude of IC1's output down to the ECLips input levels. The MC100EL32 has transition times of both outputs specified at less than 350 ps (0.35 ns) and temperature-compensated output levels. The divide-by-2 action of the device provides 125 kHz at approximately 800-mV p-p to the amplitude adjustment circuit and output stage.

The output of IC2 is terminated with loads consisting of resistor pairs R1/R4 and R2/R5. The values shown provide an equivalent load voltage of about −2 volts and a load impedance of 50 ohms. The output of IC2 is AC-coupled by capacitors C12, C13, C14, and C16 to an adjustable T-attenuator network. The various values of the coupling capacitors combine to transmit the fast rise time edges (C12 and C13)

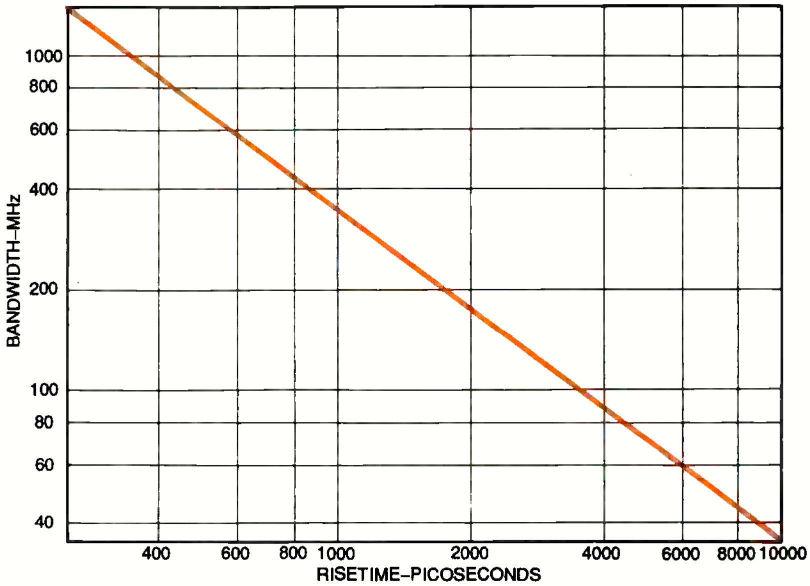


Fig. 3. The bandwidth of an oscilloscope can be found by observing how quickly the oscilloscope responds to a fast-rising input pulse. The quicker a scope responds to an input, the greater its bandwidth.

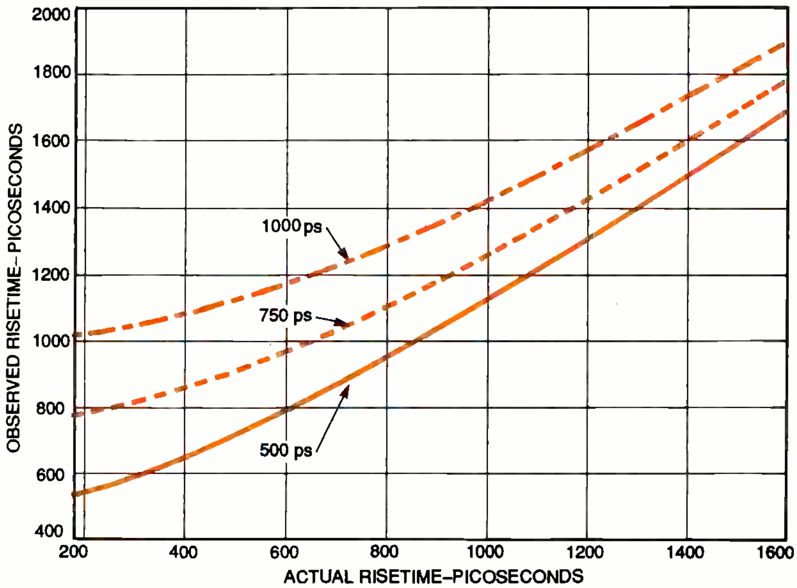


Fig. 4. A pulse with its own rise time will introduce additional error when measuring a scope's bandwidth. Keeping the pulse's rise time as short as possible will reduce such errors to an acceptable level.

PULSER SCOPE CALIBRATOR

ADDITIONAL PARTS AND MATERIALS

J1—BNC male connector (Kings KC-79-59 or similar)
L1—100µH, 0.41-amp rated coil, surface mount (TOKO 636CY-101M or similar)
S1—SPDT miniature switch (Mouser 10SP018 or similar)
XTAL1—4-MHz AT-strip crystal, surface mount
B1—Batteries, 3-volts, see text
Printed-circuit board, case, cover, battery holder (Digi-Key BH2AA), 4-40 x ¼-inch Phillips pan head screws

Note: The following items are available from: Novatech Instruments, Inc., 1530 Eastlake Avenue East, Suite 303, Seattle, WA 98102; e-mail: novatech@eskimo.com, URL: http://www.eskimo.com/~ntsales: Key Parts kit (includes J1, IC1, IC2, IC3, printed circuit board, case, and cover) (order MTS529-K), $50. Circuit Board only (order MTS529-B), $10. Completely assembled and tested Scope Calibrator (order MTS529), $125. Please add $5 for USA shipping and $10 for overseas shipping by U.S. Postal Service. These are special prices and are valid only for six months. Please mention this article when you mail payment. WA residents must add 8.2% sales tax. Please mail a check drawn on a bank with a branch in the U.S. or a money order. Sorry, phone orders and charge cards are not accepted.

while preventing droop at the 125-kHz base frequency (C14 and C16).

The output T-attenuator allows adjustment of open-circuit voltage level (R10) and output impedance (R11). Levels of 600-mV p-p open circuited and 300-mV p-p into 50 ohms were chosen to correspond to 6 divisions on an oscilloscope with a high-impedance input set to 100-mV-per-division, or 50-mV-per-division if the scope's input impedance is 50 ohms. That output is applied to a male BNC connector, which allows direct connection to the oscilloscope under test without using cables or adapters. The parasitic inductance of the output stage is kept small by the use of surface-mounted components. Even with that precaution, the output stage degrades the rise time to approximately 500 ps (0.5 ns). That rise time is adequate for testing oscilloscopes to 250 MHz with less than 10% error without using the correction formula or Fig. 4.

A switching power supply (IC3 and its associated components) was chosen to generate the required power for the circuit. The −5V supply needed to supply power to IC1 and IC2 is generated by IC3, a MAX777CSA switching regulator. Using two AA alkaline cells will supply power for almost 4 hours of continuous operation, and keep the project compact. Various types and sizes of batteries were tested with the power supply and it was found that 2 AA alkaline cells provide excellent performance without being very expensive.

Construction details. To maintain the high-speed performance of the instrument, the circuit board used consists mostly of a solid copper ground plane, with just enough area cleared away for the components. Other than a few pads and holes, the whole solder side of the circuit board is also a ground plane. Please note that if you plan to make your own boards from the artwork, the minimum trace width used is 8 mils (0.2 mm) which may cause etching difficulties. Note also that the back side ground plane is important for correct operation, so the feedthrough holes must be connected.

The parts placement diagram for the project is shown in Fig. 7. Since we

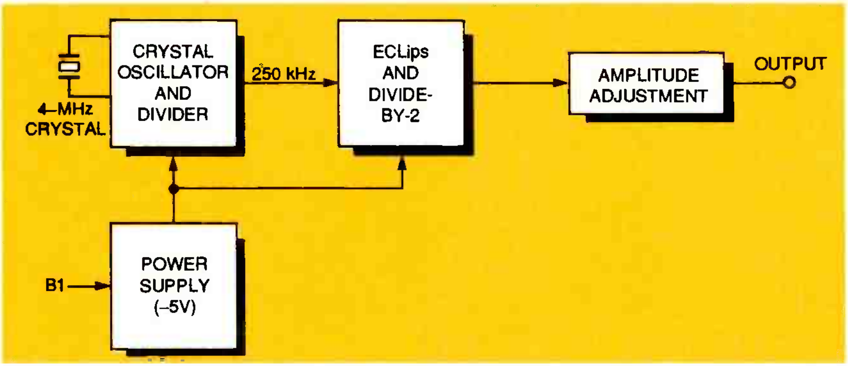


Fig. 5. Here's the block diagram of the Scope Calibrator. A crystal-controlled oscillator coupled with ECLips-based technology make for an accurate, reliable design.

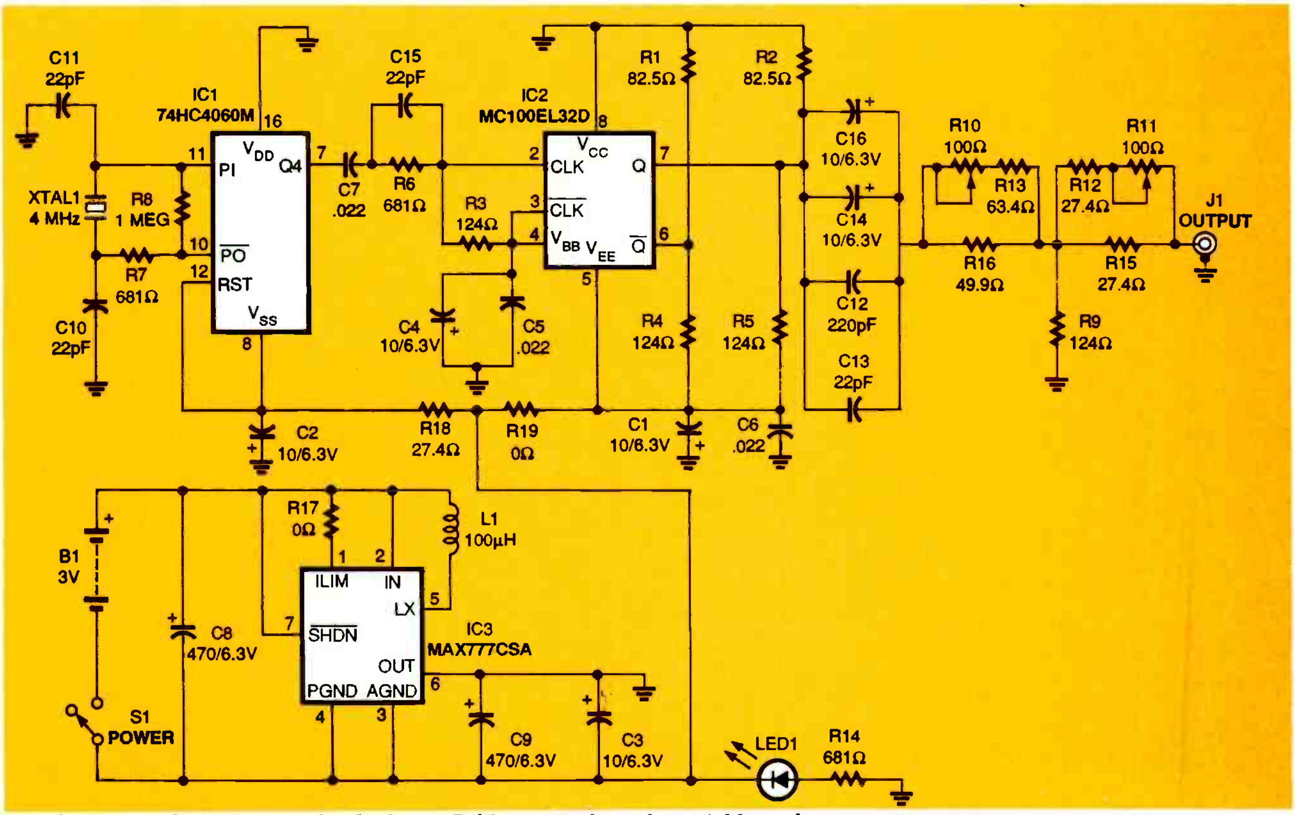


Fig. 6. The complete schematic for the Scope Calibrator is shown here. A Motorola MC100EL32D divide-by-2 ECLips flip-flop produces a signal unaffected by changes in temperature or supply voltage.

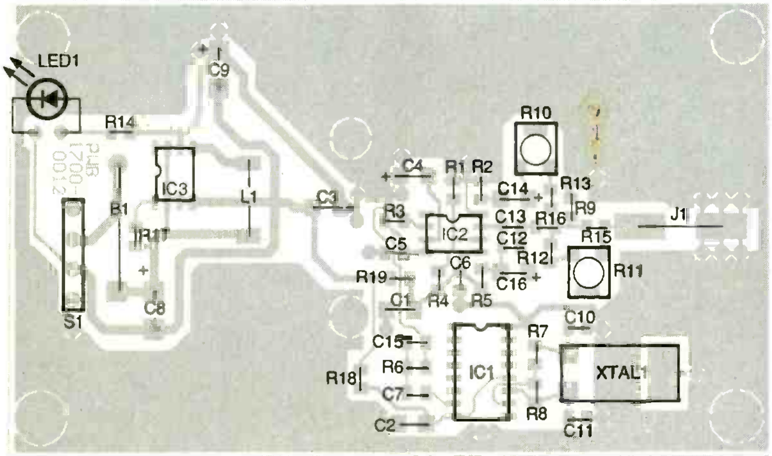
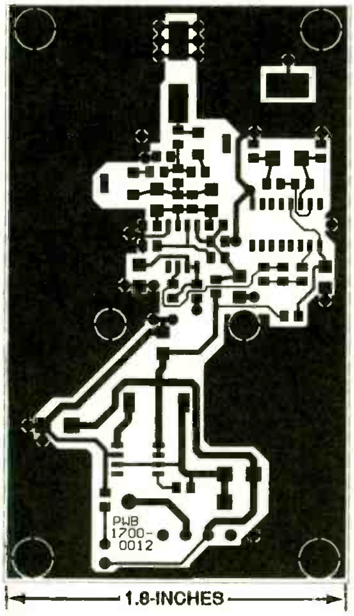
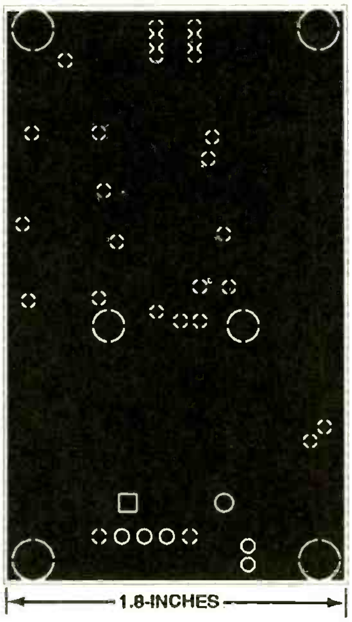


Fig. 7. Use this parts placement when building the Scope Calibrator. Surface-mount technology helps keep parasitic inductance to a minimum, as well as maintain a small physical size to the finished unit.



Here's the foil pattern for the component side of the Scope Calibrator printed circuit board. If you decide to etch your own board, take care that the narrow traces don't break apart during the etching process.



Here's the foil pattern for the solder side of the printed circuit board. Connecting the ground planes on both sides of the board to each other is important for proper operation.

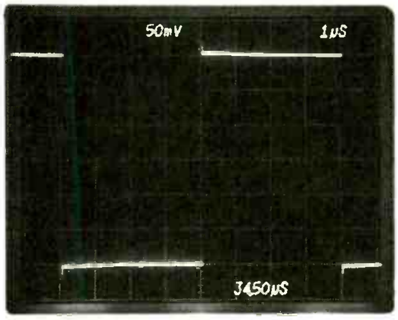


Fig. 8. Here we're testing the sweep speed and amplitude of an oscilloscope. You should count 8 divisions when the sweep is set to 1-µs/division.

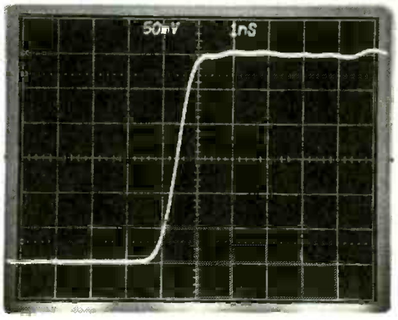


Fig. 9. Here we're testing the rise time of an oscilloscope. Measure the time it takes for the signal to rise from 10% to 90%, then use the chart in Fig. 3 to find the scope's bandwidth.

want a small sized instrument and the circuit has very high speed signals that require RF-design techniques, surface-mount components were chosen for the project. The small parts allow for optimized circuit specifications while reducing performance-degrading parasitic signals. They also allowed the complete project (less the batteries) to be enclosed in a 1.8- by 3-inch metal case.

Unfortunately, those small components make the assembly of the project rather difficult. If you have never handled SMT devices, you might want to look back at "Surface Mount Technology" in the November, 1987 issue of **Radio-Electronics**, or "A Hobbyist's Guide to Surface-Mount Technology" in the January, 1995 issue of **Popular Electronics** and first try some of the simple projects there. An assembled and tested Calibrator is also available from the source given in the Parts List.

The Scope Calibrator only needs calibration for amplitude. The basic accuracy of the crystal and the rise time are fixed by the design used and need not be calibrated. The easiest and most accurate way to calibrate the unit is to use a wideband (>200 kHz) AC rms voltmeter. With just the voltmeter load, adjust R10 for a reading of 300-mV rms (the rms value of an AC-coupled square wave is equal to one-half its peak-to-peak value). Now apply the squarewave output to the voltmeter through a 50-ohm feedthrough termination. Adjust R11 for 150-mV RMS. That sets the output impedance equal to your load, so the accuracy of your 50-ohm load determines the accuracy of your Fast Pulser calibrator.

Do not use test leads or cables as the signal will be degraded by overshoot and ringing. Use a direct connection to the meter, such as a BNC to banana-plug adapter. The assembled and tested unit is calibrated using a 1-MHz bandwidth rms meter and a ±1% 50-ohm load.

Applications. The Scope Calibrator is easy to use. Simply switch it on and connect the BNC output to the input channel of an oscilloscope under test. If the scope has a high input impedance (1 megohm is typical), set the vertical scale on the scope to 100-mV/division. If the scope has a 50-

(Continued on page 79)

WILLIAM C. HENDRY IV

Build The JamMix

Play along with your favorite artists with this easy-to-build, fun-to-use, stereo mixer.

The JamMix project described in this article is a three-channel stereo mixer that blends any amplified musical instrument with line-level stereo audio, so that a musician can accompany prerecorded music. Other benefits are that JamMix is battery powered and is universally compatible with consumer audio components. The range of suitable equipment varies from "walkman"-type stereos to state-of-the-art separate components. When headphones are used with JamMix to mute the music from the outside world, you can achieve dramatic volume levels without disturbing your neighbors (or perhaps the neighborhood). The JamMix also makes a great personal-practice amplifier, especially for guitars.

The unit's gain and level amplification stages were designed especially for guitars and offer a wide range of volume and distortion control. For example, the gain and level can be adjusted to present a clean signal until the guitar playing intensifies, whereby the distortion increases with the attack on the strings. That is a useful effect for adding power to solos. It can also be set for virtually any blend of *nasty* high-energy sound or *squeaky* clean sound.

Circuit description. Refer to the schematic diagram in Fig. 1. Nine of the ten amplifier sections in five MC1458C dual op-amp integrated circuits are used. The INSTRUMENT jack, J1, provides a signal to IC1-a, which is a non-inverting buffer-amplifier with a gain of 2. The gain is determined by R3 and R4. The amplified instrument signal is fed to audio-gain stage IC1-b which is controlled by potentiometer R6. The circuit location of control R6 provides a desirable interplay with the volume control on the guitar. Whenever the output of IC1-b exceeds about 2-volts p-p (peak-to-peak), light-emitting diodes LED1 and LED2 begin to illuminate and clip the audio signal, providing a high-quality distortion effect. LEVEL control, R10, sets the level of the output of the high-gain distortion stage IC4-a, which in turn drives the ganged potentiometers, R14-a and R14-b.

Unity-gain amplifiers IC5-a and IC5-b feed summing amplifiers IC2-b and IC3-b, which in turn drive the external load connected to stereo OUT jack J3. The load may be either stereo headphones or additional external stages used for audio amplification. Integrated-circuit sections IC2-a and IC3-a are non-inverting amplifiers, each with a gain of 2. Their inputs are the line-level stereo input signals, each having a gain of 2. Their outputs mix with the instrument signal in amplifiers IC2-b and IC3-b; both of these amplifiers also have a gain of 2.

Power is provided by two 9-volt batteries, B1 and B2, via switch S1, which is a double-pole, double-throw switch. Batteries B1 and B2 are series connected with the interconnecting lead grounded, thus providing two 9-volt supplies, one negative and the other positive.

Software circuit model. The JamMix circuit was entered into a Spice electronics-circuit analysis program to verify the design. The program was used primarily to check that no undesirable operation could result from the various component tolerance interactions and temperature changes. The circuit was modeled from R1 to R14, and R14 was taken as the load. Since the line-input amplifiers are identical to the instrument amplifier, it was unnecessary to model the entire circuit. Furthermore, the response at the output would vary with the type of load (amplifier input, headphones, etc.).

A worst-case Monte Carlo analysis was performed, which randomly adjusts the component tolerances that might be found in an actual production run of a circuit. This shows that using normal component values within their tolerances in what could be an unfavorable selection, no circuit would be rejected, indicating excellent circuit stability. The frequency response was also plotted (see Fig. 2)

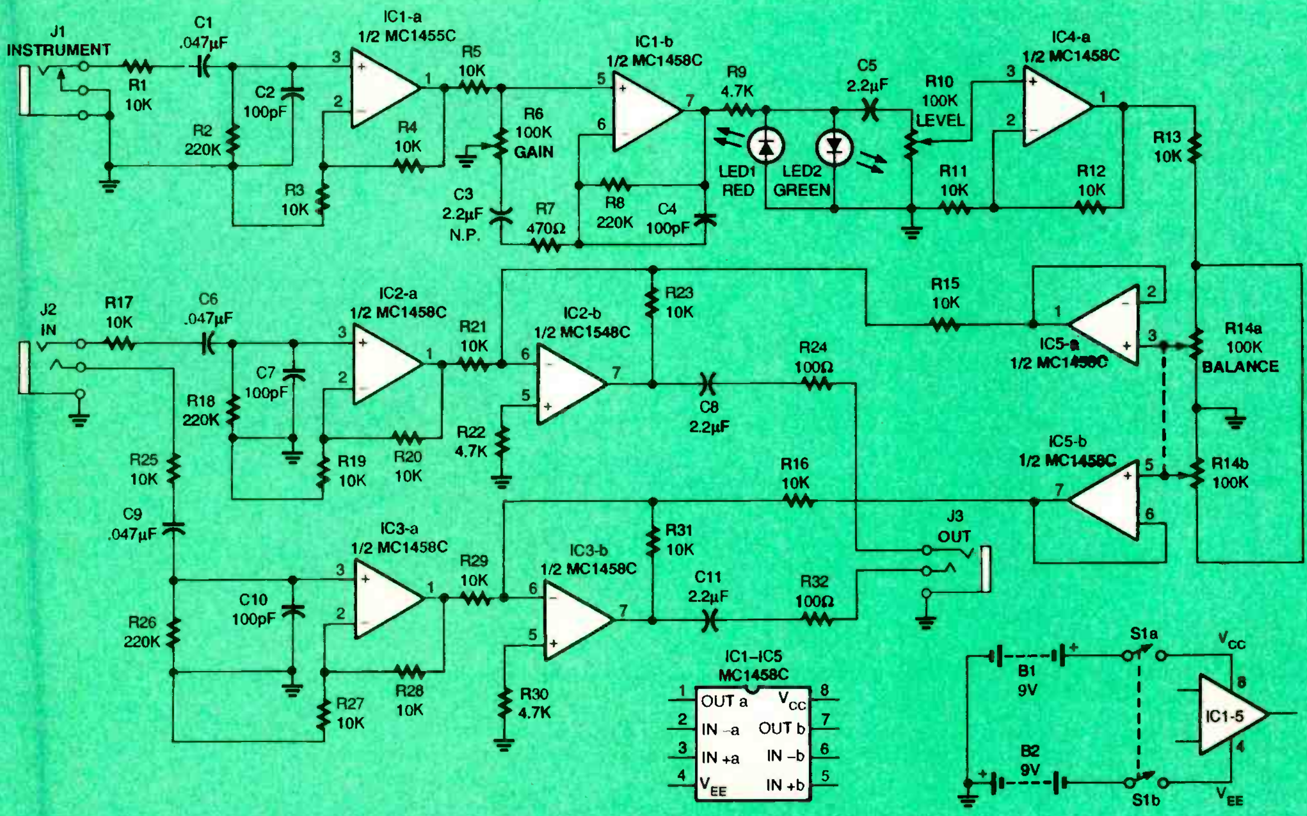


Fig. 1. Here's the schematic diagram for JamMix. Note that nine out of ten sections from five MC1458C dual op-amps are used.

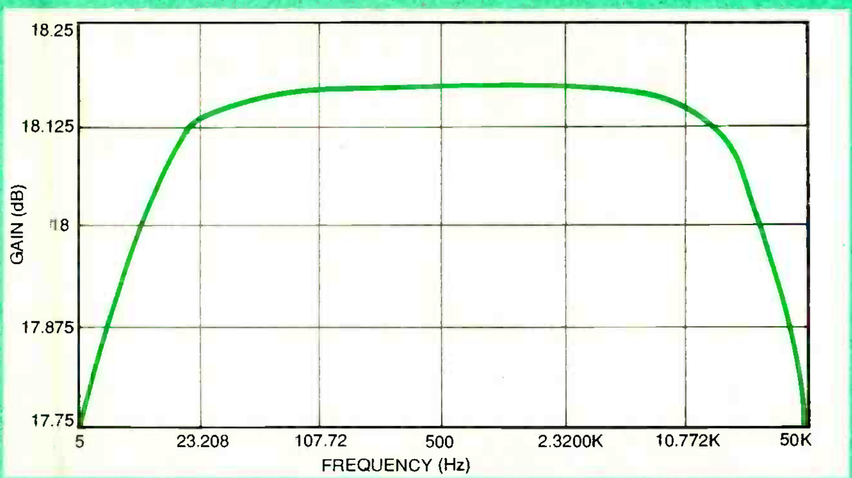


Fig. 2. Frequency response curve for JamMix is ultra flat considering that the curve shown covers only 1 dB of gain.

and proved to be far better at +0.0dB/−0.4 dB from 5 Hz to 50 kHz than required for consumer high-fidelity systems. A typical high-fidelity specification would be a flat (within 3 dB) audio response from 20 Hz to 20 kHz.

Construction. All components are readily available from local and mail-order sources. The components were selected to make the assembly of JamMix from scratch as easy as possible for the novice. JamMix is well suited for construction with perf-board or wire-wrapping techniques.

A PC board is recommended because it makes construction much easier and goof proof. A PC board can be made from the same-size foil pattern provided in the article. That pattern was developed with the AutoCad program. Iron-on and other etching-resist methods are available for PC board fabrication, and the holes can be drilled with a hand drill or Dremel tool. Novice builders are advised to install 8-pin DIP sockets instead of soldering the integrated circuits directly to the PC board. Be sure you have properly located pin 1 of each of the ICs before installing them.

The following is a suggested assembly sequence. Install all the PC-board components first (see Fig. 3). Be sure to observe battery polarity when installing the battery snaps. Don't forget to install four wire jumpers when using the PC board. Mechanically install all of the enclosure-mounted devices such as jacks, controls, and the switch on the plastic case front and rear panels. Use color-coded hookup wire between the jacks and controls to the PCB. Only one set of holes is provided for LED1 and LED2. Connect the two light-emitting diodes back-to-back (anode to cathode) and insert into the board. Polarity is not important here.

Mount the PC board inside the plastic case. Secure the PC board to the deck of the plastic case with double-sided tape or drops of RTV cement. Use the same technique to secure the

PARTS LIST FOR THE JAMMIX

SEMICONDUCTORS

IC1–IC5—MC1458C dual op-amp, integrated circuit
LED1—Light-emitting diode, red
LED2—Light-emitting diode, green

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1, R3–R5 R11–R13, R15–R17, R19–R21, R23, R25, R27–R29, R31—10,000-ohm
R2, R8, R18, R26—220,000-ohm
R6, R10—100,000-ohm, panel-mount potentiometer
R7—470-ohm
R9, R22, R30—4700-ohm
R14—100,000-ohm, dual, ganged, panel-mount potentiometer
R24, R32—100-ohm

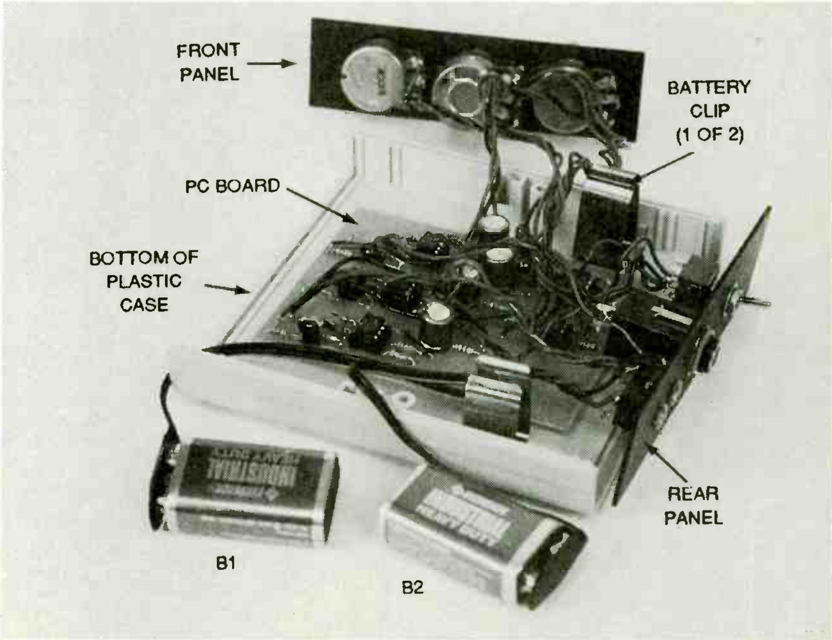
CAPACITORS

C1, C6, C9—0.047-µF, polyester-film
C2, C4, C7, C10—100-pF, ceramic-disc
C3, C5, C8, C11—2.2-µF, 50-WVDC audio-frequency non-polarized electrolytic

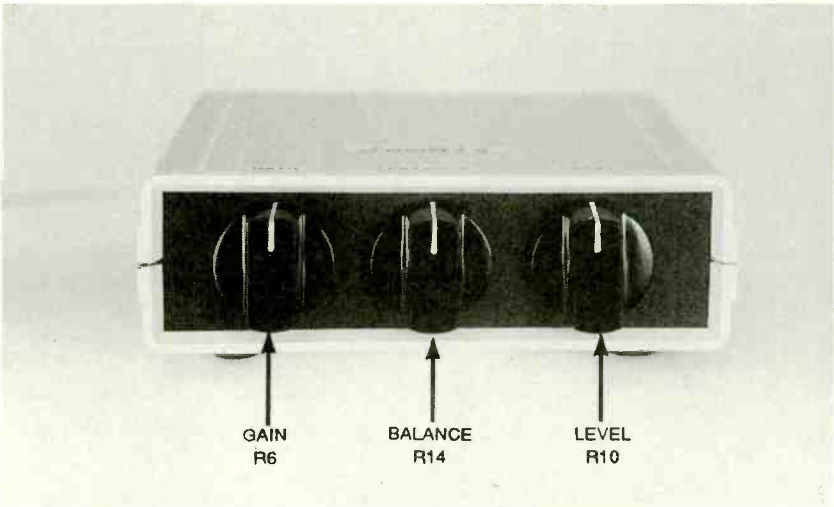
ADDITIONAL PARTS AND MATERIALS

B1, B2—9-volt, alkaline battery
J1—Phone jack, ¼-in., panel-mount, single closed-circuit
J2, J3—Phone jack, ⅛-in., panel-mount, stereo open-circuit
S1—Toggle switch, dpdt, panel-mount
Battery snap (2); battery (clip-type) holder (2); plastic case, 5 × 1½ × 5¼ inches; PC board; hardware, hookup wire, solder, etc.

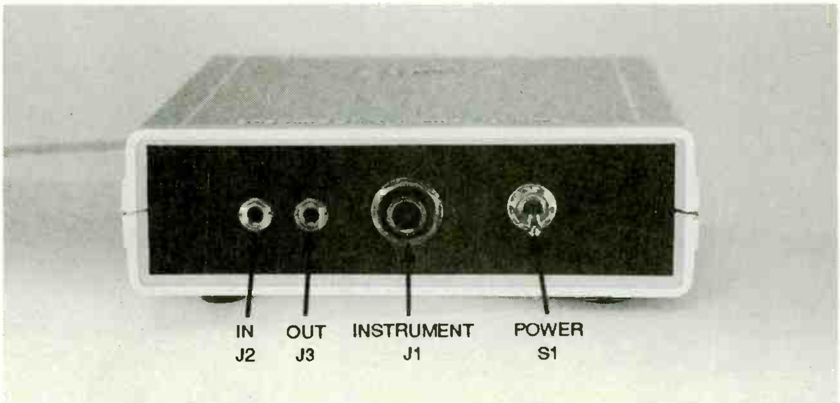
Note: The following are available from Hendry Technology, 1107 Toler Pl., Suite 2, Norfolk, VA 23503. A one-sided, etched PC board is available for $20.00. A complete JamMix kit is available for $65.00. A 3.5-in. floppy disk with the following files is available for $20.00: The original AutoCad drawings in .dxf format; all PCB Gerber, drill, and template files; the original article in .txt format; and step-by-step assembly instructions. The files will be in the .ZIP format. Check or money order in U.S. dollars only. U.S. and Canada orders only. Virginia residents must add appropriate sales tax.



Here's a view of the completed JamMix prior to closing the plastic case.



Connection to the program signal and mixing instrument signal are made from the back panel. Remember to set POWER switch to off when JamMix is not in use.



The three user controls on the front panel of JamMix are all that the musician needs to know about. The GAIN control regulates the instrument's signal level. Too much gain introduces desired clipping distortion. The LEVEL control provides the desired instrument mixing level with the input program signal. The BALANCE control moves the instrument's stage setting from extreme right to extreme left.

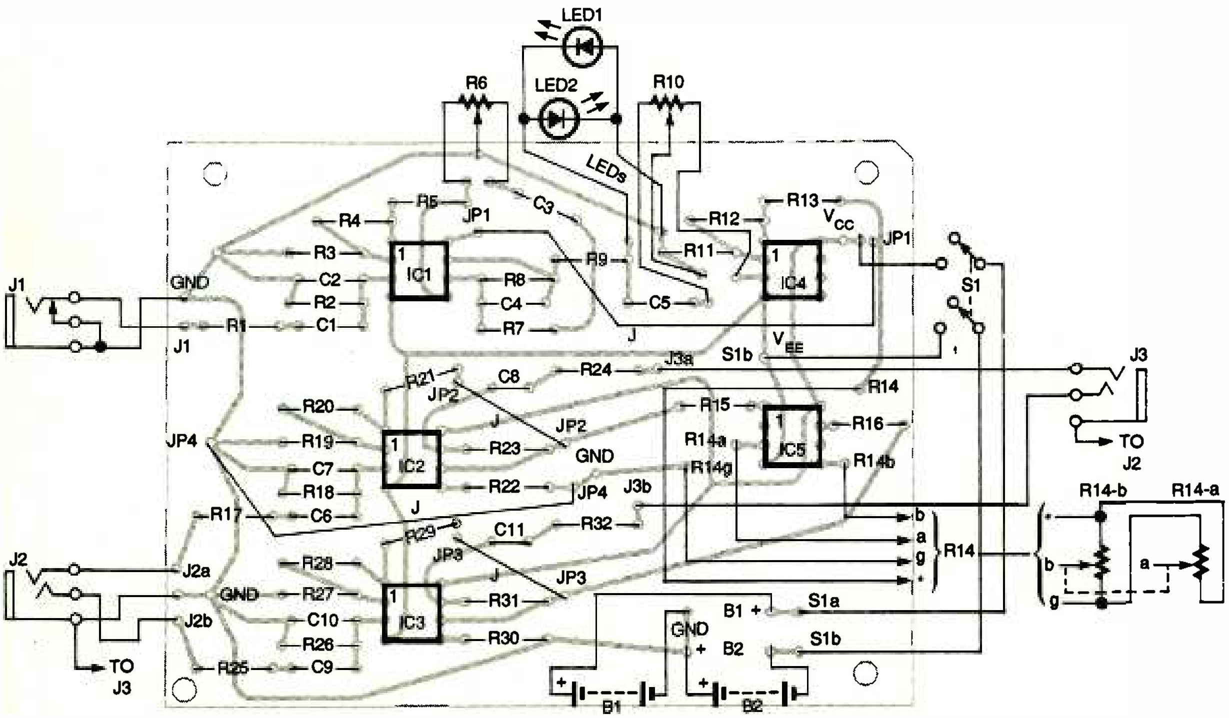
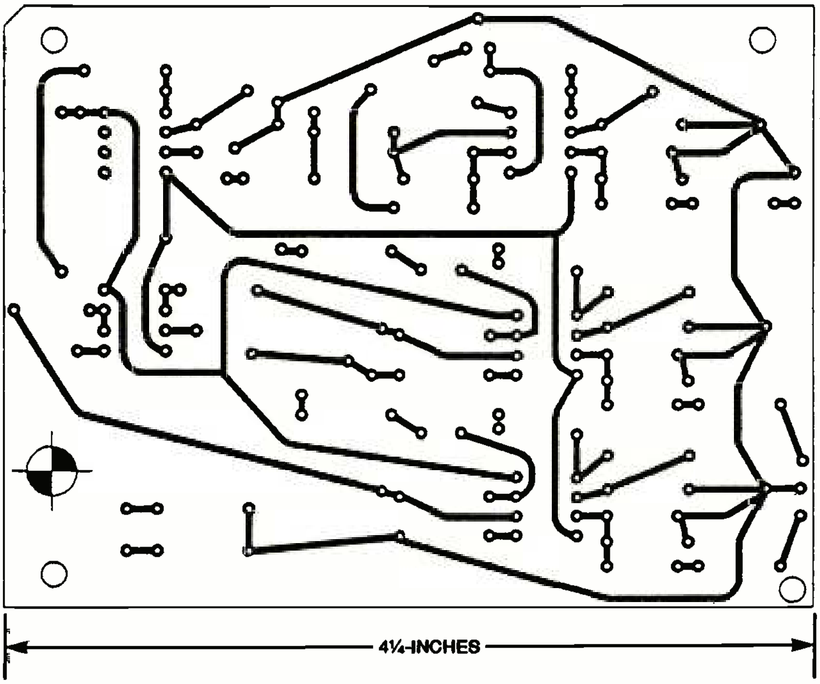


Fig. 3 Use the parts-placement diagram when mounting the components on the suggested PC board. The use of sockets for ICs is recommended.



PC board foil pattern is shown here same-size for use by experimenters who prefer to etch their own board.

battery clips. Add labels to the outside of the case to identify the jacks, switch, and controls. Close the case and you are done. The unit is now ready for jamming.

Notes on distortion. Devices that generate distortion for musical instruments have been around since amplified instruments were available. Often the distortion was an inherent and undesirable condition caused by the design or poor component quality. As a teenager, I would hunt through the local libraries for electronic projects attuned to the guitar. I recall installing a germanium diode in series with the center lead of a guitar cord. It didn't work as promised, as a local AM radio station was received much louder than any guitar sound my new "fuzz box" produced.

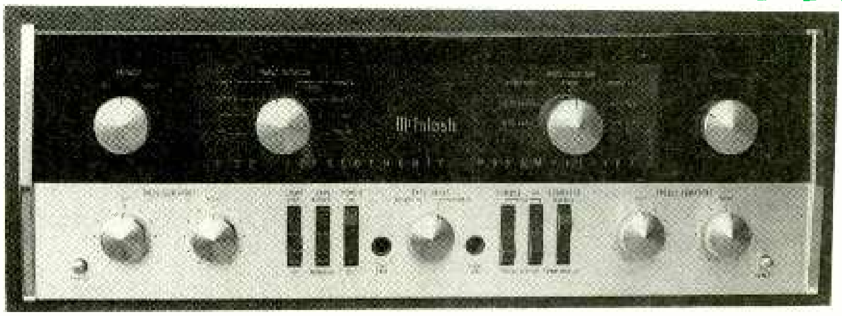
The first store-bought "stomp box" I used was a small black and silver wedge that had the guitar cord permanently connected. Since then, I have used the Big Muff (because Hendrix used one) and a Morley Distortion One, MOD-LED1B. I still have the Morley, and it was in service for many years, mostly since the distortion control would allow me to blend the distorted signal with the clean signal, and partly because it never quit working. I often prefer just a small amount of distortion that kind of rides on the clean signal. The JamMix distortion effect maintains this desirable characteristic (quite on purpose, I might add), and also provides a full range of distortion levels.

Stereo-balance control. In addition to the gain and level controls, a balance control was designed into the JamMix to enable the user to set a chosen position within the band. This is accomplished by mixing all, some, or none of the instrument's signal in the right and left channels of JamMix. The

Continued on page 81

The hot electronic components of the 1950s are today's vintage buys!

Where Has All The Good Stuff Gone?



This McIntosh C22 Preamplifier can fetch as much as $2500.

GARY McCLELLAN

Since the early 1980s, a sub rosa clandestine electronics marketplace developed and grew. Old tube-type audio and communication equipment, even specialized parts, has been methodically picked out of circulation and sent overseas by aggressive entrepreneurs. Once that equipment reaches foreign shores, it is sold to wealthy buyers or held for speculation. This article describes how choice electronic Americana equipment makes its way overseas, who buys it, and what they are looking for.

To many American and Canadian consumers this "equipment drain" may be a non-issue because they prefer the latest high-tech gear, and that's fine for them. For others, there is cause for concern because most of the vintage equipment has left our shores forever. That means there is less stereo and radio equipment here for "antique" lovers to enjoy. Worse, the leftovers on our shores tend to be in fair-to-poor condition, and their prices rise steeply with demand.

To understand the current interest in vintage electronic equipment, consider this: I have a *perfectly* restored 1955 jukebox. When kids visit, they are enthralled by its appearance and enjoy watching it play records. That is because they haven't seen a jukebox before; most jukeboxes were trashed or sold to European buyers long before these kids were born. Adult visitors often tell stories about dancing to the music, how they met their spouses over one, and so on. In short, the jukeboxes attract attention because they are rare and unique, and people buy them for those reasons. The same is true for the other types of vintage equipment described in this article.

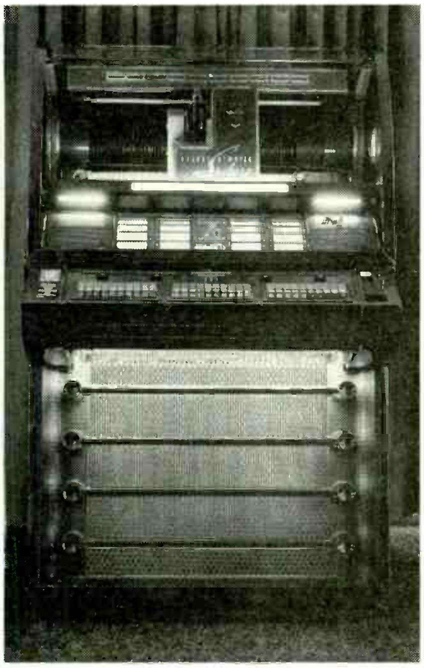
Overseas they will go. The demand for vintage American-made electronic equipment is strong and increasing, particularly in Asia. That is reflected in equipment prices and availability in North America. For example, one of the finest tube-type stereo power amplifiers is the McIntosh MC275. It sold new for $488 back in 1968: in those days you could buy a four-door sedan for about $3300. Today, a used, unrestored MC-275 in good condition sells for about $4000 (U.S.) in Japan! Even more amazing is that McIntosh Laboratory, Inc. reissued the amplifier with a $4000 price tag, and those units sold like hotcakes. When McIntosh followed up with the companion C22 preamplifier for $2000, it also sold well. My local McIntosh dealer told me that the equipment was re-issued to satisfy the red- hot demand in Asia, and that the first production runs of each model were sold out.

Asian pipeline. Over the years, I have become acquainted with many West coast vintage buyers and their purchasing methods. Then, on a vacation in Asia several years ago, I met a dealer who introduced me to the other side of the vintage-equipment market. Both sides of the story are very interesting, to say the least!

The stateside group of vintage equipment buyers known to me uncovers audio and radio equipment by using a wide range of shopping techniques. Reading newspaper want ads, attending yard sales, and visiting flea markets are mandatory. In fact, one individual waits in line at 7 AM on Thursdays to pick up the weekly classified-advertising newspaper. (There must be hundreds of local and regional newspapers like it in North America.) Many buyers attend estate sales and auctions, occasionally with spectacular results. For example, a local aerospace firm recently auctioned a dispatcher's console for $100. It contained three MC- 275 amplifiers in pristine condition!

Several buyers visit old-time electronics stores and TV service centers, particularly those in small towns. A friend who owns an electronics store (since 1956) reports that one customer methodically cleaned him out of certain receiving tubes for years. I even met a clever individual who called all of the septuagenarian and octogenarian hams in the area and asked if they had equipment or parts for sale. That led to several purchases of prime communications gear and hard-to-find parts at great bargain prices.

Vintage equipment makes its way overseas through several channels. Some North American buyers offer their equipment to individuals who represent overseas buyers. Their ads appear in newspaper classified advertisements, as well as in audio and



This 1955 Seeburg Jukebox sells for $4000-6000 when in prime condition.

antique-radio magazines. They are easy to spot by their "We pay top $$ for brand A, B, C" messages. Other buyers ship equipment directly to relatives overseas, who in turn resell to local individuals and trading companies. The relatives often hold equipment for speculation and use. They sell it directly to the end users at a premium price when the timing is right. Trading companies found in many Asian countries are basically retail distributors with import capabilities. They have their technicians refurbish the equipment before offering it for sale in their showrooms.

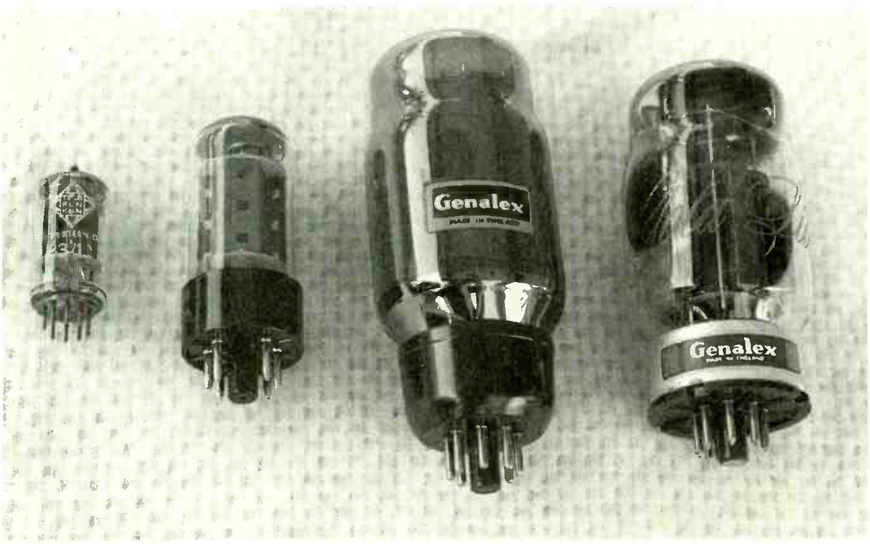
One stateside buyer I know performs a novel variation of that process. First, he "test markets" his acquisitions at local flea markets. Then he sells the leftovers to the highest bidding trading company. The advantages of that process are that we get the first chance to buy his equipment, while he saves the cost of shipping and dealing with Customs. However, he warned me that the demand for US-made tuners, preamplifiers, amplifiers, and speakers has pushed prices to levels that few local buyers are willing to pay. As a result, he must export increasing quantities of these kinds of equipment to aggressive Asian buyers to turn an acceptable profit.

In general, the stories I hear imply that most end users are wealthy individuals who have the time and living space to indulge in owning vintage equipment. That makes sense when you think about it. For example, in Japan, a typical salaried employee earns a modest income and lives in a 425-square-foot apartment. He is unlikely to invest in a vintage stereo system that costs a third of his annual salary and takes up most of the space in his living quarters.

Nevertheless, Japan is the largest marketplace for vintage equipment. Although information about this market is limited by the language barrier and other factors, I was amazed to learn that, according to published reports, Japan has approximately 55,000 antique-audio enthusiasts. Their interests in equipment range from state-of-the-art to 1930s vintage. A sizable number of Japanese enthusiasts build their equipment from scratch, mainly for cost savings and personal satisfaction (shades of the old Heathkit equipment). There are groups of over-enthusiastic users who aggressively seek out Altec-Lansing, Collins Radio, Marantz, McIntosh, and Western Electric equipment. As a result, certain models of equipment from those manufacturers fetch astounding prices when they are available.

During a vacation trip in Singapore, I spent an enjoyable afternoon visiting with a local high-end audio dealer. He told me that his customers were mostly bankers who referred him to other bankers and clients as buyers of new and vintage audio equipment. He also said that ownership of vintage US and British-made equipment carries status in Singapore as well as in Japan. That attracts a more exclusive clientele. Among other interesting tidbits, I learned that interest in vintage equipment is strong and increasing in Hong Kong, Korea, and mainland China.

A hot item in the 1960s, this "mint" Fisher 500C stereo receiver can be bought for $175.



Vacuum tubes like the 12AX7, 7591, KT-66, and KT-88 are desirable golden oldies.

Singing sales. Vintage audio equipment is especially *hot* in Asia. That includes jukeboxes, amplifiers, preamplifiers, tuners, and speakers. Here are some examples: Prize jukeboxes include the Wurlitzer 1015 from 1946, and 1950s models like the Seeburg V200. Restored units fetch impressive prices—$15,000 to $20,000 for the Wurlitzer and $6000 to $8000 for the Seeburg. Yes, the shipping charges and duties are also impressive!

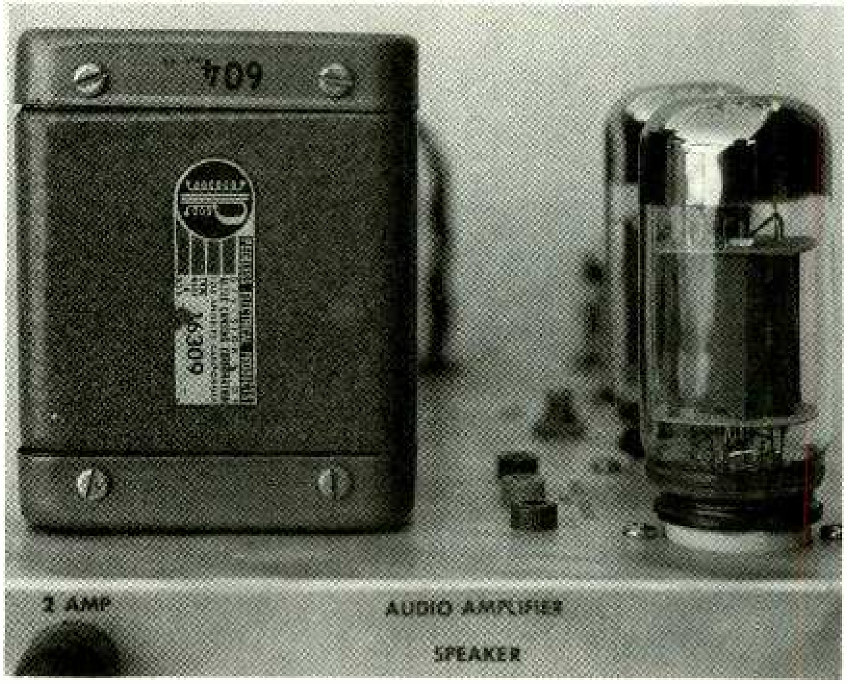
When supplies of McIntosh MC-275 amplifiers dried up, Asian buyers shifted their attention to other models like the MC-240 and MC-225. Today, a clean MC-240 brings $1500 to $2000, while the MC-225 is worth $600 to $1,000. Another desirable amplifier is the Marantz 8B; good ones fetch $2000 or more. Incidentally, McIntosh products are in heavy demand because they are well made, sound good, and look impressive.

Preamplifiers in demand include the Marantz Model 7 and the McIntosh C-22, which is pictured. Both units were top-of-the-line products during the mid-1960s, and mint examples go for $2000 to $2500.

Since McIntosh and Marantz amplifiers and preamps are now scarce, buyers have turned their attention to still-plentiful Fisher Radio products. The Fisher 400C, 500C, and 800C stereo receivers from the mid-1960s are especially sought after. They sell for $100 to $175, depending upon condition.

By far the most desirable tuner is the Marantz 10B FM tuner. That "monster" sports 26 tubes and an oscilloscope for easier tuning. Although it originally sold for $700 in 1965, a unit in mint condition goes for $3000 today. Another FM tuner in high demand is the McIntosh MR-78. That is the only piece of solid-state equipment that will be mentioned in this article. Nice ones go for $500 to $800. It's only a matter of time before all the vacuum-tube equipment is snatched up and quality solid-state units get big tickets.

In general, there is strong overseas interest in any speaker from Altec-Lansing and JBL. The gray Altec A-7 "Voice of the Theater" speakers are in heavy demand in Japan, followed by raw (replacement) speakers like the model 604. Popular raw speakers from JBL include the LE8T 8-inch woofer. Speaker prices fluctuate constantly, and there is a definite "we'll pay whatever it takes to get it" buyer's mentality.



This Peerless output transformer, vintage 1950s, was a hot item in top-quality 20-watt audio amplifiers. Prices then were from $2 to $5; they are now valued from $75 to $150.

Communications gear. There is some interest in 1950s vintage Collins, Hammarlund, and Hallicrafters equipment. The Collins 75A4 receiver is popular, followed by the matching transmitter and linear amplifier. Prices for 75A4s in good condition start at $500. Like the 75A4, the Hammarlund SP-600 receiver was popular with military and commercial users during the late 1950s. Clean examples go for $400 and up. Hallicrafters turned out vast quantities of low-priced equipment like the S38 and SX100 series receivers, which go for $30 or more, depending upon condition. (Expect those prices to escalate over time.) Hallicrafters receivers are popular with end users who are not wealthy but want a piece of Americana.

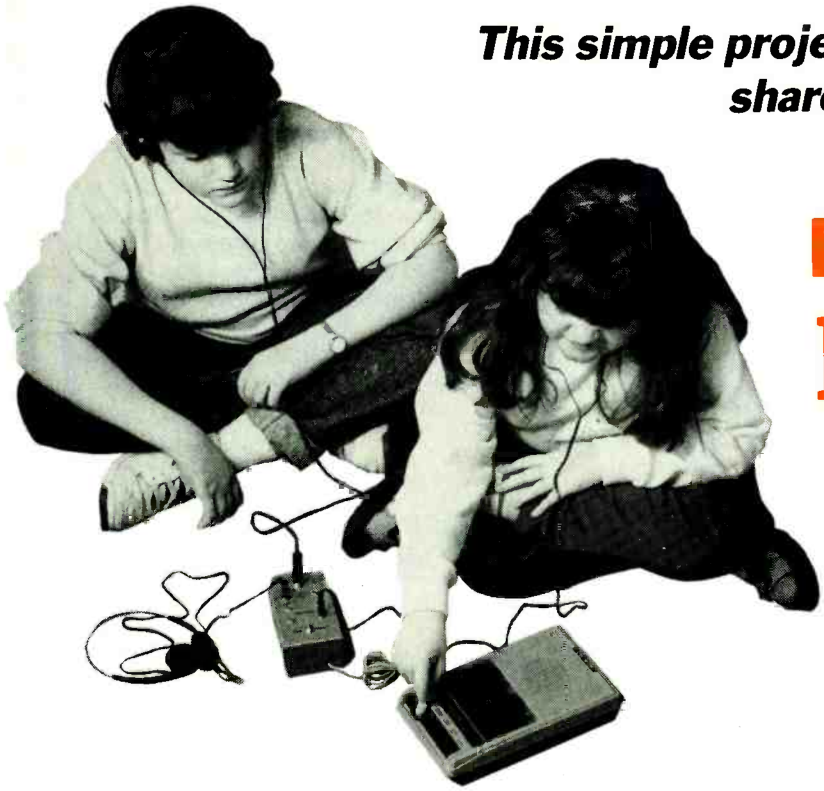
Hot parts. Although interest is higher in vintage equipment, there is a hot market for certain electronic parts. Overseas buyers want new old stock (NOS) tubes, capacitors, and audio-output transformers. Ironically, tubes imported into the United States are in far greater demand than domestic tubes. US made capacitors and output transformers, on the other hand, are highly prized.

Desirable NOS tubes include the Western Electric 300B, Genelex KT66, Genelex KT88, Mullard EL34, and Telefunken 12AX7. In fact, Western Electric resumed production of the 300B during the fall of 1994 in order to satisfy worldwide demand. Originally introduced in the early 1930s for use in theater sound equipment, the 300B now sells for $350 apiece! The Genelex and Mullard tubes were imported from Great Britain. They are arguably the finest audio-output tubes available, and their sale prices reflect that. NOS KT88s sell for $125-$300, KT66s for $100-$150, and EL34s for $30-$65 each. The Telefunken 12AX7s were imported from West Germany, and new ones sell for $45 and up when available. Like the Genelex tubes, they are considered among the world's finest.

NOS vacuum tubes in demand from domestic suppliers include the Tung-Sol 5881, Tung-Sol 6550, and any brand of 7591. Tung-Sol developed the 5881 and 6550 tubes in the early-to-mid 1950s. Many people think they were the best tubes of their kind, and they were once very common. Today those tubes are scarce and their prices reflect that. New 6550s sell for $45-$80, and 5881s go for $10-$25. The 7591 tube was made originally by

Continued on page 81

This simple projects lets multiple users share a tape player or radio through headphones.



BUILD THE Listening CENTER

MICHAEL A. COVINGTON

WHAT DO YOU DO WHEN HALF A DOZen people need to listen to the same tape player or radio, through headphones, at the same time? That situation arises often in classrooms, libraries, language labs, and anywhere speakers cannot be used because they might be too distracting to others.

Although you can connect all the headphones in parallel and hope for the best, that's far from an ideal solution. The listening center described here provides a robust and reliable way to drive as many as seven pairs of Walkman-style headphones from a single signal source. Unlike a simple parallel connection, the listening center takes care of all the following requirements:

- The radio or tape player can be mono or stereo, and either way, the listeners will hear sound in both ears.
- The radio or tape player need not contain a resistor to protect the headphones. That means you can feed the listening center from a speaker-level signal if you wish.
- Plugging a mono earphone into a stereo jack will not short out a channel.
- Even with seven 32-ohm headphones connected in mono mode, the radio or tape player sees a seven-ohm load impedance, which is high enough to protect it from damage that would be caused if it were overdriven.
- The listening center is rugged and "student-proof" for classroom use.

The circuit

How's it all done? With resistors. As shown in Figure 1, each side of each headset is fed

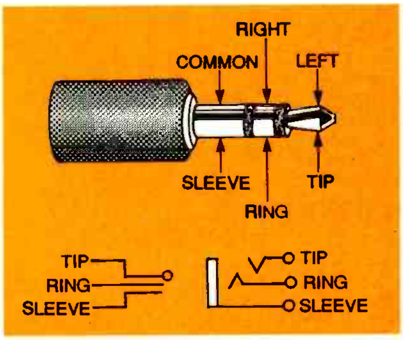


FIG. 2—A PHONE PLUG and the schematic symbols for plug and jack. A mono plug has a longer sleeve and no ring.

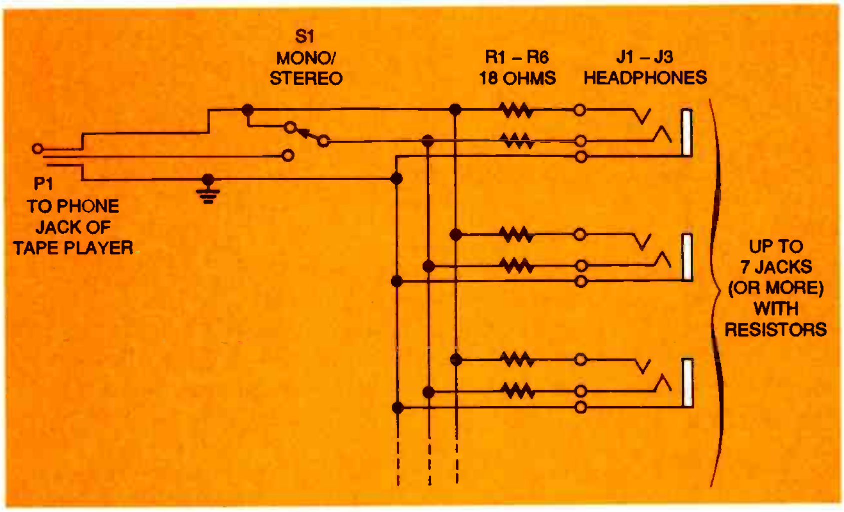
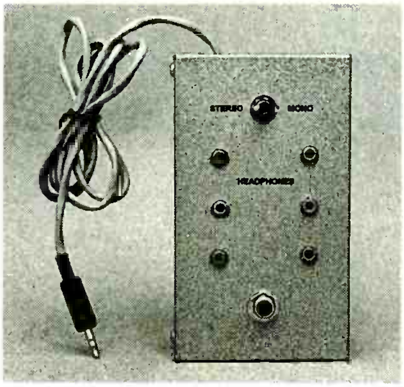


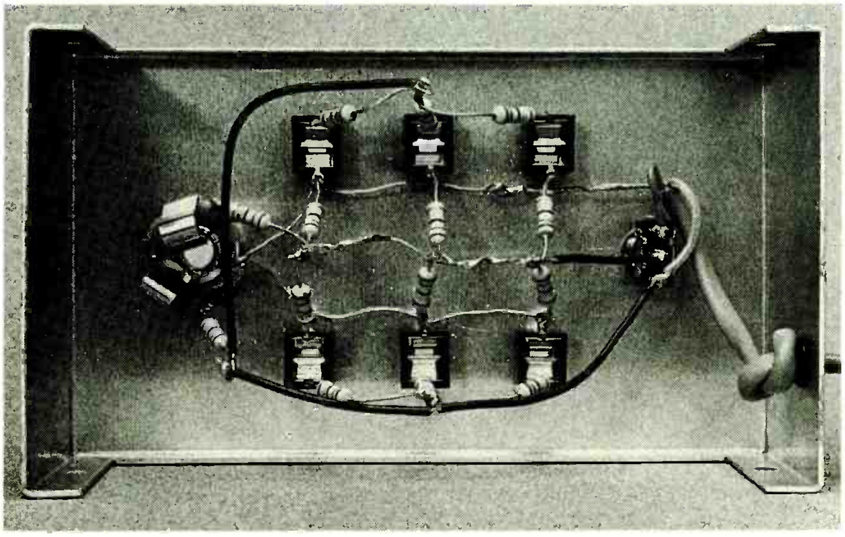
FIG. 1—THE LISTENING CENTER. Three jacks are shown, but you can use up to seven or more.



THE ENCLOSURE for the listening center can be either plastic or metal. Install both large and small headphone jacks for maximum flexibility.

PARTS LIST

- P1—Stereo (3-conductor) phone plug to fit radio or tape player (3.5-mm or ¼-inch)
- S1—Subminiature SPDT switch
- R1-R6—18- or 22-ohm, ⅛-watt resistor (two for each headset)
- J1-J3—Stereo (3-conductor) phone jack to fit headset (3.5-mm or ¼-inch)
- Miscellaneous: Metal or plastic enclosure, approximately 3×5×2 inches; flexible 3-conductor cable or 2-conductor shielded cable, about 3 feet long; hardware, grommets, labels, etc. as needed.



YOU DON'T NEED A CIRCUIT BOARD to build the listening center. The resistors are supported by their leads.

through its own 18-ohm resistor.

Because the impedance of Walkman-style headphones is normally 32 ohms, this doesn't reduce the sound level very much, but it does protect the headphones if the listening center is connected to a speaker-level signal. It also protects the headphones from each other—a single low-impedance headphone won't "hog" all of the signal, and even a short circuit to ground won't do any harm.

Short circuits are usually a risk because of the way stereo phone plugs are made. As Figure 2 shows, each stereo plug has three conductors: tip (left channel), ring (right channel), and sleeve (common ground). A mono plug has no ring; instead, the sleeve extends up where the ring would be. Therefore, if you were to plug a mono plug into a stereo socket, one channel would be shorted out, possibly damaging the amplifier.

The listening center eliminates that problem by using only stereo plugs. Its stereo/mono switch lets you feed both channels of the stereo headphones from the tip of the plug when using a mono signal source.

Construction

The listening center can be built in a small metal or plastic box. The phone jacks can be small (3.5-mm) or large (1/4-inch); we chose to use six small ones and one large one for maximum flexibility.

No circuit board is needed; the terminals of the phone jacks can serve as tie points, with each resistor supported by its own leads. The cable to the radio or tape player need not be shielded, but shielding may help prevent pickup of radio frequency (RF) interference. Shielded or not, the cable that you choose should be strong and flexible, and long enough to allow comfortable positioning.

If you want to use more than seven headsets at a time, make the resistors slightly larger (such as 22 instead of 18 ohms). Depending on the signal source and the loudness needed, you may be able to use as many as a dozen headsets.

Checkout and use

To try out the listening center, plug it into the headphone jack of a stereo system or "boom box" and plug in two or three Walkman-style headsets. If the headsets are reasonably well matched, you should hear the program with equal volume in all of them.

With the STEREO/MONO switch set to MONO, you should hear the sound for the left channel in both ears of each headset, and you can use a monophonic signal source such as a mono tape recorder.

Because the listening center includes no amplification, you'll have to turn up the volume of the signal source louder than normal, but almost any radio or tape player should be able to drive multiple headsets with no difficulty. Tiny pocket-size units are the only exception; a tape player powered by two AA cells can probably only drive two or three headsets at a time with adequate volume.

Imported Walkman-style headsets suitable for classroom use are available for as little at $1 each (check the "Everything's A Dollar" store in your local mall). As long as their impedance is 32 ohms, all the headsets should give equal loudness when used simultaneously. Headphones of other impedances can be used but will not necessarily give equal loudness. Ω

BUILD THIS

Hobby Spectrum Analyzer

At less than $100 to build, this spectrum analyzer is a must for every hobbyist!

BOB KOPSKI

Last month we looked at the Hobby Spectrum Analyzer's theory of operation. Now, let's turn our attention to its construction.

The Hobby Spectrum Analyzer circuits are built in two basic ways. The RF circuits are built on double sided printed circuit board material used as chassis material. The non-RF circuits are built on RadioShack universal prototyping boards.

Four universal prototyping boards are needed. Three are used full size and stacked together, and the fourth one is cut into smaller pieces and used on the RF circuit module. All the circuit assembly drawings for the modules (Figs. 6 though 11) are top views, *i.e.*, component side up. The printed lands are shown dotted, *i.e.*, X-ray style. On most of the circuit assembly drawings, large "X"s indicate that existing copper-foil runs on the boards are cut. Do the cutting before you begin assembly of the boards.

DC/DC converter and regulators. While all universal prototyping board circuits are built similarly, the DC/DC converter and regulators board does have a unique modification in the form of added copper foil lands on the conductor side. The board drawing (Fig. 6) includes shaded markings where the copper foils are added. This foil encompasses the board mounting holes and is pressed against the four "stack screw" double-nuts during case installation, assuring good ground contact to the cabinet floor. The board has a formed, thin aluminum shield cover over it to contain the switching emissions associated with the voltage multiplier.

Install the IC sockets first, then the parts and jumpers as indicated in Fig. 6. Finish up by adding twisted wire cables with connectors, switches, and the POWER LED2 where shown. Stake the cables to the board with insulated wire, upside-down "U"s as shown. The technique used to do this is not critical, so if you have a better technique, use it. Clean the copper side with flux solvent, and inspect your solder connections with a hand lens or eye loop for any of the usual problems.

Initial board testing of the DC/DC converter and regulators and subsequent adjustment requires an adjustable (variable) power supply and current meter. Make temporary test leads with the same pins and sockets as used on the assemblies. Begin testing the board by first setting trimmers R4 and R7 to mid-range, turn the power switch on and the comb generator switch off. Connect the power supply to the board's battery snap connector—be sure the polarity is correct! Slowly bring up the voltage from zero to the +12-volt level with an eye on the current meter. Normal current drain at 12.0-volts DC input is about 7 to 8 mA. Verify LED1 is dimly lit, and LED2 is brightly lit. If any of those indications aren't correct, re-examine the board to determine the fault(s)' location.

Use a DMM to measure the +5-volt and V+ DC regulator outputs. Varying

PARTS SUPPLIERS

DC Electronics
PO Box 3203
Scottsdale, AZ 85257-3293
Tel: 800-467-7736

Digi-Key Corp.
701 Brooks Ave So.
Thief River Falls, MN 56701-0677
Tel: 800-344-4539

Electronix Express
365 Blair Road
Avenel, NJ 07001
Tel: 800-972-2225

Hosfelt Electronics Inc.
2700 Sunset Blvd.
Steubenville, OH 43952-1158
Tel: 800-524-6464

Ocean State Electronics
PO Box 1458
6 Industrial Drive
Westerly, RI 02891
Tel: 401-596-3080

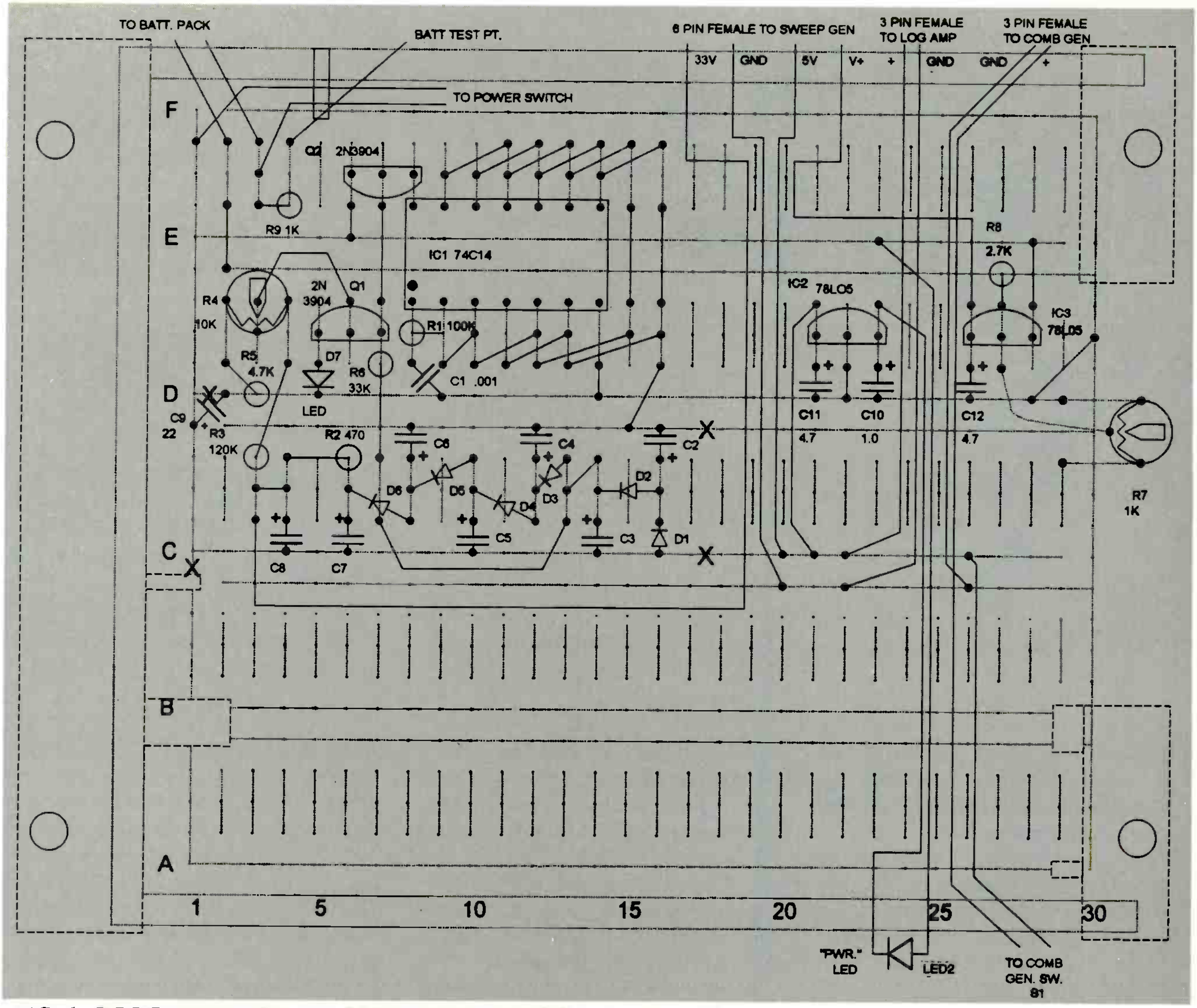


FIG. 6—DC/DC CONVERTER AND REGULATORS MODULE is diagrammed here using the author's original illustration (as are the following figures). Parts are mounted on a PC universal prototyping board (RadioShack 276-168). Original copper-foil runs are used but broken at selected points as indicated by bold "X"s in the diagram.

the setting of R7 should vary the V+ range from five to about seven volts or more. Move the DMM connection to the high-voltage terminal. The +33-VOLT potentiometer, R4, should vary the voltage from about 25 to 40-volts DC. Reset R4 so the DMM reads +33-volts DC. Now adjust the bench supply over the 10- to 13-volt range. The 33-volt DC output should stay within 0.5 volt of the set level. Connect the DMM to the comb generator connector set and verify the operation of the COMB switch (see Figs. 2 and 3). You should read five volts when the switch is on. Turn off both power switches. This completes the initial DC/DC converter and regulators board tests.

Log amplifier. Like the other boards, the log amplifier board (Fig. 7) uses 14-pin IC sockets so that all assembly work can be done and then the ICs plugged in. Assemble the board carefully as done previously, clean it, and inspect it. Temporarily short together the input signal leads. Cut the top lead of the vertically-mounted resistor R27 (located between potentiometers R26 and R28). This cut in the lead of R27 will be tack-soldered together later, so do not cut too close to the resistor body. Adjust R2, R26, and R28 to about mid-range. Now install the ICs, carefully noting pin orientation.

Set the adjustable DC power supply to zero, hook it and the current meter up to the onboard power-input connector pins, and slowly bring the voltage up, keeping an eye on the current meter. The log amplifier current drain is a very sensitive function of applied DC voltage. Prototypes drew 2.7 mA at +4.0 volts, 7 mA at +5 volts, and 14 mA at +6 volts. Expect similar behavior although the currents you measure could shift up or down as much as 50%. Set the input DC voltage to +5.0 volts for the following tests.

Using a DMM, measure the voltages at IC1, pin 8, and IC2, pin 10. Those should read +2.5 ±0.2 volts. Now measure the voltage at IC1 pins 12, 2, 4 and 6; IC2 pins 2, 4, and 6; and Q1 and Q2 emitters. Again, +2.5 ± 0.2 volts is the target, but it's possible to exceed this target value a little at one or two test points.

Connect your oscilloscope to the signal output. There should be no indication of board instability or oscillation, but there should be a 25-30 millivolts peak-to-peak broadband noise present. Vary trimmers R2 and R28 individually, and confirm that both vary to output noise level, with R28 producing the greatest effect. Reset all trimmers to mid-range position. A special note: Because of the very high gain of the log amplifier, you may experience enough hum pickup to preclude a successful noise test. If that is so, power the board from the DC/DC converter and regulators board, operating the latter from the HSA battery pack. The hum level should drop considerably allowing the broadband noise to be measured.

Connect a 10,000-Hz sinewave signal source to the log amplifier input. Set the input signal level to 1.0 mV peak-to-peak and observe the signal at IC2, pin 6. The signal should be about three volts peak-to-peak, representing about a 70-dB gain. Vary R2 from limit to limit and verify a little under 2:1 output change. Restore R2 to mid-range.

Connect the oscilloscope to the log amplifier output, and verify a signal level of about 250 mV peak-to-peak. (The input-output gain should be about 250.) Vary the setting of R28 from limit to limit, and verify an output level change of about 3:1. Reset R28 to mid-range. Gradually increase the input signal swing up to about one volt peak-to-peak, and verify that the output waveform transitions from that of a sinewave shape to a compressed appearance on both positive and negative peaks. (Waveform symmetry may vary about 5% over the range.) With a 1.0-volt peak-to-peak input, the output should be about 1.6 volts peak-to-peak. This result means the input-output gain is now only 1.6. If you vary R28's setting from limit to limit, the output will vary about 3:1. Reset all trimmers to their mid-range settings.

Solder together the cut lead at the top of R27. Set the input signal level to 10 mV peak-to-peak, and observe the output wave shape while adjusting R26. Observe that at some point the output negative- going swings get cut off. This occurence verifies operation of the base-line clipper circuit. Reset R26 fully clockwise to complete the initial board test. Remove signal and power connections and set the board aside.

Sweep circuit. The sweep circuit board is assembled like the previous boards, but it does have more land cuts, as indicated by the "X"s in Fig. 8. Because of the complex waveshapes involved and the numerous associated adjustments, this board is a bit more complicated to test and tune. In the initial checkout, the waveforms will only be roughly set to shape;

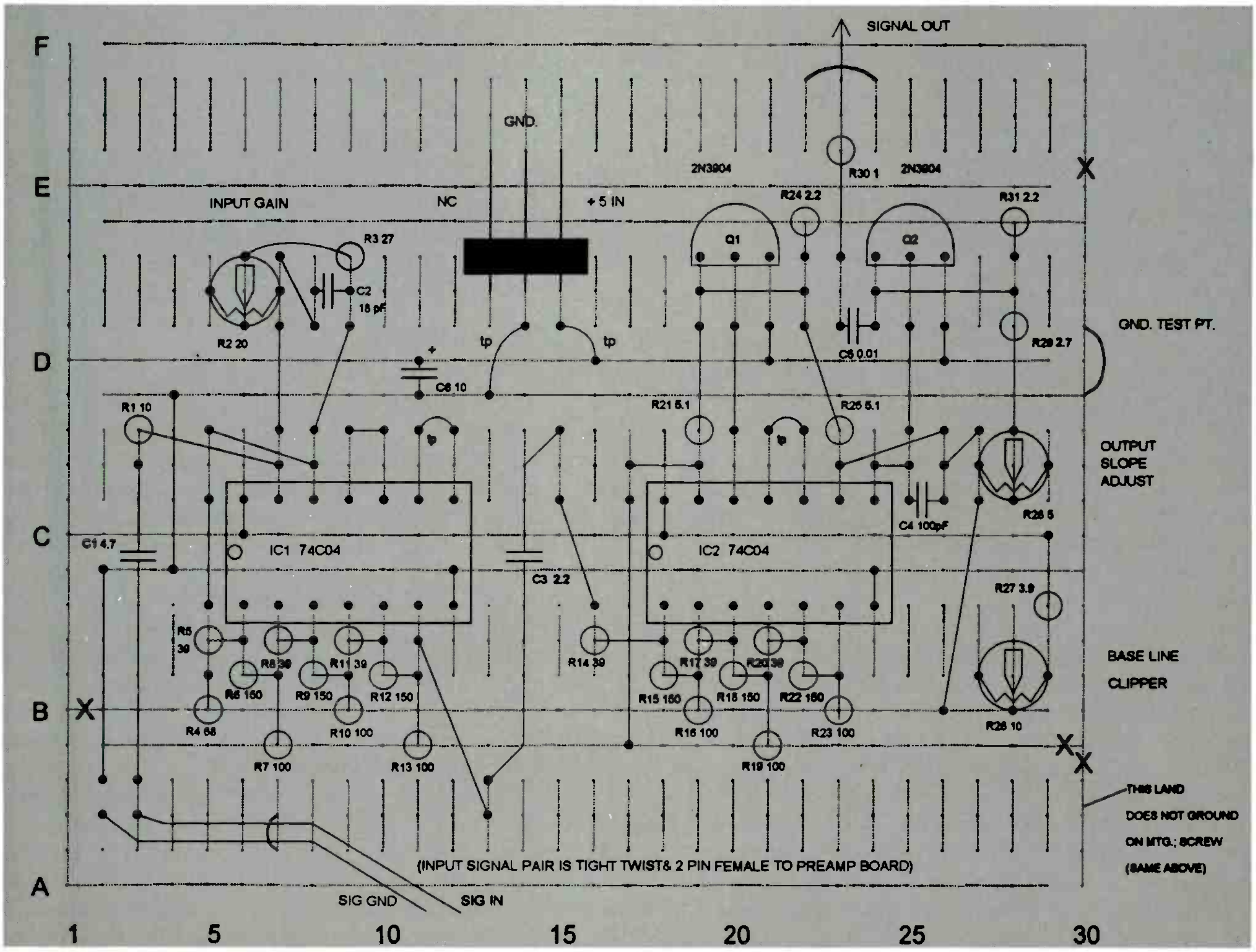


FIG. 7—LOG AMPLIFIER MODULE has its parts assembled on a PC universal prototyping board (RadioShack 276-168) in a similar style used in Fig. 6. "X"s indicate deliberate foil breaks to isolate selected circuit portions.

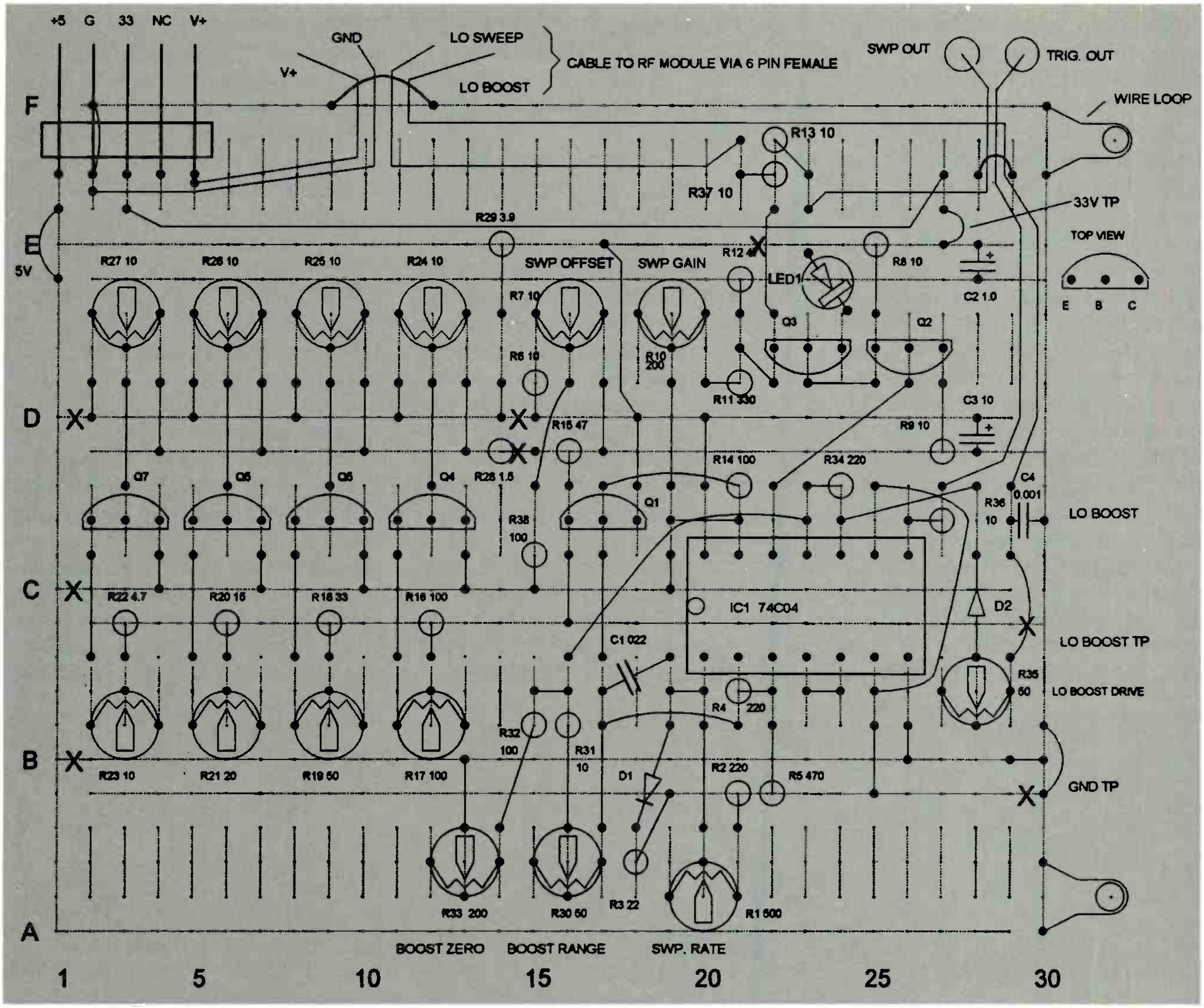


FIG. 8—SWEEP CIRCUIT MODULE contains a host of one-turn, PC-mount trimmer potentiometers that suggest an eventual complex adjusting process. Fortunately that is not the case!

final adjustments take place when the Hobby Spectrum Analyzer is assembled.

After the board is assembled, inspected, and cleaned, set all the trimmers to about mid-range settings except R35, which is set fully CCW. With a current meter in the +5-volt DC line, advance the adjustable power supply from zero to +5.0 volts, keeping an eye on the current meter. The current should be about 2.5 mA at 5.0 volts input.

If the current is satisfactory, connect an oscilloscope probe to IC1-a, pin 2, and verify the assymmetrical triangular waveform (Fig. 4). Adjust R1 for a long ramp time of about 11 mS. The short ramp time should be about 0.6 mS. The waveform should swing from about 1.3 volts to 3.7 volts, or 2.4 volts peak-to-peak. This same waveform should appear at Q1's emitter, although shifted DC downward about 0.7 volts.

Connect the oscilloscope to IC1-d, pin 8 (trigger output), and observe a 5-volt positive-going pulse about 0.6-mS wide with a pulse repetition interval of about 11 mS. If you have a two channel oscilloscope, you can observe both the triangle and pulse waveforms simultaneously, noting that the long ramp begins at the falling edge of the trigger pulse.

Set the oscilloscope time base to 1-mS per division and connect the trigger pulse to the oscilloscope's external trigger input. Adjust the triggering controls for the long ramp to begin at the left screen graticule and extend somewhat past the right graticule edge. Temporarily connect (load) the local-oscillator-boost test point using a 22,000-ohm resistor to +5-volt DC. Connect the oscilloscope to observe the local-oscillator-boost test point signal and alternately adjust R30 and R33 to approximate the waveform appearance shown in Fig. 4. (The amplitude is lower than depicted.) Final adjustments are done on the assembled HSA.

Use the DC/DC converter and regulators board to power the sweep circuit board to obtain the +33-volt DC supply. When powering that board from the adjustable supply, watch the current as you advance the voltage from zero to +12.0 volts. Current should be between 11 and 12 mA. Verify that the 33-volt level is correctly set.

Connect the oscilloscope to the sweep output at its connector pin. You should get some resemblance to the varactor sweep waveform shown in Fig. 4. Adjust all the influential trimmers one at a time (R17 through R27 and R10). Each one should affect the waveform in some manner verifying basic operation. Return them to mid-range position.

Now the sweep waveform can be trimmed closely to the estimated final shape. With the oscilloscope still connected, set the oscilloscope's vertical coupling to DC, the vertical position near the bottom of the screen, the vertical sensitivity to 5-volts per division, and the time base to 1-mS per division. Display the sweep waveform. Adjust the sweep offset trimmer, R7, so that the start of the sweep is about +4 volts above ground. Then adjust sweep gain trimmer (R10), so the ramp hits about 9 volts at 5 mS. Adjust R24, so the waveform slope *just* begins to increase about that same point. Adjust R26, so the new slope begins to increase at 7 mS.

Finally, adjust R27 for the last slope increase beginning about 9 mS. At that point, you should have a rapidly and smoothly rising voltage curve filling the oscilloscope screen. Final fine adjustment can only be made with the Hobby Spectrum Analyzer operational. Remove power and test leads, and set the sweep generator board aside.

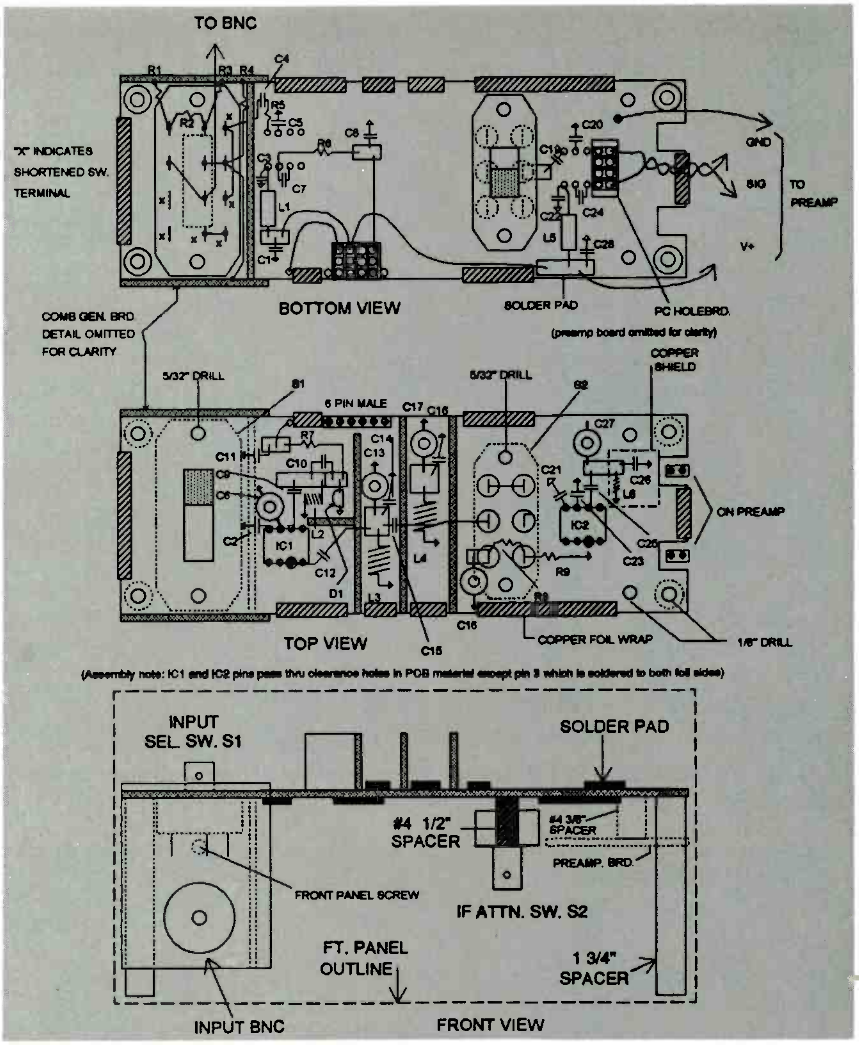


FIG. 9—RF CIRCUIT MODULE differs from other assemblies in that unetched, double-sided PC board material is used to mount components, RF (Faraday) shields, and subassemblies. Point-to-point wiring technique is used here. Soldering pads are used for common tie points.

RF circuit module. Begin the RF circuit module assembly by cutting the PC board chassis and shield partitions to size and accurately drilling the various mounting and parts holes as shown in Fig. 9. The overall size of the main board is 1⅞-inch by 5.0-inch. The four shield partitions are cut to fit on the locations indicated on the board with a height of 0.5-inch.

Carefully drill #50 holes through the plastic knobs of both slide switches as shown. Trial mount the two switches and confirm smooth operation. Test fit the ICs and six-pin connector, the latter with its piece of Universal prototyping board underneath. Note that the connector and IC pins go through the chassis. Use #60 drilled holes. The copper around those holes must be *coned* away on both sides of the board by countersinking, using a finger-driven sharp, ⅛-inch bit. That prevents accidental shorting between the copper and leads passing through the holes. Do not countersink the ground pins on the 6-pin connector and pin 3 on the ICs.

Form and sweat solder the copper foil edge wrap-arounds (Fig. 9). Install the IC's soldering pin 3 on both sides of the board. Note that all other IC connections are made directly to the device leads on either or both sides of the chassis. Install the six-pin connector.

Solder pads are used wherever wiring interconnections are needed. The solder pads are small pieces of double-sided PC board sweat soldered to the chassis at the locations shown. The top surfaces of those pads then become the soldering sites for the various interconnecting parts and wiring.

Install the solder pads and then all the small components as shown in the drawings and photos. Keep the leads short and wiring neat. Keep all capacitor leads trimmed to the minimum length. The ground end of the various components is simply a solder attachment to the copper-clad chassis. When installing the trimmer capacitors, be sure to solder the "cold" ends to ground. (The cold ends electrically connect to the adjustment screw and indicate zero ohms when measured.)

Trial place the shield partitions (see Fig. 9) as you go along, but do not solder them in place just yet. Install the slide switches noting that the switch lugs are cut short whenever possible. The center lug on switch S2 (IF attenuator switch) is bent at right angles toward IC2. Install all the components associated with the switches except

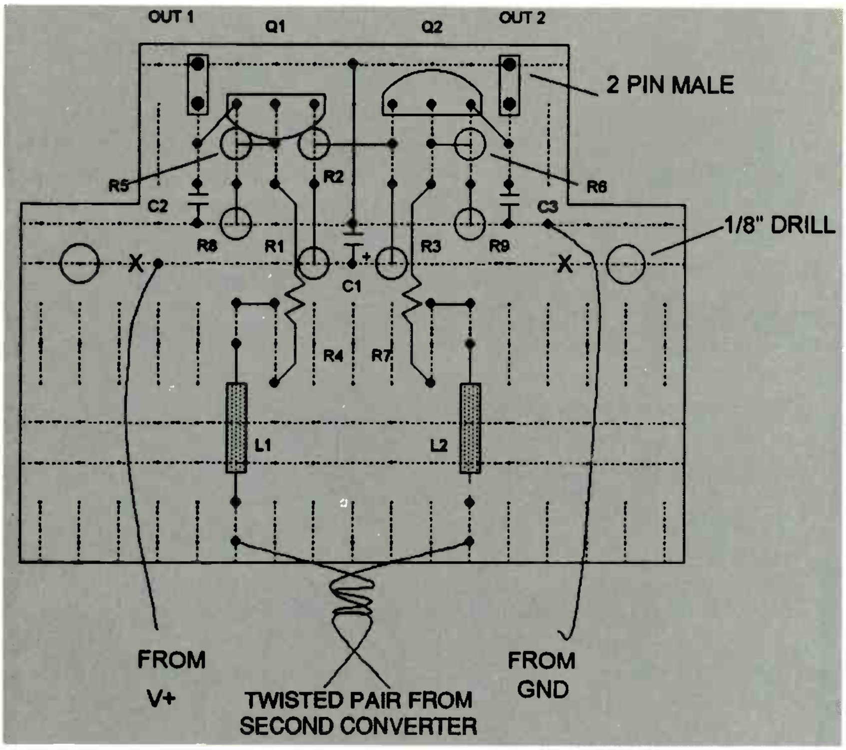


FIG. 10—PREAMPLIFIER SUBASSEMBLY, a part of the RF circuit module, is wired on a scrap piece of PC universal prototyping board with 0.1-inch hole spacing.

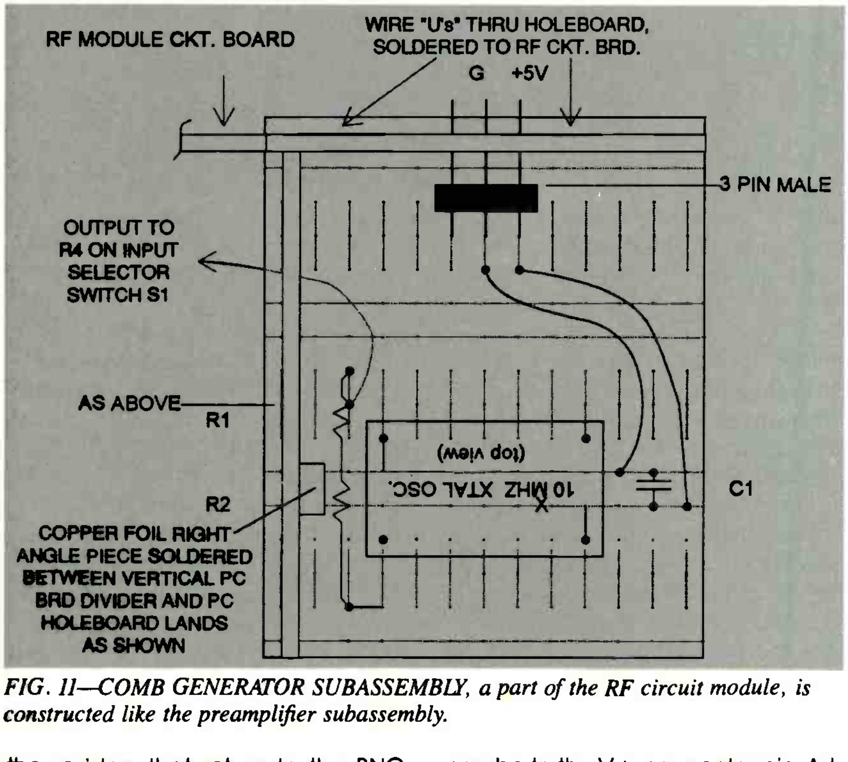


FIG. 11—COMB GENERATOR SUBASSEMBLY, a part of the RF circuit module, is constructed like the preamplifier subassembly.

the resistors that return to the BNC mounting plate.

At that point, perform a visual inspection and clean off flux as you proceed. Be sure the tricky solder attachments to the IC leads are not shorting. Following that, you can hook up the bench supply/current meter combo to the V+ connector pin. Advance the power supply voltage to +5.0 volts, watching the current. It should level out around 4 to 5 mA. Carefully check the voltage at pins 1 and 2 of each IC. They should be closely matched within each individual IC at about 1.4-volts DC. Pins 4 and 5 should be about 3.75-volts DC.

If the above is okay, remove power and proceed to tack solder the vertical partitions in place on each side of the main chassis. Install the BNC panel, and mount the BNC connector and the resistors from the input switch to the panel.

The comb generator and preamplifier boards (Figs. 10 and 11) are cut from the Universal prototyping board with a model hobby saw and then assembled as before. The comb generator can be powered up with +5.0 volts and checked for a 5-volt, 10-MHz squarewave prior to installation. The preamplifier board is best tested when interconnected to the RF chassis assembly.

Install the comb generator board by tack soldering its PC lands to the main chassis and front bottom vertical shield. Reinforce the attachment with #22 gauge wire "U"s soldered through lands in the universal prototyping board and then to the PC chassis material. Be sure the comb generator ground conductors are soldered to the main chassis underside vertical shield with the copper foil "L" as shown. Wire the generator output to the INPUT SWITCH.

Set the INPUT SWITCH to mid-position and directly connect the HSA input BNC to an oscilloscope. Power the comb generator with 5.0 volts. The 10-MHz waveform should read about 17 mV peak-to-peak. This level squarewave is about equivalent to a -30 dBm level at 10 MHz and is used in the amplitude calibration of the HSA.

Connect the four preamplifier leads to the appropriate locations, but do not mount the board yet. Again, connect the power supply to the RF circuit module V+. At 5.0 volts input, the current should now be 8-9 mA. Preamplifier Q1 and Q2 collectors should measure about 2.25-volts DC above ground. Power down and mount the preamplifier in position on the RF chassis. Form a half-round cover from copper foil and tack solder it. The copper foil serves as a RF cover over the L6 area. This prevents a flopping cable to the log amplifier from detuning the second local oscillator. That completes the assembly and initial test of the RF circuit module and all the room we have for now. Next time, we'll finish up the Hobby Spectrum Analyzer. Ω

BY DON LANCASTER

Magnetometer update, vacuum forming, and more

I CERTAINLY GET LOTS OF HELPLINE CALLS FROM INDIVIDUALS WHO ARE TRYING TO PROTECT ELECTRONIC DESIGNS WITH EPOXIES, PART-NUMBER GRIND-OFFS, AND SIMILAR STUPID PET TRICKS. WELL, ANY TIME YOU SEE A GLOPPED AND GROUND-UP project, you can pretty much rest assured that (A) All of the engineering is incompetent; and (B) The management suffers from acute recto-cranial inversion.

Besides being a monumental waste of time and energy that you should be spending improving your product and developing your design skills, those "protection" schemes simply do not work. In fact, they will have the exact opposite effect. All such "I've got a secret" stunts are red-flag invitations for people much smarter than you to spend lots of time and creative effort cracking your mystery. All you're doing is providing them with free entertainment.

Every town, no matter how small, includes a guild of highly capable epoxy-undoing specialists (for do-it-yourselfers, *Master Bond* sells a selection of epoxy-dissolving chemicals). These same folks have these neat-o X-ray machines that easily let you snoop into just about anything electronic or mechanical.

The moral? Just like that story about the fur-lined letter, the key protection secret is to always hide in plain sight. Far fewer people of far less competence will then be attracted to tracing your product. Chances are they will blow their quest anyway.

Always provide a complete, free, and detailed schematic with all of your products, and make your source code available at a fair price—one that is well under the cost of reverse engineering. Doing anything less is sheer insanity.

Magnetometer Update

Since last month's coverage, I've pinned down a bunch of new info and a few samples on magnetometers and fluxgates, so let's do an update. First off, Ripke's *Review of Fluxgate Magnetometers* in *Sensors and Actuators A*, volume 33, 1992, pages 129-141, is a real good technical starting point.

Figure 1 shows you the winding details on a classic fluxgate sensor. A softly saturating tape-wound toroidal core is normally used. The main or control winding gets driven by a low-distortion sinewave. That sinewave switches (or gates) the core in to or out of saturation.

Paired orthogonal sine and cosine sense windings tell the strength and direction of the external field as it is drawn in to and released from the core. For signal isolation, the sensing is normally carried out at the second harmonic of the drive frequency.

Although that fluxgate is a thoroughly tested and proven workhorse, it involves quite low-level, noisy, analog signals that are tricky to accurately interface to any micro. The multiple precision windings also add greatly to your final cost and complexity.

Additional details on the fluxgate support circuitry might be found in HACK14.PDF on www.tinaja.com and in the useful *Magnetic Measurements Handbook* from *Magnetic Research*. Magnetic Research also sells wound cores and working magnetometers.

Figure 2 shows us an improved circuit known as a resonant fluxgate. The op-amp operates open loop as a com-

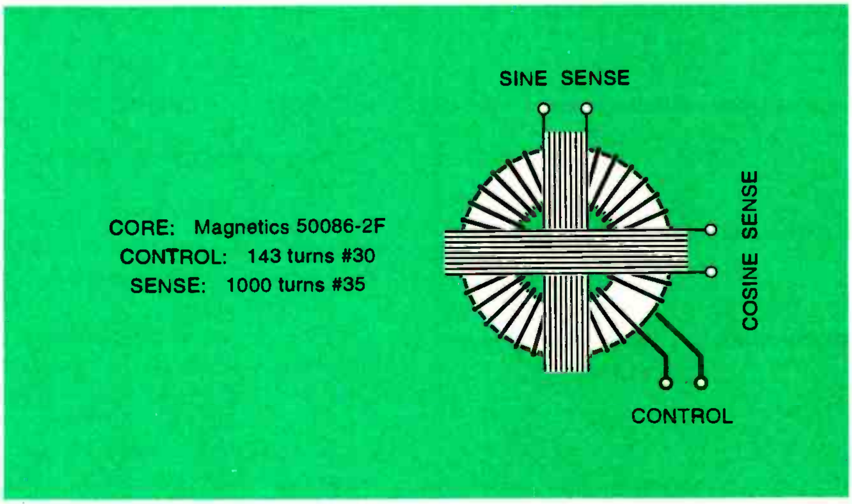


FIG. 1—CLASSIC ANALOG FLUXGATE MAGNETOMETER. An input audio drives sinewave the control input, switching (or "gating") the core in and out of saturation and drawing in or releasing an external magnetic field. Weak signals at the sense outputs end up proportional to field strength.

parator, generating a squarewave output. That squarewave is converted to a current source by the 56,000-ohm resistor. The current waveform excites the control winding, driving the core in to and out of saturation.

The high-turns secondary winding is made resonant by the 0.1-µF capacitor, producing a sinewave. The resonant sinewave then gets strongly amplified and converted back to the output squarewave.

The operating frequency is determined by your drive current, the inductance, and the time that is required for the core material to unsaturate. Any external magnetic field should bias your core material, causing the positive cycle to get longer and your negative cycle to get shorter, or vice versa with a field of opposite polarity. The net result is that the duty cycle of the output ends up proportional to the single-axis external magnetic field that you are sensing with the coil.

The amorphous ribbon core is made from an alloy of iron, cobalt, silicon, and boron. Chromium sometimes is thrown in for good measure.

For low noise, it is important your alloy has a low *magnetostriction*, or change in size with the field strength. Any core motion dramatically affects the level of the noise floor. Additional details are found in "A Resonant-Type Amorphous Ribbon Magnetometer That Is Driven By An Operational Amplifier" by Takeuchi and Harada, *IEEE Transactions on Magnetics*, MAG-20, Sept. 84, pp 1723-1725. As we've seen a time or two before, *UMI* is a great reprint source for these.

Finally, note that the circuit has both digital and analog outputs. The digital output might be interfaced with an appropriately programmed PIC or other microcontroller that will then handle the measurement function. Alternately, as shown, a simple resistor/capacitor low-pass duty-cycle integrator can create a bipolar, analog, output voltage (available at the circuit's analog output) that tracks the input field strength for you. Additional details on duty-cycle integration circuits and techniques are available in my *CMOS Cookbook*.

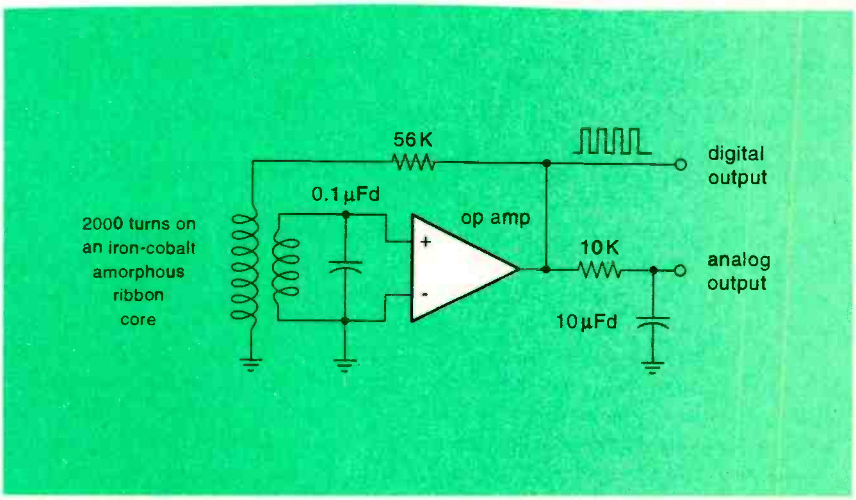


FIG. 2—A RESONANT FLUXGATE MAGNETOMETER. As before, the core will get switched in and out of saturation. The output duty cycle varies in proportion to the single axis field strength and direction. The high level output square wave is easy to interface to a PIC or other microcontroller.

The Variable Permeability Method

A brand new isotropic approach to earth's field sensing has been championed by Precision Navigation. Surprisingly-full tech details appear in their patent (#4,851,775).

The inductance of any winding is proportional to the permeability of its core. Normally, you will want your permeability to be a constant, and one that is independent of the applied field or bias currents. Fail to do that in an audio transformer and you will get mild to severe distortion.

One location where a variable or nonlinear permeability has been used for years is as a swinging inductor in DC power-supply filters. In those, a partial air gap is used to produce additional inductance (and more filtering) at low currents, and faster response at higher currents.

A unique new class of *MetGlas* mag-

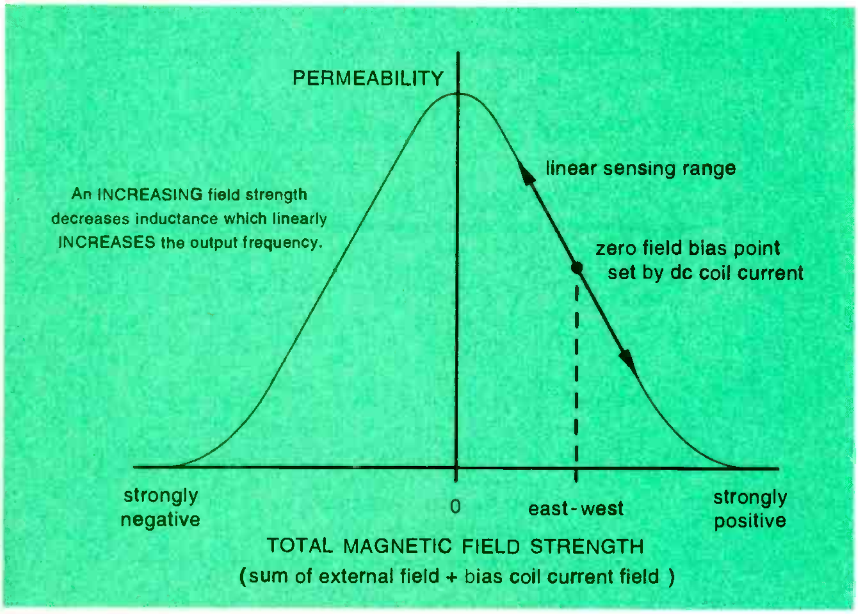


FIG. 3—SPECIAL ISOTROPIC MAGNETIC ALLOYS, whose permeability varies with field strength, are newly available. By biasing it as shown, a coil can be built so its inductance strongly varies with compass orientation.

netic materials manufactured by Allied Signal purposely goes out of its way to provide a variable permeability that changes with the applied field strength or bias current.

As Fig. 3 shows us, that new material has a high permeability with low applied fields and a much lower permeability with high fields. Note particularly the fairly linear permeability shift with applied field above and below the bias point I've shown. You can bias to that point by running some DC current through an overwound sensing coil. The earth's magnetic field (or some other magnetic source) will add to or remove from that magnetic bias level, raising or lowering the coil's inductance!

You therefore end up with a plain old coil whose inductance varies with the applied field strength. Put that in any suitable oscillator circuitry, and your output frequency should follow the strength and direction of the earth's applied field. With proper design, as much as a 2:1 frequency change can be caused when you rotate the sensor through the compass points.

What is really interesting here is that a single, ultra-cheap solenoid winding over an ordinary core bar or rod acts both as a field sensor and the control bias setter. The sensing gets done by measuring the inductance, and the biasing by inputting a DC current.

Note that this is not a fluxgate, and that your core material never really gets into hard saturation. Instead, you have a variable permeability sensor that progressively saturates.

The rest is easy. Place the coil in a relaxation oscillator, add some DC bias, and shove the variable-frequency output into your microcontroller.

Figure 4 shows us one possible circuit. Unlike fluxgates, one simple winding over the core material is all you'll need. To calibrate your sensor, rotate it through 360 degrees or else drive around the block.

Though we have not said so explicitly thus far, we are working with the falling slope of the magnetic field. The falling slope is chosen for the following reason: An increasing magnetic field will decrease the permeability. Which in turn decreases inductance, and the decreasing inductance will increase frequency in most oscillator circuits. Thus, your output frequency should linearly track your input field strength on the falling slope.

Note also that an op-amp or comparator can give you better accuracy than the simple CMOS Schmitt trigger I have shown here. Your oscillator circuit must be voltage and temperature stable if you are to get useful results. Two or three axis operation could get picked up by use of two or three sensors, and then positioning them in quadrature to each other.

Precision Magnetics offers a wide variety of sensor solutions suitable for digital compasses, robotics, and for vehicle navigation applications. The coils themselves measure about 3/16-inch in diameter by 3/4-inch long. Their typical dual-axis compass magnetometer measures a tad over an inch square, draws a few milliamps, and sells for $80 or so.

Remember that any accurate compass measurement must be dead level. To cure that problem, Precision Navigation has introduced a Vector 2XT gimbaled electronic compass module. Introductory pricing is $100 for that self-leveling unit. By making use of that exciting new isotropic technology, there's no real reason why any consumer compass, navigation device, or robotics sensor that costs less than a dollar per axis cannot be built in large quantities.

Let's have your thoughts on this. It would seem that there are all sorts of exciting new possibilities here—and a lot of tech venture opportunities.

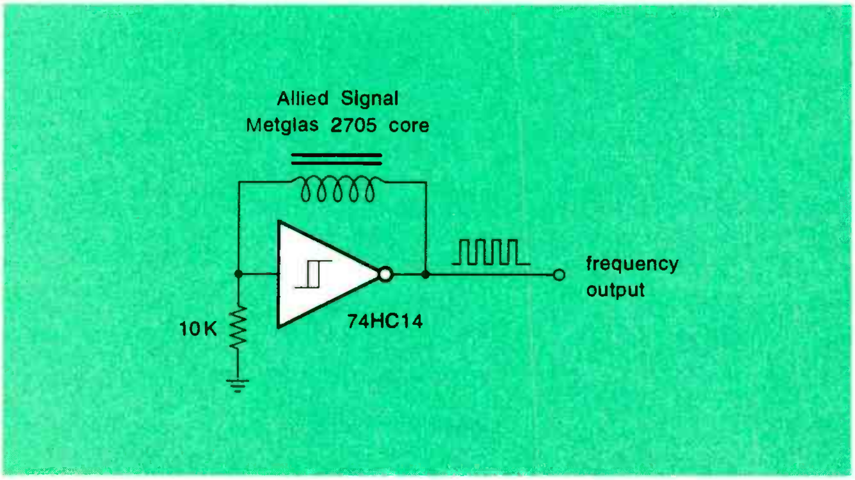


FIG. 4—THIS ELEGANTLY SIMPLE earth's field detector uses a special variable permeability cored coil. The output frequency varies with orientation.

Vacuum Forming

I just received some intriguing new vacuum forming information, so I thought this might make a useful discussion. As Fig. 5 shows, vacuum forming is the process of bending a plastic sheet. The sheet is first heated to a carefully controlled temperature above its softening point. It is then draped over a male mold.

The mold could be made of wood or plaster or most anything rigid and capable of withstanding medium-hot temperatures. The mold has zillions of tiny holes in it that are routed to a vacuum source.

A vacuum then gets applied that sucks the sheet down to conform with the mold shape. Two stages of vacuum will sometimes be applied. One is high volume to get rid of most of the trapped air, and the other is high pressure to force an exact match to the mold. Finally, the part is cooled and taken out of the mold.

Important vacuum-forming uses are signs, packaging materials, and theater props, but there should be all sorts of custom electronic-enclosure possibilities as well. The process can be cheap and low tech, especially when compared against an injection molding set up. For example, you can easily build your own machines.

Vacuum forming obviously works best when there are no undercuts and when a whole lot of stretching is not needed. As the sheet stretches, it gets thinner, so you can only go so far. However, there is no real upper limit to vacuum-forming sizes. Full four by eight plastic sheets can be formed if you need big results.

So how do you find out more? Let us start off with *The Molding and Casting Handbook* by Thurston James. That book is mostly on theatric props but includes an outstanding chapter on how to build your own vacuum-forming machine and then use it. It is available from Betterway Books. Other books on vacuum forming are sold by Lindsay Publications.

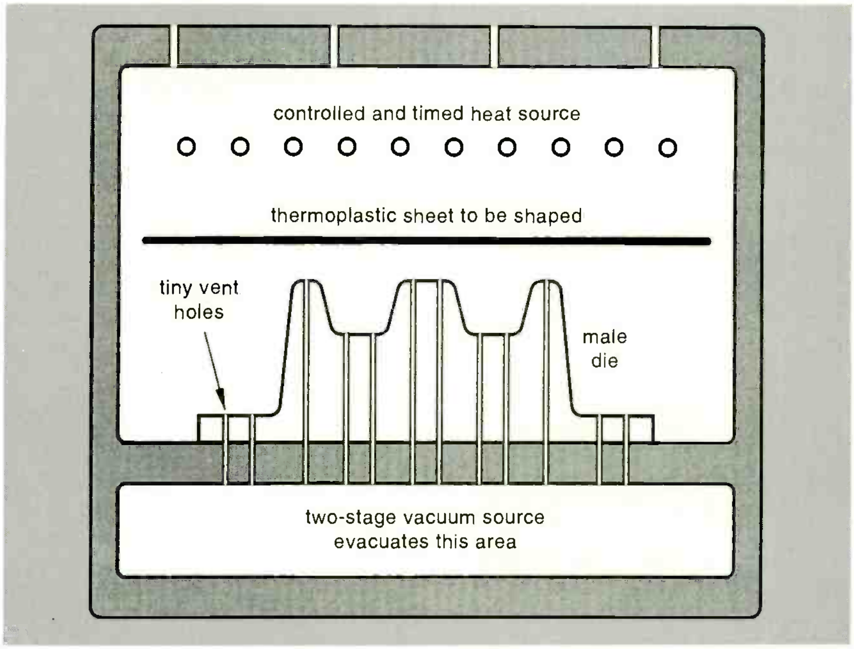


FIG. 5—VACUUM FORMING is a process that first heats a plastic sheet and then draws it against a form. This low-to mid-quantity process is fairly cheap and low tech. Custom electronic enclosures are one app.

A company calls, of all things, Vacuum Form views themselves as the leaders in low-cost vacuum forming. Prices on their Hobby-Vac series start at $99. They do cheat a little on that budget model, requiring your kitchen oven to presoften the plastic and your shop vac for first stage vacuum. A small hand pump is provided for the final forming drawdown. Even so, the unit does sheets up to 6 X 9 inches and, amazingly, can handle up to a 3/16-inch thickness. Prices on their fancier commercial machines, which include heaters and pumps, start at $458. They also retail books and precut plastic sheets (though you can save a lot by cutting your own from full sized sheets).

Other sources of low-end hobby and school vacuum formers include Pitsco, Delvies, and IASCO. Those are outfits that specialize in the school markets and they also offer reasonably priced injection-molding and blow-molding machines, molds, and materials. And,

VACUUM FORMING RESOURCES

AIN Plastics 249 E Sandford Blvd. Mt. Vernon, NY 10550 Tel: 914-668-6800	**Delvies Plastics** 133 W Haven Ave. Salt Lake City, UT 84165 Tel: 800-533-5843	**Pitsco** 1004 E Adams Pittsburg, KS 66762 Tel: 800-835-0686	**SignCraft** PO Box 06031 Ft. Myers, FL 33906 Tel: 813-939-4644
Bell Jar 35 Windsor Dr. Amherst, NH 03031 Tel: 603-429-0948	**IASCO** 5724 W 36th St. Minneapolis, MN 55416 Tel: 612-920-7393	**P-O-P & Sign Design** 7400 Skokie Blvd. Skokie, IL 60077 Tel: 708-675-7400	**Southern Sign Supply** 127 Roesler Rd. Glen Burnie, MD 21060 Tel: 310-768-8600
Betterway Books 1507 Dana Ave. Cincinnati, OH 45207 Tel: 800-289-0963	**Industrial Education** 1895 Crooks Rd. #135 Troy, MI 48084 Tel: 313-649-4900	**School Shop** Box 8623 Ann Arbor, MI 48107 Tel: 313-769-1211	**US Plastics** 1390 Neubrecht Rd. Lima, OH 45801 Tel: 800-537-9724
Cinefex Box 20027 Riverside, CA 92516 Tel: 909-781-1917	**Lindsay Publications** PO Box 538 Bradley, IL 60915 Tel: 815-935-5353	**Sign Business** 1008 Depot Hill Office Pk. Broomfield, CO 80020 Tel: 303-469-0424	**Vacuum Form** 272 Morganhill Dr. Lake Orion, MI 48360 Tel: 810-391-2974

NAMES AND NUMBERS

AlliedSignal
1090 S Milpitas Blvd.
Milpitas, CA 95035
Tel: 408-946-2411

Elantec
1996 Tarob Ct.
Milpitas, CA 95035
Tel: 408-945-1323

Epoxyworks
PO Box 908
Bay City, MI 48707
Tel: 517-684-7286

Fujitsu
3545 N First St.
San Jose, CA 95134
Tel: 800-642-7616

IEEE Transactions
445 Hoes Ln.
Piscataway, NJ 08855
Tel: 908-981-0060

Integrated Circuit Systems
PO Box 968
Valley Forge, PA 19482
Tel: 610-630-5300

Magnetic Research
122 Bellevue Ave.
Butler, NJ 07405
Tel: 201-838-6348

Master Bond
154 Hobart St.
Hackensack, NJ 07601
Tel: 201-343-8983

Phaedra Enterprises
PO Box 1241
San Bruno, CA 94066
Tel: 415-359-0432

Precision Navigation
1235 Pear Ave., Ste. 111
Mountain View, CA 94043
Tel: 415-962-8777

Science First
95 Botsford Pl.
Buffalo, NY 14216
Tel: 716-874-0133

Society of Mfg. Engineers
One SME Dr.
Box 930
Dearborn, MI 48121
Tel: 800-733-4763

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

System Three Resins
PO Box 70436
Seattle, WA 98107
Tel: 206-782-7976

Tiare Publications
PO Box 493
Lake Geneva, WI 53147
Tel: 800-420-0579

West System
PO Box 908
Bay City, MI 48707
Tel: 517-684-7286

yes, anyone can buy from those low-cost sources—they just happen to advertise mostly to the school shop market, making them hard-to-find if you don't know about them.

Two common plastics suitable for vacuum work are Styrene and Vivak. The latter is sometimes used for clear helicopter canopies. Rigid vinyl and acrylic also work fairly well. Actually, almost any thermoplastic will do just fine as long as it has a reasonable softening temperature.

Friendly plastic suppliers include both United States Plastics and AIN Plastics. Also check out the folks at Southern Sign Supply. Useful magazines to check out include *School Shop*, *Signcraft*, *Sign Business*, *POP & Sign Design*, and *Cinefex*. A lot more content on amateur vacuum forming in general appears in Steve Hansen's *Bell Jar*.

On the internet, all your usual Net-search engines will give you dozens of effective hits on vacuum forming—including a not-quite-so-useful hit on something that I've always suspected: "vacuum-formed fruitcake." I've got hot links to those sites on my www.tinaja.com. More on plastics in general can be located in my file RESBN50. PDF on the new *Resource Bin* library shelf.

New Tech Lit

From Integrated Circuit Systems comes a superb data book on a mind-blowing collection of music-synthesizer chips, video and audio circuits, multimedia, battery chargers, timers, and bunches more. A *New Products Supplement* on fast video and communications chips is now available from Elantec. From Fujitsu comes their *Wireless Communications Products* and *Power Management* data book.

There's a new book and video catalog on Santa Claus machines, on CAD/ CAM, and even on ingenious mechanisms from the Society of Manufacturing Engineers. *Outer Space Frequency Directory* is mostly a detailed listing of NASA and the other satellite related communications channels; it's from Tiare Publications.

And speaking of outer space, the fourth edition of the *International UFO Directory* by David Blevins is now available for $12.50 from Phadera Enterprises. That text is sort of a combined *Michelin Guide* and *Thomas Registry* to a wild assortment of hundreds of organizations world wide. The quality and the annotation detail is a tad down from earlier editions, but the price is certainly right.

I really enjoy watching the UFO industry move from one happening to the next. The big trouble is that they never seem to build on anything, and hard evidence sure seems to be elusive.

Science First has a new catalog on Van De Graaf generators and similar low-priced science demos. But the product that impresses me the most is their #40-500 Roman Arch Kit—a puzzle made of lightweight wooden kiddy blocks. Put them together just right without any glue or support and you can actually stand on it.

For those looking for additional fiberglass info, from EpoxyWorks comes a West Systems booklet on building, restoring, and repairing with epoxy. System Three Resins offers a similar full-resin products line, as well as support info.

For the fundamentals of starting up your own technical venture, be sure to check my *Incredible Secret Money Machine II* book, available per my nearby Synergetics ad. I've also still got lots of surplus test-equipment bargains. Those include Tek 1230 logic analyzers, a like-new TG-501 time-mark generator, and bunches of bargain-priced Heathkit test items. You can view that catalog online as SURPCAT01.PDF.

As usual, most of the mentioned resources appear in the Vacuum Forming or the Names & Numbers sidebars. Be sure to check there first before using my US tech helpline or visiting www.tinaja.com. EN

NEED HELP?

Phone or write all your US Tech Musings questions to:

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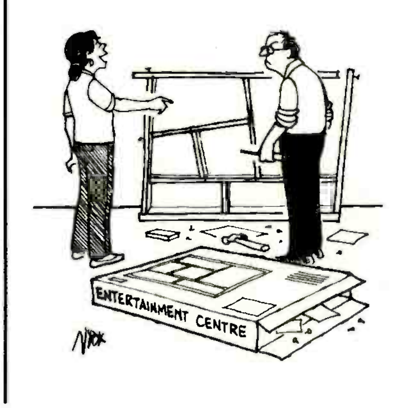
Thatcher AZ, 85552
Tel: 520-428-4073

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



BY JEFF HOLTZMAN

Delphi and Visual Basic

DELPHI 2.0 IS A PROGRAMMING TOOL FOR WINDOWS 95 AND NT. IN SOME WAYS, DELPHI IS MORE INTERESTING FOR WHAT IT IS NOT THAN FOR WHAT IT IS. PRIMARILY, DELPHI IS NOT C, AND IT IS NOT BASIC. RATHER, IT IS PASCAL—MORE SPECIFically, it is Borland's enhanced Object Pascal.

Programming is an iterative, three-stage process: Write and edit code, compile it, test and debug it. Prior to the invention of the IDE (with Borland's original Turbo Pascal in 1984), each stage was performed using a separate tool, and switching among them was a pain. When Windows started becoming popular around 1990, that pain increased drastically, because of the difficulty of creating graphical user interfaces in a non-graphical environment. Thus was born Visual Basic (VB), the first IDE for the Windows environment.

VB was an instant success. I've done probably half-a-dozen or so significant projects in VB over the past three or four years; consequently, I've got a pretty good understanding of its strengths and weaknesses. In the balance of this article we'll look at those in some detail, and see how they stack up against Delphi. As you will see, Delphi doesn't make a clean sweep, but it does excel in most areas.

Component Architecture

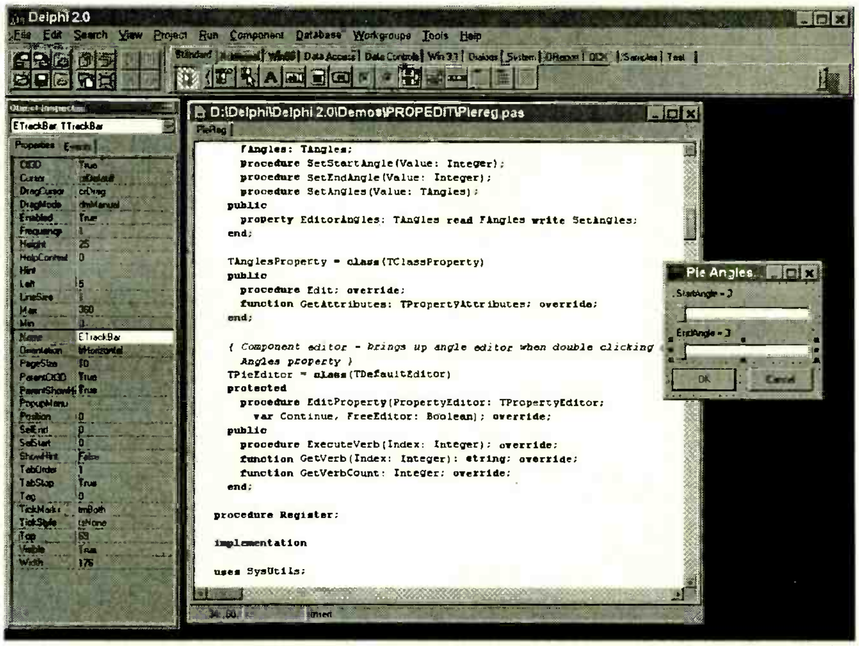
Early versions of VB depended heavily on third-party components packaged as Visual Basic Extensions (VBXs). There is a huge variety of commercial and shareware VBXs, with quality ranging all over the place. Versions of VB through 3.0 supported the VBX architecture; but with VB4, Microsoft replaced VBX with a more general component architecture, originally called OCX, then called OLE controls. OCX has, in turn, been replaced by ActiveX. At this point, there appears to be little technical difference between OCX and ActiveX, although ActiveX is designed (from a marketing point of view) to be more Internet friendly—that is, less bulky to download. Also, VBXs cannot be used in a 32-bit environment; they are 16-bit (Windows 3.x) only.

Delphi 1 supported VBX in a limited way, but Delphi 2 fully supports OLE controls, and presumably Active X. Borland had to reverse-engineer the VBX architecture for Delphi 1, but the OLE control format is public, so components should (should!) work transparently in either environment (and in others).

The bottom line here is that VB used to have a distinct advantage over Delphi, but the 32-bit world provides a more level playing field. VB will continue to attract the primary development-tool support, but Delphi indirectly benefits from that, and has its own (albeit smaller) set of support options as well.

Component Management And Distribution

Delphi can create its own components using the same language and development tools as for normal applications. VB can't, although VB5 proba-



BORLAND'S DELPHI 2.0 provides the hands-down best environment for rapidly developing Win32-based applications and utilities.

bly will have that capability, as well as an enhanced user interface.

In addition to OLE controls, Borland supports its own control architecture, called VCL (Visual Component Library). VCLs are proprietary code modules that can represent either visual or nonvisual objects the programmer can drag and drop onto forms to create applications. From that point of view, VCLs are just like VBXs and OCXs. Where they differ is that VCLs are bound into the program file itself, whereas VBXs and OCXs are stored as external files—essentially, they're just DLLs.

Microsoft's approach is architecturally superior, but Borland's has practical merits of extreme importance. With the VB architecture, a control is written once, linked once, and stored once. In Delphi, a control is written once, and subsequently linked and stored in every application that uses it. With Microsoft's approach, a bug in a control can be fixed, and the OCX file can be updated without touching the main application. With Delphi, the application would have to be recompiled.

On the other hand, VB developers and users of VB-based products know that version upgrades of VBX and OCX controls can wreak havoc with applications that depend on specific features of specific versions. For example, most installation programs blithely assume they can overwrite older versions of common files with newer versions. But sometimes newer versions can break existing applications.

Consequently, there has been a backlash among VB developers who now look for ways of including controls (written in VB itself and heavily dependent on Windows API calls, thus leading to code that looks more like C/C+ than VB) directly in compiled applications. In that way, they avoid potential version problems at the cost of increased compile times, decreased performance, and application bloat.

If the operating system tracked which applications needed which versions of which DLLs, that type of problem would go away, and Microsoft's solution would be superior. But for now, I rate Borland's approach the better of the two.

Language Syntax

Both VB and Delphi are composite languages that originated in relatively clean and conceptually pure standards. Despite (or because of) their origins, both have evolved to become hodgepodges of procedural and object-oriented syntax that is conceptually blurry, and sometimes confusing and inconsistent. Each language is controlled by a single vendor. Unlike C and C+, there is no ANSI (American National Standards Institute) committee defining a standard for all to adhere to. Microsoft has a clear market advantage with VB in that most of its current Office products use various subsets of it. In addition, Microsoft's Internet strategy is also heavily VB-centric through the use of VB Script in Web pages. Overall, I prefer Object Pascal, but I am not blind to the merits of VB syntax in its various incarnations.

Support For Object-Oriented Paradigm

VB supports a syntax that looks a little object-oriented, but isn't really. VB does not support encapsulation, inheritance, or polymorphism. Delphi does. VB loses; Delphi wins.

Debugging Support

VB has better application-level debug support than Delphi. VB's debug window allows you to view program output (via print statements) to set and get values of current variables, to evaluate arbitrary expressions, and to call functions and procedures directly. VB also provides a watch window in which key program variables may be displayed and continually updated. Delphi provides a better watch window, but nothing equivalent to the debug window. On the other hand, Delphi can work with an external debug module (Borland's Turbo Debugger), so you can trace right into assembly language. VB wins here.

Cross-Platform Support

Here, both VB and Delphi lose. They basically only support Win32, which means Win95 and NT. Delphi and VB both include 16-bit versions for Windows 3.x, but there is limited interoperability between the two, and VB4/16 has a terrible reputation regarding performance. The only potentially bright spot here is that because of increased Internet pressure, Microsoft is finally showing signs of broader platform support (*i.e.*, Macintosh and UNIX). However, whether that interest primarily concerns Internet-related technologies (such as VB Script) or across the board remains to be seen. If cross-platform support is an issue, C/C+ provides the best (although highly imperfect) solution.

Company Provided Support

VB wins here slightly. Microsoft provides some "free" support, but Borland provides none whatsoever (beyond installation). My experience with Microsoft's support was mediocre.

Performance

Delphi wins hands down in most categories. In database access, informal tests show the two to be in roughly the same ballpark. But in areas such as initial program load and screen painting, Delphi is much faster than VB.

Cost

Both VB (standard, professional, and enterprise edition) and Delphi (desktop, developer, and client/server suite) come in three levels. In general, VB tends to go for less than Delphi (for example, $90 for the VB standard edition *vs.* $359 for the Delphi desktop edition in one recent catalog), but deals such as competitive upgrades are available for both.

In general, the lower-priced models (desktop and standard) are more likely to appeal to individual programmers, and the higher-price models (client/server suite and enterprise edition) to corporate developers creating client/server database applications, and who need careful management of source-code files. I strongly believe that Borland should bring out a sub-$100 version to catch the student/hobbyist market.

The Development Environment

Delphi's IDE is generally cleaner to use than VB's, particularly regarding component organization. However, I'd like to see better organization of the property editor (which presents a single long list of all properties rather than subsetting them by database, screen layout, and other categories). Both VB and Delphi have syntax-aware code editors, but Delphi's is much more configurable.

Conclusions

I really like Delphi a lot. Like VB, it allows the programmer to become productive at simple tasks almost immediately. But unlike VB, it has considerable depth (including pointers and dynamic memory management) to grow into. Frankly, I had expected the learning curve to be shallower, but part of my problem

continued on page 69

BY LARRY KLEIN

Hi-fi fixes, stealth tweaks, and bio EQ

WHEN I LAST WROTE ABOUT THE HI-FI SERVICE BUSINESS (ELECTRONICS NOW, JANUARY, 1995), I NOTED THAT RADIO SHACK INTENDED TO SET UP A NATIONWIDE REPAIR PROGRAM COVERING ALMOST ALL BRANDS OF OUT-OF-WARRANTY electronics. Based on my own experiences with the repair business, I opinioned that RadioShack had perhaps taken on more than they could handle. Apparently, I was very wrong!

I talked with Henry Chiavelli, the VP in charge of The Repair Shop at RadioShack (to give it its full official title) this past spring, and he gave me a first year's progress report. About 40,000 repairs a month(!) are currently being processed by 6,500 RadioShack stores, which ship the items to one of 130 repair centers for the actual repairs. Audio components (receivers, CD players, and tape decks) account for the most repairs (26%), followed closely by VCRs (23%), personal electronics (20.2%), and telephones (18.7%). Everything else electronic also shows up, but in far smaller numbers (2.4%). That doesn't necessarily mean that those smaller categories are more reliable, just that there are comparatively fewer sales or, in the case of large TVs, easier local repairs.

I was puzzled by the prevalence of stereo-receiver repairs given my rule of thumb that any unit that uses drive belts is going to need fixing every three years or so. (Unlike CD players, tape decks, and VCRs, receivers don't use drive belts.) My RadioShack friends were a puzzled by that also, and Mr. Chiavelli suggested that perhaps some of the broken receivers had been languishing in closets waiting for a white-knight repair service to arrive. From all indications it has.

Spreading the Gospel

There's something about involvement in stereo equipment that tends to generate mildly obsessive behavior. Perhaps it's like other "religious" conversions: Once you've discovered "The Truth," the urge to spread the word is pretty much irresistible. For example, during my early days as an editor, perhaps a manuscript a month would arrive with a cover letter pleading for the opportunity to explain the wonders of hi-fi as newly experienced by the writer. In my rejection note, I sometimes took the time to gently explain that "there are too many exceptions to the advice and generalizations laid out in your otherwise well written manuscript. More experience, and a deeper understanding of audio technology, would be helpful to you in your writing."

Over the years, such submissions have been, in effect, replaced by letters to the editor of the audio high-end tweak publications detailing the vast sonic improvements to be experienced by, say, aligning your speaker leads in parallel with the earth's magnetic field, or by placing weights on your amplifier, your CDs, your speakers, your head, etc. Those publications, unconstrained by rationality or familiarity with the natural laws of physics—or simply pandering to the know-nothing element in their readership—cheerfully publish such letters buttressed by reviews praising a variety of cloud-cuckooland commercial products. Perhaps it's unnecessary to add that their readership, by and large, hears all the salubrious effects as advertised.

Unfortunately, there's a secondary or trickle-down effect from all that true-believer in-group blather. Stealth audiophiles employed as regular editors in

SANYO'S MAX555 MINI-SYSTEM includes a Bio EQ circuit that matches the system's equalization to your state-of-mind according to your biorhythm.

various mainstream business and news publications propagate high-end nonsense in occasional articles that somehow escape the normal fact-checking process used in reputable news magazines. Heaven knows how many hard-headed, but audio-innocent business people have been led astray in their hi-fi purchases by audio tweaks pushing nonsense in the mainstream press.

Biorhythms

Through the years, many dedicated music listeners—myself included—have noted a certain day-to-day inconsistency in the sound coming from their audio systems. Some days my system sounded just wonderful; other days I couldn't wait to turn it off. And according to my reader mail over the years, the better the system, the greater the variability. Incidentally, this phenomenon has nothing to do with the real or imagined need to "warm-up" certain high-end components before use.

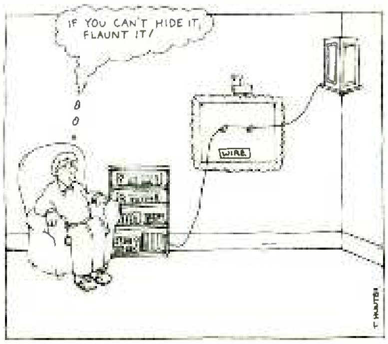
It's never been clear to me whether the perceived sonic inconsistencies have an objective or subjective source. Do they originate in the listener's equipment or in his head? Are the components somehow changing their audible performance in response to waveform or voltage changes in the AC line? Are the resonances in the speaker cones (or those in the phono cartridge) shifting in response to high or low humidity?

On the other hand, are our ears themselves responding to humidity or air-pressure changes? Is it the phases of the moon? Or perhaps random reductions in the serotonin or norepinephrine levels in our brain chemistries are producing a general dissatisfaction with hi-fi performance—and life in general? Would Prozac help?

Samsung Electronics (105 Challenger Road, Ridgefield Park, NJ 07660) thinks they have found the answer, and have built it into their new $300 remote-controlled mini-component system. Somewhat weak on specs, but strong on features, the Samsung MAX555 has an AM/FM stereo tuner, a three-CD changer, a dual cassette deck, and several novel functions—including a Bio EQ circuit. Bio EQ is based on the dubious—but widespread—belief that certain aspects of one's physical, emotional, intuitive, and intellectual life are all subject to independent cyclical variations of 23 to 33 days that started the day you were born. Once you feed the current date and your date of birth into MAX's biorhythm computer, it then selects either one of three different fixed equalizations (classical, rock, or pop) or a "PASS" (non-equalized) setting, depending upon what it decides would be most compatible with your immediate state of being. My first two days' input generated a PASS response. However, for the next four days, MAX decided that what I needed was the classical EQ.

The three EQ curves as displayed on MAX's 7-band real-time analyzer are somewhat idiosyncratic. What justifies a slight dip at 1 kHz for Classical, moderate peaks at about 160 Hz and 6.3 kHz for rock, and a single large hump centered at 1 kHz for Pop? The instruction manual offers no answers. However, Samsung's product manager has told me that a revised manual is in the works.

In playing around with the equalizations, I found that I always preferred PASS, no matter what type of music was being played or what stage my biorhythm cycle was at. More evidence, for those who want it, of my innate audio perversity. The overall sound of the system had a slight midrange "hollowness," but a surprisingly good fake bass. And for those among us whose musical biorhythms resist adjustment, "Background Natural Sound" is available at the touch of a "B.G.N.S." button. As a relaxing alternative to your everyday oppressive background noise, MAX offers the canning sonic ambiance of a rain forest, a stream, and a beach. The stream and rain-forest noises are pleasant enough except for the raucous birds in both and the intermittent foghorns at the beach. If you wish, you can give yourself the full treatment by overlaying your chosen background sound on your Bio EQed music. With the addition of a properly attuned New-Age crystal, true harmonic convergence might be achieved—assuming your astrological signs are suitably aligned. EN



COMPUTER CONNECTIONS

continued from page 67

was finding a way to undo VB-think, and to recast as Delphi-think. I'm still working on it, but doing so is a pleasure.

The Crystal Ball and More

Last month I rashly predicted that Java-based HW/SW systems could and would displace dedicated hardware subsystems such as ATMs. Interestingly enough, both Motorola and Nokia recently announced portable telephones built around J-word technology. What's next? Java-based wristwatch radios? Implantable Java-based pacemakers? The ultimate of course would be a Java-based Mr. Coffee!

RESOURCES

Delphi 2.0
Borland International
100 Borland Way
P.O. Box 660001
Scotts Valley, CA 95067-0001
Sales: 800-233-2444, ext. 1350
FastFAX: 800-408-0001
Net: http://www.borland.com/

I've begun testing a beta version of Windows NT 4.0, and it looks good. The most visible change is that it now supports the Win95 user interface. That also means that there are numerous changes from the previous version in the way you set up and administer network and other resources. But, all in all, NT is looking increasingly good. I'll pass along more information as experience and developments dictate. EN

BY CARL J. BERGQUIST

Entertaining with laser light

HAVING COVERED A LOT OF THEORY AND A NUMBER OF SERIOUS AND PRACTICAL APPLICATIONS IN OUR PREVIOUS COLUMNS, I THINK IT'S TIME TO TAKE A LOOK AT THE LIGHTER SIDE OF LASER APPLICATIONS. BUT FIRST, A SAFETY reminder. Lasers, no matter how small, are not toys. They can cause serious harm if not handled properly. So read and heed the safety notice that appears in this and every column.

Lasers are the source of some very practical gadgets, and can provide a great deal of entertainment. One of the most interesting, and most common, laser devices in recent years is the laser pointer. Early versions were built around miniature 0.25- to 0.5-milliwatt lasers that had small battery-operated power supplies packaged together in a hand-held case. Bulky by today's standards, at the time they were a marvels of miniature electronics, and were priced at about $300.

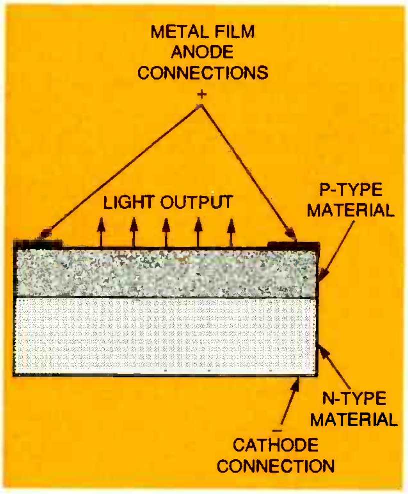


FIG. 1—THE PHYSICAL CONSTRUCTION of an LED. Note that it emits light in all directions and the light is not coherent.

With the development of the laser diode came the pocket pointers, shaped and sized much like a fountain pen. Easy on batteries, and bright enough to be seen clearly on an illuminated TV or projection screen, those pen pointers are a favorite for lectures and business presentations.

The heart of those devices is a laser diode—a specialized light-emitting diode (LED). It may look like an LED, but it sure doesn't work like one.

In a standard LED (see Fig. 1), when the Gallium-Arsenide junction is forward biased, it emits light in all directions and different colors—red, green, yellow or even blue—are produced. The ratio of the two elements and the doping, together with an epoxy filter, determines the output color. The light output, unlike that of a laser diode, is not coherent. The light is usually diffused, by a clear plastic casing, into a soft, omnidirectional pattern.

The laser diode (see Fig. 2) performs much in the same fashion except that additional structuring of the semiconductor matrix, which includes micro-mirrors, results in the emission of a collimated beam. That beam, while not nearly as well defined as the one from an He-Ne tube, is focused by standard optics to produce a fine spot.

We can make a pointer out of surplus gaseous laser parts, but it will end up no smaller than an 8- to 10-inches long by 1½-inches around—and that's quite a handful. So, for practicality, if you want one of these, the commercial version is probably the best choice. I've seen them for as little as $40.

On a similar note, lasers, both the tubes and diodes, are frequently used as gun sights. By attaching a protected tube

WARNING!!!

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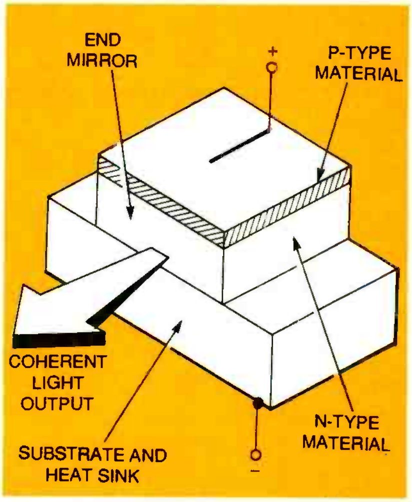

FIG. 2—LASER DIODES LIKE THIS ONE may seem to be LEDs but are actually quite different. They produce a beam of coherent light.

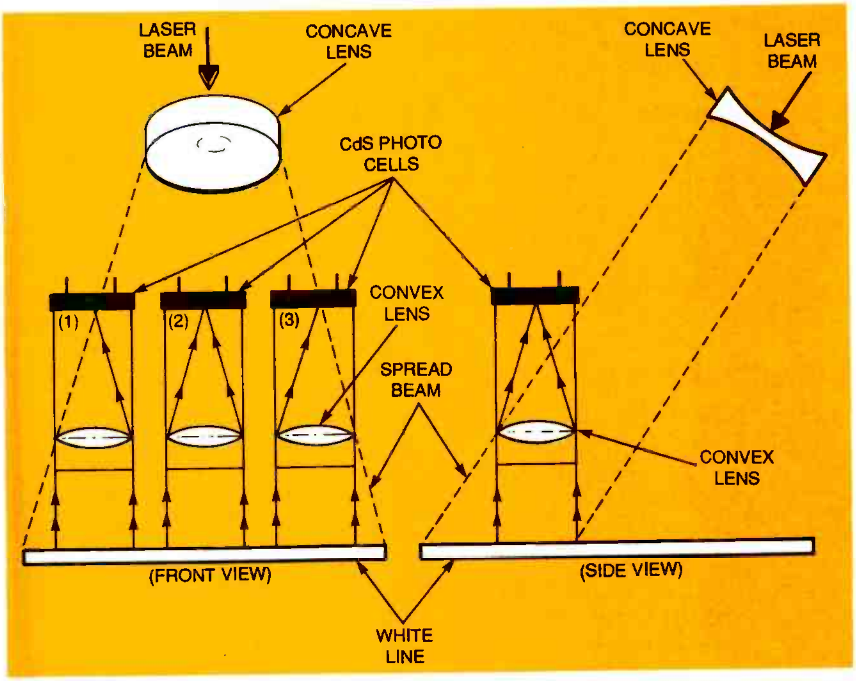

FIG. 3—HERE ARE THE OPTICS NEEDED to build a robot-motor control assembly. This setup is used to enable a robot to follow a line on the floor.

or a pointer to a rifle or pistol with an adjustable mounting, the accuracy of the weapon can be improved a great deal. Once the laser is in place, alignment calls for a visit to a gun range, and some simple bore sighting, following the same procedure that you would use for a telescopic sight.

Follow the White Line

Robotics has become a popular hobby. It also offers many places where a laser could come in handy. The laser is a natural for both movement control and special effects. One method used to guide the direction of a robot is to have it optically follow a path, such as a white or black line painted on the floor. Using photodetectors to detect deviations from the course, the robot's motors can be commanded to react and keep it on track. Figure 3 shows the optics involved in such a system. Figure 4 is the electronics needed to control the robot's steering motors.

As for special effects, a laser could be used to light up the robot's eyes. With reflectors and motors, a variety of swirling patterns could be generated to "dance" around the robot as it moved, and timers could make them intermittently appear or vanish. So, it is easy to visualize the many ways that the laser can enhance the operation and image of a robot.

Games with Laser Light

One area where the laser can provide hours of amusement is games. Again, the variety of applications is limited only by the imagination; so here are a few ideas to start with. Let us know of any others you come up with. Send your ideas to Laser Editor, **Electronics Now**, 500 Bi-County Blvd., Farmingdale, NY 11735 or e-mail to lartronics@aol.com.

The laser has been called the "ultimate cat toy" due to the fascination cats, especially the young ones, find in the red spot it casts. Dance the beam around the floor, and most felines will chase it for hours. They will sneak up on the spot, swat it down, only to find—to their amazement—that it has magically reappeared on top of their paw. Dart the dot off a few feet, and, they are right after it. That will amuse both cat and owner for long periods. Just be very careful not to shine the laser directly into the cat's eyes

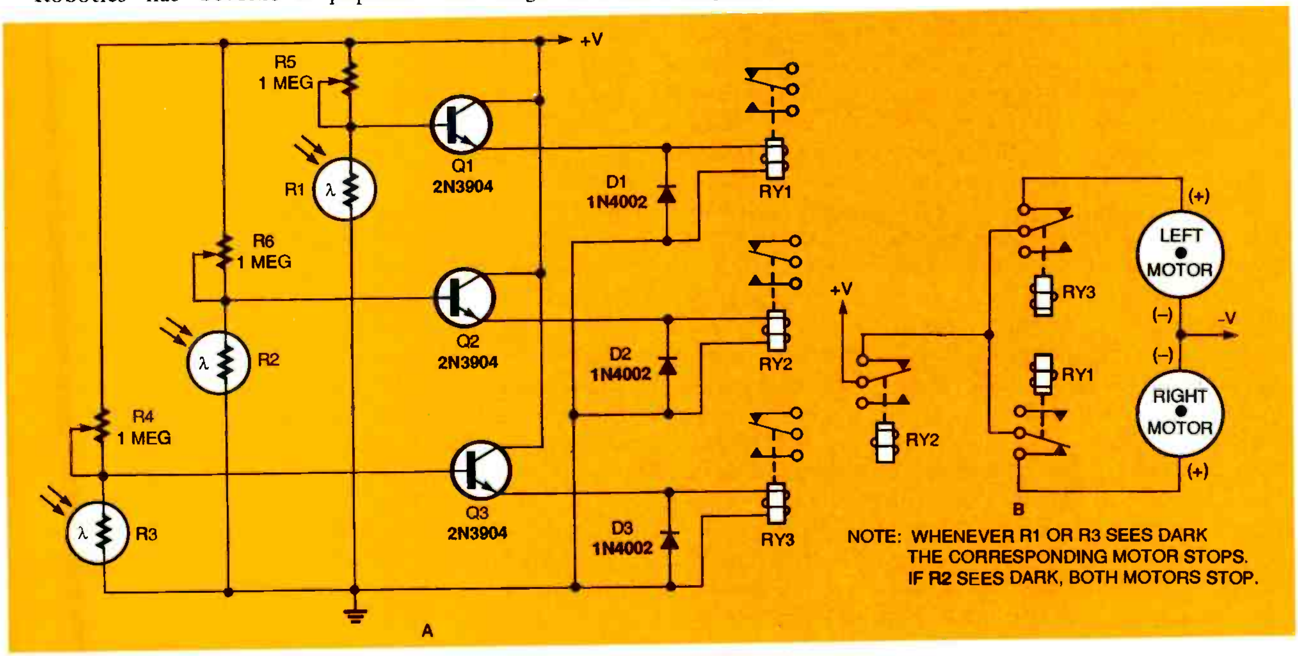

FIG. 4—THE MOTOR-CONTROL ELECTRONICS takes the signals from the optics system in Fig. 3, and uses them to control a robot's steering motors to keep it on course.

as they are sensitive and could be damaged.

Another favorite is "find the light." Using temporarily placed mirrors and reflectors, you can create a maze of light beams that crisscross back and forth and all around a room. The object of the game is to find the source of the beams, namely the laser.

Use smoke, fog, or a mist of fine powder. Let the beam shine on a piece of paper and trace it back. Or use whatever other method you choose. As the hunter moves within the maze, he will block the beam from time to time, and the trail will disappear. That definitely adds challenge to the task as sometimes the beam is lost and has to be found again to continue the search. The maze can be altered as much or little as desired, offering unlimited trails to set up and follow. It's a lot of fun, so give it a try.

With the aid of some motors and gears and ingenuity, a "cradle" mounting can be built to hold the tube, or tube and power supply. Using switches, a potentiometer, or even a "joystick," semi-automated beam aiming can be provided for any number of games or projects. Testing reaction skills or timing would be one possibility. A home built version of a "video"-style game could be another.

Detecting and Counting

Let's next shift to a practical application—a system for counting anything that needs to be counted. That can have a fun side when used to count laps at track events; swimming meets; or model-car, bicycle, auto, dog, or horse races. Such a system might even find a more important role when applied to factory assembly lines for item counts, quality control, traffic monitoring, etc.

Taking advantage of the laser's collimated beam and relative immunity to ambient light, all that needs to be done is position the laser unit on one side of the item to be counted and a special receiver/counter assembly on the opposite side. With the beam aimed at the detector, each time one of the items—say a box of candy—passes through it, the beam is momentarily broken. That tells the counter to advance one digit. The same set-up would, of course, work just as well for automobiles passing through a monitored intersection or a swimmer passing the starting line during a race.

The system does need a specialized, but reasonably simple receiver to detect

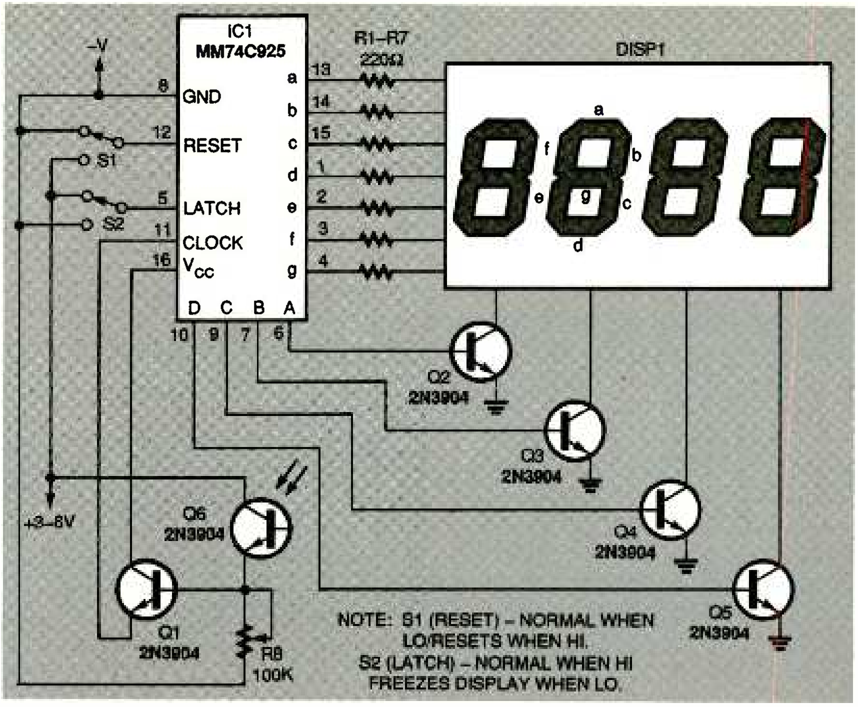

FIG. 5—HERE'S A FOUR-DIGIT COUNTER for laser-game and other applications. The single MM74C925 makes it easy.

and maintain the count. Figure 5 shows just such a unit. The heart of the circuit is the MM74C925 integrated circuit. That IC contains the counter, multiplexer, and 7-segment digit drivers, all in one convenient package. Add a simple detector circuit like the ones used before, a handful of support components, box it up with a light shield for the phototransistor, and it's ready for action.

Here's a couple of important notes about the circuit: The seven 220-ohm resistors (R1–R7) are used as "dropping" resistors between the driver outputs and the segments of the display to protect the LEDs and keep the 74C925 from overheating. The four 2N3904 transistors (Q1-Q4) act as amplifiers for the digital drivers to keep the display at full illumination.

Switches S1 and S2, for reset and latch respectively, are not crucial but are highly recommended. The latch will freeze the count if needed, and it is nice to be able to reset the unit at the flip of a switch. If the switches are not used, pin 12 needs to go to ground, and pin 5 to +V (the circuit's voltage supply).

On a final note, if more than four digits are needed, use the MM74C926 IC. The functions are the same, but it has a "carry out" to cascade more than one chip and 4-digit display.

Patterns and Designs

In an artistic vein, let's briefly explore the world of geometric patterns and design. The laser market is filled with equipment—from X-Y axis units and scanners to the more elaborate computerized professional controllers—all designed to manipulate one or more laser beams into designs, patterns, moving artwork, lettering, and even sheets of light as desired.

What are the applications for this gear? Well, one that immediately comes to mind is for special effects during rock and other concerts. For those that would like to experiment, the speaker modulator presented in the June and July 1996 installments of this column could be used again for that. Here's how:

If a certain section of a musical piece produces just the right patterns, save that section on audio tape, maybe several times in a row, and have it available when needed. After a while you will have a comprehensive library of sounds for future use. Then, by assembling the specific sound passages and re-recording them, you can create a lengthy segment of taped music to produce the desired graphics. Either replay or repetition can keep the process going for as long as necessary.

That winds things up for now. Next month we are going to look at a variety of geometric light-pattern generators. Then we will go on to show you how to use them to create your own light show. See you next time EN

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BY ALEX BARKUME*

New digital storage scope has LCD display

AS LCDs COME OF AGE, OSCILLOSCOPE MANUFACTURERS ARE MERGING DIGITAL STORAGE OSCILLOSCOPE (DSO) TECHNOLOGY WITH LCD DISPLAY ADVANCEMENTS TO PRODUCE HIGH-PERFORMANCE HANDHELD AND BENCH INSTRUMENTS.

Two factors make combining those two technologies possible—the advances in LCD technology and the movement from traditional CRTs to A/D converters as the signal-acquisition system. Once the display is no longer the capture device, the acquisition system is free of the constraints of display-update rates.

That combination has paved the way for scope manufacturers to capitalize on today's LCD technology. LCDs, for their part, have evolved to a point where shortcomings such as questionable reliability have been completely resolved. At the same time, other deficiencies, such as the limited viewing angle, are steadily improving.

Historical Perspective

For a long time, the electrostatic CRT display (see Fig. 1) used in analog scopes was the only oscilloscope-display technology available. In addition to bright, easily-read displays, electrostatic CRTs provided oscilloscope users with trace intensity variations (gray scaling) and very fast update rates.

With the advent of DSOs, raster-scan displays replaced the analog CRT display (see Fig. 2). While the original analog display was, in fact, a signal-acquisition device, modern DSO displays are not. That has made it possible for scope designers to concentrate on improving acquisition and update rates.

Digital Real-Time (DRT) acquisition has significantly improved acquisition rates of some DSOs, while new display methods such as Tektronix' Dynamic Display Mode has increased the amount of information shown on a display with modest update rates.

By decoupling display and acquisition functions, scope manufacturers have been able to seek out new display technologies. Among the most promising is flat-panel LCDs. Flat-panel technology is changing rapidly, and costs are coming down. Millions of dollars in research and development are being pumped into that market to improve reliability and overcome other objections to LCD displays. Those objections have included limited viewing angle, contrast, brightness, ruggedness, temperature and humidity restrictions, and pixel speed. All of those have been inherent shortcomings of LCD displays.

Today, LCDs have come a long way

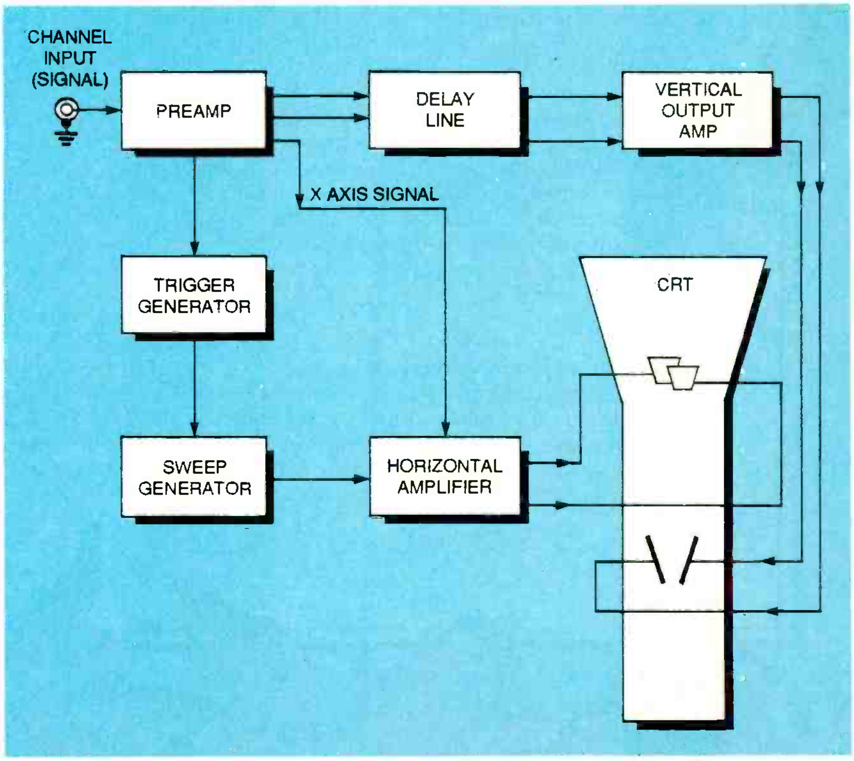


FIG. 1—A BLOCK DIAGRAM OF A typical analog CRT and its associated electronics. Originally, the CRT doubled as both the display and the capture device of an analog oscilloscope.

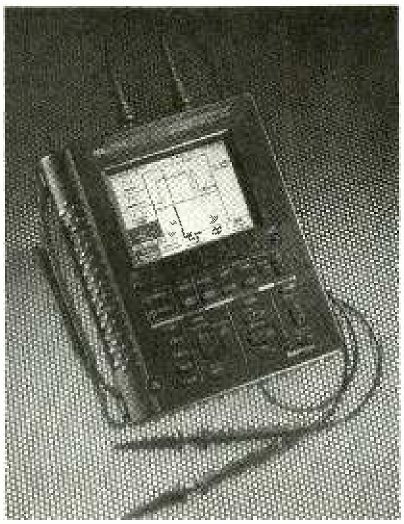
*DISPLAY TECHNOLOGY ENGINEER
TEKTRONIX, INC.

as oscilloscope and other instrument displays. Just about every portable computer made uses some type of LCD display. But the questions that face instrument users are: How do LCDs measure up to standard CRTs? What does the future hold for these two important technologies? And how will end-users ultimately benefit?

CRTs—The Industry Standard

The long-established technology for oscilloscope displays, CRTs have set the standard for user expectations of what a scope display should be. In most minds, CRTs have many advantages over LCDs. Brighter displays, faster update speed, and an unlimited viewing angle are the three that come to mind first.

What many users do not realize is that the CRT industry is fully mature and shrinking rapidly. There are only a few manufacturers and little money is being spent on new CRT technology for screens smaller than 14 inches. As a result, the industry simply isn't keeping pace with instrumentation advances. For example, few manufacturers offer color capability in small-size CRT displays. Today, when many users have come to



THE TEKTRONIX *TEKSCOPE* combines DSO technology with LCD advancements—smaller footprint, low power, and high reliability.

really need color capability, the CRT industry cannot supply it in any meaningful form.

In addition, the large physical size of conventional CRTs continues to dictate the shape and size of new instruments. At a time when the service industry is demanding smaller and more portable tools for field service technicians, the size of available CRT displays makes it difficult to design lightweight, handheld scopes.

CRTs also seem to come with many reliability problems. They have a high failure rate and require frequent service and maintenance. That weakness first shows up during scope manufacturing, where CRTs require any number of adjustments and "tweaks" before being installed in the instruments. Reliability issues continue throughout the life of the product and have a negative impact on long-term serviceability.

Finally, CRTs have always presented safety concerns. While great care is taken to minimize the danger, problems such as X-ray radiation and exploding cathode-ray tubes continue to plague the industry. Also, regulatory issues such as electromagnetic interference have never been totally resolved. And one of the more recent problems is disposing of old CRTs and instruments.

CRTs have played a long and important role as oscilloscope displays, and will certainly be used in many new instruments for some time to come.

However, now is the time to take a fresh look at new display technologies. LCDs are certainly a leading alternative.

LCDs—New Kid On The Block

In marked contrast to CRTs, there are more than 100 LCD vendors. That gives oscilloscope manufacturers a wide choice of LCDs, with many options in size, price, and performance. The market-driven nature of LCD product development also fuels the many choices available and often results in a much shorter time-to-market for instrument manufacturers.

The thin, flat LCD footprint makes it easy for designers to package it in all kinds of instruments. The low-power needs of LCDs make them ideal for use in portable, battery-powered instruments. Together, these attributes make LCDs ideal for hand-held tools. The smaller footprint (see Fig. 3) also affords an excellent opportunity to design more compact benchtop scopes to alleviate overcrowded benchtop conditions in the lab.

But what about the reliability issue? In the past, LCDs have been labeled as less than reliable. Today, however, the reverse is true. The newest LCDs have excellent reliability. With a mean time between failure (MTBF) that exceeds 50,000 hours, LCDs compare very favorably with a MTBF of 25,000-40,000 for CRTs.

What's more, LCDs are delivered to the scope manufacturer ready to use, eliminating the time-consuming and tedious adjustments needed to install CRTs during manufacturing. A secondary benefit is that no adjustments are needed to counter the effects of the earth's magnetic field when moving the scope over large distances, a problems that has consistently plagued CRT displays.

Perhaps the most convincing argument can be made for the value LCDs add to instrumentation such as oscilloscopes. Transflective LCDs, for example, provide users with excellent readability in bright sunlight, making them ideal for portable field instruments. Moreover, LCDs are available in two other types: transmissive and reflective. Those three choices in display technology let product designers optimize the display for factors including cost, power, and viewing capability in either sunlight or dark environments.

Another bonus is color. Although color LCDs are expensive in fast, active-matrix displays; in slower, passive LCDs, color is available at a more reasonable price. Both faster and cheaper color capability is clearly on the horizon.

There are a few disadvantages with LCD displays, but they do involve a certain amount of tradeoff, particularly for scope manufacturers and, less directly, for users. For example, display speed is still closely tied to cost. To get update rates and performance comparable to CRTs requires more expensive LCD technology. Nonetheless, research is focused on developing new LCD technologies that will improve update rates at lower cost. It's only a matter of time until the tradeoff between cost and performance will no longer be an important issue.

LCDs are known for their limited viewing angles. However, LCD viewing angles have significantly improved recently and promise to continue to widen as new models appear. For example, older LCDs provided a 60° viewing angle. Today that has increased to 90°; tomorrow's LCDs promise viewing angles greater than 120°.

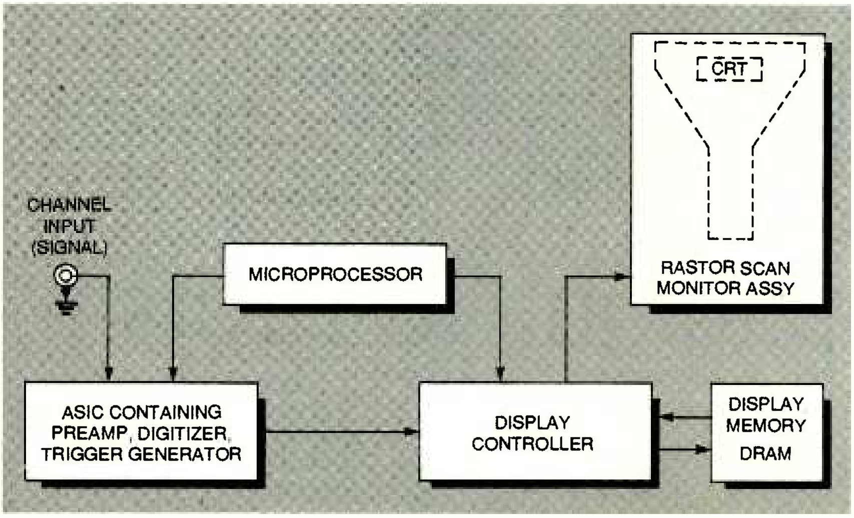


FIG. 2—WITH THE ADVENT OF DSOs, raster-scan displays, like the one shown here in block diagram form, replaced the analog CRT display.

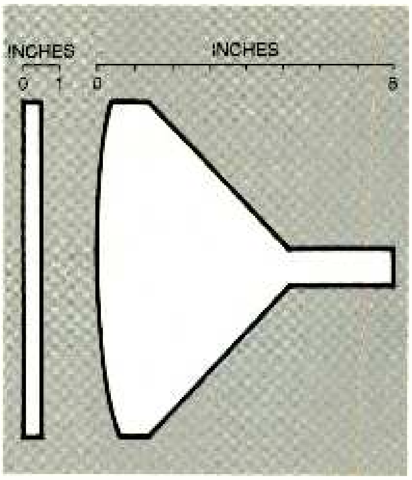


FIG. 3—THE SIGNIFICANTLY SMALLER FOOTPRINT of the LCD makes it ideal for use in handheld instrumentation as well as more compact bench instruments.

Another LCD limitation has been lack of gray scaling. Today, it is possible to get gray scaling with LCDs, but, again, higher cost is the tradeoff. While color has already become more cost-effective in LCDs, black-and-white (monochrome) LCD displays promise to be cost-effective with CRTs over the next few years.

The Best Of Both Worlds

By capitalizing on underlying DSO/CRT technology, oscilloscope manufacturers are designing great new handheld and benchtop instrumentation that give users the best of both worlds. The strong foundation provided by today's DSOs—acquisition speed coupled with fast update rates—is being combined with the best of LCD technology. That includes the smaller footprint, safety, low power usage, and high reliability of LCDs.

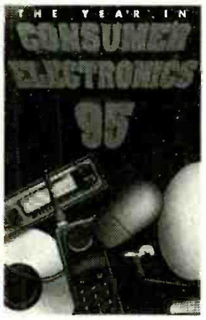
The recently introduced Tektronix *TekScope* is a good example of the benefits of marrying DSO technology with LCD technology. A small handheld oscilloscope, it gives users bench scope performance in the palm of their hands: 500 megasamples per second acquisition rate, plus a backlit LCD that pumps out enough light to be easily seen in the dark or bright sunlight. This tool is but one of many that will allow users to benefit from the exciting convergence of LCD and CRT technologies, both now and well in the future. EN

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

The Year in Consumer Electronics 95

The Consumer Electronics Manufacturers Association (CEMA)
2500 Wilson Boulevard
Arlington, VA 2201-3834
Tel: 703-907-7674
Fax: 703-907-7690
Web site: http://www.eia.org/cema/
Free with a $1.93 stamped, self-addressed 6×9 envelope



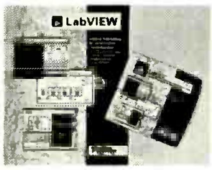
CIRCLE 337 ON FREE INFORMATION CARD

With the help of charts, graphs, and comprehensive text, CEMA's annual review of the consumer-electronics industry—which grew by 10% to $62 billion last year—reports on highlights, product development, and emerging trends. Among the figures quoted: Home office products shot up 23% to $22 billion; sales of multimedia PCs jumped 32%; home-theater component sales rose a more modest 10% to $8 billion; and the one-millionth Digital Satellite System was sold.

The book offers a combination of statistics that track factory sales to dealers of consumer-electronics products, and the text describes emerging technologies and trends and examines issues that faced the industry in 1995. For example, it describes how CEMA took action on behalf of computer manufacturers to produce a voluntary industry guideline for the depiction of display screen sizes to consumers. It also reveals how CEMA's Government and Legal Affairs department helped to amend laws in several states to allow the front-seat use of monitors for vehicle navigation systems. All the statistics were compiled through CEMA's market activity report program, which provides comprehensive statistical reporting on the consumer-electronics industry.

LabVIEW Evaluation Software and Brochure

National Instruments
6504 Bridge Point Parkway
Austin, TX 78730-5039
Tel: 1-800-433-3488 or 512-794-0100
Fax: 512-794-8411
E-mail: info@natinsst.com
Web site: http://www.natinst.com/
Free



CIRCLE 338 ON FREE INFORMATION CARD

National Instruments is offering free LabVIEW evaluation software (for Windows 3.1/95/NT PCs, Macintosh and Power Macintosh computers, Sun SPARCstations, and Hewlett-Packard 9000 Series 700 workstations), as well as a 16-page, full-color LabVIEW brochure filled with screen captures and descriptions of virtual instrumentation applications. The LabVIEW Evaluation CD-ROM, based on the recently announced 4.0 version of the award-winning graphical instrumentation software package, features tutorial-style online documents. (Windows users who do not have access to a CD-ROM drive can use the LabVIEW version 4.0 Overview disks.) Its menu-based system allows users to access a variety of information, including details about LabView add-on toolkits, technical support, customer education, and the Alliance Program.

The LabVIEW evaluation software allows users to build custom applications and to automatically run a variety of applications involving instrument control and data acquisition, analysis, and presentation for test-and-measurement and industrial-automation applications. The software introduces new and long-time users to new features of version 4.0, including the FlexVIEW customizable development environment and high-end development tools. An online tutorial guides users step-by-step through building a custom virtual instrumentation system.

Build a World Wide Web Commerce Center

by net.Genesis Corporation
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 1-800-225-5945
Web site: http://www/wiley.com/compbooks/
$29.95

CIRCLE 339 ON FREE INFORMATION CARD

Created by net.Genesis Corporation, a pioneer in Web-site and software development whose clients include CBS, Microsoft, Fox Network, and *The New York Times*, this comprehensive guide provides a total blueprint for building and managing a state-of-the-art Web commerce center. The book shows how to use Windows NT-based Web-server software to establish a secure and sophisticated commerce site. The techniques and guidelines presented open up the exploding Web marketplace to a broad new range of businesses, small and large, by making electronic commerce manageable and affordable.

The book integrates the vital technical and business issues that must be mastered to set up a secure Windows NT Web-commerce server, prepare content for the site, and support marketing and selling functions. It explains how to formulate an effective commerce strategy that is in line with marketplace needs and technological trends, choose and set up Web server software packages that meet your company's present and future needs, select and implement appropriate Internet payment schemes, and configure and customize Windows NT commerce servers. The book also reveals proven business and technical strategies used by top corporations.

Communication Excitement Radio

C. Crane Company
558 10th Street
Fortuna, CA 95540-2350
Tel: 1-800-522-TUNE (in Canada, 1-800-521-8863)
Fax: 707-725-9060
E-mail: ccraneco@aol.com
$1

CIRCLE 340 ON FREE INFORMATION CARD

This 79-page catalog offers a wide selection of communications products, with an emphasis on radio. Product categories include AM/FM radios and AM and FM antennas; shortwave radios, antennas, and books; scanners and related antennas, books, and accessories; mobile electronics; satellite receiving equipment; telephones, fax machines, and videoconferencing products; weather-monitoring equipment; CB radios, antennas, and transceivers; alternative power sources; audio; and general accessories. In most of those categories, two basic lines of products are offered: the "best made" and the "best for the money." The catalog also provides informative text about each area of communications, and some pointers about getting started.

Electronic Interconnection Systems Ordering Guide

3M Electronic Products Division
6801 River Place Boulevard
Austin, TX 78725-9000
Phone: 1-800-225-5373
Free


CIRCLE 341 ON FREE INFORMATION CARD

The CD-ROM version of 3M's 650-page catalog contains information on more than 5000 electronic products, including board and wire-mount sockets; board-stacking systems; "MIX" stacking connectors; headers; plugs; PCB connectors; cables; assembly equipment; heat-shrink tubing; tape and reel packaging; wire-marking products; and DIP, D-Sub, D-Ribbon, and DIN connectors.

The electronic catalog provides product specifications, technical drawings, and color photos, as well as complete ordering information. Easy-to-use menus allow quick access to specific information. The CD-ROM requires Windows 3.1 or 3.11, and a 386/486/586-based PC with a minimum of 4 megabytes of RAM and a CD-ROM drive.

Just Java

by Peter van der Linden
The SunSoft Press
Prentice Hall PTR
Order Processing Center
P. O. Box 11071
Des Moines, IA 50336
Tel: 1-800-811-0912 or 515-284-6751
Fax: 515-284-2607
E-mail: orders@prenhall.com
Web site: http://www.prenhall.com/
$34.95, including CD-ROM

CIRCLE 342 ON FREE INFORMATION CARD

This book cuts through all the hype to give readers a straightforward introduction to Java and object-oriented programming. Written with a sense of humor that makes learning fun, the book conveys the sense of excitement and enjoyment that lies in computer programming.

Using clear explanations and practical examples, the book covers the basics before presenting the more advanced elements of Java programming, including window and network programming. Topics discussed include "The Story of O—Object-Oriented Programming," "The Robot Ping-Pong Player," "GIGO—Garbage In, Gospel Out," and "Associativity and the Coffeepot Property." More traditionally titled chapters cover applications versus applets; identifiers, comments, keywords, and operators; packages, classes, and interfaces; and arrays, exceptions, and threads. The accompanying CD-ROM contains Java source code and applets discussed in the book, an anagram program, images, and the Java Developer's Kit.

Amazing and Fascinating Devices! Catalog No. 29A

Information Unlimited
P. O. Box 716
Amherst, NH 03031-0716
Tel: 1-800-221-1705
Fax: 603-672-5406
Web site: http://www.amazing1.com/
Free

CIRCLE 343 ON FREE INFORMATION CARDD

Dedicated to the experimenter and technology enthusiast, this 24-page catalog is filled with plans and kits for exciting projects. Categories include lasers, Tesla coils, microphones, high-voltage, night vision, security, pest control, FM/wireless, solar, ultrasonic, and electromagnetic devices. New products include a body-heat-sensing telescope, a plasma disc, a bug blitzer, and a plasma pen. If you'd like more information about one of the items in the catalog, you can order the plans first, and the cost of the plans will be credited toward the purchase of the complete kit or item.

1996 Supplement Catalog

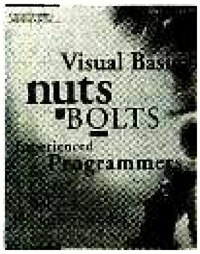
L-com
1755 Osgood Street
North Andover, MA 01845
Tel: 1-800-343-1455
Fax: 508-689-9484
Free

CIRCLE 345 ON FREE INFORMATION CARDD

The 64-page supplement to L-com's main catalog contains thousands of the company's newest and most-popular components that are used to interface with computer and instrumentation-related needs. Some unusual product categories are featured, including SCSI-1, -2, and-3 cables, terminators, and adaptors. The supplement also features a wide variety of cables, including VGA, coaxial, data, modular, DIN, IEEE-488, and V.35, along with a broad selection of adaptors, adaptor kits, and rack panels.

Visual Basic 4 Nuts & Bolts for Experienced Programmers

by Gary Cornell and Troy Strain
Osborne/McGraw-Hill
2600 Tenth Street
Berkeley, CA 94710
Tel: 1-800-822-8158
Fax: 614-759-3644
$24.95

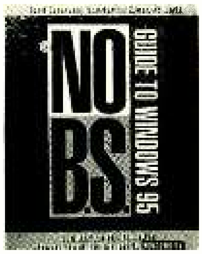


CIRCLE 344 ON FREE INFORMATION CARDD

If you already know the basics of programming and would like to add Visual Basic 4 to your tool chest, this book skips the remedial information and guides you swiftly along the road to mastering the latest version of Microsoft's best-selling rapid-application development tool. The book teaches the concepts and structures of Visual Basic 4 in a simple, straightforward format that allows you to learn what you need to know and then quickly move on to the next topic. It covers all of the essentials, including the fundamentals of Visual Basic's language, designing a form, handling errors, debugging, objects, advanced program features, and OLE.

The No B.S. Guide to Windows 95

by Scott Spanbauer
No Starch Books
401 China Basin Street at Pier 50
Suite 108
San Francisco, CA 94107-2192
Tel: 1-800-420-7240
Fax: 415-284-9944
E-mail: info@nostarch.com
$19



CIRCLE 346 ON FREE INFORMATION CARD

This book does not tell you absolutely everything about Windows 95. Instead, it provides all the information you really need to quickly become an expert Windows 95 user. The book omits useless, time-wasting information in favor of the good stuff you need to fine-tune your system to suit your needs.

Anyone who uses Windows 95 can take advantage of the book's breezy, humorous question-and-answer format. The book offers clear, no-nonsense solutions to such dilemmas as how to upgrade and install Windows 95, how to undo an installation gone wrong, what to do with older hardware that doesn't work with Plug-and-Play, and what the bundled applications do and how to use them. The book provides the tips you need to make Windows 95 work smarter and faster, and tweak it to perfection—without wreaking havoc with your system.

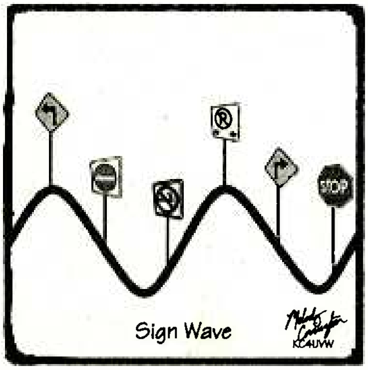
Standby Uninterruptible Power Supplies

Superior Electric
383 Middle Street
Bristol, CT 06010
Phone: 860-585-4500
Fax: 860-582-3784
Free

CIRCLE 347 ON FREE INFORMATION CARD

This 13-page catalog from Superior Electric describes the company's SP Series Stabiline standby uninterruptible power supplies (UPS). The supplies are compact, and efficient alternative powersources for personal computers, workstations, point-of-sale (POS) systems, and other electronic equipment by instantly switching to battery backup when a power outage occurs.

The standby supplies include audible and visual alarms, and advanced management circuitry to prolong battery life. The offer fast recharge time and provide advanced notification of impending battery faults. A wiring fault indicator lights when the UPS is connected to an improper outlet. Optional computer interface software for Novell, UNIX, and other computers is available for some models. Product photographs, technical tutorial and selection guides are included. EN



FAST PULSER
(Continued from page 45)

ohm input impedance, or if you have applied the signal through a 50-ohm feedthrough termination, set the scope to 50-mV/division. You should see 6 divisions of amplitude as shown in Fig. 8 (Fig. 8 and 9 are scope photos from a 500 MHz Tektronix 7904 oscilloscope with a 7A19 vertical amplifier). Using only the flat parts of the waveform, ignore any leading or falling edge aberrations when measuring amplitude.

To test sweep accuracy, set the horizontal sweep speed of the scope to 1 µs/division. You should see 8 divisions as shown in the photo of Fig. 8. The best possible accuracy is obtained by centering the signal on the screen and measuring from the center point of the waveform.

To measure the approximate bandwidth, set the sweep speed to the fastest rate and adjust the triggering so the complete rising edge of the waveform is visible as shown in Fig. 9. If that is not possible, it is likely that the scope under test does not have a vertical-amplifier delay line, which should be considered a serious deficiency. Ignore the amplitude of any ringing or overshoot, and measure the rise time by noting the time to go from 10% to 90% of the waveform amplitude. Some scopes have that precalibrated on the screen using either 5 or 6 divisions for 100%. If your scope has a 6 division scale for 100%, just use the variable vertical scaling commonly available to adjust the waveform to 5 divisions. Otherwise, just measure from 0.6 divisions to 5.4 divisions. That gives the rise time of the scope and the pulser combined. If the observed rise time is small (<1.5 ns), then use Fig. 4 or the formula to correct for actual rise time (use a nominal 0.5 ns for the pulse output rise time). Remember that the bandwidth is found from:

$$BW = 0.35/t_r$$

The total ringing or overshoot should be less than approximately 15% of the signal's final value. Ringing beyond that value might indicate problems with the vertical amplifier such as a peaked response, miscalibration, or faulty components. Ω

EQUIPMENT REPORTS

continued from page 24

detail are the DMM's 38 range/functions, auto power-off (in 20 minutes), transistor-gain and capacitance ranges, continuity buzzer, diode check, logic-probe function, current measurements to 20 amperes AC and DC, and frequency-counter function to 20 MHz.

The RadioShack LCD Digital Multimeter, Model 22-168A, comes with a rugged high-impact case, vinyl storage case, two test leads, manual, and software-loaded diskette, and sells for $129.99. For more information, see your local store, or contact RadioShack (Fort Worth, TX 76102) directly. EN

NEW PRODUCTS

continued from page 28

plied free of charge to keep the programmer up to date.

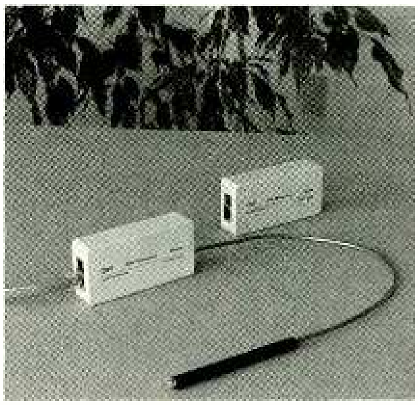
The LV40Portable costs $1295.

ICE TECHNOLOGY INC.
P. O. Box 1438
Henderson, NC 27536
Tel: 1-800-624-8949
Fax: 919-693-0681
E-mail: icetechusa@icetech.com
Web site: http://www.icetech.com

Windows-Compatible Thermometer

THE QTEK SOFT THERMOMeter connects to a serial port on any PC running Microsoft Windows and displays digital temperature readings in a small window. Unlike traditional scale thermometers—which are often awkward to read, can break and spill toxic fluid, and must be read at the location where installed—the Soft Thermometer is virtually unbreakable and can be read from any location. It can also be used to record temperature readings in a file while the PC is unattended.

The thermometer is easy to install and use. All of the serial-device setup parameters have been eliminated, and because the device is powered from the serial port, no external power source is needed. The included software provides a convenient way to display temperature readings in Fahrenheit or Celsius, set alarm points, and record temperature readings in a file for use with other software packages. Should the temperature go beyond the user's preset limits, a pop-up window warns of the problem.



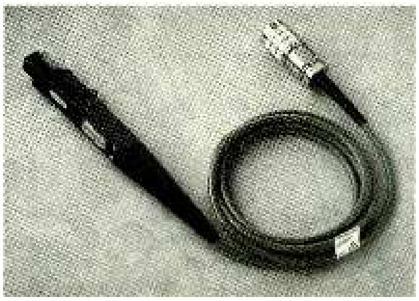
CIRCLE 25 ON FREE INFORMATION CARD

The Soft Thermometer, including software and a serial cable, costs $99.

QTEK
106 Song Meadow Road
North York, Ontario M2H 2T7, Canada
Tel: 416-492-9211
Fax: 416-492-5242
E-mail: qtek@hookup.net

100-Mhz Current Probe

THE TEKTRONIX MODEL A6312 current probe, when used with the Tektronix AM503 series amplifiers or AM503S current-measurement system, provides DC to 100-MHz bandwidth and low-intrusive access to signals of interest for engineers and technicians who design and evaluate high-speed digital and electronic power switching circuits. It is available separately to existing owners of AM503 series amplifiers, or as Option 5 to the AM503S system.



CIRCLE 26 ON FREE INFORMATION CARD

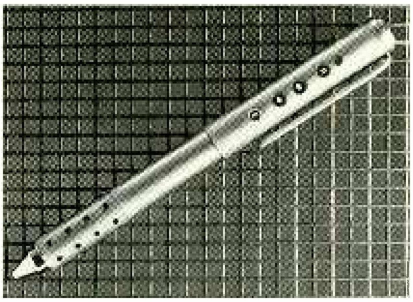
The A6312 offers a maximum continuous input current of 20-amps DC and peak AC current of 50 amps. Its split-core construction allows for easy connection to the circuit under test with a minimum of insertion loading. The current probe is compatible with all BNC input oscilloscopes.

The A6312 current probe costs $995, or $145 when ordered as Option 5 to the AM503S current-measurement system.

TEKTRONIX MEASUREMENT BUSINESS DIVISION
P. O. BOX 1530
Pittsfield, MA 01202
Tel: 1-800-426-2200 (press 3, code 544)
Web site: http://www.tek.com/measurement

Recording Pen

WHY USE YOUR PEN TO JOT down memos and reminders when you can just speak into it to record voice messages? Six inches long and 9/16-inch in diameter, the Pencorder 60 from Machina looks and writes just like a standard pen, but features a microchip that can record up to 60 seconds of personal memos.



CIRCLE 27 ON FREE INFORMATION CARD

Four thumb-operated buttons are used to activate all functions—record, play, repeat, and erase—with one hand. Major functions are programmed with audio cues, allowing the Pencorder to be used while driving without taking your eyes off the road. Lifetime memory stores the memos until they are erased, even if the batteries are completely discharged. Advanced features include the ability to skip forward and back, repeat and selectively erase memos, and recover accidentally erased memos. Batteries and a spare ink refill are included.

The Pencorder 60 has a suggested retail price of $70.

MACHINA, INC.
21 South Park
San Francisco, CA 94107
Tel: 1-800-223-4340
Fax: 415-243-4359 EN

GOOD STUFF

(Continued from page 52)

Westinghouse, and it was widely used in Fisher receivers. Today, most tube sellers consider the 7591 extinct and price it accordingly at $45-$150.

Desirable capacitors include electrolytic capacitors of recent manufacture and Sprague *Vitamin Q* pigtail tubulars.

As you may know, the Mallory Company offers a line of twist- lock, high-voltage electrolytic "cans" for replacement purposes. Unfortunately, the cost of those capacitors has doubled over the past year, so there is renewed interest in equivalent electrolytic types made within the last five years. Desirable values include 4 × 20 µF at 450 volts and 40/20/20/20 µF at 500 volts. Sprague Vitamin Q paper-oil capacitors were widely used in 1950s and 1960s military equipment. Some people claim those capacitors make their equipment sound better, and that hype has raised prices to the $1 to $22 range. Hot values include 0.047 µF, 0.1 µF, and 0.22 µF at 600 volts.

As far as output transformers are concerned, Peerless and Acrosound are the leaders. Typical part numbers sought out by overseas buyers include the Peerless S248Q and Acrosound TO-330. Both transformers were widely used in top-quality 20-watt amplifiers back in the 1950s. Prices for those units range from $75 to $150, depending upon appearance.

Tips for sellers. Think twice about selling your vintage equipment. If it is absolutely necessary to do so, why not look for a buyer who is genuinely interested in using it? By doing so, you will probably save yourself some grief and also benefit a person who appreciates vintage equipment.

Let's be frank: Don't think for one instant you can drag out that Truetone stereo amplifier you bought in 1961, sell it, and retire! Of the equipment built during the 1950s and 1960s, only a few items became classics like the ones listed. Therefore, the chances of finding a gold mine in your attic are slim. The keys to success in selling vintage equipment are:

- The equipment is in demand.
- You know current sale prices.
- You have access to potential buyers.

The hottest equipment in demand was described previously. For more examples, check the classified advertisements of this magazine. An excellent "one-stop" audio equipment catalog is available from *Audio Classics*. Key reference books on the subject include the *HiFi Spotter's Guides* by Charles Kittleson. That book, and many others, are available from Antique Electronics Supply.

Determining the sale prices of your equipment is tricky. Be careful; most sellers lose out because they guess on prices. In general, the right price depends upon the condition of your equipment and what the local market is willing to pay for it. Some sellers refer to catalogs like the one listed for current prices, and then sell for a multiple of that price (*e.g.* three-quarters of catalog price). Other sellers "shop" local exporters and flea-market sellers in order to determine the local asking price. Regardless of the method you use, a little time spent on pricing pays off later!

Reaching potential buyers is merely a matter of making your presence known. There are so many people out there chasing a dwindling supply of vintage equipment that they will come to you. You can advertise in a local paper, respond to an exporter's advertisements, or sell at flea markets. But beware! It is not uncommon for a buyer to drive 100 miles in response to your ad, browbeat you into giving a discount, and then try to pay with a check! With flea-market sales, some buyers expect big discounts.

You can eliminate those hassles by arranging a private sale with friends or by specifying disposition of the equipment in your will. These tactics work; I bought most of my audio equipment from people I originally met at flea markets and through a prominent uncle. Why not do the same? Ω

ADDRESSES

Antique Electronic Supply
6221 S. Maple Ave.
Tempe, AZ 85283

Audio Classics, Ltd.
PO Box 176
Walton, NY 13856

JAMMIX

(Continued from page 49)

balance can be set to place you essentially anywhere on the stage.

Positioning your guitar opposite the lead instrument often gives rise to stimulating exchanges with the recorded artist. The ability to position the instrument also allows you to master your own recordings. To do this requires two stereo tape recorders. A typical "home-studio mastering" might be done as the following scenario suggests:

Connect a tape recorder to the stereo OUT jack of JamMix. Set the BALANCE control of JamMix to mid-range and record a rhythm track with, say, a guitar. Rewind and remove the tape from the tape recorder (do not disconnect the machine) and install it in a tape player connected to the JamMix stereo IN jack. Position the BALANCE control to the right side and perhaps turn up the GAIN for some distortion. Install a second tape in the tape recorder. Start the tape player with the rhythm track, as well as the tape recorder, and add your lead guitar solos via the INSTRUMENT jack. Rewind and swap the tapes, and move the balance control to the left. This readies you to mix in another instrument such as a bass guitar, keyboards, or perhaps vocals. Of course, it might be easier to simply mix yourself into a recording of Johnny B Goode, or perhaps your favorite blues number. Plug into JamMix and you become a member of the band!

Your guitar's audio signal can be adjusted to the same position and levels of the lead artist, which is useful for memorizing note-for-note passages. Of course, the JamMix can be jacked into your home stereo with excellent results, where the guitar is played through the stereo. This helps to ensure that your instrument is appropriately mixed with the band with which you are "jamming." Ω

SUPPLEMENT TO ELECTRONICS NOW OCTOBER 1996

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Phone: 513-222-0173 ◆ Fax: 513-222-4644

Amplified Indoor FM Antenna

17" tall, amplified FM antenna. Improves reception with weak FM signals. 18 dB of gain. Includes AC adaptor, gain control, and 75 ohm coaxial cable terminated with an "F" connector.

HOT NEW ITEM!

#EN-219-055 .... $12.90

Cable TV Stereo Decoder

When used in conjunction with a cable TV converter or cable ready VCR, this handy device allows you to feed the cable TV stereo signal into your home sound system for superb audio reproduction of your favorite shows, movies, and sporting events.

#EN-189-110 .... $19.90

Digital Video Stabilizer

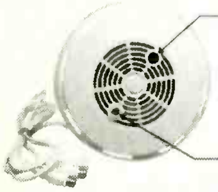
The digital video stabilizer will eliminate the constant picture distortion caused by the copyright protection on movie videotapes. This unit is fully automatic and operates on one 9V battery which is included.

#EN-180-320 .... $17.95

Decoy Cameras

These 1/3" CCD cameras offer a clever means of disguise. Both feature a 3.6mm wide angle lens, built-in electronic shutter, and a 12 VDC power supply. Minimum illumination: 0.3 lux. 400 line resolution. Smoke detector decoy camera includes an audio output.

AFFORDABLE HIGH TECH SURVEILLANCE!



Part #	Description	Price
EN-335-535	Smoke detector decoy	$249.50
EN-335-540	Decoy clock camera	299.95

"The Sound Bridge" FM Stereo Wireless Transmitter

The Sound Bridge is a mini FM wireless transmitter that can be used to broadcast stereo sound from any audio source like portable CD players, TVs, electronic games, CD-ROM, even computer soundcards, to your home stereo receiver! Adjustable from 89 to 95.5 MHz.

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Portasol/Weller Butane Soldering Tool

NO CORDS, NO BATTERIES!

This cordless, refillable, butane powered soldering tool is ideal for any on-site soldering job. Provides up to 35 watts with a temperature range up to 700 degrees F. Includes flint ignitor in plastic case, safety cut off switch, and C-2 chisel tip.

#EN-372-150 .... $25.95

150 MHz Oscilloscope Probe Kit

Deluxe probe kit features a modular design for longer life, switchable 10:1 probe with 150 MHz bandwidth, 2.8 ns rise time, and adjustable capacitance from 10-35 pF. 60" in length.

GREAT VALUE!

#EN-390-100 .... $29.95

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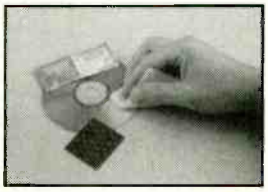
Don't throw away expensive CDs because of annoying mistracking and skipping errors! The Memorex CD Repair kit contains enough solution and materials to clean and repair 12 compact discs.



#EN-249-032 .... $1.95

5" Sealed Back Midrange

5" heavy duty sealed back midrange with deluxe mesh grill. 1" aluminum voice coil. Popular midrange for auto sound installations. ◆Power handling: 35 watts RMS/50 watts max ◆Voice coil diameter: 1 inch ◆Impedance: 8 ohms ◆Frequency response: 800-10,000 Hz.

#EN-280-030 .... $7.50

3 Channel Color Organ Kit

This sound to light unit features three separate outputs, which can be controlled independently. Each output reacts to three different bands of the musical spectrum: bass, midrange, and treble. Has built-in microphone, so no connection is required to music source, but a line input is provided.

HIGH-Q velleman-kit

SUPER QUALITY KIT!

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Features a ferro fluid cooled Kapton voice coil and a rubber surround. Very natural sounding high frequency reproduction with extended response to 30KHz.
◆Power handling: 50 watts RMS/75 watts max
◆Voice coil diameter: 1", ◆Impedance: 8 ohms
◆Frequency response: 2500-30,000 Hz.

Dayton Loudspeaker Co.®

RESPONSE TO 30KHz!

#EN-275-050 .... $16.50

6-1/2" Woofer

Polymer resin treated paper cone with poly foam surround. Long throw voice coil design helps to deliver powerful bass output. Perfect for bookshelf type speakers. Mfg. #C16L020-51F. ◆Power handling: 60 watts RMS/120 watts max. ◆Voice coil diameter: 1-1/4 inches ◆Impedance: 8 ohms ◆Frequency response: 57-7000 Hz.

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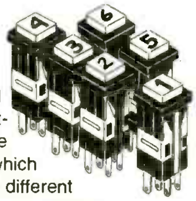

Twelve push-on/push-off switches (only 6 pictured). Each switch has a 0.6" square yellow lens with a 0.25" high black numeral 1 through 12. They are lighted by a 28 volt, #85 wedge base incandescent lamp which can be easily replaced if a different voltage is desired.

CAT #PBL-12 $15.00 per set of 12

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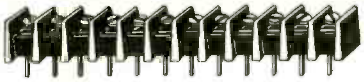

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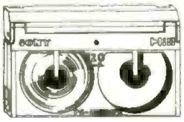

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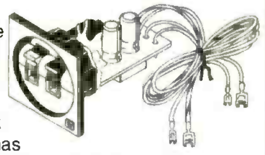

JBL # 70561
No specs available on this two way crossover made for JBL speakers. 2.38" square black plastic backplate has color-coded spring lever terminals and fits a 1.95" diameter hole. Crossover is attached to backplate and extends 3.17" behind mounting plate. Color coded wire leads.

CAT # LX-70561 $3.50 each

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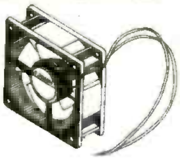

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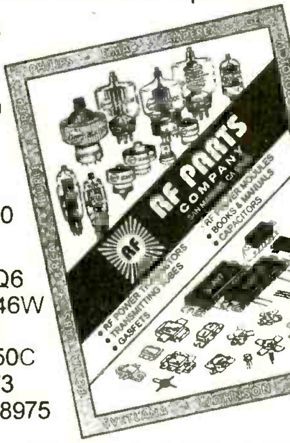

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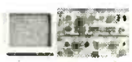
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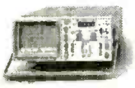
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General

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

DC Voltage (DCV)

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

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

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

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

AC Voltage (ACV)

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

Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding. Calibrated in rms of a Sine Wave.

Resistance (Ω)

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

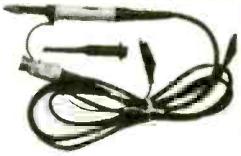
Maximum Open Circuit Voltage: 2.8V

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

hFE Test
Measures transistor hFE.

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

Switchable Scope Probe Sets



(Selectable X1/Ref/X10) These high quality scope probe sets are for oscilloscopes up to 60MHz (model HP9060) or 150MHz (model HP9150). Both sets include a handy storage pouch and include an IC test-hook adapter for the probe. The BNC connector rotates to avoid cable tangle or kink. Cable length is 1.4 meters.

CAT NO	DESCRIPTION	PRICE EACH 1	10	100
HP-9060	Scope Probe Set DC~60MHz	$16.49	$14.49	$11.58
HP-9150	Scope Probe Set DC~150MHz	24.95	21.95	18.62

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 185mm/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

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 185mm/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

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

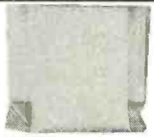
CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 185mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30

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

Developer



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

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

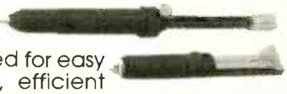
Etching Tank

This handy etching system will handle PC boards up to 8"x9", 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

Desoldering Pumps



These powerful plastic body desoldering pumps are designed for easy one hand operation for fast, efficient desoldering. Double O-ring piston seals for maximum suction.

CAT NO	DESCRIPTION	PRICE EACH 1	5	10
08-366S	Large Desoldering Pump	$15.89	$13.49	$11.95
08-366E	Regular Desoldering Pump	10.89	8.59	7.39
08-366TIP	Replacement Tip	1.95	1.95	1.95

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Electronic Soldering System

Here's the ideal solution when **Temperature Control** is required. Easy to use slide control allows user to set system from 300°F to 840°F. Voltage to iron from control unit is 24V Iron heating power is 48W. Replaceable 5.3mm tip is standard. Replacement irons and tips are available.

AS LOW AS $50.00

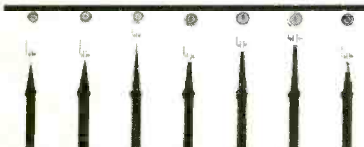
CAT NO	DESCRIPTION	PRICE EACH 1	5
SL10	Temp Controlled Soldering Iron	$56.00	$50.00
SL24V	Spare 24V Soldering Iron	10.50	7.50

Electronic Soldering System with LED Display

Deluxe temperature controlled system with LED display for maximum accuracy. Temperature is adjustable from 160°-480°C (320°-900°F). Iron heating power is 48 Watts. Runs on 24V from controller unit. Replacement irons and tips are available. Tip size is 5.3mm.

AS LOW AS $75

CAT NO	DESCRIPTION	PRICE EACH 1	5
SL30	Deluxe Soldering System w/LED	$86.00	$75.00
SL24V	Spare 24V Soldering Iron for SL10 or SL30	10.50	7.50



Replacement Tips for SL10/SL30

We now offer a variety of replacement tips for the SL10/SL30 soldering stations.

CAT NO	DESCRIPTION	PRICE EACH 1	5
821	1/32" Pencil Tip	$1.39	$1.19
822	1/32" Pencil Tip	1.39	1.19
823	1/64" Pencil Tip	1.39	1.19
824	1/16" Chisel Tip	1.49	1.29
825	1/8" Chisel Tip	$1.49	$1.29
826	3/64" Chisel Tip	1.49	1.29
827	3/64" Pencil Tip	1.59	1.39

Ball Bearing 12V DC Fans

These High Quality Fans feature Ball Bearings and Brushless DC Motors. All of them are designed to meet UL, CSA & VDE Standards. Design these fans into power supplies, computers or other equipment requiring additional air flows for heat removal. These fans are regular Circuit Specialists stock items — they are not surplus.

INDUSTRY BEST PRICING!

CAT NO	PRICE EACH 1	10	25	100
CSD 4010-12	$ 9.88	$ 6.38	$5.48	$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE (INCH-H_2O)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

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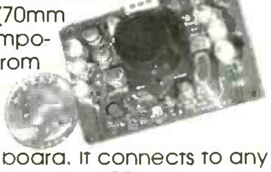
CAT NO	DESCRIPTION	PRICE EACH 1	10	25
RH60-1	1-lb. Spool, .031", 60/40	$ 6.90	$ 5.96	$ 5.30
RH63-1	1-lb. Spool, .031", 63/37	6.95	6.10	5.41
RH60-4	4.4-lb. Spool, .031", 60/40	24.00	21.90	17.92
RH60-TUBE	6-oz. Tube, .031", 60/40	.99	.89	.79

CCD Camera - IR Responsive

As Low As $109!!



This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 46mm). The lens is the tallest component on the board (27mm high from the back of the PCB) and it works with light as low as 0.1 lux. It is IR Responsive for use in total darkness. It comes with six IR LED's on board. It connects to any standard monitor, AUX or video input on a VCR or through a video modulator to a TV. Works with a REGULATED 12V power supply (11V-13V). Hooks up by connecting three wires: red to 12V, black to ground (power & video) and brown to video signal output.

CAT NO	DESCRIPTION	PRICE EACH 1	5
CA-H34A	PCB Mounted IRCCD Camera	$125.00	$109.00

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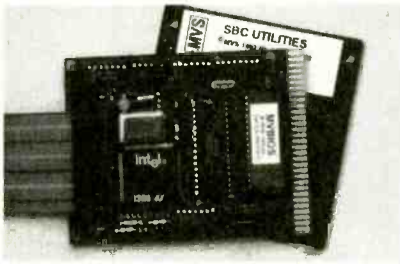

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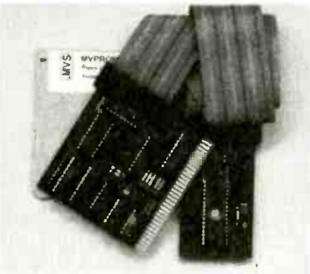

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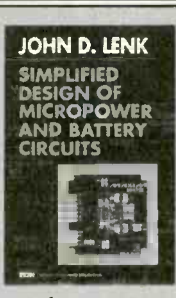

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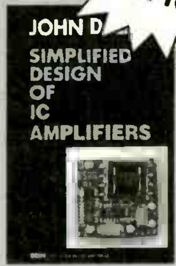

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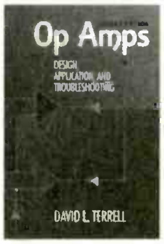

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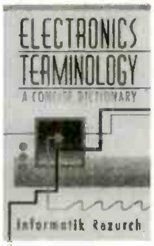

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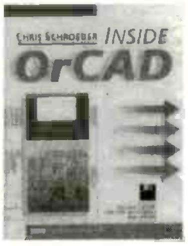

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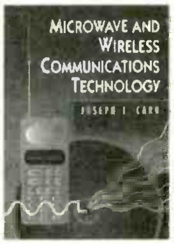

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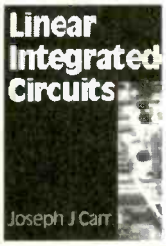

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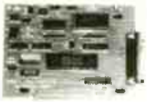

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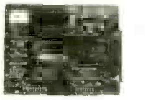

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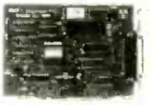

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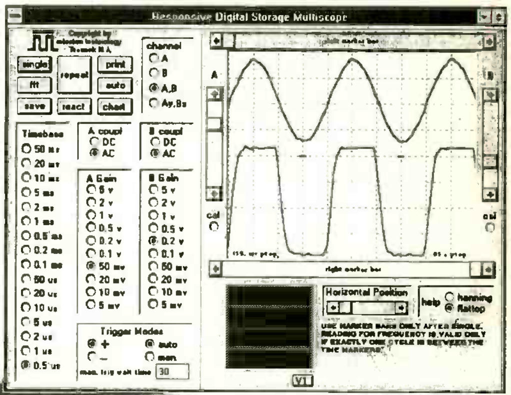

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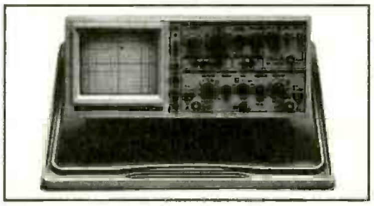

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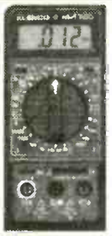

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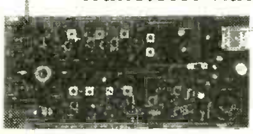

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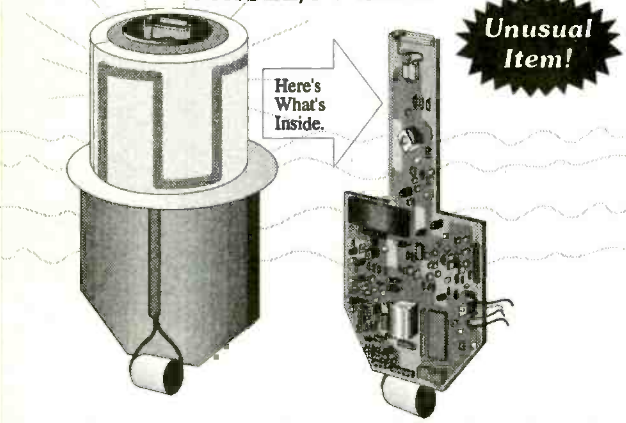

Consists of the "insides" of a very sophisticated ocean beacon. Perhaps these were designed to track and transmit at VLF ocean currents, track storms, show hazardous locations in the ocean, shipwreck locations, etc.-We don't know!

These are brand new and are about 14 1/2" Tall x 6 1/2" Dia. They have a round antenna device near the top, and a bright strobe tube that flashes at the very top. The circuit board operates from 12VDC and the strobe tube starts to flash about once a second when power is applied. We think that it also has a built-in transmitter as it has quite a few coils (however these could also be for an RF receiver, or both transmitter and receiver)We have no specs, schematics or other info on these. Circuitry consists of sveral hundred parts including an 80C31 CPU, a 27C256 RAM, 10 other ICs, various power transistors, a reed switch, various small signal transistors, a quantity of tantalum caps, trimmer caps, resistors, a crystal oscillator that operates at 5.0753125MHz, a 12MHz crystal, a copper/brass shielded circuit area. These were made by Westinghouse and have 3D60376 Rev E marked on the circuit board.

We will give $500 worth of our catalog merchandise to the first person who can supply us with the schematics, frequency of operation and general operational data on this item-Please call us if you have it!

These are new in manufacturer sealed cardboard boxes-We don't have the outer plastic beacon case or any other data, however, these must have cost a fortune! Here's your chance to own a piece of very interesting technology for experimenting at a tiny fraction of the original cost.

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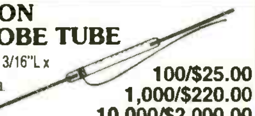

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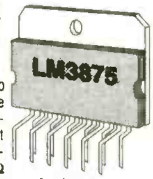

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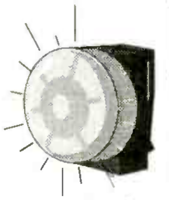

These small warning lights operate from 2 AA batteries (not included) and produce brilliant flashes of light to warn approaching motorists of your presence. Clips onto belt or the back of your bicycle seat with the built-in clip. These appear to be brighter than the popular rectangular units that we have seen and we are selling them for much less. Size: Approx. 2 3/4" dia. x 2" thick. Brand new in retail card packaging. We have two types!

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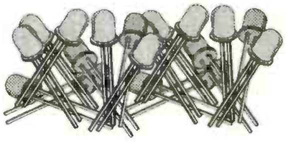

Low current high reliability TI case red LED by Stanley. 6mcd@20mA typical output. Pastel diffused pinkish lens type. Peak wave length: 630nm, V_f=2.0V. These are brand new and very nice!

G7862.................. 20/$1.00
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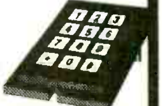
GRAYHILL KEYBOARD



These are high quality keyboard switches by Grayhill. Part # 86YY3515-1 G-96-008-J-9611. They feature white buttons on a black base as shown. The pads are the type that give you a click to let you know for sure that an entry was made (not like the cheap membrane types). Size: 2 3/16" x 3".

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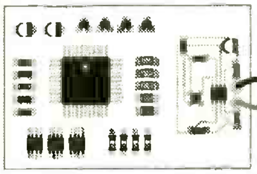

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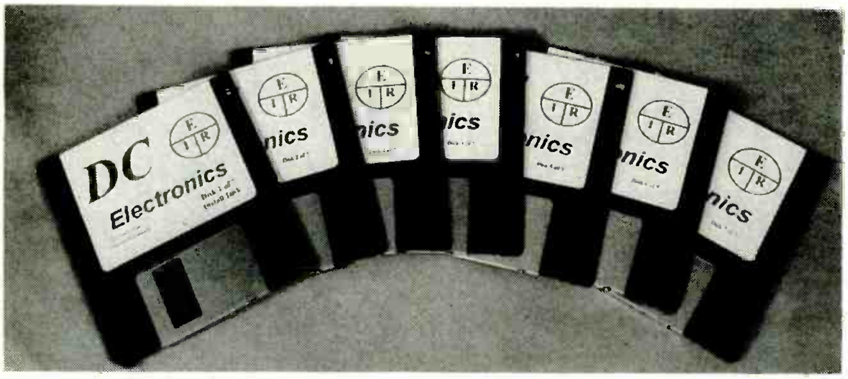

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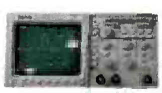

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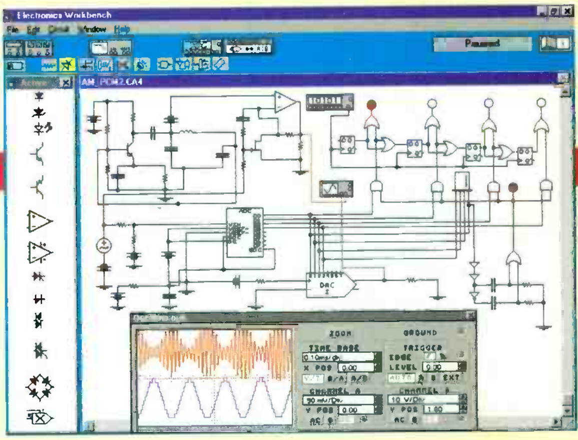

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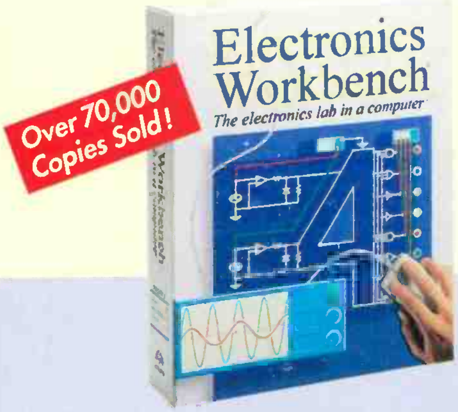

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