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Light weight makes the 2225 easy to carry even to remote servicing sites.

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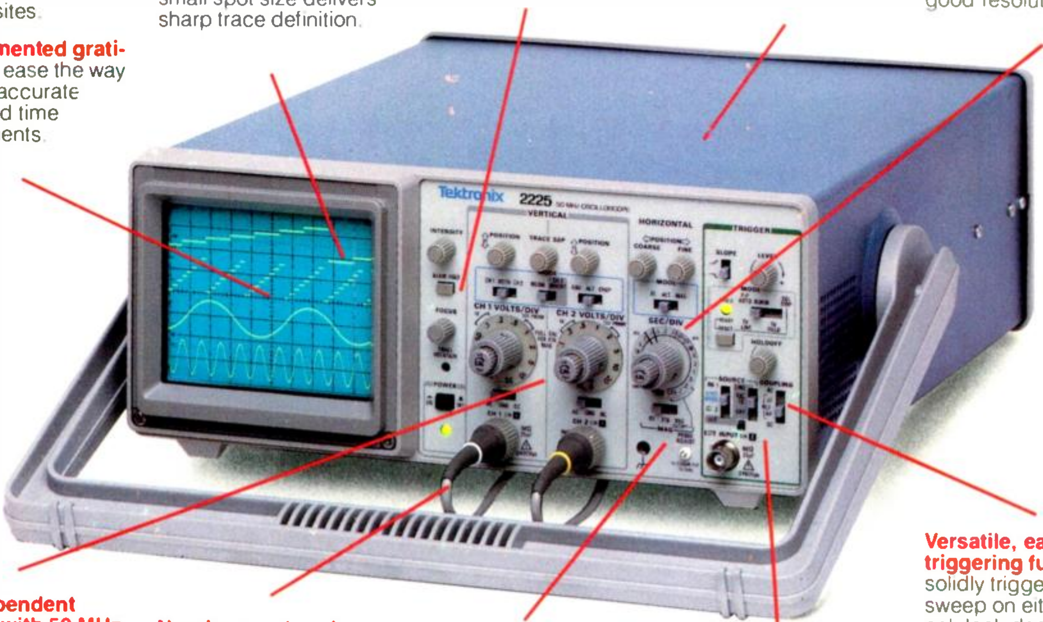

Versatile, easy-to-use triggering functions solidly trigger the sweep on either channel. Included are asynchronous triggering capability; flexible coupling via DC, AC, HF and LF reject filtering; hands-free triggering from virtually any signal; plus independent selection of either TV line or TV field triggering regardless of time-base setting.

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September 1987 Radio-Electronics

Vol. 58 No. 9

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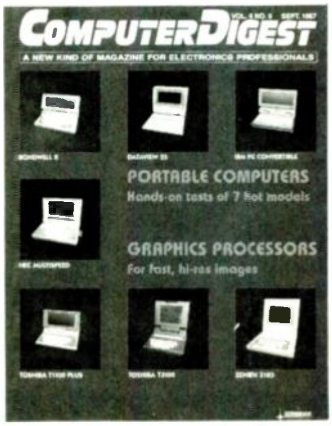
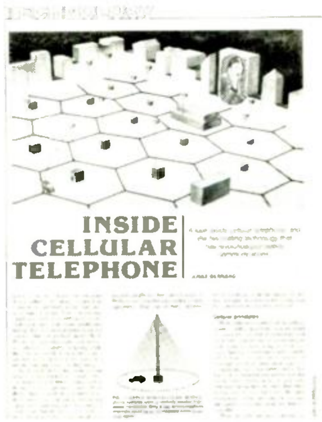


PAGE 71

TECHNOLOGY



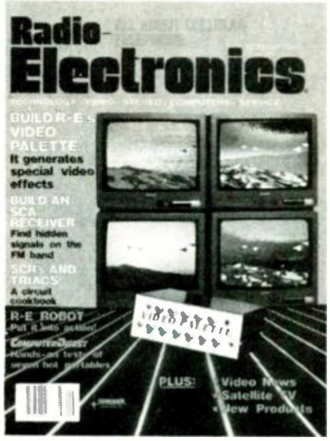
PAGE 53

CIRCUITS AND COMPONENTS

DEPARTMENTS

AND MORE

ON THE COVER



If you have ever wanted to take complete control over the appearance of your video productions, this month's cover story is for you. It's a video-effects generator that will let you tailor a signal's tint, color, and brightness to create a custom look or to add special effects such as solarization, and posterization.

Some of the actual effects you can create with the Video Palette are shown on the screens of Sharp's model *3MM67* TV's. Sharp's digital VCR model *VC-D75U* was used to obtain the excellent still-frame images. We'd like to thank everyone at Sharp Electronics Corporation for their help and cooperation.

COMING NEXT MONTH

THE OCTOBER ISSUE IS ON SALE SEPTEMBER 1

BUILD THE LASER BUG
This laser receiver let's you use laser light to hear what's going on.

BUILD THE VIDEO PALETTE
Part 2 features circuit details, construction, and more.

TRIACS AND SCR's
Twenty-eight practical circuits from a zero-voltage line switch to a smart lamp- dimmer.

HOW TO SERVICE SWITCHING POWER SUPPLIES
A practical guide.

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Advertising Sales Offices listed on page 114.

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The new 2945 is well suited for both the analog and digital worlds. DC V accuracy is 0.05%, with 10μV, 10nA, 0.01Ω resolution. Data hold freezes voltage and current readings. °C and °F temperature readings are from −20° to +1000°C frequency from 20 Hz to 200kHz. AC voltage and current are read in true RMS. Also checks continuity and diodes. $250.00 Contact: B&K-PRECISION, 5460 W. Cortland Street, Chicago, IL 60635 (312) 889-9087.

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HAND-HELD TEST BENCH READS VOLTAGE, RESISTANCE, CURRENT, HFE TEMPERATURE AND LOGIC.

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WHAT'S NEWS

New chips to have more accurate spacing

Using a new technique known as mask-proximity correction, researchers at General Electric have made it possible for exposure systems that now can make chips with structures as small as 1.5 microns to be used for making next-generation devices with structures as small as 0.7 micron.

The new technique will greatly extend the effectiveness and hence the useful life of the million-dollar-plus optical lithography systems used in chip patterning.

The main problem experienced when pushing present-generation optical-exposure systems to make chips with sub-micron structures is that of proximity effects. Light from the exposure systems diffracts as it passes through the tiny openings in the masks. Because of that, areas of dense patterning tend to be underexposed. To compensate, exposure times must be lengthened, but doing that overexposes the isolated features, causing them to be undersized.

GE's proximity-correction technique solves the problem by causing the features on the masks to be enlarged slightly in isolated areas of patterning. A special software routine analyzes the spacing between features and then causes selected dimensions in the masks to be enlarged.

The routine can specify a continuous correction range, from none, for the most dense areas, to heavy, for the most isolated features. Then when exposed, isolated features can be brought to within 0.05 micron of the target width.

A GE RESEARCH PHYSICIST, Dr. Yoav Nissan-Cohen, examines a computer-generated plot of a 0.8-micron chip, the first to be fabricated using mask-proximity correction.

Spray painting solves problems of brittle superconductors

Scientists at IBM's Research Center at Yorktown Heights, NY report that they have found a way to circumvent the problem of brittleness in the new ceramic superconductor materials

The IBM scientist's solution is to use a plasma-spraying technique—heating the material until it is ionized, then spraying it on a suitable surface and cooling it. After annealing, the painted surface is again completely superconductive at 68 degrees Kelvin. The researchers have even coated preformed wires, and painting traces like those found in printed circuitry is comparatively simple.

New optoelectronic chip increases speed 10 times

Honeywell has developed an integrated GaAs monolithic receiver chip with a density speed about 10 times faster than that of any presently known circuit. The new chip contains a photodetector and 200 gates on the same GaAs substrate. It was demonstrated at 1-gigabit clock frequencies.

Measuring about 2 × 2 cm, the chip contains an optical detector, preamplifier circuit, and 1:4 demultiplexer. It was designed to decode a 1-gigabit optical signal input into four parallel 250-megabit electrical outputs. Its high data rates make the chip particularly useful for optical interconnects between computer chips.

That second-generation device is compatible with current manufacturing processes using direct ion implantation and metal organic vapor deposition for epitaxial growth. It provides greater power and capability than earlier devices because of its greater complexity and true integration of gallium-arsenide microelectronics and optical components.

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **Video numbers.** As of June 1, 98% of all U.S. households had TV sets of some type. Breaking that figure down further, a color TV-set could be found in 93% of all U.S. households, projection TV-sets in 4%, LCD TV-sets in 2%, and some 7% of all U.S. households owned color TV-sets with multichannel (stereo) sound. Also, VCR's could be found in 45% of U.S. homes, camcorders in 3%, and 36% owned pre-recorded videocassettes.

Those estimates are from EIA, which also forecast that 18,300,000 color TV-sets will be sold this year. Of those, 4,300,000 will be stereo and 325,000 will be projection sets. Americans will also buy 13,725,000 VCR's, of which 12,000,000 will be table-model decks and 1,600,000 will be camcorders. Of the total VCR sales, the EIA predicts 2,500,000 will be equipped to receive and record stereo TV.

• **CD-Video Bows.** The CD has now formally been introduced in video form. Compact Disc-Video (or CDV, as it's expected to become known) has now been embraced by a sizeable number of hardware manufacturers, record companies, and movie firms. Although the audio CD is a digital medium, the visual part of the CDV is analog and uses the same record and playback principles as the *Laservision* videodisc.

The little 4¾-inch CDV disc—the same size as an audio CD, but distinguished by its gold color—carries five minutes of video and up to 20 minutes of audio. The principal proponent of CDV, Phillips, has proposed changing the name of all *Laservision* players and discs to Compact Disc-Video, and several manufacturers have agreed to make players that will accommodate 4¾-inch CDV's and audio-CD's, as well as 4¾-, 8-, and 12-inch Laservision discs. Also in the works are mini-players that will play only the smaller discs; a little further down the line are possible CDV "boomboxes", portable audio-video systems with LCD displays.

Sales of CDV players and discs are scheduled to start this year. Many hardware and software manufacturers are standing aside for now, watching very closely to see if it is possible to reincarnate the optical videodisc as a mass-market item via the magic of Compact Disc.

• **Super-VHS bargains.** When the first SVHS (*S*uper-*VHS*) recorder was announced by JVC in Japan, the suggested list price was set at more than $1,500, based on the yen-to-dollar exchange rate at the time. That led to speculation that the price of an SVHS recorder in the United States would be about $2,000, effectively pricing the new medium out of the market. But consumer-electronics pricing can be full of surprises, and when Hitachi announced the first SVHS recorder for the American market, it was priced at about $1,300. When JVC unveiled its model, it carried a U.S. suggested list price of just under $1,200, although essentially the same model bore a list price of about $1,550 in Japan. Facing that pricing challenge, other manufacturers are quoting $1,100 for their units for the American market. Therefore, even before the first SVHS had reached the market in the U.S., prices had already come down by almost one-half.

By press time, SVHS decks had been announced for sale this year by Hitachi, JVC, Magnavox, Mitsubishi, Panasonic, Quasar, RCA, Sharp, Toshiba, and Zenith. JVC forecast that SVHS would soon replace standard VHS, but most other manufacturers disagree, arguing that there would be dual standards for some time to come.

One of the problems of SVHS currently is the lack of pre-recorded cassettes. Because cassettes recorded in the SVHS mode can't be played on standard VHS recorders (although VHS cassettes can be played on SVHS recorders), it will be some time before pre-recorded cassette makers will be willing to release much pre-recorded material in the new high-resolution format.

On another front, there is surprising interest in SVHS in the industrial and broadcast fields. Both JVC and Panasonic are preparing industrial models of SVHS, and there are forecasts that the new system could take over from the standard ¾-inch U-matic format in industrial video. And it is also felt that the format has potential for use in broadcast newsgathering. **R-E**

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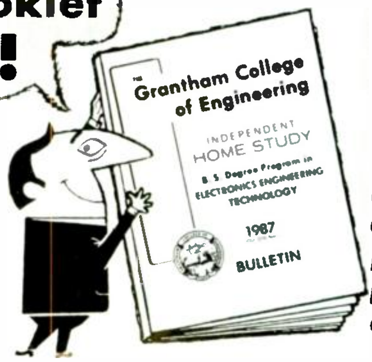

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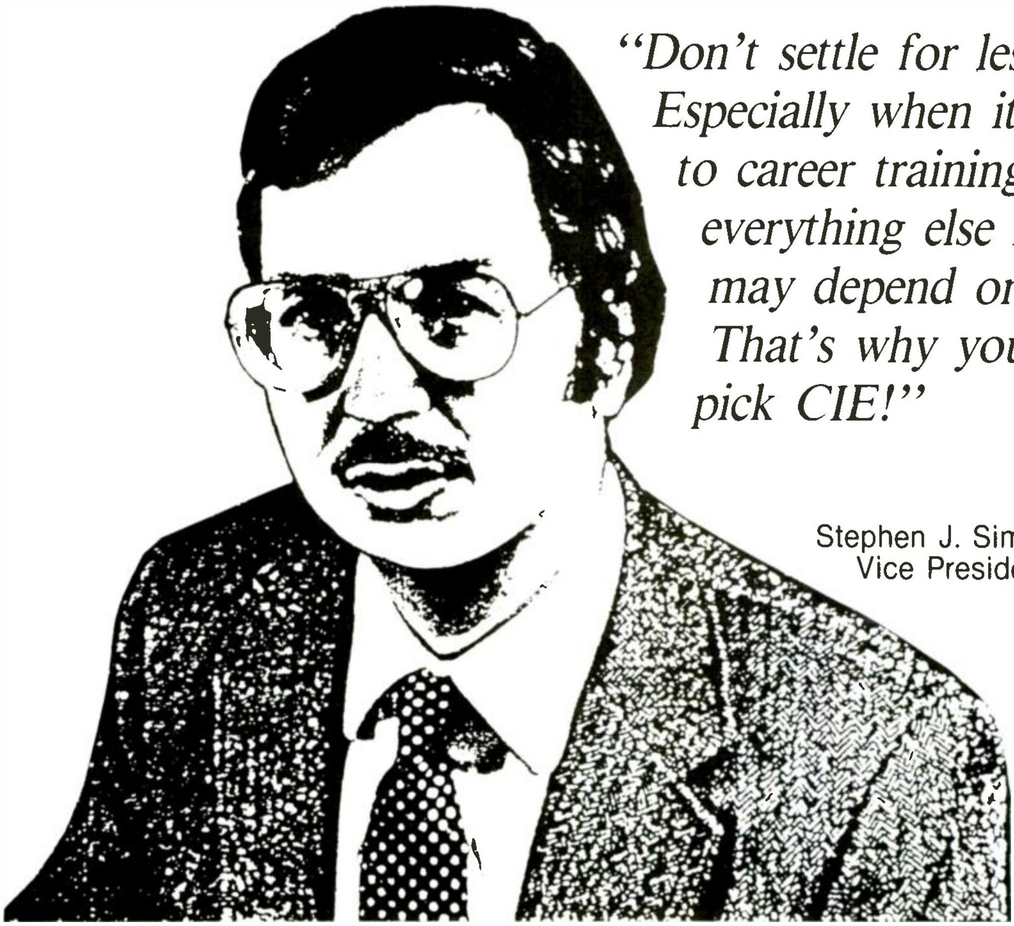

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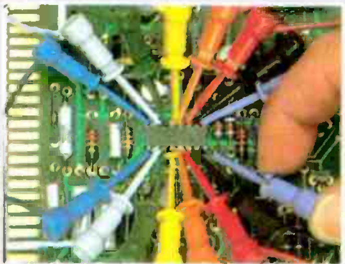
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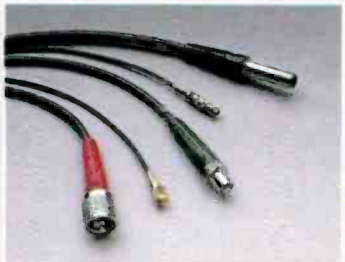
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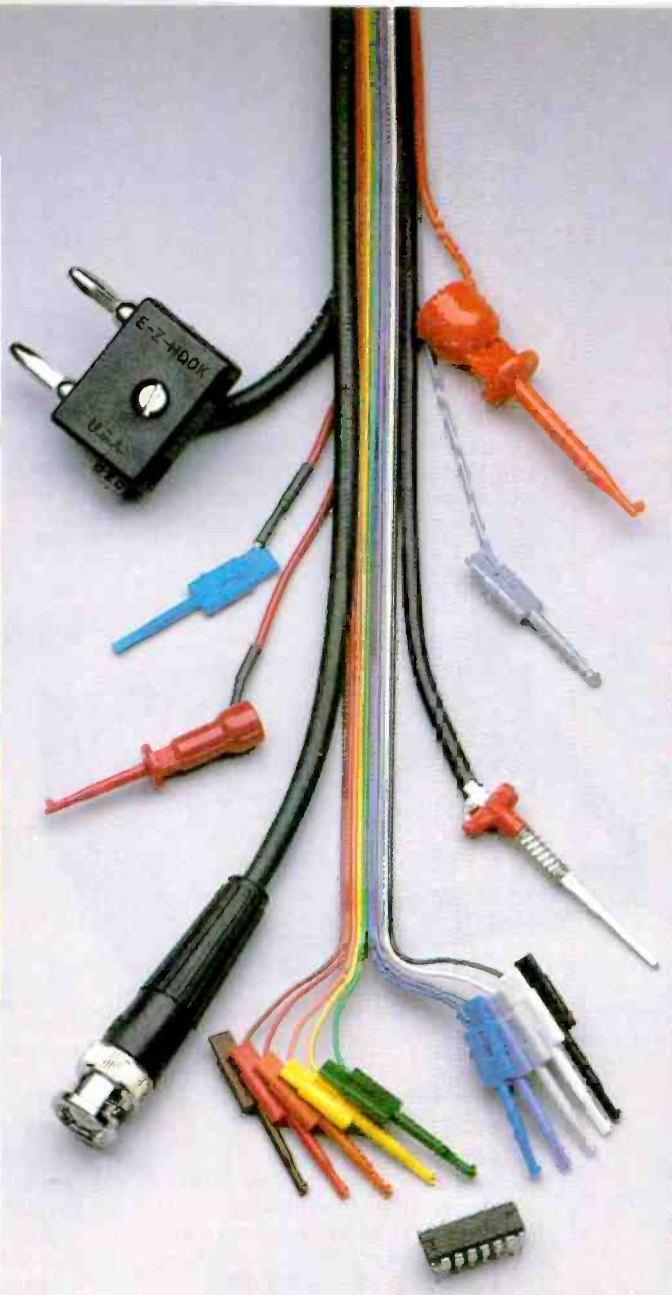
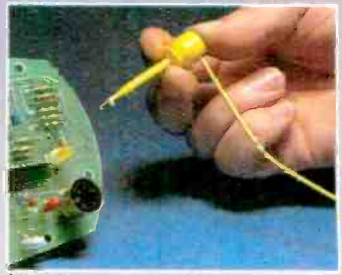
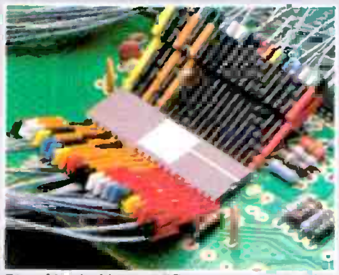
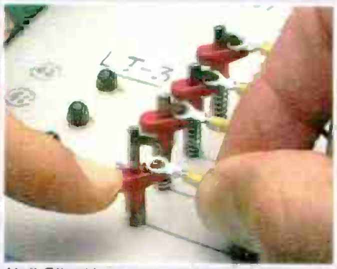
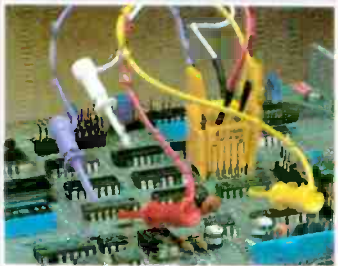



Mini-Hook Test Leads


Pico-Hook, Narrow/IC


Nail-Clip, Harnessing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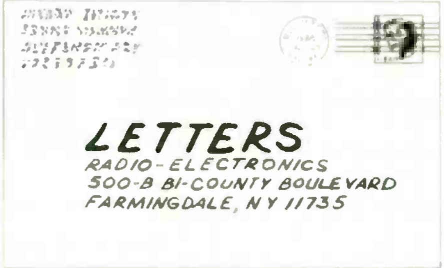

COMPONENT NUMBERING SYSTEMS

I enjoy reading your department, "Antique Radios." It's brought back memories of our first Atwater-Kent, and how I first began in radio around 1938.

Some of the history of those days is, I fear, becoming lost. One of the things that distresses me is when I hear someone refer to a diode, such as a 1N914 as an "eye-en" 914.

Did you know that the XN (1N, 2N, 3N, 4N) system of numbering semiconductor devices was actually invented before there were transistors? Before there were transistors (prior to 1948) there were tubes and solid-state "crystal" diodes. During World War II solid-state diodes, the venerable 1N21, 1N23, 1N23A, and 1N23B among them, were used as mixers in radar receivers. Their function was to downconvert the incoming RF energy so that it could be amplified at a lower frequency.

The tube-numbering system most in favor at the time was of the form nXn; for example a 6L6. The first number indicated the nominal filament or heater voltage. The letter indicated whether the device was an amplifier or a rectifier. Letter designations in the first half of the alphabet were amplifiers; letter designation in the second half of the alphabet were rectifiers. (From that, we see that the L in the tube number indicated that the 6L6 was an amplifier.) The final number indicated the number of active electrodes.

With CRT's, the first number in-

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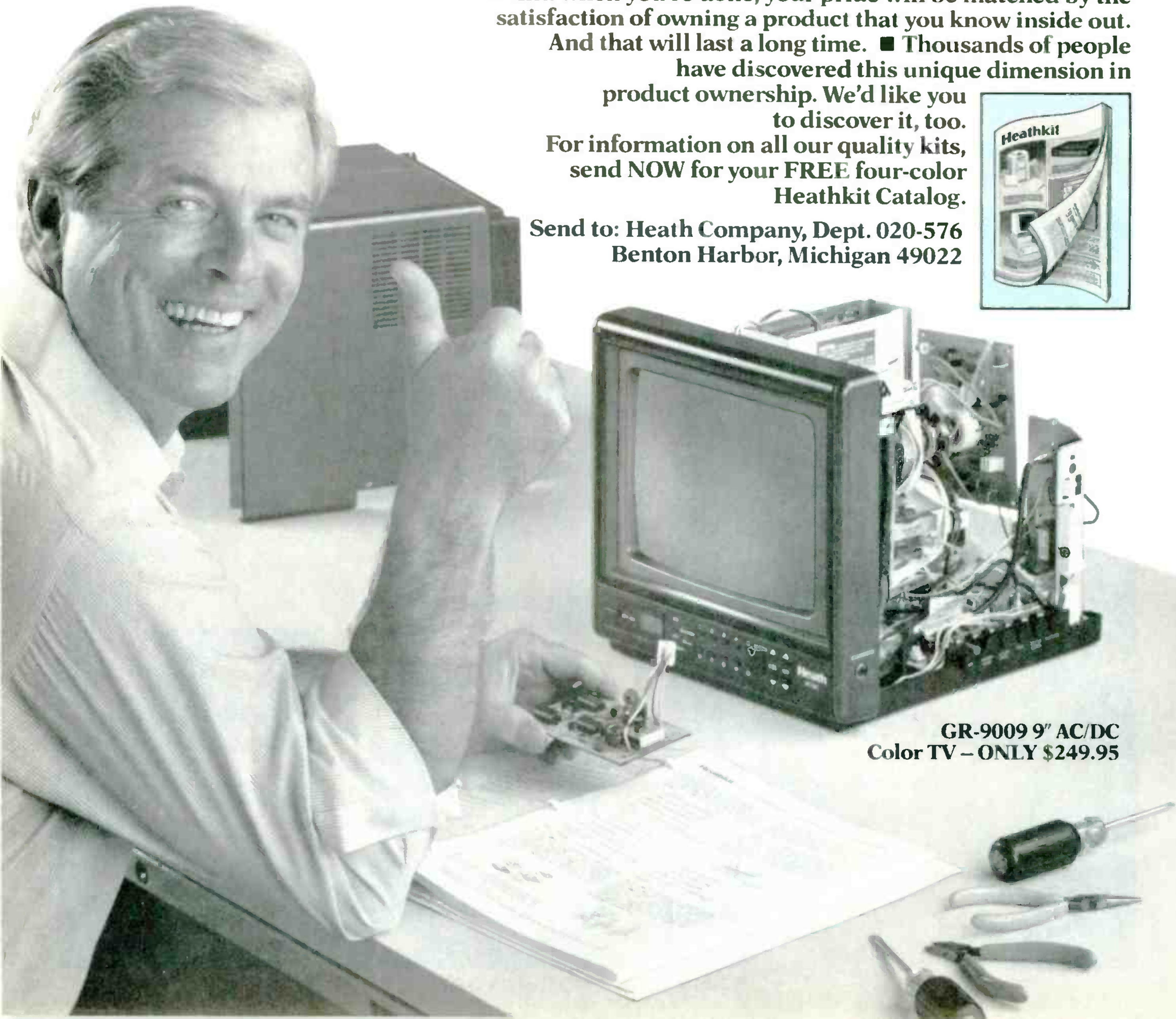

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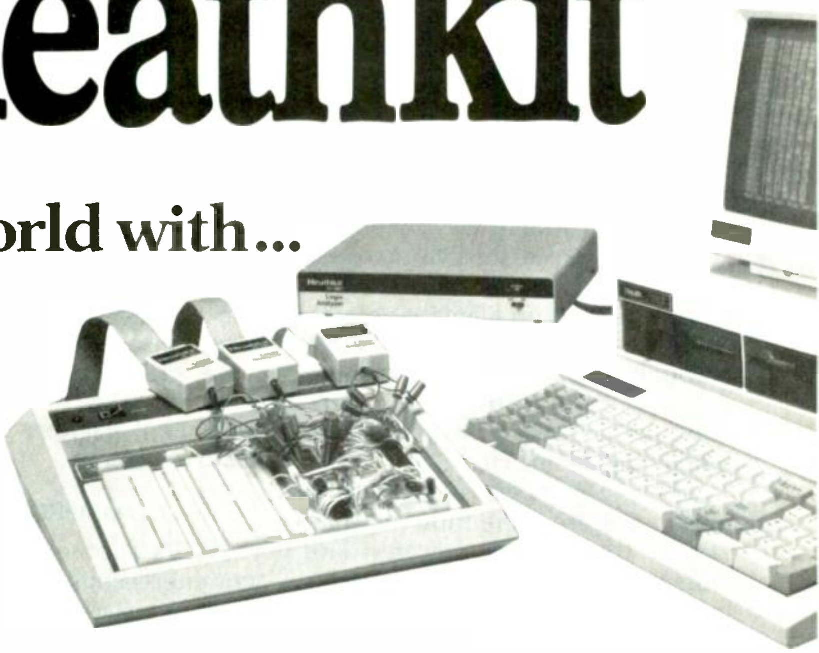

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dicated the maximum screen dimension in inches instead of the heater (or filament) voltage. Thus 5BP1 was a tube with a 5-inch screen. The final "P1" indicates the phosphor type. That numbering system for CRT's is still used today, by and large, for both oscilloscope and TV CRT's.

Because solid-state diodes had no filament or heater, a different numbering system was called for. Using a zero designation would not work because there were tubes that had no filament or heater; the 0Z4, for example.) Although the specific origins of the nNxxxx numbering system are obscure (at least to this writer), the following seems clear:

The prefix 1N was chosen to be distinctive from the tube designations. The initial 1 indicated one less than the number of electrodes or contacts; even though, at the time, all semiconductor devices had only two contacts. Perhaps the numbering system was chosen with an eye to a possible future where more contacts would be added. In any event, it was a fortuitous choice, because when the transistor came along, a ready-made numbering system was already in place!

It is true that as far back as 1925 (some would say even earlier) researchers had dreamed of transistor-like devices. However, the fact remains that there were no such devices generally available until sometime after the work of Shockley, Bardeen, and Brattain that culminated in the invention of the transistor in 1948. Nor was it generally believed, prior to that time, that such a device was even possible.

HOMER B. TILTON
Tucson, AZ

FM COMMERCIAL KILLER

Here's another idea for the FM commercial killer that works on at least one station in my area:

Subtract the left and right channel from each other using a differential amp. When the station is broadcasting anything but music, the left and right channels will be identical (mono), and that can be used to kill the audio output.

There are several ways to find out if that will work with a particular station. One is to connect one side of a speaker to the positive terminal of the left-channel output and the other to the positive terminal of the right-channel output. The signal produced will be the difference between the two channels. Adjust the balance control for no output with a mono signal, and then listen for while. If the commercials can't be heard, the technique will probably work. A more traditional way to see if the technique will work is to examine the the left and right outputs with a dual-channel oscilloscope to see if the commercials are mono or to measure the voltage between the center conductors of the left and right tape-output jacks; for a mono signal, the voltage seen on an AC voltmeter during commercials should be near zero.

STUART ENGELKE
Whitehouse Station, NJ

continued on page 92

Oops Proof. Now Even Better.

Industry's Most Popular Heavy-Duty DMMs... Now Even Better With Dual-Fuse Protection And A Tougher Case.

The tough just got tougher. When Beckman Industrial introduced heavy-duty DMMs tough enough to withstand accidental drops, input overloads and destructive environments, they quickly became the industry's most popular.

Now they're even tougher, thanks to the best dual-fuse protection you can buy and a new case. Covered by a one-year, no-fault guarantee against damage to the meter other than gross abuse.

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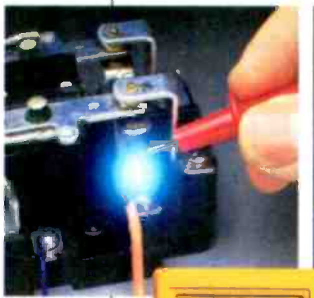
EMERSON



Our heavy-duty DMMs can withstand accidental drops, literally bouncing back for more, thanks to a new case made of Valox,® one of the most impact and corrosive chemical resistant thermoplastics around. Sensitive components are shock mounted for impact protection.

Even oil, water and industrial grime can't keep our heavy-duty DMMs away from the action. *Everything* is sealed with o-rings for maximum protection.

Of course, even the toughest DMM isn't much good if it can't deliver accuracy and the right combination of capabilities at the right price.

Check the HD DMM specs for yourself: Maximum voltage rating of 1500 volts DC, 1000 volts AC; tested to 40KHz; diode test function; and exclusive INSTA-Ohm® capability, now with an audible beeper, to make your HD even easier to use.

What's more, you can select just the model you need without paying extra. Start with the economical HD-100 at $169.00 for solid, all-around meter performance. Choose the HD-110 with continuity beeper. Or, the HD-110T that lets you select Farenheit or Celsius temperature measurement with a simple field adjustment, accurately measuring from −4°F to +1999°F, and works with any K-type thermocouple. It also has a measurement range of 32°F to 392°F with the thermocouple provided.

You can even get the true RMS capability on the HD-130, or with a 4½ digit display required by the HD-140's accuracy.

HEAVY DUTY DMMS	HD100	HD110	HD110T	HD130	HD140
Digits	3½				4½
Accuracy (Vdc)	0.25%			0.1%	0.05%
Input Impedance	22 Megohms				10 Megohms
AC Conversion Type	Average			True RMS	True RMS
Bandwidth (AC Volts)	10KHz			40KHz	10KHz
Current Range Min. Reading	0.1μA				0.01μA
Max. Reading	2A	10A (20A for 30 Seconds			
Continuity Beeper		✓			
Battery Life (Alkaline type)	2000 Hours				100 Hours

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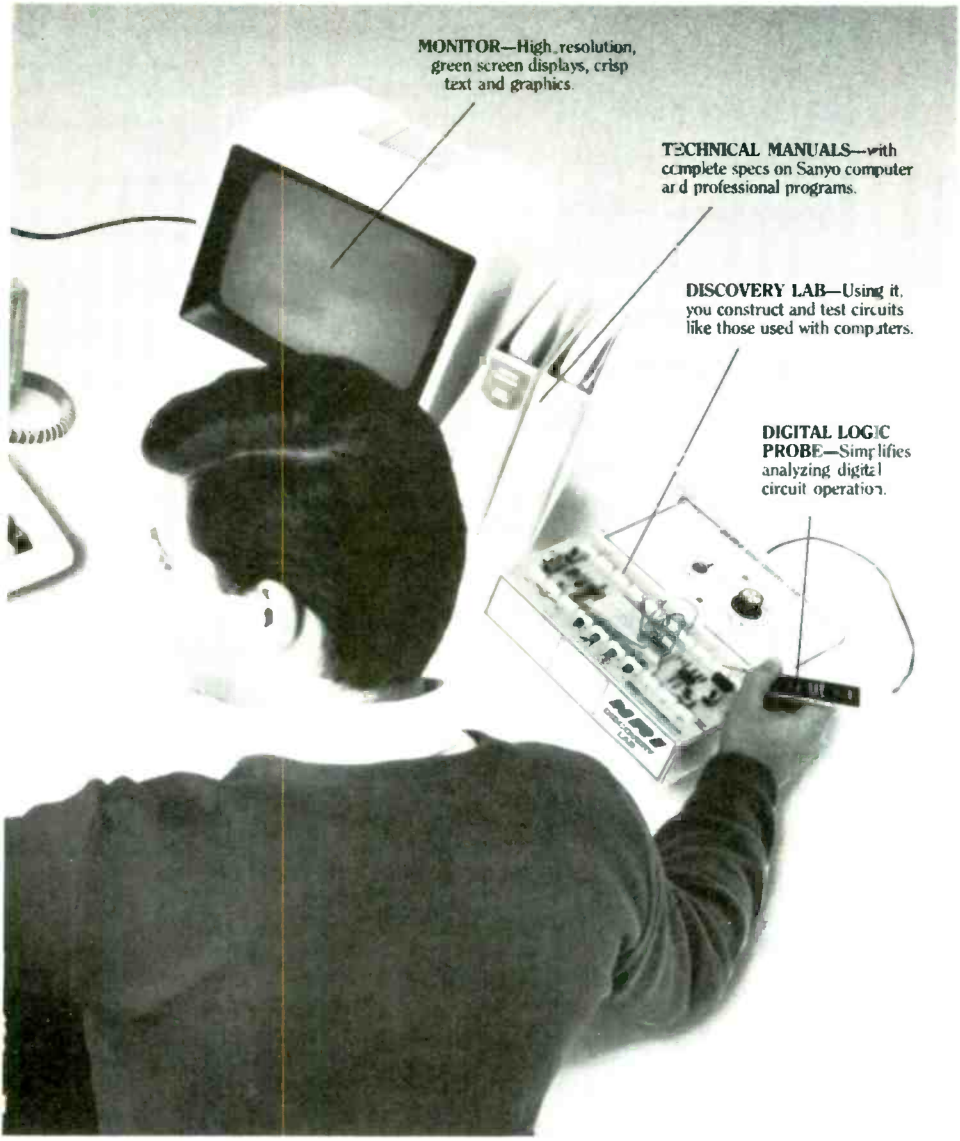

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EQUIPMENT REPORTS

Onkyo Unifier Universal Programmable Remote Control

A single handheld remote control for all your audio and video needs.

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IN MARCH 1986, WE LOOKED AT THE FIRST programmable remote control, G-E's *Control Central*. Since that time, several other companies have manufactured similar products. The latest entry is the model *RC-AV1M*, better known as the *Unifier*, from Onkyo (Onkyo U.S.A. Corporation, 200 Williams Drive, Ramsey, NJ 07446).

It makes sense that an audio manufacturer has come up with a solution to having too much of a good thing, because the new remote-controlled CD players, stereo tuners, and amplifiers have added their share to the growing clutter of handheld remote controls on consumers' coffee tables. But the *Unifier* does more than simply remove some coffee-table clutter—it is a device that can unite audio and video functions in a single control. And the marriage of audio and video equipment is sure to sell a great many systems over the next few years.

The *Unifier* is an infrared remote control with a memory capacity of more than 100 functions. Despite the array of 35 buttons, 5 LED's, and a 3-position slide switch on the front panel, the remote is surprisingly easy to program, and even easier to use.

The *Unifier* incorporates three major modes: AUDIO, VIDEO, and AUXILIARY; the front-panel slide switch determines which mode the unit is in. Each key can be programmed with a separate function for each mode.

The keyboard layout consists of 5 major key groupings: AMP/TV, PHONO, TUNER, TAPE/VCR, and CD/CATV and each button has one or two color-coded labels. For example, the AMP/TV section has keys labeled in white for CD, PHONO, TUNER, TAPE, etc. Those same keys are labeled in blue with the numerals 1 through 4. The white labels, of course, correspond to the audio mode, while the blue labels correspond to the video mode.

The function of each key, however, depends not on its label, but on how you program it. A keypad template is provided for any changes you make, as well as incorporating any additional auxiliary functions.

Programming the *Unifier*

Teaching the *Unifier* the codes of your current remote units is almost as easy as using the remotes themselves. Its 5 LED's guide you through the process.

The first step is to put the *Unifier* in the learn mode by flipping a small, recessed switch on the back of the unit to the LEARN position. Once you flip the switch, an LED labeled PRESS MATCHING FUNCTION KEYS lights. You then place the unifier head-to-head with your remote and do what you're prompted to—you simply press the matching function keys. After the *Unifier* recognizes the code, the LEARNING RELEASE LED lights, prompting you to release the keys. Immediately after doing so, you're prompted by the INPUT AGAIN LED to repeat the process for that key—a great double-check. Assuming everything is OK, the FUNCTION LEARNED/SENDING LED lights to verify that the key is set. If, for any reason, the two codes don't match, or if anything else goes wrong, the ERROR LED lets you know.

continued on page 29

NEW PRODUCTS

CIRCLE 24 ON FREE INFORMATION CARD

POWER BOOSTER for infrared remote controls, *Zapit* attaches to the front of the handheld remote, where it receives the infrared signals, and re-transmits them at a higher power. The high-power infrared output of *Zapit* bounces off walls and ceilings so that it is not necessary to carefully point the handheld remote unit at the device you want to activate. *Zapit* has a suggested retail price of $24.95—**Monster Cable**, 101 Townsend Street, San Francisco, CA 94107.

CURRENT CLAMP, the model *80i-1010* clamp-on probe is an accessory for digital multimeters that accurately measures AC current to 700 amperes, and DC current up to 1000 amperes. The probe clamps around a conductor and senses the magnetic field produced by current flow, allowing safe, accurate measurements without breaking into the circuit.

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A special feature of the model *80i-1010* is a thumbwheel *ZERO* control that allows the user to compensate for residual core magnetism in the clamp, thereby improving the accuracy of DC measurements down to 1 ampere.

The model *80i-1010* has a suggested U.S. list price of $229.00.—**John Fluke Mfg. Co., Inc.**, P.O. Box C9090, Everette, WA 98206.

ELECTROSTATIC INTERFERENCE SIMULATOR, the model *2600* is designed as a complete and field-portable ESD (spark discharge)

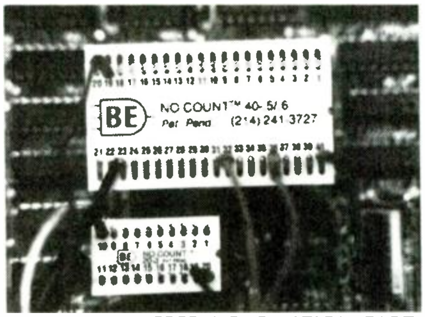
test system, consisting of an analog controller, a separate high-voltage test head, and application modules. A series of plug-in tips, in conjunction with the various operating modes available on the

CIRCLE 26 ON FREE INFORMATION CARD

controller, provide a range of functions that include spark discharge, current injection, ion generation, corona generation, and electric field propagation and collapse.

The model *2600* is a complete system, with no additional hardware or calibrators needed. It is priced at $4195.00.—**IMCS Corporation,** 1300 Spacepark Way, Mountain View, CA 94043.

PIN LOCATOR, the *No Count,* slips over the pins of an IC test clip and remains with the clip. When the



CIRCLE 27 ON FREE INFORMATION CARD

test clip is attached to the IC, each pin is easily identified, eliminating time-consuming pin counting.

No Count is available in 14 configurations from 14 to 64 pins; prices range from $3.50 to $6.50.—**L. J. Broder Enterprises, Inc.,** 11105 Shady Trail, Suite 115, Dallas, TX 75229.

AUDIO TAPE DECK CLEANER, *Standard System II,* combines Discwasher's Perfect-Path Cassette Head Cleaner and the Capstan Pinch Roller Cleaner to provide complete tape-deck care in one cassette shell. A deluxe version with a carrying case is also available.

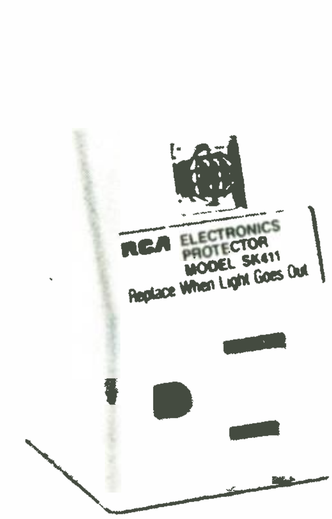
The Perfect Path Cassette Head Cleaner is designed to clean audio-cassette heads on car or home cassette decks quickly and safely. It uses no fluid and contains no alcohol that can damage cassette

CIRCLE 28 ON FREE INFORMATION CARD

mechanisms, nor are there any abrasive polishing compounds to cause excessive wear.

The Capstan Pinch Roller Cleaner is based on a special fluid formula that will not extract vital rubber stabilizers. The *Standard System II* is priced at $11.95; the deluxe version is $2 higher.—**Discwasher,** 4309 Transworld Road, Schiller Park, IL 60176.

SURGE SUPPRESSORS, the model *SK411,* (shown) the model *SKM411,* the model *SK416,* all contain metal-



CIRCLE 29 ON FREE INFORMATION CARD

oxide varistors and feature an indicator lamp that offers assurance that the equipment is being protected continuously.

The model *SKM411* is a single-outlet electronics protector, and is priced at $22.15.

The model *SKM411* is a single-outlet microwave protector, and is priced at $26.20.

The model *SK416* is a six-outlet electronic protection center surge suppressor and is a corded power center with ON/OFF switch. It is priced at $73.80.

The model *SKF416* is a six outlet protection center. In addition to suppressing surge, it also filters out radio interference noise, with 35 dB noise attenuation at 1 MHz. It has an ON/OFF switch. It is priced at $86.75.—**RCA,** 2000 Clements Bridge Road, Deptford, NJ 08096.

TEMPERATURE AND HUMIDITY METERS, the model *HT-410* (°C), shown in photo, and the model *HT-411* (°F) are designed to aid in the control of both parameters in

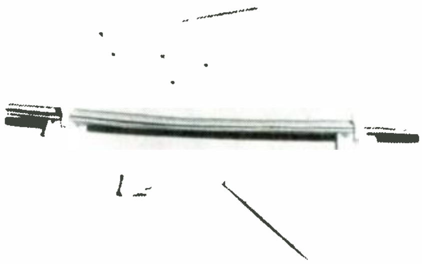
CIRCLE 30 ON FREE INFORMATION CARD

applications such as pharmaceutical, chemistry, agriculture, forestry, food, electrical/electronics, and building environments.

Among the features provided by those state-of-the-art digital temperature and relative-humidity meters are excellent water resistance, enabling measurements for long periods of time, even when the main unit, sensor, and probe are subjected to condensation, and instant switching between temperature and humidity displays. Simultaneous analog outputs for temperature and humidity facilitate use in environmental control and monitoring applications.

The model *HT-410* and the model *HT-411* both have the same price: $450.00 each.—**North American Soar Corporation,** 1125 Cornell Ave., Cherry Hill, NJ 08002.

MINIATURE ADHESIVE MOUNT, *ABMIM* is an adhesive-backed mount ½ × ½ inches, designed to meet the needs of limited-space applications. It is used with subminiature or miniature cable ties



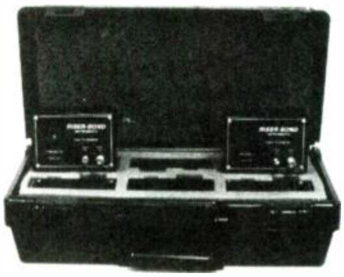
CIRCLE 32 ON FREE INFORMATION CARD

to provide secure mounting of wire and cable. Four-way entry design (of cable ties to mount) saves orientation time.

No hole-drilling or special fasteners are required. The user peels off the mount and then applies it. Four mounts are supplied on a common release liner for easy handling.

The miniature mount supports a maximum load of .13 lb. It can be used in applications with continuous temperatures up to 120°F with rubber foam-tape backing or up to 180°F with acrylic foam-tape backing. It is priced at $24.49 per 100 pieces.—**Panduit Corporation,** 17301 Ridgeland Ave., Tinley Park, Il 60477-0981.

CABLE DESIGNATOR, the model *525,* is designed for identifying individual cables in a common bundle. It can transmit through taps and a splitter, and is therefore able



CIRCLE 33 ON FREE INFORMATION CARD

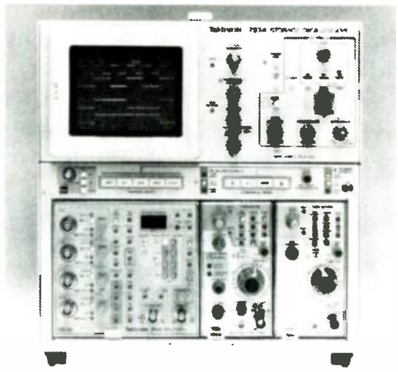
to identify individual cables that are already in place, with all components installed.

The model *525* is useful in various construction applications including CATV or SMATV in apartment buildings, local-area networks and other computer systems, schools, hospitals, offices, high-rise buildings, and ships.

The model *525* "SIX PAK," consists of one receiver, five transmitters, an operator's manual, and a carrying case; it is priced at $395.00.—**Riser-Bond Instruments,** 505 16th Street, P.O. Box 188, Aurora, NB 68818.

OSCILLOSCOPE, the model *7934,* is a screen-storage oscilloscope that takes over where digital storage leaves off.

Speed begins in the model *7934* with a high bandwidth—500 MHz—and a fast single-shot



CIRCLE 34 ON FREE INFORMATION CARD

risetime—700 picoseconds. The real speed advantage, however, is in the model *7934*'s 4-cm/nanosecond stored writing rate.

Along with fast storage, the model *7934* also offers the flexibility of multiple-storage modes and controls to meet changing application needs. A bistable storage feature provides long viewing times, which allows time-lapse displays of changing events, which is ideal for checking pulse jitter or digital timing margins. Fast variable persistence with reduced scan captures fleeting events, such as arcing or plasma discharge. A SAVE mode gives the user up to 30 times longer viewing time; and storage level adjusts writing rate, which is useful in suppressing storage of random noise on low-level signals.

The model *7934* is priced at $20,355.00. That prices includes the *7934* mainframe, a *7A29* vertical-amplifier plug-in for a 500-MHz bandwidth, and a dual timebase plug-in for 500-MHz triggering.—**Tektronix, Inc.,** PO Box 500, Beaverton, OR 97077. **R-E**

EQUIPMENT REPORTS

continued from page 23

Using the *Unifier*

The *Unifier* is no more difficult to use than any standard remote control—once you get used to it. It has more keys than most remotes, so finding the key you're looking for can be difficult. The unit can be difficult to handle, as well, because it weighs about ½ pound and measures about 7 × 3 inches, with a thickness that ranges from about ⅞ to 1⅛ inch. What those numbers translate to is this: One-handed operation is possible for those with long fingers, but it's not easy to find a single grip that will let your thumb comfortably reach every key. For users with small hands, one-handed operation will be very clumsy. On the positive side, however, the most-used keys are grouped within easy reach, and the keys are large and spaced well enough that you won't hit a key you don't mean to.

Unfortunately, the labels used for the video functions are printed in blue, on a black background. If you keep your lights low in your media room, you may have a hard time finding the right key. Of course, searching for the VCR PLAY key on the *Unifier* can certainly be easier than trying to find the play key on your VCR's handheld remote unit—especially when it's buried somewhere on your coffee table between the remote for your TV, CD player, tuner, and maybe your cable box!

One problem that plagues some remotes is limited range. That's not the case here. The infrared power output from the *Unifier* is probably more powerful than the remotes you're currently using.

The *Unifier* is powered by 4 "AAA" alkaline batteries. You'll know when it's time to change the batteries thanks to a low-battery indicator. When you do change the batteries, what happens to the 100 functions that you programmed? Fortunately, a charged-capacitor backup system gives about one hour of memory retention. After that, you'll have to reprogram the unit

The *Unifier* has a suggested retail price of $119.95. **R-E**

SERVICE CLINIC

Quirks and queerities

JACK DARR,
SERVICE EDITOR

THE TERM "QUEERITY" IS A SNIGLET meaning something queer and unusual. I've found my share of queerities when working on radios and TV's, so let's look a few of the tougher ones that I've had the (dis)pleasure of troubleshooting over the years.

One of my first queerities was a boat-anchor TV chassis having a queer sound. It wasn't actually oscillating, but it sounded as if it were on the verge of breaking into shrieks and whistles. Bridging all the filter and bypass capacitors didn't accomplish anything, but bridging the powerline bypass capacitor (which had nothing to do with the signal circuits) cured the problem. So I replaced the cabinet and sent it back to the customer. Although I never did figure out why the line bypass caused the instability there was no doubt that it did and the set was still working years after I made the "repair."

That case is typical of the hundreds that I've worked on since, where some component that can't possibly be the problem turns out to be the culprit. Of course, it's really impossible for unrelated components to affect circuit operation. Usually, if you trace a circuit carefully enough you'll eventually locate the feedback path: There must be one or the circuit wouldn't be oscillating.

Bad bypasses

In general, most of the queerities I've run across were caused by open or leaky bypass capacitors, which are often difficult to locate because they don't necessarily create the same problems and conditions each and every time. Bypass capacitors are in effect filters, whose job it is to remove unwanted signals from wiring before they can flow into other circuits. A defective bypass can allow signals to flow where they don't belong, resulting in mysterious oscillations, squeals, gurgles, or other strange sounds, and possibly video disturbances. For example, an open AGC bypass capacitor can cause oscillation if it permits signals to get into the grid or base circuit of the following amplifier stage.

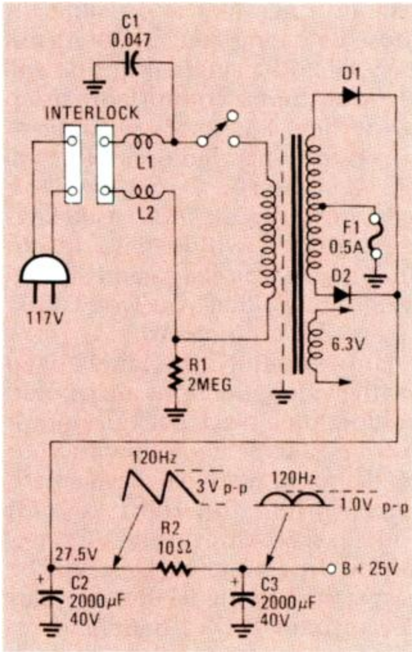


FIG. 1

Video problems caused by defective bypass capacitors are handled somewhat differently because you usually can see the problems they cause right on the TV screen. One of the easiest and

continued on page 89

NEW LIT

TEST EQUIPMENT CATALOG, is a letter-sized, two-color, 377-page book, addressed to all new and used test-equipment needs. It includes amplifiers, distortion analyzers, avionics, telecommunication, filters, signal and sweep generators, transistor and tube testers, logic analyzers, calibration equipment, phase/synchro/resolvers, signal conditioning, microwave components, environmental test, and many others. Photos of the equipment offered are sharp and clear. The catalog is available upon request from **Tucker Electronics Company,** 1717 Reserve, Garland TX 75042.

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QUARTZ CRYSTAL CATALOG #30, is 5½ × 8½ inches, 11 pages, and covers crystal units in both fundamental and high-frequency overtone modes, microprocessor crystals, scanner crystals, marine crystals, sockets, holders, amateur-band crystals, and CB crystals—both standard and nonstandard. It is available on request from **Jan Crystals,** 2400 Crystal Drive, P.O. Box 06017, FL 33906-6017.

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NEW IDEAS

Audible logic tester

A LOGIC TESTER WITH AN AUDIBLE INdicator can be handy when troubleshooting or testing a crowded circuit board. It allows you to keep your eyes on the circuit, rather than on an LED on the tester. The project described in this article is just such a tester. It provides an audible indication of the logic level of the signal presented to its input. A logic high is indicated by a high tone, a logic low is indicated by a low tone, and oscillation is indicated by an alternating tone. The input is high impedance, so it will not load down the circuit under test. It can be used to troubleshoot TTL or CMOS logic.

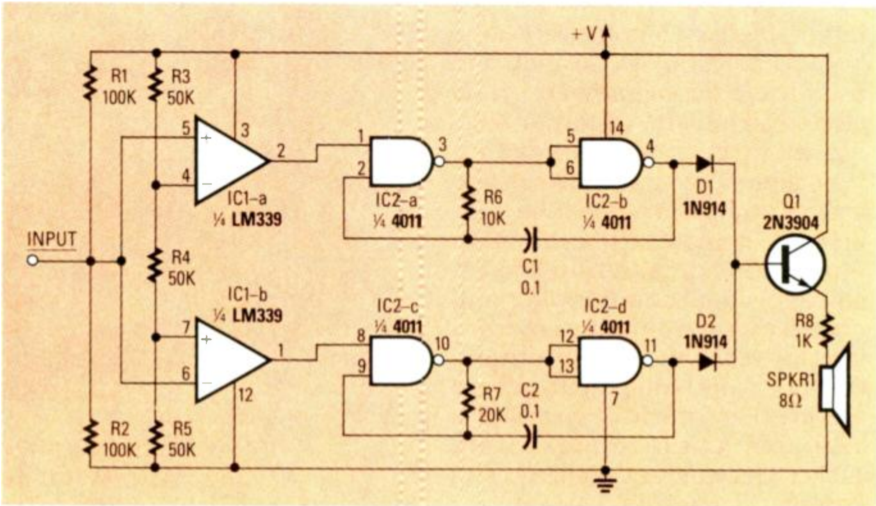

FIG. 1

The circuit

A schematic of the circuit is shown in Fig. 1. The input section determines whether the logic level is high or low, and enables the appropriate tone generator; it consists of two sections of an LM339 quad comparator. One of the comparators (IC1-a) goes high when the input voltage exceeds 67% of the supply voltage. The other comparator goes high when the input drops below 33% of the supply. Resistors R1 and R2 ensure that neither comparator goes high when the input is floating or between the threshold levels.

The tone generators consist of two gated astable multivibrators. The generator built around IC2-a and IC2-b produces the high tone. The one built around IC2-c and IC2-d produces the low tone.

Two diodes, D1 and D2, isolate the tone-generator outputs. Transistor Q1 is used to drive a low-impedance speaker.

The tester can be built on a small piece of perforated construction board; a PC board could also be used, if desired. Layout is not critical. The completed board should be mounted in a case. The size of its case will most likely be determined by speaker's size.

Two notes on the IC's: The 4011 is a CMOS device. As with all other CMOS devices, extra care should be exercised in handling to avoid subjecting the IC to damaging static electricity. Also, all unused inputs on the LM339 should be tied to ground.

The tester is designed to draw its power from the circuit under test. Therefore, the power and ground leads should be terminated by small alligator clips. Connect a spare multimeter probe to the tester's input and you are all set.

Connect the power-supply lead to the positive supply rail of the circuit under test. Connect the ground lead to the circuit-under-test's ground rail. At this point, the tester should be silent. Now, touch the probe tip to the circuit's positive supply rail. The tester should produce a high-pitched tone. Next, touch the probe to the ground rail. The tester should produce a low-pitched tone. If all is well, your tester is ready for use.

—Philip L. Kane

DESIGNER'S NOTEBOOK

Very simple delay circuits

ROBERT GROSSBLATT,
CIRCUITS EDITOR

I'VE GOTTEN SEVERAL LETTERS ASKING for a simple circuit that will accept a trigger pulse, wait a specified length of time, and then output another pulse. Now, there are almost as many ways to design delay circuitry as there are uses for it; how you go about such a design depends on the particulars of your application. But if precision is what you have in mind, nothing works better than a stand-alone counter.

Two stand-alone counter "circuits" are shown in Fig. 1. Actually, we are being generous in calling them circuits because there is nothing to them aside from the IC itself. Figure 1-*a* is a 4017 Johnson counter; Figure 1-*b* is a 4040 binary counter. The choice of which one to use for your delay circuit depends on your answers to three interrelated questions:

- How much of a delay do you want?
- What clock frequencies do you have available?
- What degree of accuracy do you want?

Once you know exactly what your circuit needs, you can figure out which of those IC's, or some similar one, will work best for your particular application.

The 4017 Johnson counter will give you a very accurate time delay for up to 10 clock pulses. All you have to do to create a delayed pulse is tie the ENABLE input to the 9 output, and your clock to—you guessed it—the CLOCK input. When you first apply power, the counter will advance and as soon as the 9 output goes high, it will freeze the count. The 4017 will stay in that condition until your trigger pulse comes along to zap the RESET pin (pin 15). That pulse will reset the counter, which will then count up to 9 and freeze again. Once the count starts you can pick off your

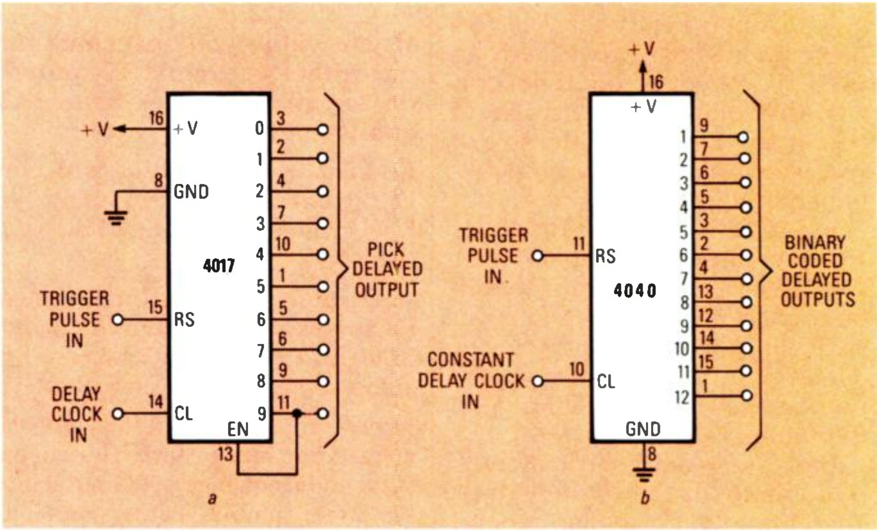

FIG. 1

delayed pulse from any of the other output pins; the choice of pins is determined by the amount of delay needed.

By using a binary counter like the 4040, you can generate a much longer delay. Since there's no enable pin available, things have to be done a bit differently. The IC is set up to start counting as soon as power is applied. The trigger pulse will cause the device to reset to zero and you can pick off your delayed pulse at any of the device's output pins.

The price you pay for simplicity is that the circuit you hang on the output has to be set to ignore pulses until the trigger pulse is generated. That is because the 4040 will always be counting through its full range and your selected output will be high once per complete count. That problem can be solved with some additional gating, but the idea here is to keep the circuit as simple as possible.

In any event, those suggestions are just that—suggestions. More than likely you can think of lots of simple alternatives that are even more flexible than these.

Product of the month

Every so often I run across a product that's not only reasonably priced and extremely handy, but helps eliminate all kinds of hassles as well. From now on, when I find one of those things, I'll be awarding it the soon-to-be-famous "Silver Soldering Iron." I probably won't be bestowing that honor too often, because there's a lot of junk out there; but when I find something that's really worth honoring, I'll let you know about it.

FIG. 2

The winner of the first Silver Soldering Iron is the *Portasol* from The Boardworks (1077 East Edna Place, Covina, CA 91722). See Fig. 2. It's a butane-powered, pocket-sized soldering iron. Imagine, no batteries, no static electricity, no grounding problems, etc. At a list price of $25.00, it is a really neat and inexpensive alternative to battery-powered portable soldering irons, and you don't have to worry about running out of power before you get to the last connection.

The *Portasol* can be refilled with any ordinary cigarette-lighter butane cartridge and gives about an hour of operation per charge. There are several different tips available for the unit, and the heat can be adjusted with a twist valve in much the same way a cigarette-lighter flame is regulated.

I've been using my *Portasol* for a few months and it works perfectly. It's a well-built realization of a good idea. I owe my living to electricity, but this is one time when gas is better. If you're in the market for a portable iron, get one of those. They're cheaper, faster, and much more convenient. **R-E**

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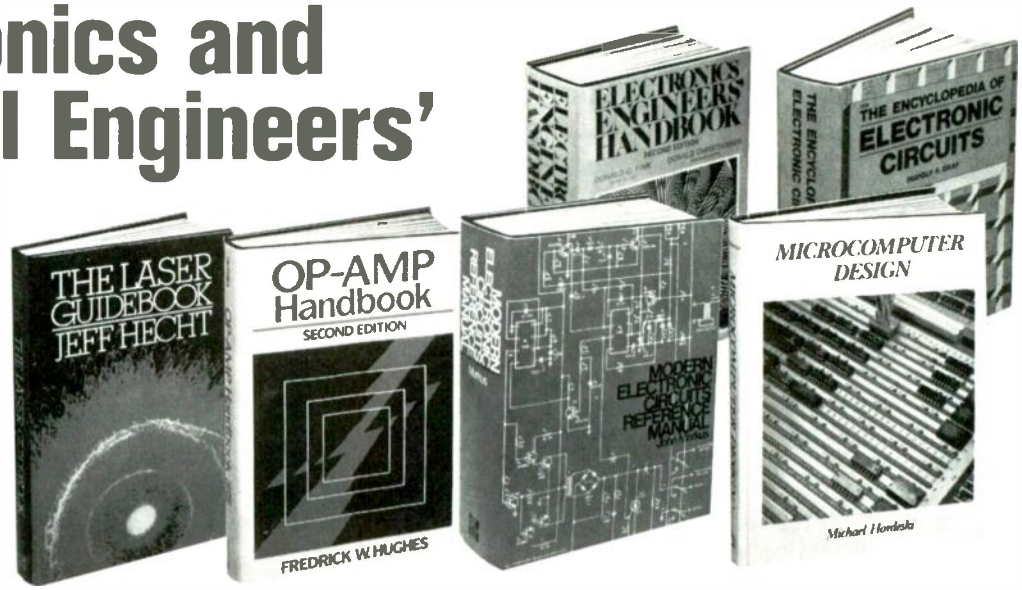

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THERE ARE MANY INSTANCES IN VIDEO work when it is desirable or necessary to modify a video signal in one way or another. In the home, modifying a video signal usually means a simple color correction attained by adjusting the TV's tint and color controls. But for professional or artistic video-signal control, a much-wider range of signal modification must be available. For example, there must be a way to correct contrast when the the color is OK but the signal's luminance component is weak. Another modification might include deliberate distortions of the signal

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for the purpose of creating special effects: such as color and/or luminance reversal (positive-negative); posterization, in which the video signal is altered such that there are only a few discrete values of luminance (usually 2, 3, or 4); or solarization, in which the gray scale (luminance) is "folded" on itself, producing an eerie, surrealistic-looking picture that contains both positive and negative tones. Of course, several effects may be performed simultaneously.

Devices that provide a high degree of color control are used in virtually all major TV production facilities. Regardless what the brand name might be, technicians often refer to such a device as a *video palette*; hence, we will also call our device a video palette.

Our video palette is designed to work on any standard NTSC video signal. It has many applications, and is also great fun—it can be more fun than a video game. Some of its serious applications are:

1. **Video Recording**
   - a. Tint correction
   - b. Chroma boost/cut
   - c. Luminance/synch boost and cut
   - d. Additions of special effects to recordings
   - e. Posterization and solarization for effects and titling
2. **Photographic Uses**
   - a. Viewing color negatives as positives (a separate camera is required)
   - b. Advance predictions of the finished appearance of photographic special effects
   - c. Negative inspection and analysis
3. **Video Production**
   - a. Simulation
   - b. Special effects
   - c. Artistic effects

Some of the video palette's effects are shown in Figs. 1-*a*, 1-*b*, 1-*c*, and 1-*d*, and they are just a tiny sampling of what is possible. It will be evident after an hour or so of experimentation, using a video source (VCR, TV tuner, etc.) and a video monitor to observe the results, that a wide range of effects are possible by manipulating the front-panel controls.

How it works

A block diagram of the video palette is shown in Fig. 2. A standard baseband (0–4 MHz) 75-ohm source impedance NTSC video signal having a nominal amplitude of 1 volt peak-to-peak with negative sync is applied to the system via the VIDEO IN jack. A BYPASS SWITCH is provided to bypass the system, and a VIDEO LOOP-THROUGH connection is also provided for loop-through setups. Switches enable AC or DC coupling, and 75 ohm or Hi-Z (high impedance) input, which is useful in loop-through applications or where another 75 ohm device is already terminating the input line.

A video amp boosts the input up to 3 volts p-p, and at the same time inverts it so that the sync tips are positive. The video signal, which is now still unaltered but greater in amplitude and inverted, is then fed to a sync separator and a SPDT CMOS video switch.

The video switch splits the video signal into two components:

1. Synch, blanking, and burst pulses only;
2. Video and chroma information without sync, burst, or blanking.

The reason for the splitting up of the signal is to allow separate processing and treatment of the four signal components: sync, burst, luminance (black-and-white component), and chroma (color-difference). (Figure 3 shows the four components parts of a standard NTSC color signal.)

There are other reasons why it's necessary to extract the discrete signal compo-

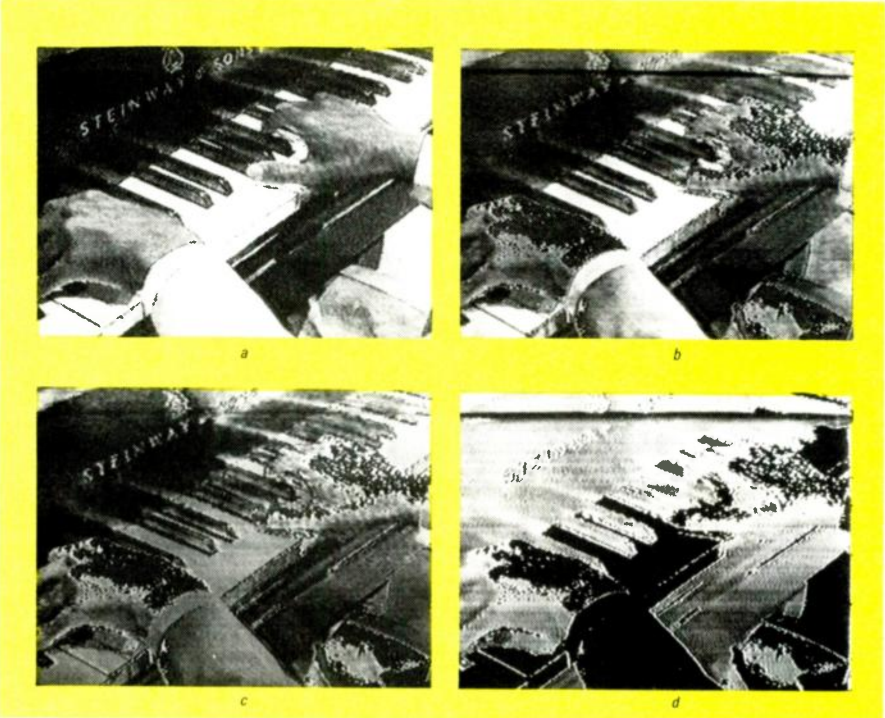


FIG.1—THE VIDEO PALETTE'S EFFECTS CAN BE STACKED. In this black and white series, *a* is a normal picture, *b* is posterized, *c* has solarization added, *d* has negative video added.

nents. For example, the sync signal is used for timing and cannot be modified unless intentional scrambling of the picture is required. If we want an inverted (negative) picture, we cannot just reverse the phase of the whole signal, because the video monitor needs sync pulses of a given polarity; therefore, a simple inverter will not work. If we want to introduce special effects, we may want, for example, to just operate on the chroma signal and leave everything else the same. Therefore, the splitting up of the signal is obviously necessary; otherwise, improper operation of the sync and color-burst circuitry in the monitor, VCR, or TV receiver will result.

Synch and blanking are separated from the burst pulse by a lowpass filter having a cutoff frequency of 2.5 MHz and a maximum rejection frequency of 3.58 MHz.

Luminance and chrominance are separated the same way. Strictly speaking, a comb filter would be the ideal way to separate luminance and chrominance, but it would complicate construction and increase cost. For that application, simple M-derived filters do the job adequately.

Synchronization

A switching signal to control the video splitting is derived from the original signal's sync information. A sync separator strips the horizontal and vertical sync information from the original signal. (Note that the original signal must be a legitimate NTSC signal, with the sync tips most negative. Therefore, a scrambled signal will not operate this unit.)

The horizontal sync drives a monostable multivibrator having a nominal 53-microsecond pulse width. That multivibrator drives a second multivibrator that generates a gating pulse having a nominal 10-microsecond pulse width. The 10-microsecond pulse is timed to be coincident with the blanking pulse on the original NTSC signal; it is done by adjusting the 53-microsecond multivibrator's pulse width. The 10-microsecond pulse causes the video switch to route the video signal into the sync and burst side of the switch. When the pulse is not present (during horizontal line scan), the video is routed to the video and chroma side of the switch.

Vertical sync is separated in a similar manner. A monostable multivibrator having a delay of one frame (nominally 16 microseconds) is used to trigger a second monostable multivibrator whose output is a pulse having a width of nominally 600-microseconds. That pulse should be timed to occur during vertical retrace. Therefore, the entire composite vertical blanking pulse will be gated to the sync and burst side of the video switch. (The setup of the switching circuit consists of adjusting the delays and pulse widths of the four multivibrators so as to correctly switch the sync pulses, blanking pulses, and the burst pulses to the sync and burst outputs of the video switch.)

The video switch's sync output is fed to a lowpass filter that removes the burst. It then goes to an amplitude control, and then into a summing amplifier, which reassembles the video signal.

The burst output goes to a highpass filter that eliminates the sync. Then the signal is fed to a phase-correction network and on to the burst amplifier, a differential amplifier having two outputs 180° out of phase. A potentiometer connected across both outputs functions as both a gain and polarity control: At the center position there is zero output (no burst); fully clockwise and counterclockwise, full positive or negative burst is available respectively. In that way, the burst phase and amplitude can be altered or corrected as required, independent of everything else. The burst can be varied from plus three times normal to minus three times normal. By using a negative burst phase, the monitor or TV screen will show reversed (complimentary) colors. The burst is then fed to the summing amplifier for reassembly into a complete video signal.

Luminance is treated in a similar manner to that of the sync. It goes through a lowpass filter that is similar to the sync filter and is then fed through a level control to the input of the summing amplifier. There it is summed with the sync and the burst information.

Chrominance, or chroma, is extracted by a highpass filter. It is fed through a differential amplifier having positive and negative outputs. (It is similar to the burst differential amplifier). A potentiometer allows either positive or negative amplified chroma to be fed to the summing amplifier at any desired level. That feature allows weak chroma to be amplified or inverted. Since some 2.5 MHz (or higher) luminance components will be present along with the chroma signal, the chroma control functions as a sharpness control in black and white applications. The ability of using either positive or negative burst with positive or negative chroma at first will seem redundant because negative chroma with a negative burst will yield a positive picture. However, the phase of the high-frequency luminance components will not be the same, and the total effect can be used as a sharpness control for color video.

The summing amplifier has a nominal gain of unity when the level controls for chroma, burst, sync, and luminance are about halfway open. Since the video signal was amplified by a factor of three by the input video amplifier, allowing for normal circuit losses within the video palette, about 2 volts of composite video component is present at the input of the summing amplifier. Therefore, a 2-volt peak-to-peak reassembled video signal is present at the output of the summing amplifier.

You may be wondering what we have really accomplished so far. What we now have is the ability to disassemble the video signal, control each of its four components on an individual basis, and recombine them into a new video signal.

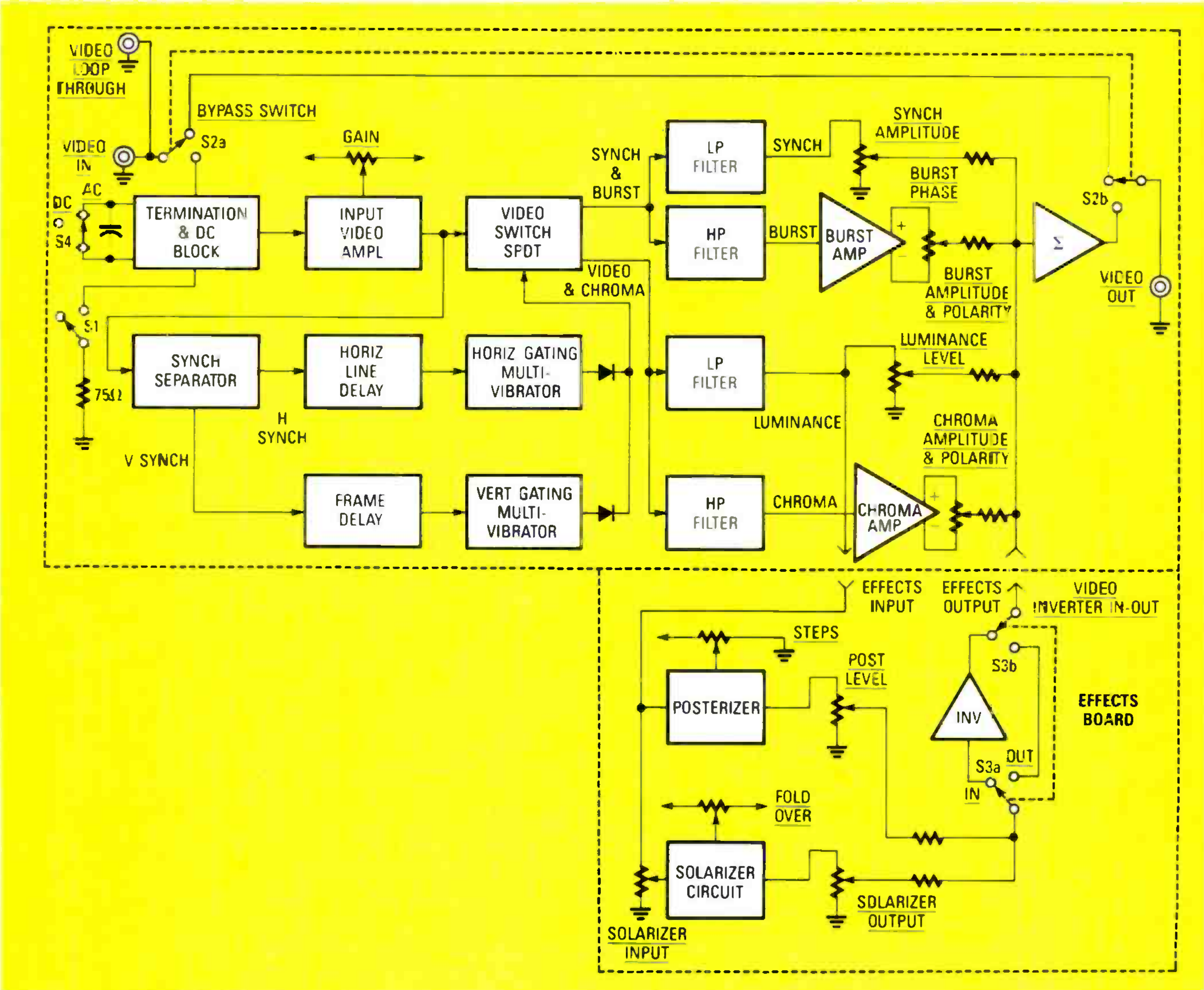


Fig. 2—THE CIRCUITS FOR THE video palette are arranged on two separate circuit boards. A bypass switch allows all functions to be instantly bypassed without having to reset the individual controls.

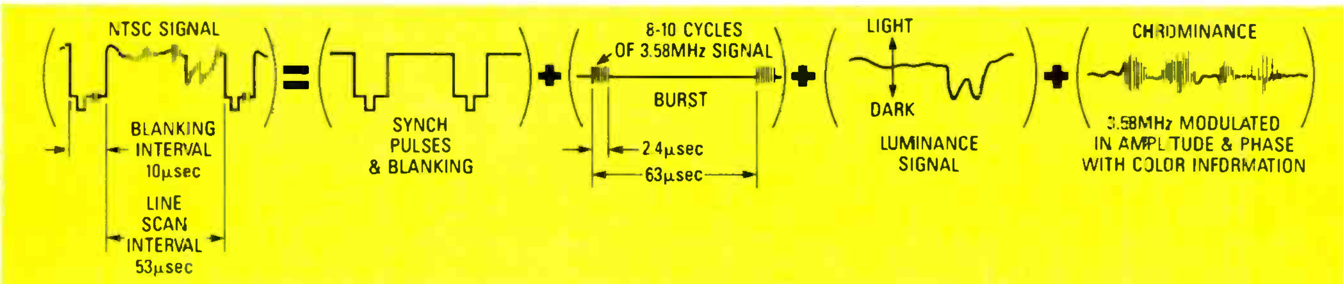


FIG. 3—AN NTSC COLOR SIGNAL has four individual components, all of which can be separately controlled by the video palette.

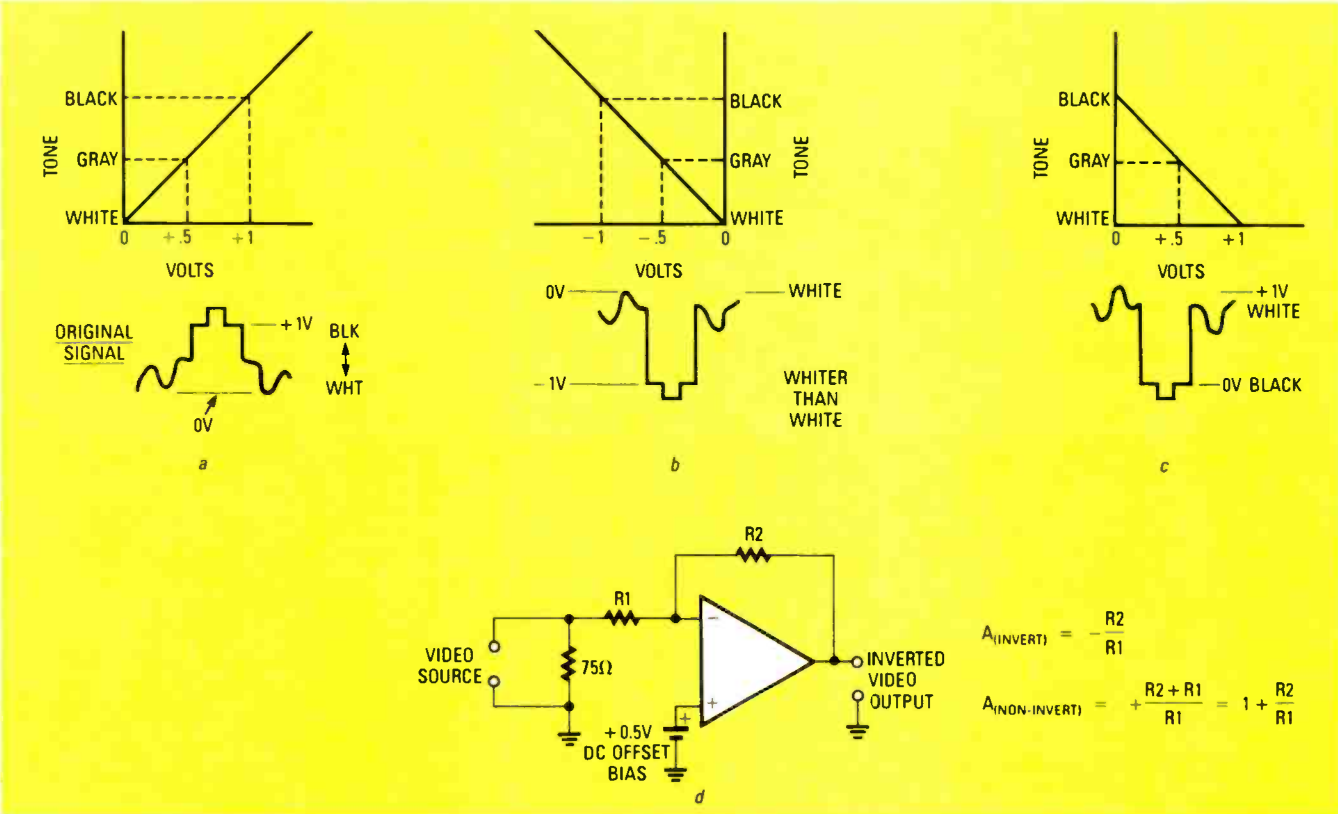
Depending on the settings of the controls, we might get an improved picture, a degraded picture, or an altered picture. By this method, we can custom-correct individual faults in the video signal. For all practical purposes, we have a graphic equalizer for video.

Analog effects

A few analog effects are incorporated in the video palette. Those are inversion, posterization, and solarization.

Inversion, shown in Fig. 4, is simply what it implies: the video signal levels are inverted about a given reference axis. For example, if zero volts represents maximum white and 1 volt represents maximum black (Fig. 4-*a*), passing the signal through an inverter such that the output is 1 volt when the input is zero volts, and the output is zero volts when the input is 1 volt, will produce an inverted video signal (Fig. 4-*b*).

Note that a true inverter would just change the sign. For example, let us take the case of a signal at +0.5 volt, which would represent a middle gray. Ideally, if we invert a gray tone, it is gray. (Gray is its own complementary color.) However, a true inverter would give −0.5 volts output, which would be whiter than white. Therefore, we must add a DC offset of +1 volt to the output so a that a zero volt input produces a +1 volt output, thereby restoring the original gray (Fig. 4-*c*). As shown in Fig. 4-*d*, that can be done by adding a



$A_{(INVERT)} = -\frac{R2}{R1}$

$A_{(NON\text{-}INVERT)} = +\frac{R2+R1}{R1} = 1 + \frac{R2}{R1}$

FIG. 4—SIMPLY INVERTING THE VIDEO signal (*a*) will result in a signal that goes whiter-than-white (*b*). By using a DC offset bias for the amplifier the signal-level values are restored, but the tones are reversed—white is now black (*c*). In *d* we see how the offset is applied through the amplifier's noninverting input.

DC offset level to the amplifier's input. Only +0.5 volt input is needed because the op-amp's configuration has a gain of two at the non-inverting input. (A + INPUT = 1 + R2/R1.)

Inverting the luminance signal produces a negative picture. If the original picture is black-and-white it will have the appearance of a black and white photographic negative. If the original is color, the colors will still be correct but the tones will be reversed. (Actually, since the color is really the sum of luminance and chrominance, the hues are unchanged but the saturations may be different, giving the effect described.)

In order to get a negative picture similar to a true color photographic negative (without the masking built into color negative film that is needed to make a color print), you would also invert either the chroma or the burst.

Using the correct light source, if you looked at a photographic color negative with a video camera/monitor set-up, and ran the resulting video through the video palette, you would see a positive color image. In fact, that technique is widely used by the commercial color-photo printing industry to predetermine correct color-printing exposure and filtration (light source color balance) so that the final photographic print is correct the first time. That kind of photo printing technique is known as *video analysis*.

Posterization

Posterization is the term used to describe the process of converting a photographic or video image of a scene containing a wide range of tones into a scene containing only a few discrete tones, sometimes only two (black and white). No intermediate shading between tones are present. Commonly, four tones are used in practice: white, light gray, dark gray, and black. Colors are sometimes left in their natural state, or they may be saturated (chroma is limited to one value—maximum). In practice, a pleasing visual effect is attained by posterizing only the luminance.

The effect of posterization is shown in Fig. 5-*a*. Note how the shading from white to black on the ball and cylinder is changed to discrete bands of gray by posterization. Figure 5-*b* shows how the video ramp waveform is changed to discrete steps by the posterization. A posterized video scene has a distinct computerized or cartoon effect because there are only a few discrete values of luminance. Since a very small difference in luminance at the transition points may produce a large difference in the posterized output, small noise signals, snow, and glitches are enormously magnified, which produces a grainy effect. Although grain is usually considered objectionable, as shown in Fig. 5-*c*, it can be used to add an artistic effect to the picture.

Analog to digital

Posterization is done by using an A/D converter to convert the analog video signal to a digital format, and then immediately converting back to analog.

A simplified approach to posterization is shown in Fig. 6. Four comparators are biased with a reference voltage obtained from a resistance voltage divider ($R_X \times 4$). The amplifiers are biased so that amplifier A4 has +1 volt, A3 has +¾ volt, A2 has +½ volt, and A1 has +¼ volt on their inverting inputs. All four non-inverting inputs are connected to a nominal zero-volts (white) to 1-volt (black) video source.

The outputs of each comparator can be either zero or a positive voltage ($+V_{out}$). Assume V_{out} = 5 volts. Each comparator's output terminates in common load resistor R_L, which is much smaller than R_Y. Typically, R_X = 10 ohms, R_Y = 4700 ohms and R_L may be about 220 ohms. The comparator amplifiers must be capable of fast response since the video input components are as high as 3 MHz.

Assume the video level is zero. All four amplifiers will have a zero output. As the video level rises to ¼ volt, amplifier A1 will suddenly change state and about ¼ volt will appear across R_L (5-volt output from A1 attenuated by voltage divider R_Y and R_L). As the video level exceeds ½ volt, A2 will change state and now A2 will contribute a current through its R_Y, so now there is ½ volt across R_I. (With a high-gain comparator, a few millivolts change in the video level produces an abrupt ¼-volt change in the output across R_I.) Amplifier A3 conducts at ¾ volt, and A4 conducts at 1 volt. Therefore, a ramp input voltage produces a staircase output with four discrete levels +¼, +½, +¾, and +1 volt (actually five discrete levels because zero volts is a level as well). In that way, we can produce only several discrete levels from a continuously varying level.

By varying the reference voltage we can vary the spacing between the steps, and, hence, for a given input video level the number of steps can be varied.

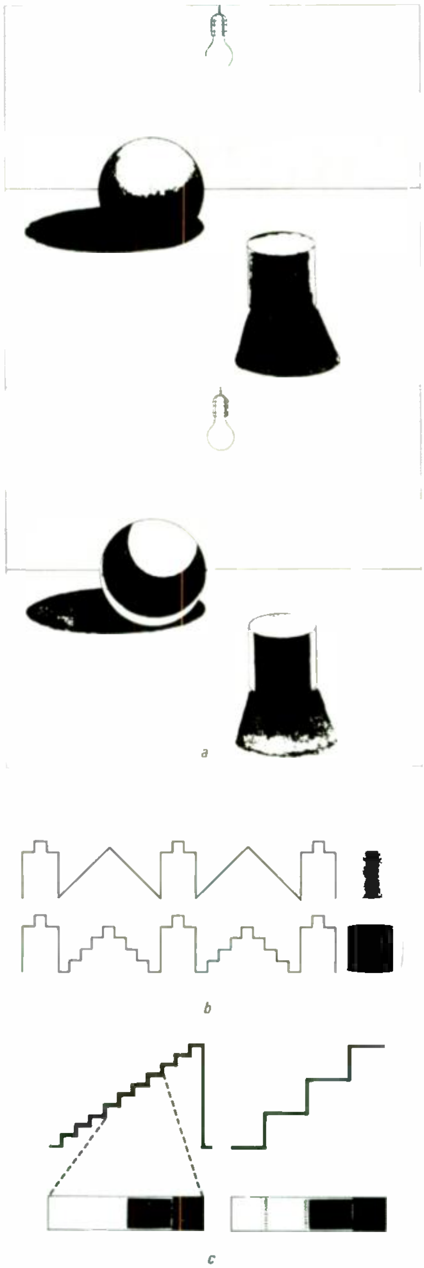


FIG. 5—POSTERIZATION CHANGES GRADUAL shading to discrete transitions (*a*). In *b* we see how the normal video signal, which originally represented increasing and decreasing ramps, is changed to a stairstep. In *c* we see how posterization creates grain at each transition. The grain isn't necessarily a problem because it's often used as a special video effect.

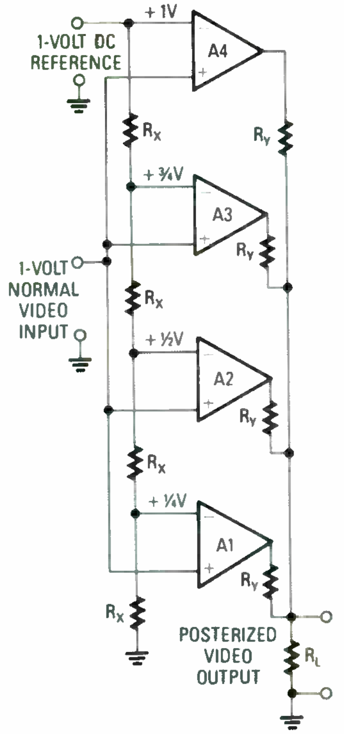


FIG. 6—AN ELEMENTARY POSTERIZER circuit. The value of the DC reference voltage determines the width of each step.

Solarization

In contrast to posterization, solarization is a linear distortion technique. However, as shown in Figs. 7-*a*, *b*, *c*, and *d*, what is done is to fold the gray scale back on itself. White becomes white, light gray becomes dark gray, gray becomes black. As the tones tend further toward black, the video output goes back towards white. Therefore, the picture highlights are positive and the shadows turn negative. Inversion can be used in conjunction with solarization, so that the shadows are positive and the highlights are negative.

Solarization is accomplished by using an amplifier that has the transfer characteristic shown in Fig 8. As shown, two amplifiers, one having a gain of two and one with a delayed gain of minus four—with their outputs combined—result in the necessary transfer characteristic. Although gains of two and four are shown, we can use any other 2:1 combination, resulting in a different gain figure. In our palette, we used gains of 0.5 and 1, giving an overall loss. That was done so that a larger input signal could be used.

As shown in Fig. 9, the solarization circuit uses a single op-amp. Assume that diode D1 is reverse biased, and that resistor R3 provides unity gain. Since R1 = R2, only half of the input signal appears at the inverting input.

As the input goes positive, D1 gradu-

continued on page 86

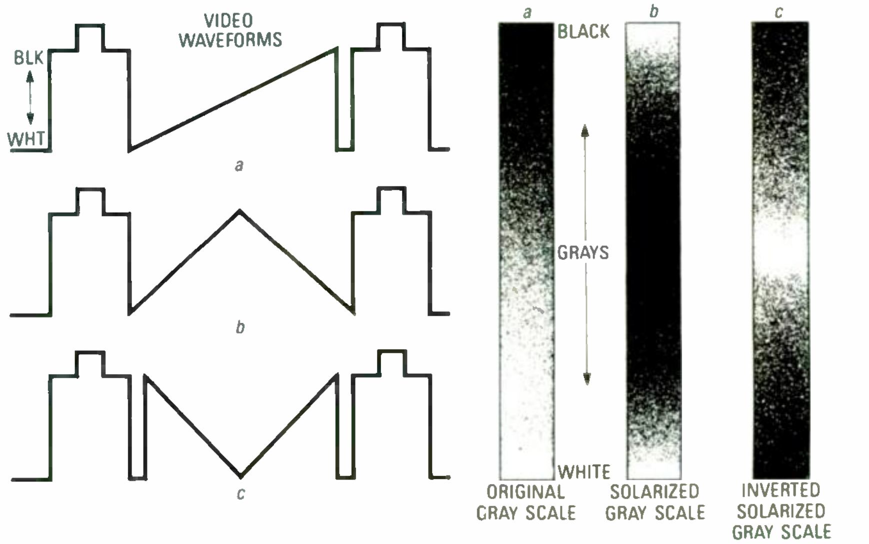


FIG. 7—SOLARIZATION FOLDS THE SIGNAL back on itself so that white remains white, gray becomes black, and black becomes white, or vice versa. The original signal is shown in *a*. The solarizied signal is shown in *b*. An inverted solarized signal is shown in *c*. The original waveform for each condition is shown in *d*.

WHERE TO GET PARTS

Next month we will present the schematics and construction detail for the video palette, for which the following items are available from North Country Radio, P.O. Box 53, Wykagyl Station, NY 10804. The main printed-circuit board, $12.50; the effects printed-circuit board, $12.50; the main printed-circuit board and all parts that mount on the board, $49.95; the effects printed-circuit board and all parts that mount on the board, $39.95. A kit containing both the main and effects boards and their parts is $84.95. The effects board, with or without components, is sold only in conjunction with the main board. Include $2.50 postage and handling per total order. New York State residents must add appropriate sales tax.

SCA/FM-STEREO RECEIVER

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RUDOLF GRAF and WILLIAM SHEETS

Part 2 LAST TIME, WE looked at the circuit for an FM-stereo/SCA receiver. This month we'll show you how to build that circuit.

Construction

The parts-placement diagram for the receiver is shown in Fig. 4. The pattern for the single-sided board is shown in PC Service. Upon examination, you may notice that the board uses a rather unusual parts layout. The layout shown was used to solve stability and crosstalk problems that are commonly encountered in high-gain, high-frequency designs of this type. It is based on the authors' experience with similar receivers, and with the particular IC's and transistors used.

The decision to use a single-sided board was made for several reasons. One, it makes it easier for a hobbyist with limited resources to reproduce the PC board at home. It also minimizes stray board capacitances, which can be a real problem at the frequencies involved. However, the use of a single-sided board does present some problems of its own. Such boards are much more difficult to lay out, and present RF grounding and stability problems. Those problems have been solved in the layout shown. Therefore, we *strongly* urge that you use our layout if you are contemplating building the receiver or any portion of it.

When stuffing the board, use a low-wattage iron (25 watts) and keep soldering time to a minimum to avoid overheating the components. All capacitors should be mounted as flush with the board as possible to minimize lead length. Be sure to adhere to the types and values specified in the Parts List. In particular, C16, C19, C37, C43, and C55 should be dipped silver-mica or NPO-ceramic types only.

With the obvious exception of the potentiometers (R71–R75), all resistors are ¼-watt, 5% types. Again, make sure that all components are mounted flush with the PC board.

Be sure to observe the polarity on all appropriate components, such as the electrolytic capacitors. Varactor diodes D1, D2, and D4, and Zener diode D3 must be oriented correctly or the circuit will not work. Be sure to orient all IC's as shown in Fig. 4; otherwise they will be instantly and permanently damaged when power is applied. Care must be taken with ceramic filters FL1–FL3; they are somewhat delicate and easily broken. When you mount the AFC jumper (between C34 and R17), use a direct run to keep the lead as short as possible.

The tuning potentiometer, R71, should be mounted off the board, on the front panel. Further, it should be a good-quality multiturn unit for greatest tuning ease. (Note that the R71 included in the kit available from the supplier is a PC-mounted unit; if the supplied R71 is used, it is mounted directly on the board and R18 is deleted. While that configuration is satisfactory for testing and experimentation, we recommend using a good-quality multiturn unit as described for best results.) If desired, R74 and R75 can also be mounted on the front panel.

Use a cabinet that is ample for the board. In particular, you should be able to mount the board at least ½-inch away from the sides, top, or bottom. The unit shown in the photographs has a wood base and a plexiglass front panel. We mounted the board on ½-inch metal spacers.

You can arrange the front-panel controls to suit your needs or preferences.

WARNING!

SCA is not a broadcast service, and SCA transmissions are not intended for reception by the general public. As a result, SCA transmissions may be governed by Section 605 of the FCC Rules, which forbid unauthorized individuals from receiving such communications and using them for their own or other's profit, or divulging their contents, intent, or meaning to any other unauthorized individual.

Many for-profit services make use of SCA, and reception of those in most cases is permitted by paying subscribers, and under certain circumstances, only. Some not-for-profit services do make use of SCA also, however, such as those providing assistance to the blind. It may be possible to receive those without obtaining prior permission or paying a subscription fee, as long as the terms of Section 605 are observed. We advise you to contact the approriate programmers in your area for more information and to obtain any necessary authorizations.

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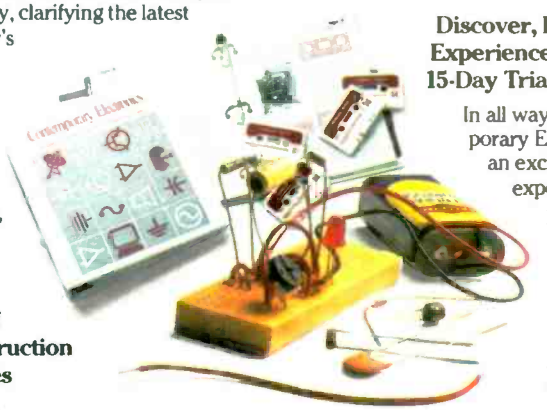

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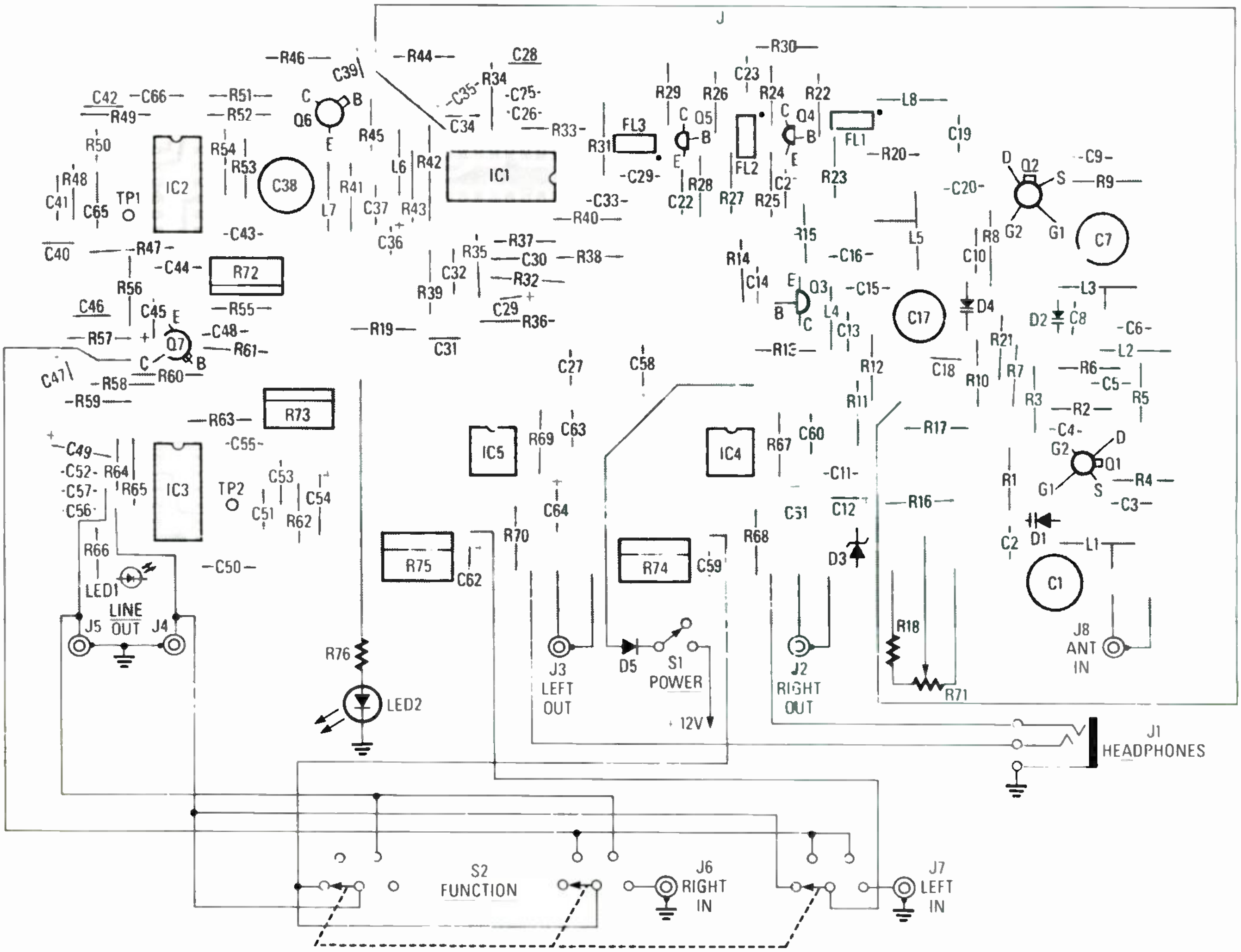

FIG. 4—**MOST OF THE COMPONENTS** mount on a single-sided PC board. However, for best results, we recommend removing R71, replacing it with a multiturn potentiometer, and mounting that unit on the front panel.

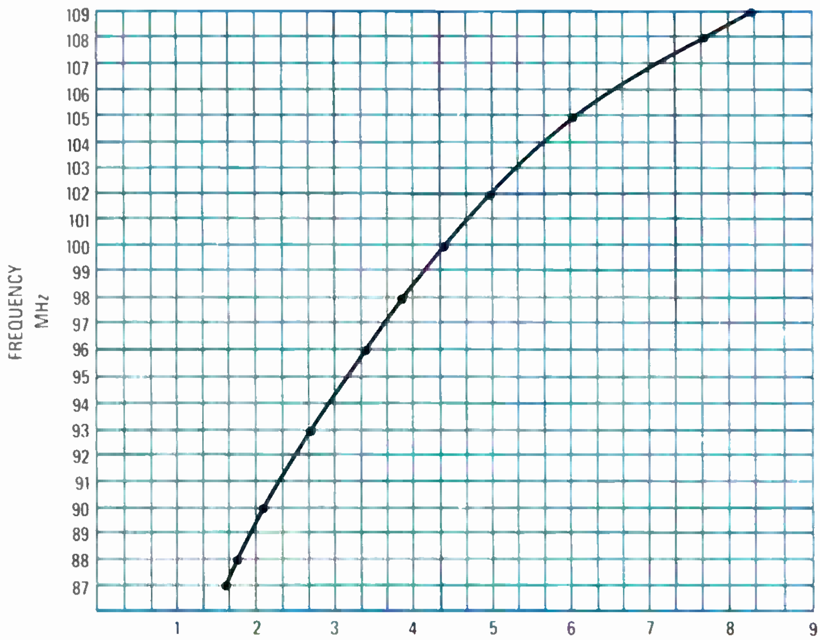

FIG. 5—USE THIS CHART to find the tuning voltage for the frequency of interest. Then adjust the setting of R71 so that voltage appears at the junction of R16 and R17 and tweak C17 until the station is received.

Connect front-panel mounted potentiometers to their appropriate pads using shielded cable for best results, especially if any of the runs are long. If the power supply is located physically close to the receiver, the AC power cord should be routed as far away from the front panel as possible. Otherwise, the leads from the potentiometers (particularly if shielded cable is not used) may be susceptible to AC-hum pickup.

The handwound coils for the front end are made using No. 20 tinned copper wire. They should be wound on a 3/16-inch form; the shank of a 3/16-inch drill bit is ideal for that purpose. Coils L1 and L3 are 5 turns each, and are tapped at 1.5 turns from the grounded end; L5 is four turns, tapped at 1.5 turns from the grounded end. The easiest way to build the coils is to wind each one, install it so that it sits 1/8- to 3/16-inch from the PC board, and then, using a length of No. 22 or 24 wire (a clipped-off lead from a resistor or capacitor is useful for that purpose) install the tap on the coil—simply tack-solder it on. You also can can use short lengths of clip-

PARTS LIST

Resistors ¼ watt, 10% unless otherwise noted
R1, R3, R7, R8, R10, R46, R60—100,000 ohms
R2—47,000 ohms
R4, R25, R28, R68, R70—100 ohms
R5, R31, R32, R35—470 ohms
R6, R21, R39—150 ohms
R9, R11—220 ohms
R12, R14, R18—2200 ohms
R13—3500 ohms
R15, R30, R56, R57, R62, R66, R76—1000 ohms
R16, R23, R27, R36–R38, R40, R43, R45, R49, R54, R58, R59, R61—10,000 ohms
R17—1 megohm
R19, R67, R69—10 ohms
R20, R24, R29, R33—330 ohms
R22, R26—33,000 ohms
R34, R42, R44—22,000 ohms
R41, R47, R51–R53, R64, R65—4700 ohms
R48, R50—18,000 ohms
R55, R63—15,000 ohms
R71–R75–10,000 ohms, potentiometer
Capacitors
C1, C7, C17—2–18 pF trimmer
C2, C5, C6, C8, C9, C11, C13–C15, C18, C20–C26, C28, C30–C34—0.01 µF, ceramic disc
C3, C4, C66—470 pF, ceramic disc
C10, C16, C37—100 pF, silver mica
C12, C29, C35, C36, C39, C47, C49, C59, C62—10 µF, 16 volts, electrolytic
C19—8 pF, silver mica
C27–not used
C38—3–40 pF, trimmer
C40–C43—220 pF, silver mica
C44—0.001 µF, Mylar
C45, C60, C63—0.1 µF, Mylar
C46, C51—0.047 µF, Mylar
C48, C52—0.0022 µF, Mylar
C50, C53—0.22 µF, Mylar or tantalum
C54—0.47 µF, Mylar or tantalum
C55, C65—470 pF, silver mica
C56, C57—0.022 µF, Mylar
C58, C61, C64—470 µF, 16 volts, electrolytic
Semiconductors
IC1—LM3189N FM receiver IF system (National)
IC2—LM565 phase-locked loop (National)
IC3—LM1310N FM stereo demodulator (National)
IC4, IC5—LM386 audio amplifier (National)
Q1, Q2—40673 dual gate MOSFET transistor
Q3–Q5—2N3563 NPN transistor
Q6, Q7—2N3565 NPN transistor
D1, D2, D4—MV2107 varactor diode
D3—1N757 diode
D5—1N4001 diode
LED1—jumbo red LED
LED2—jumbo green LED
Other components
L1, L3, L5—see text
L2, L4—1.8 µH
L6, L7—18 µH
CF1–CF3—10.7 MHz ceramic filter
J1—stereo headphone jack
J2–J8—phono jacks, RCA type
S1—SPST toggle switch
S2—3P4T rotary switch
Miscellaneous—PC board, No. 20 solid uninsulated wire for winding L1 L3, and L5 (18 inches total required), wire, solder, hardware, knobs, cabinet, etc.
The following are available from North Country Radio, P.O. Box 53, Wykagyl Station, NY 10804: Kit consisting of PC board and all PC-board mounted parts (jacks, switches, D5, LED's, power-supply components, etc. *not* included), $75.00 plus $2.50 postage and handling; Etched and drilled PC board, $12.50 plus $2.50 postage and handling. NY residents please add appropriate sales tax.

PARTS LIST—POWER SUPPLY

C67—2200 µF, 25 volts, electrolytic
C68—0.01 µF, ceramic disc
C69—0.1 µF, ceramic disc
C70—470 µF, 16 volts, electrolytic
T1—117-volt primary, 16–18 volt 500-mA secondary
IC6—LM7812 three-terminal regulator
D6–D9—1N4001 diode

ped resistor or capacitor lead for the pc-board test points.

Once construction is complete, check your work carefully. Make sure that all components are oriented correctly. Examine your work for poor solder joints and for solder bridges. Once you are certain that everything is OK, you can proceed.

Checkout and alignment.

Begin by setting all potentiometers to the middle of their ranges. Set C38 so it is ½ meshed. Set C1, C7, and C17 so they are about ¼ meshed. Connect two 8-ohm speakers to the audio outputs, or a pair of 32-ohm headphones to the headphone jack. Connect about 6 feet of hookup wire to the antenna input, J8, to serve as a temporary antenna.

Once that is done, measure the DC resistance between the power and ground traces on the board. It should be above 100 ohms. If it is significantly less, you likely have a short somewhere on the board. Find it and fix it before proceeding.

If everything is OK, apply +12-volts DC to the +12-volt input. Check the current drawn from the supply; it should be about 125–150 mA at 12 volts.

When power is applied, you should hear a rushing noise in both speakers (or headphones). If not, find the source of the problem and correct it before going on. If only one channel is dead, the best place to look is around the appropriate audio amp (IC4 or IC5).

Set the FUNCTION switch (S2) for FM-stereo and rotate R71. In most areas of the U.S. you should hear a few FM signals. Note that at this point the audio may seem distorted. Using a non-conductive tuning tool, adjust C38 for clearest audio (lowest distortion). Adjust R74 and R75 for a comfortable volume level.

Next, we'll calibrate the tuning potentiometer. Locate and identify a weak station at the high end (between 106 and 108 MHz) of the FM broadcast band using a commercial FM receiver. Try to tune that station using our receiver. If your tuning range does not extend high enough, adjust C17 to correct the tuning range. Once the station is tuned in, use Fig. 5 to find its corresponding tuning voltage. Set R71 so that that voltage appears at the junction of R16 and R17. Then tweak the setting of C17 so that the station is tuned at that setting of R71.

To calibrate at the low end of the broadcast band, locate and identify a weak station between 88 and 91 MHz. Adjust R71 to get the appropriate tuning voltage at the junction of R16 and R17 as before. Then, compress or expand the turns of L5 until that station is received at that setting of R71. Double check your calibration to be sure that the entire band is covered.

Once you are satisfied with the band coverage, adjust C1 and C7 for best reception and note their settings. To tweak reception, tune in a weak signal between 88 and 91 MHz. Adjust C1 to see if a different setting will provide better reception. If it does, note whether the adjustment results in increasing (greater meshing) or decreasing (less meshing) the capacitance of C1. Return C1 to its original setting. If increasing the capacitance resulted in better performance, compress L1 for optimum reception; if decreasing capaci-

SCA RADIO MANUFACTURERS

Commercial Elects./Multiplex Music 38-40 Washington Avenue, St. Louis, MO 63108
Dynamic Sound, PO Box 840, Exeter, NH 03833
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Johnson Electronics, Inc., PO Box 4723, Winter Park, FL 32707.
McMartin International, Inc., 111 Camino Del Rio, Gunnison, CO 81230
Norver Co., Inc., 7300 North Crescent Blvd., Pennsauken, NJ 08110
Panasonic/Matsushita Technology Center, 1 Panasonic Way, Secaucus, NJ 07094
Radio Systems, Inc., PO Box 356, Edgemont, PA 19028
Repco, Inc., 1940 Lockwood Way, Orlando, FL 32854
SCA Data Systems, Inc., 3000 Ocean Park Blvd., Suite 1040, Santa Monica, CA 90405
SMC International, 14745 Madison Cir., Omaha, NE 68137
Toa Electronics, Inc., 480 Carlton Ct., South San Francisco, CA 94080

ADDING A FILTER

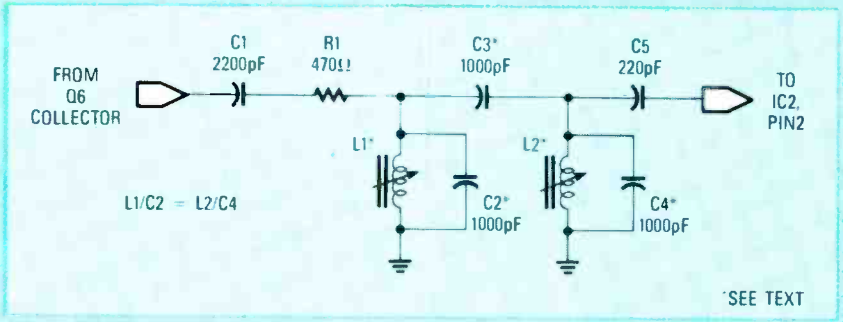
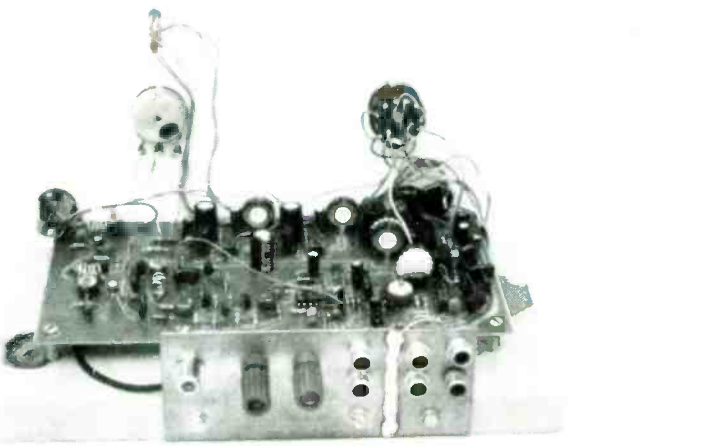


FIG. 1—THIS TUNABLE BANDPASS FILTER effectively suppresses main-channel sputter to provide superior performance for your SCA receiver.

Whether or not the main-channel audio interferes with an SCA signal depends on several factors, both at the receiver and transmitter. In particular, however, the precision of the components used in the Twin-T filter that feeds the SCA demodulator strongly affects how much main-channel sputter and splatter will be heard in the SCA signal's background. If the filter is made from high-tolerance components—1% resistors and capacitors—the main channel suppression will be adequate in most instances.

If you need an SCA signal that is virtually immune to interference by the main channel, then we suggest adding the tunable bandpass filter shown in Fig. 1 to your receiver. The value of L1 and L2 is found from the formula $L = (1/6.28 \times f)^2/C$, where f is the SCA subcarrier frequency and C is the value of the capacitor in the resonant circuit. The values of C2–C4 depend on a number of factors, including the characteristics of the coils used, the impedance at the filter's input and output, etc. Start with a value of 1000 pF for each as shown, but be prepared to experiment with the values of the components marked with an asterisk to obtain optimum performance. Of course, bear in mind that L1/C2 and L2/C4 must be resonant at the subcarrier frequency.

The filter can be assembled on a small PC or wire-wrap board and piggy-backed onto the main board with double-sided tape, or small metal brackets. **R-E**



THE AUTHOR'S PROTOTYPE was mounted in a simple homemade cabinet. Whatever cabinet you use, be sure that it is ample to house the board.

tance yielded better reception, expand the coil. Repeat the procedure for C7 and L3. Then tune to a weak station at the high end of the band and repeat. Continue the process until you are satisfied that no further improvement is noted.

Adjust C38 so that the voltage across R43 is zero when a station is tuned in properly. Detuning the station should cause that voltage to rise or fall slightly (±1 to 2 volts is typical). Adjusting C38 in that manner should produce the clearest audio.

Next, tune in a weak station that you are certain is transmitting its signal in stereo. Adjust R73 for best stereo reception. When R73 is adjusted properly, LED1 should light. For more precise adjustment, connect an oscilloscope or frequency counter to TP1 and adjust R73 to produce a 19-kHz signal.

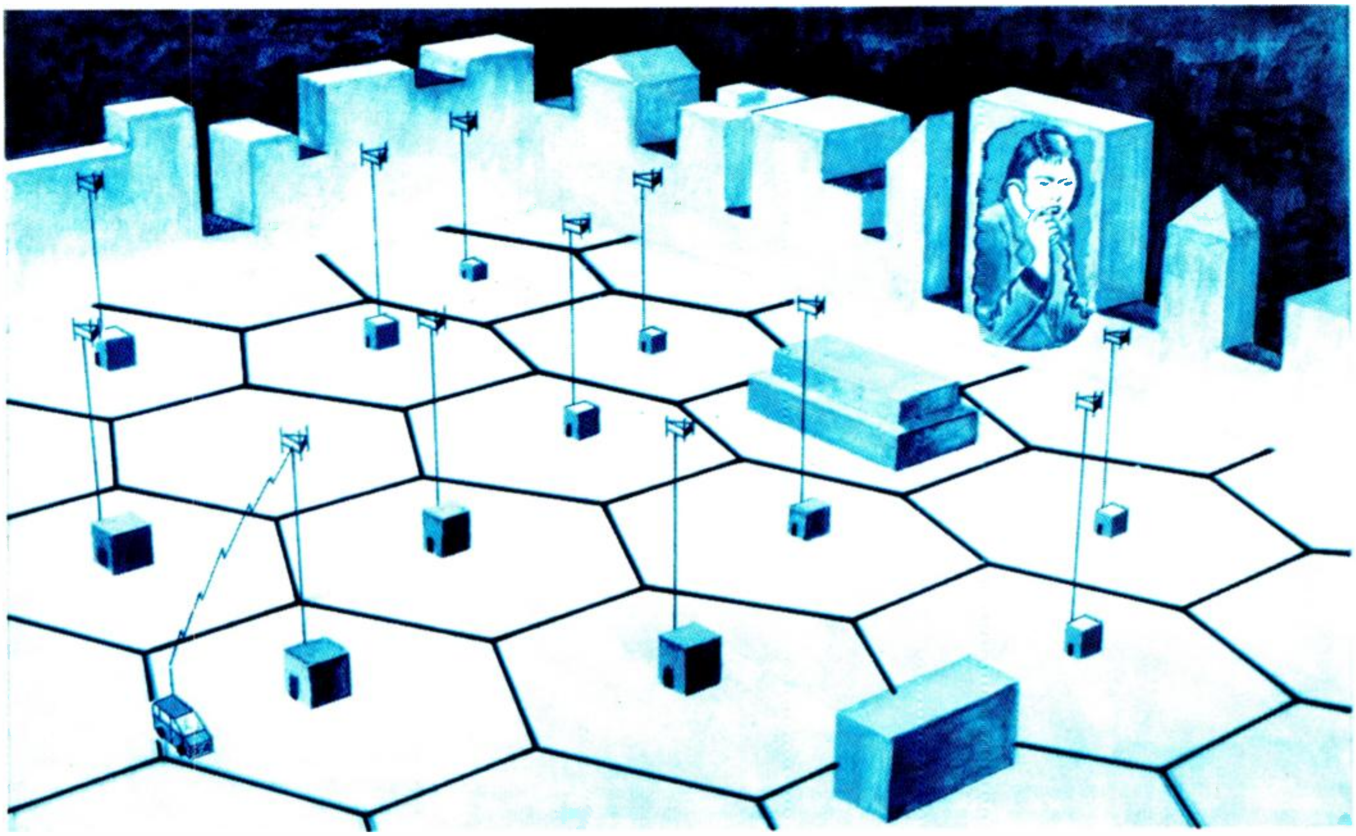
Now, set S2 for SCA reception and R72 to its midrange position. *Slowly* tune across the FM broadcast band. You may hear several SCA signals. Tune one in and adjust R72 for best reception. If you cannot hear any SCA signals, change the setting of R72 *slightly* and try again. Note that if you do not have good fortune, aligning the receiver in this manner can be tedious and time-consuming, but with patience it can be done. There is, however, a short cut available to you if you have access to a frequency counter or an oscilloscope: Simply connect the instrument to TP2 (pin-6 of IC2) and set R72 to produce a 67-kHz signal there. To tune in other subcarrier frequencies, set potentiometer R72 to produce a pin 6 signal of the appropriate frequency.

If you know that a certain FM station has SCA activity, the receiver's TUNE function offers yet another method of alignment. When S2 is set to TUNE, the main channel audio is fed to one output, while the SCA audio is fed to the other. That allows you to hear both the main channel and the SCA subcarrier simultaneously. Using a pair of headphones for best results, tune the receiver so that the desired station's main-channel audio can be heard in one ear. Then, adjust R72 until the desired subcarrier can be heard in the other ear.

That completes the alignment procedure. Though there are a lot of steps to follow, most of the adjustments are broad and the radio should work in the FM-stereo position even with just the initial adjustments outlined. An exception to that is the setting of C38, and, to a lesser degree, the setting of C17; correctly adjusting those components requires some precision. Still, if the setting of any component is so critical that even breathing on it causes problems, something is not working properly.

Searching the bands

One of the authors lives on the New York/Vermont boarder, about 50 miles north of Albany, NY. From that relatively rural location he has received FM-stereo signals from as far as 170 miles away using only a two-foot clip-lead antenna. In addition, six SCA subcarriers could be received. Obviously, in major metropolitan areas many more SCA signals should be heard. In the New York City area alone, for instance, upwards of 20 FM-radio stations have some type of SCA activity. If you want to find out what stations in your area have SCA activity, and what type of programming is available, an excellent reference is the *FM Atlas and Station Directory*, written by Bruce Elving (FM Atlas Publishing, Adolph, MN 55701-0024). **R-E**



INSIDE CELLULAR TELEPHONE

A look inside cellular telephone, and the fascinating technology that has revolutionized mobile communications.

JOSEF BERNARD

NOT SO LONG AGO, WHEN ONE THOUGHT of a telephone, the image conjured up would be of a jet-black, rotary-dial, electromechanical device. Now, conventional telephones come in a rainbow of colors, sport sleek lines, and feature pushbutton dialing. But even more impressive are the features that are packed inside them. Thanks to microprocessors and memories, phones are capable of storing a telephone-book's worth of most-often-called numbers to be dialed at the push of a button. And that's only the beginning.

But if you think that the phone on your desk or in your kitchen is "smart," then you would have to place cellular mobile phones in the "genius" class. Those phones have to perform a number of sophisticated tasks, including monitoring signal levels and frequency switching, in such a way that the user is not aware of them. Because of that, many people who use cellular phones daily aren't aware of the high level of technology built into their equipment. That's unfortunate, because the technology inside the phones is, for the most part, much more interesting than the conversations that they transmit.

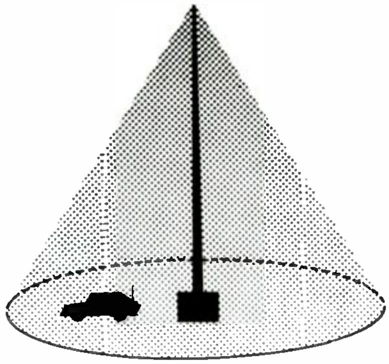


FIG. 1—EARLY, NON-CELLULAR, MOBILE-phone systems used a centrally located high-power transmitter. Only a few communications channels could be accommodated within a service region.

Cellular principles

Prior to the development of the cellular system, mobile telephone systems relied on centrally located transmitting and switching equipment to communicate with vehicles subscribing to their services. See Fig. 1. Cellular systems, on the other hand, divide their region of coverage into many small areas, each encompassing only a few square miles. See Fig. 2. It is that territorial subdivision that allows the mobile units to use low-powered transmitters (no more than three watts), and to use and reuse the same frequencies in the same area to increase the number of communications channels available.

There are 999 two-way communica-

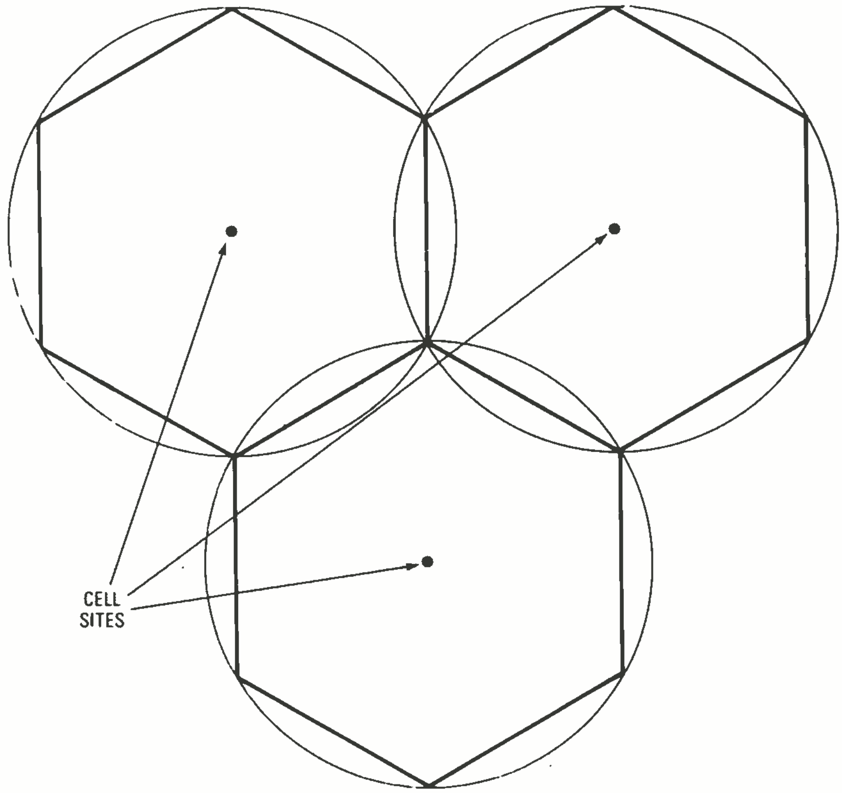


FIG. 2—A CELLULAR SYSTEM DIVIDES its region of service into a number of small cells, each with its own cell site containing a low-power transmitter and receiving equipment. As a vehicle passes between cells, the signal is analyzed and any further communications are handed off to the cell best able to handle them.

tions channels allocated for cellular service, although the phones currently available can use only 666 of them. (The other 333 frequencies were allocated in 1986 and equipment manufacturers, as of this writing, have not yet caught up with the FCC.) Of those channels, 42 are devoted to carrying control signals between cellular phones and the cell sites, where the transmitting and receiving equipment for each cell are located. It is over those channels—which you never hear, and rarely hear about—that a cellular system coordinates its activities.

All kinds of information flows on those channels, including that for coordinating frequency changes, identifying phones, and even adjusting power levels.

Handing off

When a mobile unit leaves the region of coverage of one cell site and enters that of the adjoining one, it is said to be *handed off* from one cell to the other. There is a lot of behind-the-scenes activity connected with that transfer of responsibility, and the intelligence built into cellular phones handles a lot of it.

As a vehicle equipped with a cellular phone traverses a particular cell, it eventually reaches a point where its signal is no longer strong enough for reliable communications. Fortunately, by the time it has reached that point, it is well within the region of coverage of an adjacent cell. The handing-off process of transferring the responsibility for a call-in-progress from one cell site to another requires a lot of "intelligence" on the part of both the cell site and the mobile unit.

The first thing that has to be done is to sense when a signal is approaching the point where it is about to become too weak to be usable. That's easy—all you need is what amounts, more or less, to a signal-strength detector. More complicated is the task of determining which new cell site is to receive the hand-off. The cell sites in the system have to "confer" to see which of them is receiving the signal in question the best, and make arrangements for transferring the call without interruption. That's not too difficult, either. The next part of the process, however, is quite complex.

Because adjacent cell sites cannot use the same frequencies, even though others in the same system can, a new set of frequencies must be used after the hand-off. And, since the new cell site will be using different frequencies, so must the mobile phone. That is where the control channels, and the intelligence built into a cellular phone, come into play. The new cell site knows which of its frequencies are in use and which are free, and makes a decision to allocate one of its frequency pairs (one channel) to the new conversation entering its district. It then transmits, over the control channel, instructions for the cellular phone carrying the conversation to switch to those new frequencies. The phone adjusts the voltages of its frequency synthesizer accordingly, and the conversation continues in the new cell site, on the new frequencies—all of that with only an unnoticeable interruption of a millisecond or two.

Power levels

A cellular system can use the same frequencies for different conversations at the same time, provided, of course, that the signals of one cell site do not interfere with those of another. That non-interference is accomplished in several ways.

The first is simple coordination of frequencies. While several cells in the same system may use the same frequencies, no two adjacent cells do. That puts cells using the same frequency far enough away from one another that the signal from one to a vehicle in its area, and vice versa, will override another signal from farther away. That is further ensured by the *capture effect*, which is a characteristic of FM, the transmission mode used by cellular phones. If there are two signals on the same frequency, one stronger than the other, the capture effect guarantees that a receiver will lock onto the stronger one, and ignore the weaker. Unless the two signals are nearly identical in strength, the stronger one will completely capture the receiver, and no trace at all of the weaker one will be heard.

All that is the consequence of good planning, and of the nature of FM equipment. Inside a cellular phone is circuitry that adds another level of interference protection. There is a constant dialogue going on between a cellular mobile unit and the cell site it is using. One "topic of conversation" is signal strength. Cellular equipment is low powered. Cell-site transmitters have an output of only 25–35 watts (compared to about 250 watts in older systems using central transmitters), and the mobile equipment a maximum output of three watts—and as low as 600 milliwatts for handie-talkie-size units.

One of the rules of cellular telephony is "use only as much power as you need." Consequently, a cell site monitors the strength of the signal it receives from a mobile unit. If the strength increases to a predetermined level, the cell site sends instructions over the command channel for the low-powered phone to reduce its power to an even lower level. Conversely, if the received signal strength drops, a mobile phone can be instructed to increase its power. Cellular phones are capable of between 3 and 8 discrete output levels. Keeping output power to the minimum required for good communications

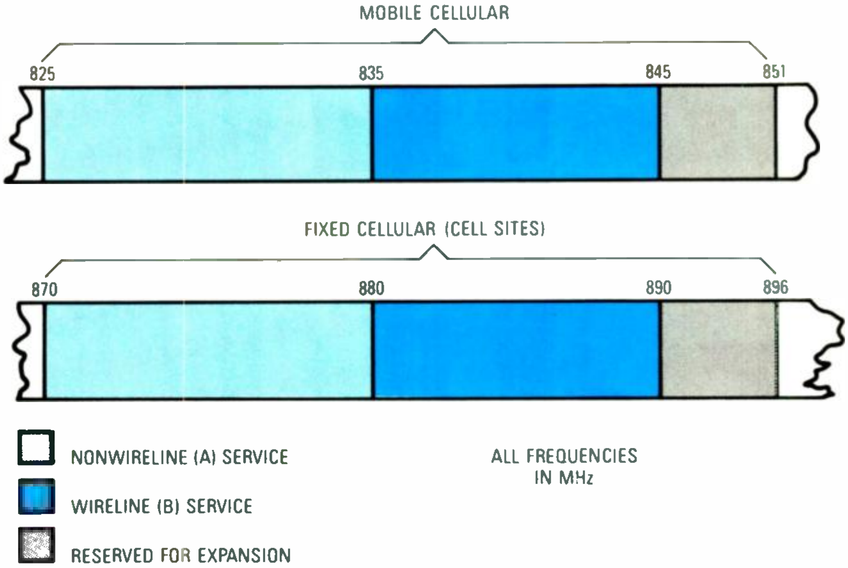


FIG. 3—THE 666-CHANNEL CELLULAR PHONE RF spectrum is divided into bands for fixed and mobile equipment (cell sites and phones), and for non-wireline (A) and wireline (B) service.

also reduces the risk of interfering with communications in a nearby cell.

NAM's

Every cellular phone contains an "identification" PROM or EPROM. In cellular terminology, this is called a NAM (*N*umeric *A*ssignment *M*odule). A phone's NAM is programmed at the time the phone is purchased; it contains such information as:

- The telephone number, or ESN (*E*lectronic *S*ervice *N*umber), assigned to the phone.
- The serial number given to the phone at the time of its manufacture.
- Personal codes that can be used to lock and unlock the phone electronically, to prevent its unauthorized use.

NAM information is more useful than you might at first imagine. For one thing, it is the job of the NAM to identify the phone containing it to the cellular systems it uses. When a cellular phone is turned on, it makes an announcement over a control channel that says, "Here I am." The cell site responds, "And exactly who *are* you?" The reply from the phone consists of information contained in its NAM.

That information tells the cellular system several things. First, of course, is that that particular phone is now on the air and is ready to receive calls placed to its number. The cell site is connected to a computer at the MTSO (*M*obile *T*elephone *S*witching *O*ffice), which is the link between the cellular system and the conventional landline phone system, and which recognizes all the cellular phones registered in the calling area it is responsible for. If the phone is a local one, the process is more or less complete at the point of recognition.

Because they are mobile, cellular phones may frequently be used outside of the area in which they are permanently registered. That is called *roaming*, and is one of the outstanding features of cellular telephony. You can take your cellular phone almost anywhere in the country where there is service, turn it on, and use it to call anywhere in the world.

In some areas you can roam and use a foreign system without advance notification. Other cellular systems require that you let them know ahead of time that you are coming. In either case, the NAM information transmitted to the system allows you to log on to it, and tells that system what to do about your billing.

NOT JUST FOR CARS, cellular phones come in portable models, like this one from GE, that keep you constantly in touch.

Cellular phones have a ROAM indicator, which lights when you have left your local area and are in the operating area of another system. (The phone realizes that it has entered a system other than its own, and lets you know that.)

The serial number contained in the NAM, incidentally, can serve a second purpose. Should a phone be stolen and reported so, it is possible for a system to recognize that phone when it is next used. While tracking down the phone would be rather difficult, it is easy to cut off service to that number automatically, avoiding the possibility of your being charged for calls you never made.

A/B switching

When it established the cellular phone service, the FCC provided for two cellular carriers in each region. One, the *wireline* service, would be operated by a phone company engaged in conventional telephony, frequently the one that already provided landline service to the area. The other, known as the *non-wireline*, service would be operated by a company that was engaged in other forms of mobile communications—perhaps paging, or private two-way radio services. Sometimes a region of cellular service has both types of carriers, and sometimes only one, at least when service is inaugurated. Each service is assigned a separate set of frequencies. See Fig. 3.

Regardless of where in the country you are, the non-wireline service is referred to as the *A service*, and the wireline one as the *B service*. Normally you subscribe to only one service or the other (provided your area offers you a choice), but you may at times have occasion to use the other type—when you are roaming, for example.

To provide for that, cellular phones have A/B switches to allow you to go from one type of service (band of frequencies) to the other. Those switches are generally not mechanical devices, but are programmable from a phone's keypad. Some of the switches are more flexible in their capabilities than are others, and the more sophisticated of them offer at least the following modes of operation:

- A (or B) service only—the other is locked out.
- Give priority to one type of service over the other.
- Automatic selection of the one active service in an area.

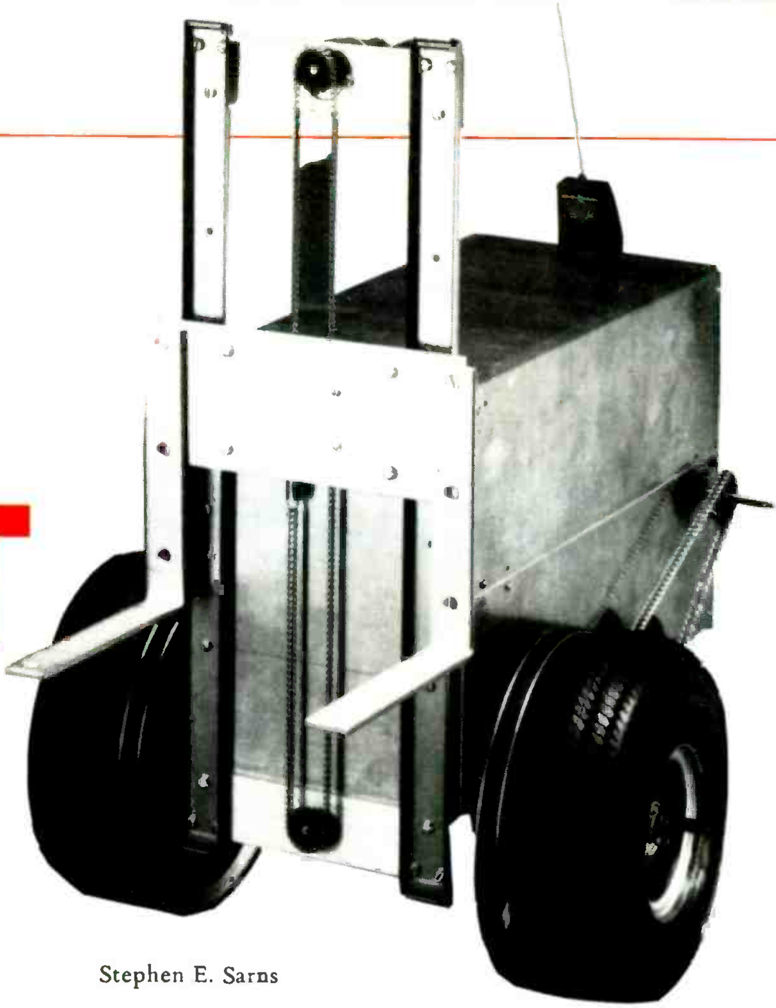
Again, it is the intelligence a phone applies to the information coming in over its control channel that makes it possible for it to select the appropriate A or B setting.

When you are roaming, the phone lets you know you are outside of your normal area of use by illuminating its ROAM indicator. Some phones can apply their

continued on page 93

R-E ROBOT

Here's an application that can give a robot builder great "joy."



Stephen E. Sarns

Part 10

Now that we've finished building the *R*obotic *P*ersonal *C*omputer (RPC), the mechanical drive system, and the interface and controller board, we have a robot that is ready to run. But what are we going to do with it? In this article we are going to show you a simple application program that will demonstrate how to:

- Develop programs on the RPC.
- Read the A/D converter.
- Read the switch status.
- Control motor direction.
- Control motor speed.

In addition, our first application, a joystick controller for the robot, illustrates the use of the underlying Forth-83 language. You will want to become familiar with Forth-83, even though you have the power of the *R*obotic *C*ommand *L*anguage (RCL) at your disposal, because Forth-83 allows you to extend the RCL to suit your needs. Remember, the RCL is simply an application written in Forth-83. Your application can use the resources of RCL or Forth-83 or both. That is shown graphically in Fig. 1.

The application

A joystick is attached to the discrete user bus (PL3 on the control board). Analog channel 0 is used to monitor the joystick's forward/backward position. Analog channel 1 monitors its left/right position. For safety, a pushbutton *deadman* switch is connected to the D7 (data bit 7) input. That switch must be depressed for the robot to operate; if it is released, all power to the motors is cut. The schematic for the joystick hookup is shown in Fig. 2.

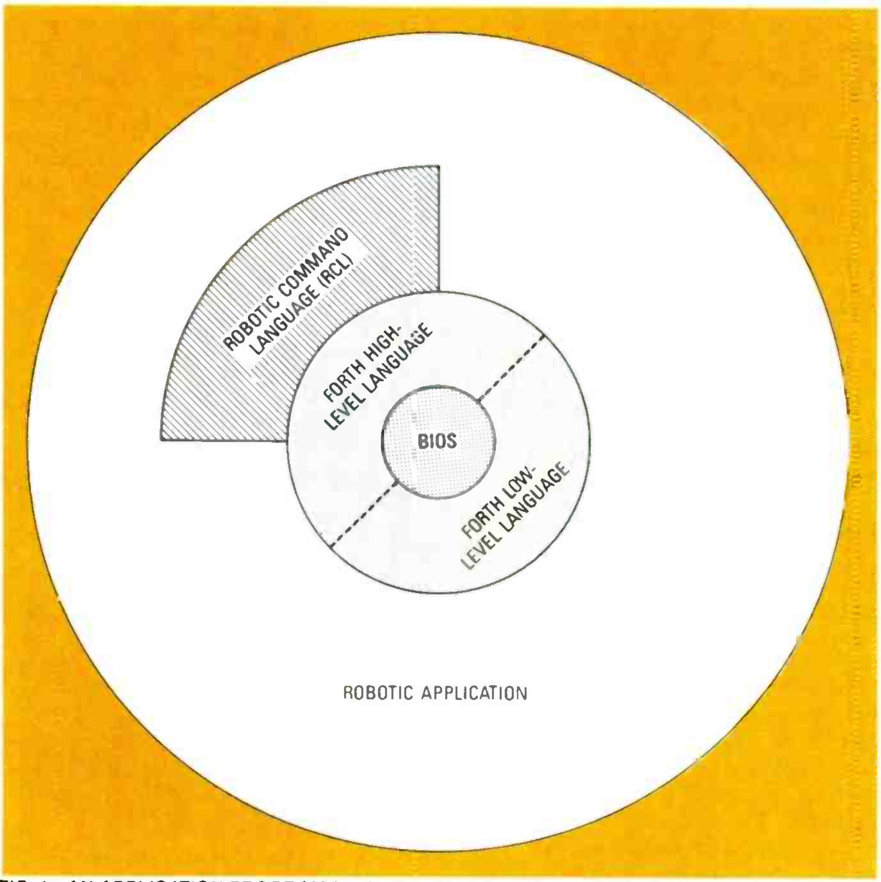


FIG. 1—AN APPLICATION PROGRAM for the robot can be written in RCL, Forth, or both.

All of the code we are going to write will fit into six Forth screens. Therefore, you do not need a disk drive. You can use the RAM word to store all of your source code in virtual memory above 32K. Alternatively, you can attach a disk drive and keep all of your code on disk. Last, you could type in all of the colon definitions from the keyboard, but doing so is handy for testing, not developing an application.

If you are going to use RAM as the development media, power down and install a RAM IC in the IC5 socket on the RPC, execute the RAM word, and remember that you now have virtual memory screens 32 to 39. If you have a disk drive attached, simply insert a disk formatted under MS-DOS version 2.x or the BIOS formatter. Decide where you want to start (never screen 0) among the 360 available screens on the disk. For simplicity and clarity, we'll assume that you'll start your first screen at 32 just like the RAM-based example. Incidentally, the example was developed on a disk, but there is no functional difference after executing the RAM or DISK word.

Install a blank 2764 EPROM at IC31, the EPROM programming socket on the RPC; once again, power should be off when doing that. It's handy to keep an EPROM installed there, especially if you are developing code in RAM and do not want to risk losing it during a power down.

Invoke the editor by typing 32 EDIT. The 32nd screen is read in from disk (or RAM), the terminal's display is cleared, and then the screen of text is listed. Alternatively, you can type EDITOR 32 LIST. Your first command will probably be WIPE; that clears the entire screen. Now begin entering the source code with the editor. When you want to test a word, make sure you FLUSH your changes to disk before you LOAD the screen, otherwise all of your changes will be lost if your system crashes.

LISTING 1

```
Scr # 32
/ joystick documentation
/ analog channel 0 is used by forward/reverse joystick
/ analog channel 1 is used by left/right joystick
/ digital input D7 is a normally open "deadman" switch
/ variables LSPEED and RSPEED contain the joystick position
/    in the range of -127 to +128
-->
Scr #33
/ joystick - i/o
/ all low level drivers for reading and controlling here
hex
: atod ( channel number --- byte )
   dup 150 pc! 150 pc! 100 0 do loop 150 pc@ ;
: switch? ( ---f ) 120 pc@ 80 and 0= ;
: lmtr-period 36 103 pc! 100 /mod swap 100 pc! 100 pc! ;
: rmtr-period 36 113 pc! 100 /mod swap 110 pc! 110 pc! ;
: stop-left      0 124 pc! ; : stop-right      0 125 pc! ;
: enable-left    1 124 pc! ; : enable-right    1 125 pc! ;
: lfwd 0 121 pc! 1 120 pc! ; : rfwd 0 122 pc!  1 123 pc! ;
: lrev 0 120 pc! 1 121 pc! ; : rrev 0 123 pc!  1 122 pc! ;
-->
Scr #34
/ joystick - joystick interrogation
/ INTERROGATE reads both channels of a/d. Results of fore/back
/ are stored in LSPEED and RSPEED. The left/right position is read
/ and the contents of LSPEED and RSPEED are modified according
/ to DIFF-CONV
hex
300 constant maxspeed    variable lspeed     variable rspeed
: speed-conv ABS 5 * maxspeed swap - ;
: diff-conv 5 / ;
: interrogate
   0 atod 80 - dup lspeed ! respeed !
   1 atod 80 - diff-conv dup negate swap
   lspeed +! rspeed +! ;
-->
```

The program

One of the most common criticisms of Forth is that it is unreadable and therefore unmaintainable. We think you will find Forth quite the opposite—if you start at the end and work backwards. Remember, in Forth, you can design your program from the top down, meaning that you can figure out how it should work, write that part of the code, and later add the support words to make it work that way. By starting your examination of the application from the end, you will understand how the program works, leaving the details for later.

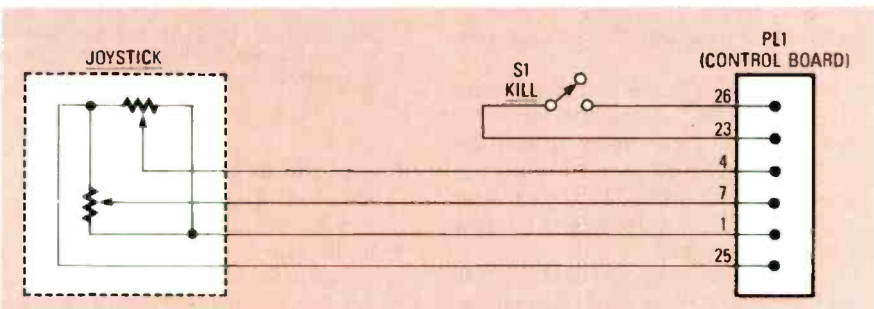


FIG. 2—A SIMPLE JOYSTICK can control the robot. The circuit is wired to the user interface on the control board. For safety, a "deadman" or kill switch must be provided.

Therefore, for now we'll ignore the low-level words, which can be rather esoteric, and begin with screen 37, which contains a single word called JOY. That is the joystick program. While it is executing, pushing the stick forward causes the robot to go forward; pulling the stick back causes it to reverse. Turns are made by moving the joystick in the desired direc-

LISTING 1 (continued)

```
Scr #35
  0 / joystick - left motor control
  1 decimal
  2 : leftmotor
  3      lspeed @ 10 > switch? and
  4       if lfwd lspeed @ speed-conv lmtr-period enable-left then
  5      lspeed @ -10 < switch? and
  6       if lrev lspeed @ speed-conv lmtr-period enable-left
  7       then
  8      lspeed @ -10 10 between switch? 0= or
  9       if stop-left then ;
 10
 11 : testleft
 12     begin interrogate leftmotor lspeed @ . key ? until ;
 13 -->
 14
 15
Scr #36
  0 / joystick - right motor control
  1
  2 : rightmotor
  3      rspeed @ 10 > switch? and
  4        if rfwd rspeed @
  5          speed-conv rmtr-period enable-right
  6        then
  7      rspeed @ -10 < switch? and
  8        if rrev rspeed @
  9          speed-conv rmtr-period enable-right
 10        then
 11      rspeed @ -10 10 between switch? 0= or
 12        if stop-right then ;
 13
 14
 15 -->
Scr #37
  0 / joy
  1 hex
  2
  3 : joy
  4      begin
  5        interrogate rightmotor leftmotor
  6        lspeed @ 10 .r rspeed @ 10 .r
  7        cr key?
  8        if key 0d =
  9        else 0
 10      then
 11     until ;
 12
 13 decimal
 14
 15
```

tion. Speed is controlled by the displacement of the joystick.

Note the BEGIN/UNTIL structure in screen 37. The code executed within the loop is indented for easier understanding. The loop repeats or ends depending on the value of an argument left by the IF/ELSE/THEN construct. The loop checks to see if a key has been pressed. If so, the KEY statement retrieves the character and it is compared to a 0DH (carriage return). If the result of the comparison is true, a *true* flag (−1) is left on the stack. If the KEY statement is false, ELSE is executed, which leaves a *false* flag on the stack (0). UNTIL causes the loop to continue until a *true* flag is found on the top of the stack. Thus, JOY will execute until the carriage-return key is pressed.

Why not terminate on any key? Sometimes after you disconnect your terminal, the floating RS-232 input can be subject to noise. Generally, after your code is in ROM and you are running without the terminal, install a shorting bar between RxD and ground on the RS-232 connector.

INTERROGATE (in line 5 of screen 37) is a word that updates the two variables LSPEED (left motor speed) and RSPEED (right motor speed). The numbers in LSPEED and RSPEED range from −128 to +127. Positive means forward, negative means reverse.

The next two words, RIGHTMOTOR and LEFTMOTOR, examine the contents of the words of LSPEED and RSPEED respectively and set the appropriate motor's speed accordingly.

Finally, the contents of variables LSPEED and RSPEED are fetched and displayed on the screen followed by a carriage return. The .R word is used to right justify the displayed values.

Testing

Each word should be tested after it is written and compiled into the dictionary (LOADED from disk). A common test/debug method is to load up the stack with a few easily identified values, such as 1, 2, and 3. Then type in each word of the definition being tested (not in a colon definition, but interactively). After each word, execute .S, which prints out the contents of the stack without modifying it. Do so to make sure that nothing has been removed from or left on the stack.

It can be useful to define small test. For example, having defined the word ATOD, which takes a channel number off the stack and returns the value of the corresponding A/D converter, you can make sure that it works with all 8 channels by using the following word:

```
: TEST-ATOD
BEGIN 8 0
DO I ATOD . LOOP CR KEY?
UNTIL ;
```

That word prints out the results of all 8 A/D conversions. Your joystick should show up at the first two positions. Terminate the test by pressing any key.

SOFTWARE SOURCES

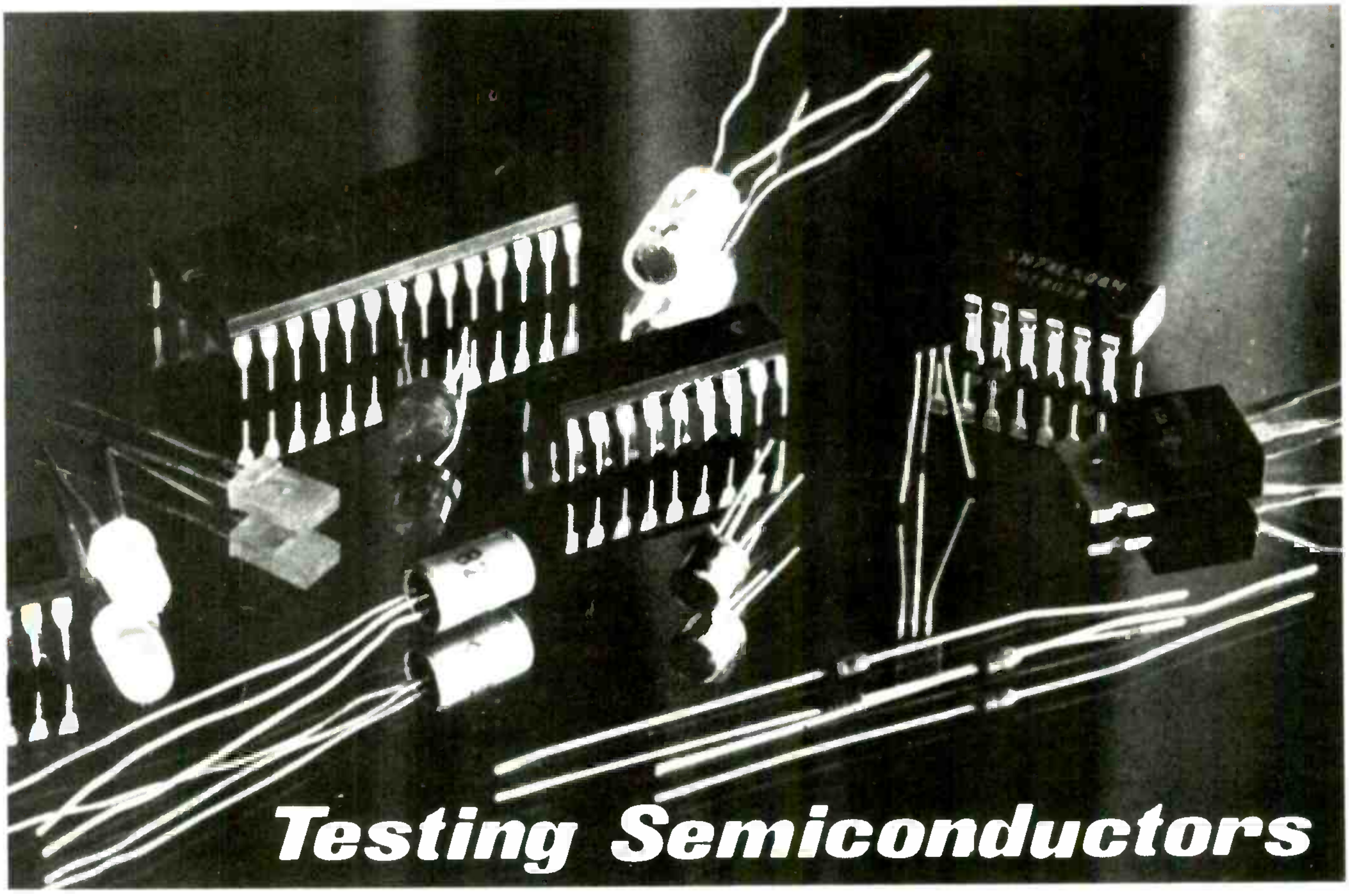
Micro K Systems (15874 East Hamilton Place, Aurora, CO 80013, 303-693-3413) will provide the following: Commented source code in RE-robot disk format, $2.00. Printed source-code listing, $15.00. Two 27128 EPROM's with source screens (and without comments) for the R-E Robot, $39.00. With EPROM's you won't need a disk drive, but you should also obtain the printed listing to read the comments. The Laxen and Perry F83 Model disk with full source code and metacompiler for customizing F83, in MS-DOS 360K format, for a PC compatible computer, $25.00. (Very useful for learning FORTH if you already have a PC.) All orders must be prepaid. NO COD's. Include $3.00 for shipping with each order. Additional source code and applications will be available from Micro K Systems. Contact them for more information.

Speed and direction

The word RIGHTMOTOR, shown in screen 36, examines three possibilities:

- Is the value of RSPEED greater than +10 and is the switch pressed?
- Are the contents of RSPEED less than −10 and is the switch pressed?

continued on page 63



Testing Semiconductors

Op-amp characteristics and how to measure them

TJ BYERS

Part 6 THIS MONTH WE'LL turn our attention to a device that is a staple in electronics: the operational amplifier.

The term operational amplifier (op-amp) was coined some years ago to describe the building blocks of analog computers; they performed integration, multiplication, subtraction, and other mathematical operations. Today, mathematical functions are largely performed by digital circuits, and we find that the widest application of the op-amp is in signal conditioning.

Op-amp basics

There are many different types of op-amps available: they're based on bipolar, JFET, and MOSFET technologies. Regardless of internal makeup, all op-amps function in a similar manner. That is, any voltage difference between the two inputs is reflected in some form at the output. If the input signals are equal, the output voltage will be zero.

In many ways, the op-amp possesses the characteristics of the ideal amplifier: infinite-input impedance, zero-output impedance, infinite bandwidth and gain, and zero noise. In fact, quantifying the ways in which an op-amp differs from the ideal amplifier is the subject of this article.

Input bias current

Ideally, an operational amplifier has infinite input resistance; realistically, it doesn't. The input transistors must have a finite bias current before they will function properly; and for current to flow there must be a finite impedance.

The value of that impedance varies depending on the type of device. Bipolar-transistor inputs consume quite a bit of current (nanoamps), and have the lowest input impedance. JFET's fare better, and MOSFET's, with their miserly picoampere input requirements, very nearly approach the ideal, with input impedances exceeding 10,000 megohms.

Input bias current is relatively independent of input voltage, and that makes measuring it easy. Input bias can be measured using the circuit shown in Fig. 1. Simply apply a voltage to the input and then read the bias currents directly from the meter.

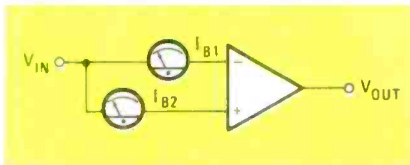


FIG. 1—MEASURE INPUT OFFSET CURRENT of each input separately by applying a common voltage to each.

Input offset current

In the ideal amplifier, operational characteristics of both inputs would be identical. In real life, though, there is always some difference between the two input transistors.

One difference is called input offset current; it's labeled I_{OS}, and is calculated as the difference between I_{B1} and I_{B2}:

$$I_{OS} = I_{B1} - I_{B2}$$

In that formula, I_{B1} is the inverting input's bias current and I_{B2} is the non-inverting input's bias current.

Actually, to obtain the true value of the bias current, the two input currents must be averaged:

$$I_{OS} = (I_{B1} + I_{B2}) / 2$$

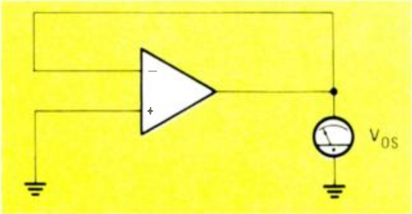


FIG. 2—MEASURE INPUT OFFSET VOLTAGE by grounding the non-inverting input. With a bipolar power supply, the inverting input is held at virtual ground by the op-amp's output.

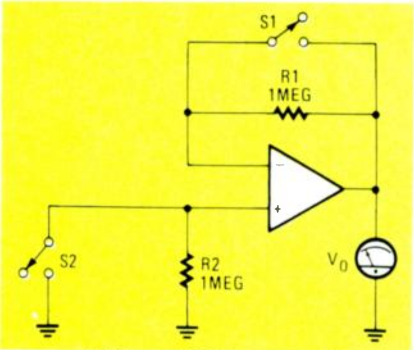


FIG. 3—OFFSET VOLTAGE AND CURRENTS may be measured with this circuit, depending on the state of S1 and S2.

As before, I_{B1} refers to the inverting input and I_{B2} refers to the non-inverting input.

Input offset voltage

Another result of mismatched differential-amplifier inputs is offset voltage, V_{OS}. The error is reflected as a voltage at the output when both of the inputs are grounded.

A test circuit for measuring V_{OS} is shown in Fig. 2. Looking at the circuit, however, we see that only one input is directly tied to ground; the other is at a *virtual ground*. That concept is important in understanding how op-amps work. One of the basic properties of an ideal op-amp is that its differential input voltage is zero. Hence, when the non-inverting input is tied low, the sum of the voltages at the inverting input must also be zero, or at ground. That sum consists of the input signal and the feedback.

In an ideal device, with no input signal there would be no output. But, in a real device mismatched base-to-emitter (or gate-to-source, as the case may be) voltages between the input transistors will cause a DC offset voltage at the output. Input offset voltage is defined as the voltage necessary at the inputs to bring the output to zero.

Returning to Fig. 2, in that configuration, the op-amp attempts to balance its inputs by forcing the inverting input voltage high or low to compensate for any voltage difference between the two inputs. The result (V_{OS}) can be read directly with a voltmeter.

A circuit that allows you to measure all three characteristics (offset voltage and the input bias currents) is shown in Fig. 3. V_{OS} is measured by closing both switches S1 and S2. The value is read directly from the meter.

The input bias currents are measured by alternately opening each switch. With S1 open and S2 closed, we read an offset voltage that we'll call V1. Closing S1 and opening S2 gives us V2. I_{B1} is calculated from this formula:

$$I_{B1} = V1 - V_{OS}$$

I_{B2} is calculated in a similar manner:

$$IB2 = V2 - V_{OS}$$

The calculated bias currents are displayed in microamps. I_B is derived by averaging I_{B1} and I_{B2}; I_{OS} is the difference between them (in microamps).

Variations in offset parameters

The values of I_{OS} and V_{OS} are dependent on the gains of the input transistors. Generally, the lower the gain of a transistor, the less the offset parameter will be affected. Lower input gains, however, tend to increase input bias currents, and that reduces input impedance. In addition, open-loop gain of an amplifier also has a pronounced effect on the overall influence of the offset parameters.

Temperature effects

Offset differences can be affected greatly by temperature change. It's not the offset itself that is the culprit. Offset voltage and current can be compensated for in a given circuit simply by using trimmer potentiometers.

The problem is in the tracking of the offset values. Even "perfectly" matched transistors have slightly different temperature curves. The differences arise because of slight temperature gradations within the semiconductor substrate of the device itself, and because of impurities that are introduced during the manufacture of the device.

The result is that one transistor's leakage current or offset voltage can change at a rate that is faster than that of the other transistor, thereby creating mis-matched outputs. For example, an offset voltage that is handily compensated for at room temperature may prove too much to handle at 125°F. The overall effect is called temperature drift.

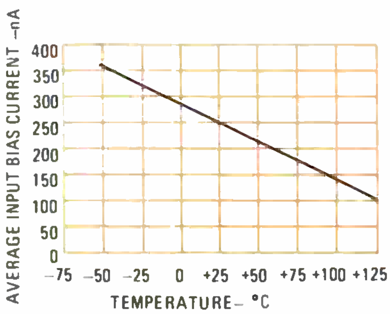


FIG. 4—INPUT BIAS CURRENT is a function of temperature.

All op-amps are designed to minimize the effects of temperature drift—some just do it better than others. The effects of temperature drift can be measured using the circuit shown in Fig. 3. With both S1 and S2 closed, record the value of V_{OS} at room temperature. Now raise the temperature and note how V_{OS} changes. With properly tracking transistors, the change should be slight, if it's noticeable at all. The table in Fig. 4 shows how input bias current of a typical device varies with changes in temperature.

Temperature drift is normally expressed numerically in terms of temperature coefficient. The temperature coefficient of offset voltage is calculated from this formula:

$$\text{TEMPERATURE COEFFICIENT} = \frac{\delta V_{OS}}{\delta T}$$

and the temperature coefficient of offset current is calculated:

$$\text{TEMPERATURE COEFFICIENT} = \frac{\delta I_{OS}}{\delta T}$$

Temperature coefficient usually is specified in units of microvolts per degree Centigrade ($\mu V/°C$) and in units of microamps, nanoamps, or picoamps per degree Centigrade ($\mu A/°C$, $nA/°C$, or $pA/°C$), depending on the type of device.

Remember, we're not concerned with the actual change in input bias—it will fluctuate. What concerns us is that the individual input currents change together. The smaller the temperature coefficient, the better the two inputs track.

Aging

Another factor that influences how an op-amp works is aging. Op-amp characteristics have a tendency to change as operating time increases. Change is especially noticeable in the offset values. Devices that change much can be inconvenient to use, because the equipment in which they're used may have to calibrated fairly often.

Aging is accelerated with continuous exposure to elevated temperatures—such as that frequently experienced inside an enclosure. Fortunately, aging is not a continuous process. Most changes take place within the first 100 hours of operation. Once stabilized, you can expect an amplifier to perform very reliably over the next 10,000 hours or so.

In fact, forced aging is one way to increase life and enhance the performance of a part, as we shall learn later on in this series.

Common-mode rejection ratio

Another consequence of imperfect matching is common-mode voltage. Normally you see it expressed as the common-mode rejection ratio. The common-mode rejection ratio is an important—yet often misunderstood—parameter.

In an ideal amplifier, both inputs—inverting and non-inverting—amplify equally. So, theoretically, identical signals to both inputs should be expected to result in zero output.

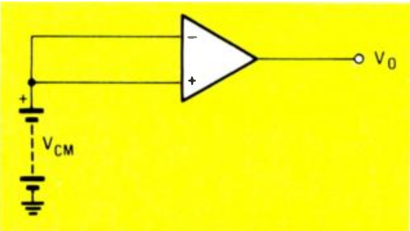


FIG. 5—SLIGHT GAIN DIFFERENCES between the inverting and the non-inverting inputs produce an erroneous output voltage. The ratio of the output voltage to the common-mode input voltage is the common-mode rejection ratio.

Unfortunately, that's not the case. Due to slight differences in the gain between the two inputs, some output voltage usually is produced for a common-mode input voltage.

Common mode refers to the fact that both inputs are referenced to the same identical source. One way to produce a common-mode condition is to tie the two inputs together and bias them above ground, as illustrated in Fig. 5. The output voltage of that circuit is the common-mode error voltage.

Common-mode error voltage, however, is not a useful parameter. It changes according to the gain of the amplifier and common-mode input voltage. Consequently, it is an ambiguous measurement that is dependent upon circuit conditions and does not relate easily to another amplifier for comparison.

The *ratio* between the common-mode output voltage and the common-mode input voltage, on the other hand, is a constant quantity. It is expressed by the term common-mode rejection ratio—or—more usually— CMRR.

Simply put, CMRR is the amount of resistance the amplifier offers to producing erroneous common-mode outputs. The higher the value of the CMRR, the smaller the common-mode error.

Although common-mode rejection ratio is a DC quantity, it is more easily measured with an AC source. The circuit shown in Fig. 6 shows one way of determining CMRR.

In that circuit, the common-mode input signal is derived from a 1-kHz signal generator that drives two identical resistors, R1 and R2. The common-mode voltage is developed across the series combination R2 and R3. The 50K potentiometer (R7) compensates for input offset voltage.

To use the test circuit, with no AC input, adjust the 50K potentiometer until the DC voltmeter reads 0 volts. Now set the signal generator to 1 kHz with an amplitude of 1 volt. Measure the AC output voltage, and calculate CMRR as follows:

$$CMRR = 100 / V_O$$

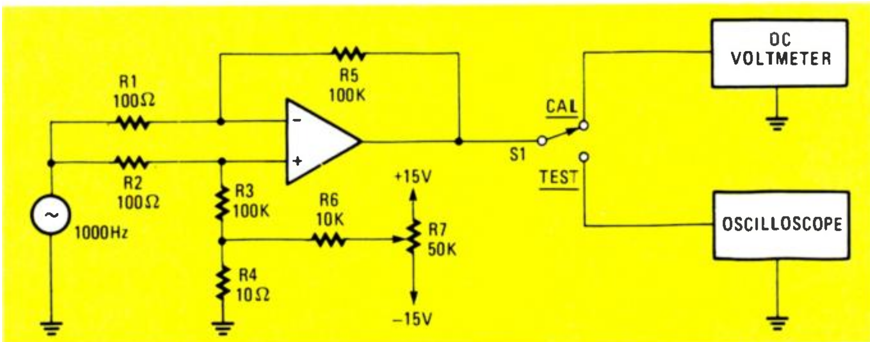


FIG. 6—TO MEASURE CMRR, use this test setup. With the 1000-Hz source off, adjust R7 for zero volts DC. Next, apply the test signal and measure the output with the oscilloscope. Last, calculate CMRR as discussed in the text.

V_O is the AC voltage measured by the scope.

CMRR numbers are rather large, and that makes them difficult to work with. So CMRR is most-often expressed in decibels. The conversion is easily made using this equation:

$$CMRR\ dB = 20 \log (100 / V_O)$$

Monolithic operational amplifiers typically display CMRR values on the order of about 100 dB.

Be aware that the value of CMRR is valid only over a limited common-mode input range. Fortunately, that range is rather large, usually exceeding 90% of the power-supply voltage. Input voltages outside the limit often produce very high common-mode output voltages. However, errors due to CMRR only arise in applications in which the amplifier is used in the non-inverting or the differential configuration. Inverting amplifiers tend to cancel out CMRR error.

Unfortunately, that's all we have room for this time. In the next installment we'll continue our discussion of op-amp test procedures, and we'll show a special circuit for measuring various op-amp characteristics. **R-E**

R-E ROBOT

continued from page 60

- Are the contents of RSPEED between −10 and +10 or is the switch released?

You will see the three IF/THEN statements that test those cases.

Assuming motion is going to take place, RFWD (right-motor forward) or RREV (right-motor reverse) is executed. Those words enable the appropriate relay and disable the other so that motion takes place in the desired direction. It is important to notice that the relays are set before the motor is enabled. That prevents inrush currents from damaging the relay.

Next, the value of RSPEED is fetched and used as an argument to SPEED-CONV. SPEED-CONV takes an argument (from the stack) that is proportional to the speed and returns an argument (on the stack) that is the period of the motor control-frequency generator. Speed may vary from 0 to 128. When reverse motion has been requested, the speed argument is negative. We could NEGATE it before passing it to SPEED-CONV; however, it is more convenient to have SPEED-CONV use the ABS operator to make sure all arguments are positive.

As shown in lines 5 and 9 of screen 36, the output of SPEED-CONV is passed directly to RMTR-PERIOD (right-motor period), which sets the frequency of the 8253 control element in the right motor's phase-locked loop circuit on the control board.

Last, ENABLE-RIGHT (again shown in lines 5 and 9 of screen 36) electronically enables the high-power output stage of the motor-control circuit. If no motion is going to take place, STOP-RIGHT is executed. The code is identical for the left motor; it is shown in screen 35.

Moving on to screen 34, INTERROGATE reads channel 0 of the analog-to-digital converter, converts it to the −128 to +127 range and stores the result in both LSPEED and RSPEED. Next channel 1 (sideways displacement) is read. That result is converted to the ±128 range and passed as an argument to DIFF-CONVERT on the stack. The result is duplicated (DUP), one copy negated (NEGATE) and used to alter the contents of LSPEED and RSPEED.

Low-level control

Now we start getting into the low-level words shown in screen 33. Those words could be rewritten many different ways and the overall program would still function the same, but the response would change. For example, SPEED-CONV could be rewritten to provide a greater range of motion, limit the top speed, or provide a constant speed.

continued on page 86

USING TRIACS AND SCR's

SCR's and Triacs are high-speed, solid-state switches used in AC- and DC-power control applications. Find out how they work and practical applications for them.

RAY MARSTON

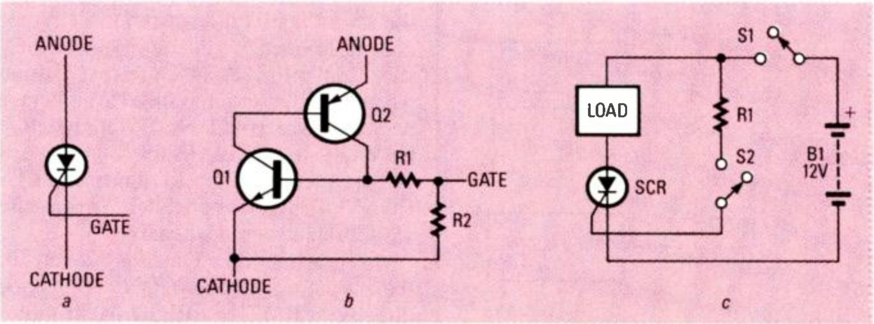


FIG. 1—THE SCR'S SYMBOL (a) and equivalent circuit (b) are shown here. In (c) is shown how the SCR can control a DC-operated load.

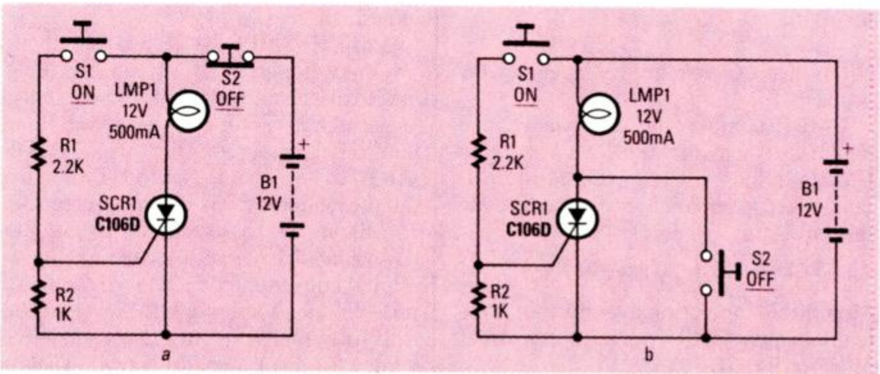


FIG. 2—PRACTICAL SCR CONTROL CIRCUITS are shown in (a) and (b). Both circuits have separate on and off switches.

SCR'S AND TRIACS ARE BOTH MEMBERS OF the thyristor family. The SCR (*S*ilicon *C*ontrolled *R*ectifier), is a four-layer (PNPN) sandwich of semiconductor material. Its symbol is shown in Fig. 1-*a*, and its equivalent circuit is shown in Fig. 1-*b*. The circuit is a complementary regenerative switch in which Q1's base current is derived from the collector of Q2, whose base current is in turn derived from the collector of Q1. We'll discuss that regenerative action in much greater detail shortly.

Figure 1-*c* shows the basic circuit that lets you use the SCR as a switch in a DC power-control circuit. The circuit works as follows. When power is first applied to the SCR by closing S1, the SCR is "blocked" and appears as an open-circuit switch. That action can be understood by examining Fig. 1-*b*, where it can be seen that, because Q1's base is shorted to the cathode terminal via R1 and R2, Q1 is cut off through lack of base current. Therefore Q1 feeds no base current to Q2, so it is also cut off. Because both transistors are cut off, only a small amount of leakage current can flow between the anode and cathode terminals.

The SCR can be turned on (made to act like a closed switch or a forward-biased silicon rectifier) simply by applying a positive gate current. That can be done in the circuit shown in Fig. 1-*c* simply by closing S2. The gate current thus applied causes the SCR to switch on very quickly.

If the externally applied gate current is sufficiently large, it will cause Q1 to start to turn on. As it does, its collector current feeds Q2's base, thereby causing Q2 to turn on and feed additional base current to Q1, and so on. The way in which the two transistors feed each other is called regenerative switching.

After the SCR turns on and is conducting significant forward current, the SCR stays on even if gate drive is subsequently removed. Therefore, only a brief pulse of gate current will be needed to latch the SCR on. Note in Fig. 1-*b* that, because of the presence of R1 and R2, the SCR cannot be turned off by shorting or reverse-biasing the gate-cathode terminals of the device.

In fact, the only way of turning the SCR off is by momentarily reducing its anode current below a value known as the *minimum holding current* (I_H). So it follows that turn-off occurs automatically in an AC circuit near the zero-crossing point at the end of each half cycle.

A finite amount of internal capacitance exists between anode and gate of an SCR. Consequently, if a sharply rising voltage is applied to the anode, that internal capacitance can cause part of the rising voltage to break through to the gate and thus trigger the SCR on. That "rate effect" turn-on can be caused by supply-line transients, and it sometimes occurs at the moment when power is applied to the SCR's anode. Rate-effect problems can usually be overcome by wiring a simple RC "snubber" network between the anode and the cathode of an SCR; the network limits the rate-of-rise to a safe value.

Those are the basic characteristics of the SCR. As you can see, it's a fairly simple device. When choosing an SCR for a particular application, you'll usually find that the most-significant parameters are the peak voltage and current ratings, the gate sensitivity rating, and (occasionally) the value of the device's minimum holding current. Table 1 lists basic specifications of several popular SCR's.

Basic DC circuits

SCR's are used in both AC and DC power-control circuits; let's look first at some basic DC circuits. Two ways of using the SCR as a pushbutton-controlled power switch are shown in Fig. 2. In both circuits, the SCR (and thereby the lamp) can be latched on by momentarily closing S1, thereby feeding gate drive to the SCR via R1. In both circuits the gate is tied to

TABLE 1—POPULAR SCR'S

Device	PIV	Current rms/average	V_{GT} (max)	I_{GT} (max)	I_H (max)
C106D	400V	4A/2.5A	0.8V	0.2mA	3mA
2N3525	400V	5A/3.2A	2V	15mA	20mA
BT109	500V	6.5A/4A	2V	15mA	3mA
IR122A	100V	8A/5A	1.5V	25mA	30mA
IR122D	400V	8A/5A	1.5V	25mA	30mA
C116D	400V	8A/5A	1.5V	20mA	35mA
C126M	600V	12A/7.5A	1.5V	30mA	35mA

the cathode via R2 to improve stability of the circuit.

Of course, after the SCR turns on, it can be turned off again only by momentarily reducing anode current below the device's I_H value. In Fig. 2-*a* the SCR is turned off by momentarily opening S2; in Fig. 2-*b* that is done by using S2 to short the anode and cathode terminals of the SCR momentarily.

Figure 3 shows another way of turning the SCR off. Here, after the device turns on, C1 charges up to almost the full supply voltage via R3 and the anode of the SCR. When S2 is subsequently closed, it clamps the positive end of C1 to ground, and the charge on C1 forces the anode of the SCR to swing negative momentarily,

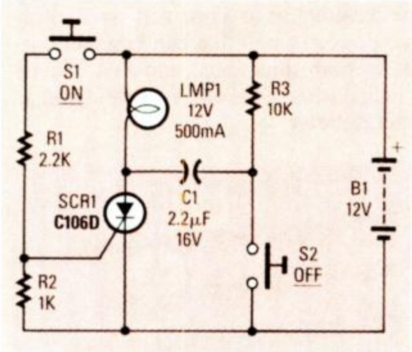


FIG. 3—CAPACITOR TURN-OFF CIRCUIT: C1 charges via R3 so that its right side is positive. When S2 is closed, C1 dumps its charge into the SCR (which is oppositely polarized), thereby turning it off.

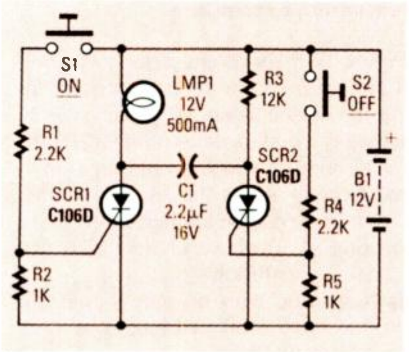


FIG. 4—ANOTHER CAPACITOR TURN-OFF circuit uses a second SCR (SCR2) to control charge dumping by C1.

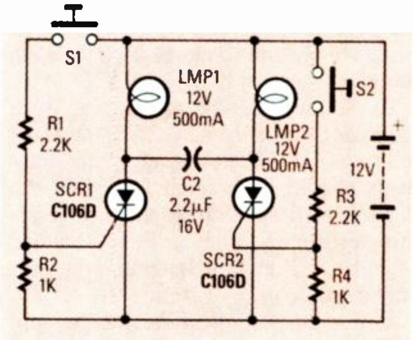


FIG. 5—A BISTABLE LATCH (or flip-flop) can be built from two SCR's.

thereby reverse-biasing the SCR and causing it to turn off. The capacitor's charge bleeds away rapidly, but it has to hold the SCR's anode negative for only a few microseconds to ensure turn-off. Note that C1 must be a non-polarized type.

A variation of the capacitor turn-off circuit is shown in Fig. 4. A slave SCR (SCR2) replaces the turn-off switch (S2) in Fig. 3. The master SCR (SCR1) is turned off by briefly turning on SCR2 via S2. The slave SCR turns off after S2 is released, because the anode current provided by R3 is lower than SCR2's holding current.

Figure 5 shows how the previous circuit can be modified so that it acts as a bistable latch (flip-flop) that drives two independent lamps. To understand how it works, assume first that SCR1 is on and SCR2 is off, so that C1 is fully charged, with its LMP2 end positive. The state of the circuit can be changed by pressing S2. As SCR2 turns on, it turns SCR1 off capacitively via its anode. Capacitor C1 then recharges in the opposite manner (i. e., the left end is now positive). The state of the circuit can be changed again by pressing S1, thus driving SCR1 on by way of its gate, and driving SCR2 off capacitively via its anode.

The DC circuits that we have looked at so far have all used simple resistive loads (lamps), and they have inevitably produced a self-latching action in the SCR's. The circuit shown in Fig. 6, however, shows a simple DC alarm that drives a

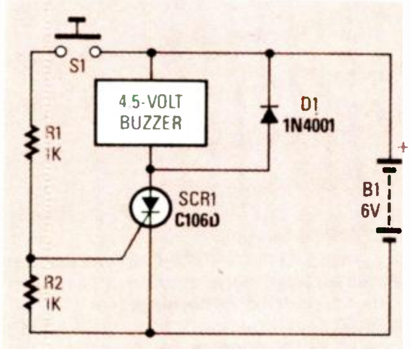


FIG. 6—A BUZZER (or other self-interrupting device) can be used to build an SCR power controller that remains on only so long as S1 is pressed.

"self-interrupting" load, such as a bell or a buzzer. That circuit provides a non-latching action.

When a self-interrupting device is connected to a voltage source, a current flows through a built-in solenoid via a pair of contacts. That current induces a magnetic field in the solenoid, and it causes a striker to fly outwards and open the contacts, thereby causing the current to fall to zero and the magnetic field to collapse. After the field collapses, the striker releases and the contacts close again, so current is again applied to the solenoid. That oscillatory action will repeat *ad infinitum*, as long as power is applied to the circuit.

The point is that that type of load functions as a switch that repeatedly opens and closes. When a load of that sort is connected to the Fig. 6 circuit, therefore, the circuit does not latch in the normal way, so the alarm operates only as long as S1 is closed. Because of the inductive nature of that type of load, a damping diode (D1) must be wired across it.

The circuit can be modified to provide a self-latching action simply by wiring a 470Ω resistor in parallel with the alarm, as shown in Fig. 7. The circuit latches because the anode current of the SCR does not fall to zero when the alarm self-interrupts, but to a value that is deter-

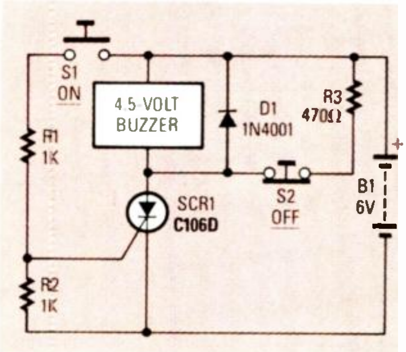


FIG. 7—ADDING A RESISTOR (R3) to the previous circuit allows you it to latch on. Turn it off by pressing S2.

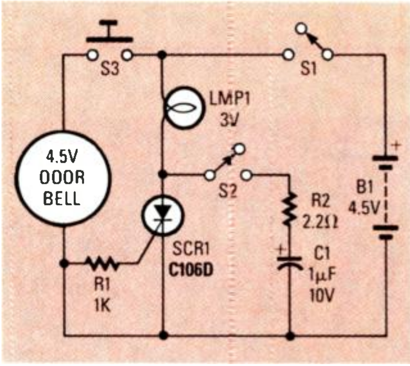


FIG. 8—RATE-EFFECT TURN-ON: Note that the SCR has no input signal connected directly to its gate. Closing S1 does not trigger the SCR, but closing S3 does. However, by filtering the spikes generated by the doorbell (by closing S2), the SCR once again will not turn on.

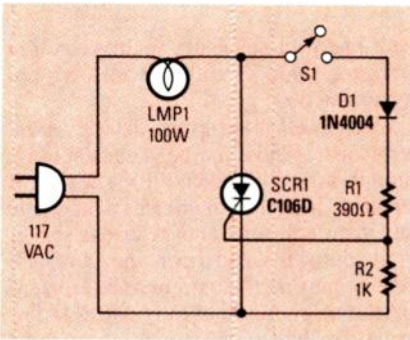


FIG. 9—AC POWER-CONTROL CIRCUIT: Close S1 to apply power to the load. After opening S1, the circuit will de-energize at the next zero crossing of the AC signal. Power is only delivered to the load during positive half-cycles.

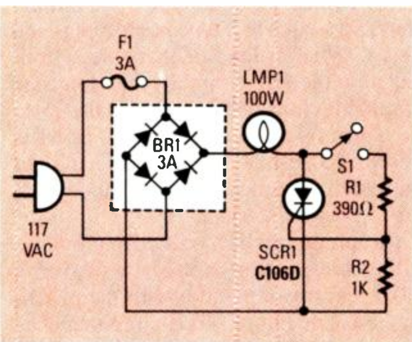


FIG. 10—FULLWAVE POWER-CONTROL CIRCUIT: Power will be delivered to the load during each AC half-cycle.

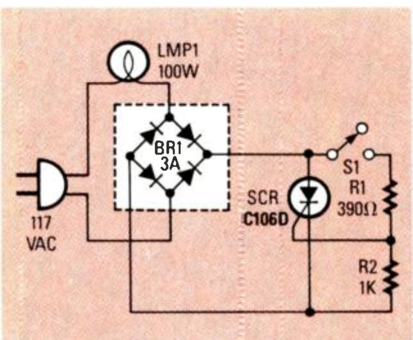


FIG. 11—ALTERNATE FULLWAVE power-control circuit places the load in series with the AC side of the bridge, rather than the DC side, as in the previous figure.

mined by the value of R3. The circuit can be unlatched by pressing S2, thereby enabling the anode current to fall to zero when the alarm self-interrupts.

To complete our discussion of DC SCR circuits, Fig. 8 shows a circuit that can be used to demonstrate the rate-effect turn-on of the SCR, and a method of suppressing rate-effect turn-on. In that circuit the SCR uses a 3-volt lamp as its anode load, and it is connected to the 4.5-volt battery supply via S1. In addition, a 4.5-volt doorbell can be connected across the supply via S3; the doorbell allows transient modulation to be applied to the supply line, and thereby to the anode of SCR1. That modulation can cause rate-effect turn-on of the SCR, which has a critical rate-of-rise value of 20 volts/μs. The snubber formed by R2 and C1 can be used to defeat rate-effect turn-on by closing S2.

To demonstrate the rate-effect, open S2, close S1, and then close S3 so that the bell rings. The resulting supply line transients should be enough to trigger the SCR and turn the lamp on; if not, wire a 1-ohm resistor in series with the battery. After the SCR and the lamp turn on, they can be turned off by opening S1.

To demonstrate the effect of the suppresser network, close S2 and S1, and then operate the doorbell via S3. The resistance of the lamp (in combination with R2) acts with C1 as a smoothing network that reduces the rate-of-rise of the anode modulation signal, thereby protecting the SCR against false triggering. The reason that R2 is wired in series with C1 is to limit the capacitor's discharge current to a safe value when the SCR triggers on a legitimate signal.

Basic AC circuits

Figure 9 shows a basic halfwave on/off circuit driving a 100-watt lamp from the AC power line. With S1 open, no gate drive is applied to the circuit, so the SCR and the lamp are off. When S1 is closed, during a negative half-cycle, the SCR is reverse-biased, and gate signals are inhibited by D1, so the SCR is off. On a positive half-cycle, however, the full available line voltage is applied to the gate via the lamp, D1, and R1.

Shortly after the start of the half-cycle, sufficient voltage is available to trigger the SCR, so it turns on. As it does, its anode voltage falls to near zero, thus removing the gate drive, but the SCR remains self-latched for the duration of the half-cycle. The SCR automatically turns off again when the half-cycle ends and anode current falls to zero.

That circuit provides halfwave operation only. Figures 10 and 11 show two ways of obtaining fullwave operation. In those circuits, the AC is converted to unsmoothed DC via a bridge rectifier, and the rough DC is applied to the SCR. With S1 open the SCR is off, so zero current flows through the bridge and the load. When S1 is closed, however, the SCR is driven on shortly after the start of each half-cycle of rough DC, so power is applied to the load during both half-cycles.

As the SCR goes on in each half-cycle, gate drive is removed automatically, but the SCR stays latched on for the duration of the half-cycle. The SCR switches off at the end of each half-cycle as its anode current falls to zero, so power is removed from the load when S1 is opened.

In the Fig. 10 circuit the load is connected to the DC side of the bridge. A fuse must be placed on the AC side of the bridge to protect against a possible short in the bridge. However, in the Fig. 11 circuit, the load is placed on the AC side of the bridge. No fuse is needed in that circuit because the load itself will limit currents to a safe value in the event of a bridge failure. You may, however, wish to include a fuse anyway, to protect against a possible load failure.

A pair of SCR's can be wired in inverse parallel (anode to cathode and cathode to anode) to provide fullwave power control without using a bridge rectifier. However, a far more effective way of obtaining fullwave power control is to use a Triac rather than a pair of SCR's.

Basic Triac theory

You can think of a Triac as two conventional SCR's connected in inverse parallel, arranged so that they share a single gate terminal. The Triac acts as a solid-state power switch that can conduct current in both directions, and that can be switched from off to on by a gate signal of either polarity.

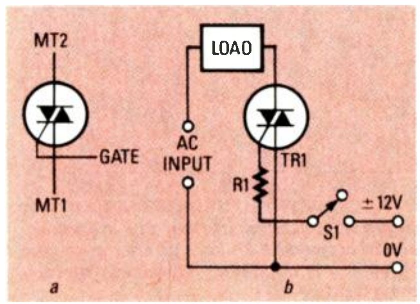


FIG. 12—THE TRIAC'S symbol (a) and basic control circuit (b) are shown here.

Figure 12-*a* shows the Triac's symbol, and Fig. 12-*b* shows the basic circuit for using the device as an AC power switch. The load is wired in series with the Triac's main terminals, and the combination is wired directly across the AC power line. DC gate drive can be applied to the Triac by closing S1. The basic characteristics of the Triac are as follows.

1. Normally, with no gate signal applied, the Triac is off and functions as an open-circuit switch.

2. If MT2 is appreciably positive or negative with respect to MT1, the Triac

TABLE 2—POPULAR TRIAC'S

Device	PIV	Current rms	V_{GT} (max)	I_{GT} (max)	I_H (max)
C206D	400V	3A	2V	5mA	30mA
2N6073	400V	4A	2.5V	30mA	70mA
C226D	400V	8A	2.5V	50mA	60mA
SC146D	400V	10A	2.5V	50mA	75mA
TIC246D	400V	15A	2.5V	50mA	50mA

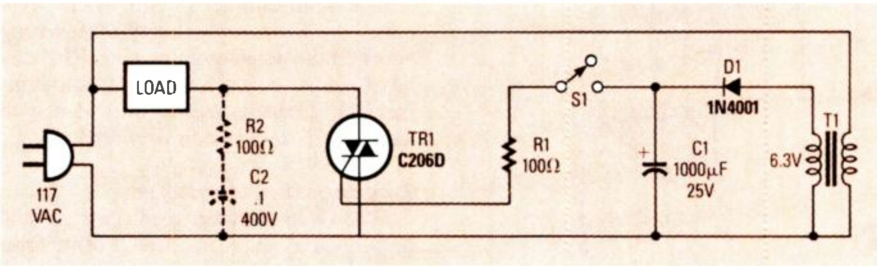


FIG. 13—STEP-DOWN TRANSFORMER T1 provides a low-voltage DC signal for triggering the Triac. The optional R2-C2 network can be used to suppress RFI.

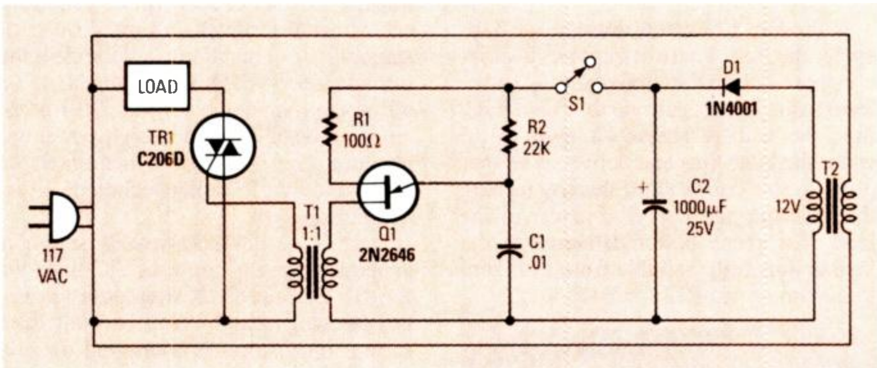


FIG. 14—THE CONTROL CIRCUIT connected to the secondary of T2 causes UJT Q1 to oscillate at about 50 Hz. The secondary circuit is isolated from the primary circuit here, unlike the previous figure.

can be turned on by applying a brief pulse to the gate of the Triac. The device takes only a few microseconds to turn on. A saturation potential of one or two volts is developed across the Triac in the on state. After the Triac turns on, it self-latches and remains on for as long as main-terminal current continues to flow.

3. After the Triac self-latches, it can only be turned off again by reducing its main-terminal current below a minimum holding value. When the Triac is used as an AC power switch therefore, turn-off occurs automatically at the zero-crossing point at the end of each half-cycle, as main-terminal currents fall to zero.

4. The Triac can be turned on by either a positive or a negative gate signal, irrespective of the polarities of the main-terminal voltages. The device thus has four possible triggering modes or "quadrants." With current flowing through MT2 in either the positive or the negative direction, gate current can be either positive or negative. The differences among the four modes are primarily that the device's gate sensitivity is greater when both MT2 current and gate current are the same (positive or negative).

5. Triacs can handle very high surge currents. Typically, a device with a 10-amp (rms) rating may be able to handle a single-cycle non-repetitive 60-Hz surge current of 100 amps.

Table 2 shows basic specifications for several popular Triacs. The information presented there should be sufficient to help you to select a Triac for many applications. With the basics in mind, let's move on and look at practical ways of using the Triac.

Basic Triac circuits

Figure 13 shows the circuit of a simple DC-triggered Triac power switch, in which the DC supply is derived via step-down transformer T1. When S1 is open, no current flows to the gate of the Triac, so it remains off. When S1 is closed, however, gate drive is applied to the Triac, so it and the load turn on. If an inductive load (a motor, for example) is used in this circuit, the R2-C2 snubber network must be wired in place as indicated to prevent false rate-effect triggering.

In that circuit the negative side of the DC supply is connected directly to one side of the AC power line, so it's live and therefore dangerous. That snag can be overcome in the UJT-triggered isolated-input circuit shown in Fig. 14. In that circuit, as long as S1 is closed, the UJT oscillates at several kHz and thus delivers roughly 50 trigger pulses to the gate of the Triac (via isolation pulse transformer T1) during each half-cycle of the AC power line waveform. Consequently, the Triac is fired by the first trigger pulse occurring in each half-cycle; that pulse occurs within a few degrees of the start of the half-cycle. The point is that the Triac is on almost constantly while S1 is closed, so virtually full power is applied to the load.

Figure 15 shows how the Triac can be used as a simple line switch with line-derived triggering. With S1 open, no gate drive is applied, so the Triac and the lamp are off. Suppose, however, that S1 is closed. At the start of each half-cycle the Triac is off, so voltage is applied to the gate via the lamp and R1. Shortly after the start of the half-cycle, enough drive is available to trigger the Triac, so it and the lamp go on. As the Triac goes on and self-latches, it saturates and thereby removes gate drive until the start of the next half-cycle, thus minimizing R1's dissipation.

The circuit in Fig. 15 can be modified to

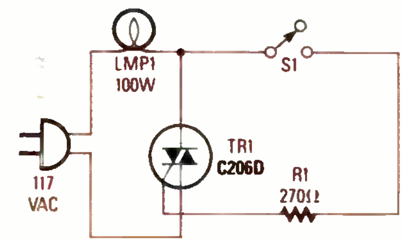


FIG. 15—SIMPLEST TRIAC CIRCUIT is composed of a switch, a resistor, and a Triac.

provide halfwave operation by placing a diode between S1 and R1. The diode's polarity will determine whether the Triac will trigger on positive or negative half cycles.

Phase-triggered power control

The SCR and Triac circuits that we have looked at so far have all been designed to give a simple on off form of power control. The same devices can, however, easily be used to give fully-variable power control in AC circuits. In fact, they're widely used in lamp dimmers and electric-motor speed controllers, etc. The most widely used system of AC variable-power control is known as the *phase triggering* system.

In a basic phase-triggering circuit that uses a Triac as the power-control element, rather than triggering the Triac directly from the AC power line, it is triggered via a variable phase-delay network that is connected between the power line and the gate of the Triac.

Phase delay works like this. If the Triac

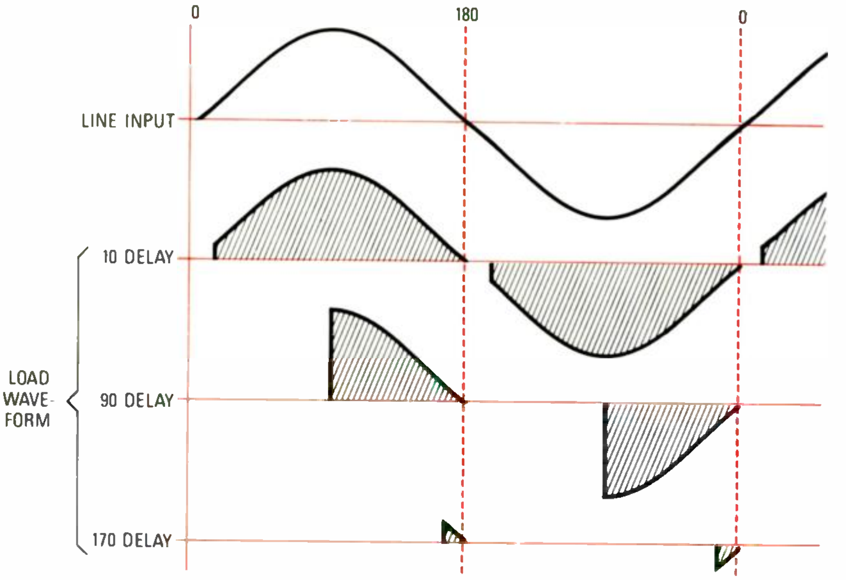


FIG. 16—A VARIABLE AMOUNT OF POWER is delivered to the load depending on when in the AC cycle the device is triggered.

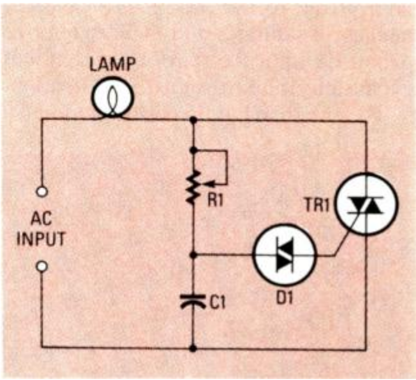


FIG. 17—A DIAC and an RC network provide a simple means of implementing a variable phase-delay network.

is triggered 10° after the start of each half-cycle, most of the power of that half-cycle is fed to the load. On the other hand, if the Triac is triggered 90° after the start of each half-cycle, only half the available power is fed to the load. Finally, if the Triac is triggered 170° after the start of each half-cycle, only a very small part of the available power is fed to the load. Figure 16 illustrates how phase delay works.

There are several methods of obtaining variable phase-delay triggering, but the three most popular ones are to use a line-synchronized UJT, a special-purpose IC, or a Diac/RC network. The latter approach is shown in Fig. 17.

The Diac can be regarded as a bilateral threshold switch. When connected across a voltage source, it functions as a high impedance until the applied voltage rises to about 35 volts, at which point it switches into a low-impedance state and remains there until the applied voltage falls to about 30 volts, at which point it reverts to the high impedance state. It stays in that state until the applied voltage rises to 35 volts, at which point the process repeats.

In the Fig. 17 circuit, during each half-cycle, the R1-C1 network applies a variably phase-delayed version of the AC waveform to the Triac's gate via the Diac. Each time the voltage across C1 rises to 35 volts, the Diac fires and delivers a trigger pulse to the Triac's gate, thereby turning the Triac on and applying power to the load. The mean power delivered to the load is thus fully variable from near-zero to maximum via R1.

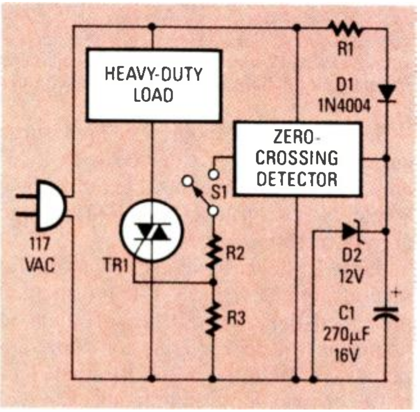


FIG. 18—A ZERO-CROSSING DETECTOR can be used to trigger a triac when power is at a minimum, thereby reducing RFI to a minimum.

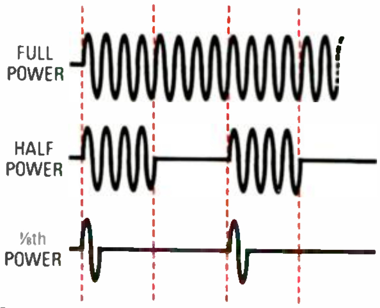


FIG. 19—AN INTEGRAL NUMBER OF CYCLES are passed by the zero-crossing detector to the load.

Radio-frequency interference

Each time the Triac turns on, load current rises abruptly (in a few microseconds) from zero to a value determined by the load resistance and the instantaneous supply voltage. That transition generates RFI (*R*adio *F*requency *I*nterference). RFI is greatest when the Triac is triggered at 90°, and it is least when the Triac is triggered close to the 0° and 180° zero-crossing points of the waveform.

In a lamp-dimmer circuit where there may be considerable lengths of wiring between the Triac and the load, RFI may be offensive. So, in a practical lamp dimmer, the circuit is usually provided with an LC RFI-suppression network.

Zero-crossing techniques

When a high-power load (an electrical heater, for example) is driven from Triac circuitry, special techniques must be used to minimize RFI. Even if the Triac is used as a simple on-off switch in such applications, a "spurt" of RFI will be generated each time the switch is turned on; that spurt will be of maximum amplitude if the instantaneous phase delay happens to be 90° at the moment of turn-on. RFI problems can be eliminated in high-power applications by using the synchronous or "zero crossing" gating technique illustrated in Fig. 18.

Here, a low-power 12-volt DC supply is generated directly from the AC lines via R1, D1, D2, and C1. A simple zero-crossing detector (which could be built from several transistors) is connected directly across the power line; it controls the passage of current from C1 to S1 in such a way that the C1 current is made available for only 5° or so on either side of each zero-crossing point of the waveform. So, if S1 is closed, a pulse of gate current is fed to the Triac at the start of each half-cycle at the point at which voltage is closest to zero. Therefore, the Triac always generates minimal RFI as it turns on.

The zero-crossing technique can be used to provide RFI-free variable power to a high-power load by replacing S1 with a variable mark/space-ratio waveform generator, so that a variable and integral number of complete AC cycles are alternately fed (or not fed) to the load.

Figure 19 illustrates the basic principle, in which the total integral period is equal to eight power-line cycles. If power is alternately switched on for four cycles and off for four cycles, the mean load power is equal to half the total available power, and if the power is on for one cycle and off for seven cycles, the mean power is equal to only one eighth of the total available power.

That concludes our discussion of the SCR and the Triac. In this article we've seen many practical example circuits. Now it's up to you to put them to use in your own designs. **R-E**

PC SERVICE

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

We can't tell you exactly how long an exposure time you will need as it depends on many factors but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it.

Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

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500-B Bi-County Blvd.
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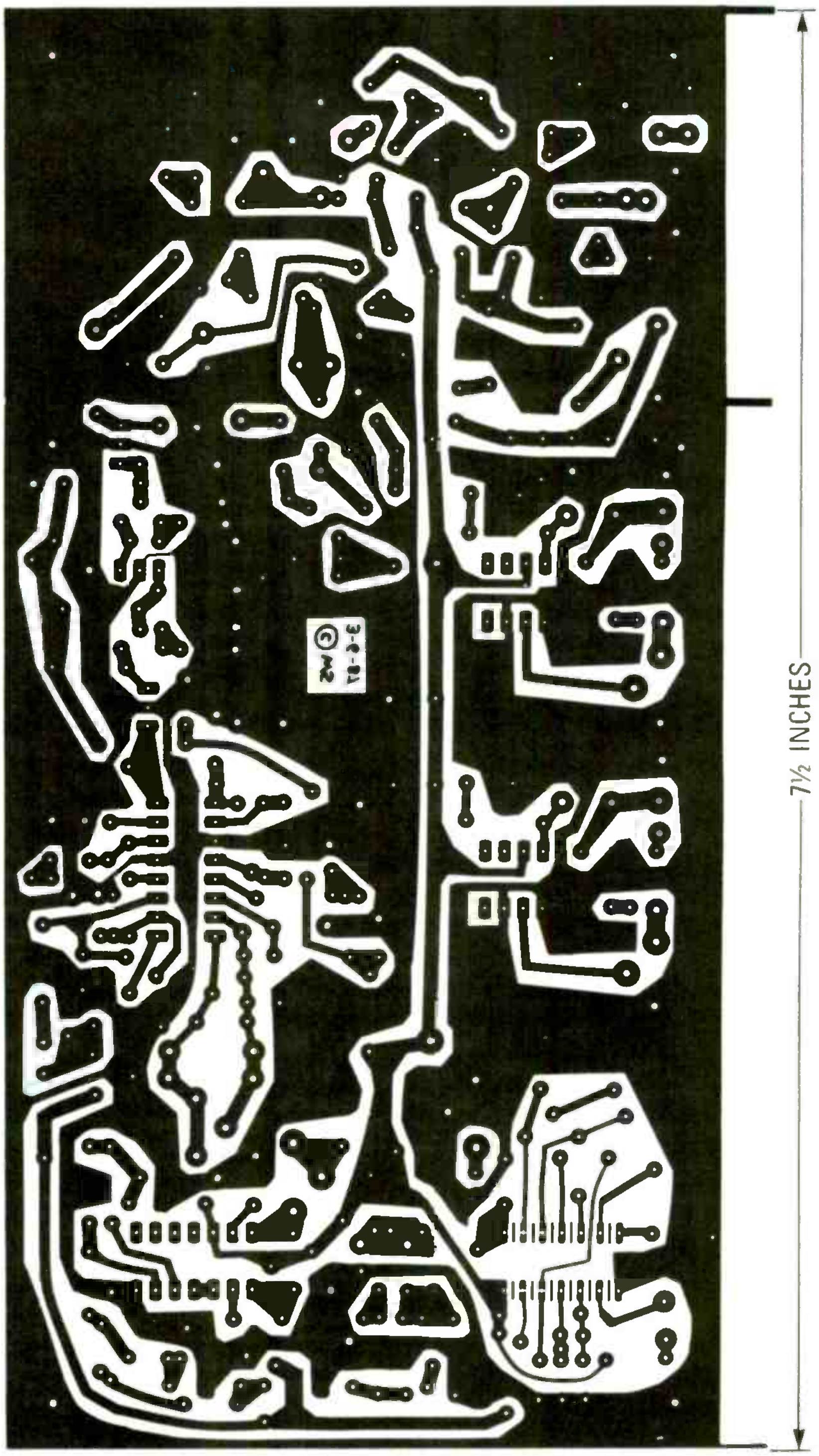

TUNE IN THE HIDDEN WORLD of FM radio with the SCA receiver. Most of the components mount on this single-sided PC board.

PC SERVICE

VOL. 4 NO. 9 SEPT. 1987

COMPUTER DIGEST

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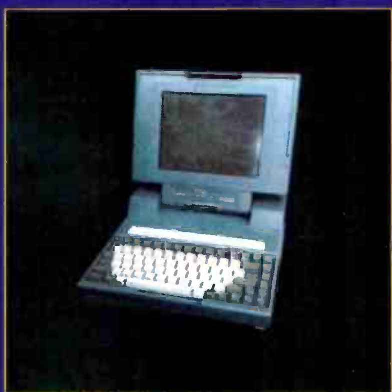
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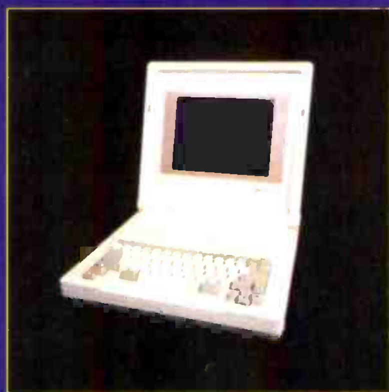
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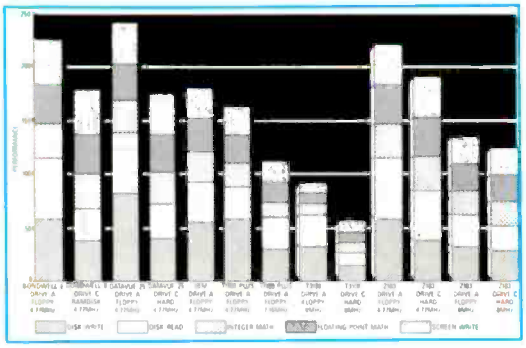
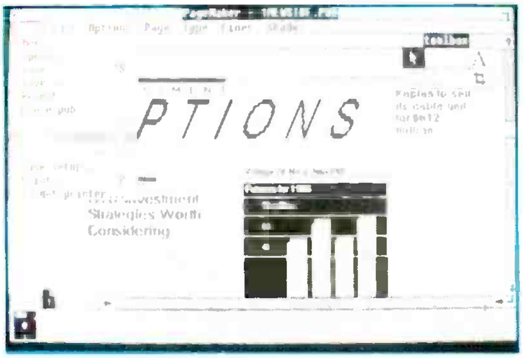
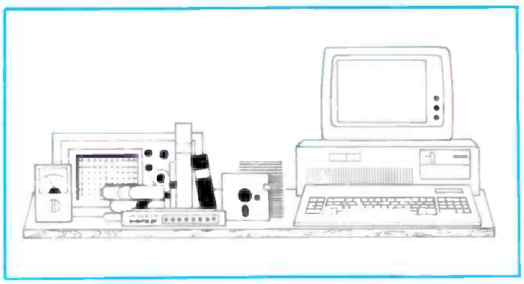
CONTENTS SEPTEMBER 1987

Vol. 4 No. 9







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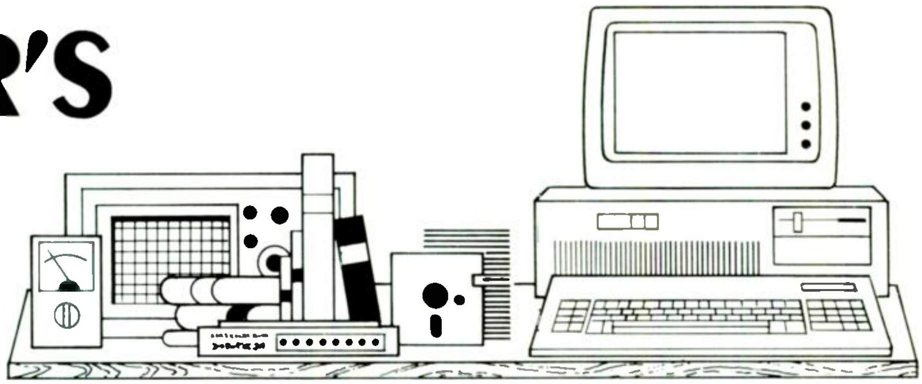


REPORT FROM ATLANTA

Comdex, held twice a year, is the Computer Dealer's Exposition. As the name suggests, dealers get together with manufacturers, distributors, independent developers, and members of the press to show hardware and software, discuss trends, make deals, eat, drink, and generally be merry. Because of current market conditions (good and getting better), things were merry indeed this year for those involved in the business end of things. For those interested in the technical end of things, there was less cause for celebration.

By number of booths and square feet of floor space, clone manufacturers, distributors, and dealers easily were the most prevalent exhibitors. Most have products that are virtually indistinguishable from one another; very few have products that offer truly advanced features.

The graphics explosion

There is a great deal of activity in microcomputer graphics these days. There are two reasons for that activity: falling hardware prices (of RAM and custom video chips), and the increasing popularity of graphically oriented software (CAD, drawing and painting programs, and desktop publishing).

Just before Comdex, NEC introduced two new members of the MultiSync line: the MultiSync Plus and the MultiSync XL, with pixel resolutions of 960 × 720 and 1024 × 768, respectively. All MultiSync monitors are compatible with *all* members of the PC family (PC, XT, AT, and PS/2), as well as the Macintosh II. Other monitor manufacturers scrambled to clone the original MultiSync, and will probably do so again with the new models.

Complementing the new high-res monitors, many companies introduced new high-res adapter cards, most of which provide EGA compatibility, as well as proprietary new modes with resolutions approaching the one-mega-pixel (1024 × 1024) level, often with 16 or more colors. Even though the new boards provide backward compatibility with at least some previous standards (CGA, MDA, Hercules, and EGA), the companies manufacturing those boards must write special drivers for the new non-standard high-resolution modes to be useful, and a special driver must be written for each program that is to use a high-res mode. Inevitably, only the most popular programs (AutoCAD, PageMaker, etc.) will be supported.

The problem is that those video supersets are all incompatible with each other at the software level, even though a multiscanning monitor can save users from premature hardware obsolescence. Therefore the user may suffer if he buys a video adapter to run a specific application and later on discovers he wants to run other applications that are not supported.

Overall, IBM must take the blame for the situation, because it has been so slow to introduce better adapters, not to mention truly serviceable ones (technical problems prevent an EGA from being used in a multitasking environment, for example). In fact, in many ways VGA is really only IBM's attempt to catch up to what other companies have been doing (640 × 480 lines × 16 colors) for some time.

Eventually Microsoft Windows may be what saves PC users from the lack of a true video standard. Programs written to run under Windows are supposed to be ignorant of the underlying hardware, so that, after installation, boards from Tseng Labs, Number Nine Computer, STB, or anyone else will run programs in the best possible resolution, etc. Of course, few programs currently take advantage of the device-independence that Windows can provide. And you need an AT-class machine to run Windows at an acceptable rate. However, hardware prices are falling, and Windows applications programs are starting to appear, most of which are graphically oriented (drawing and painting programs, desktop publishing, and CAD).

PS/2

As you might expect, there was much discussion of the impact that the new PS/2 line will have. Right now, it seems that, outside of the corporate market, PS/2 will have little impact. The clone manufacturers clearly aren't worried. In fact, some industry analysts think that IBM may have made a huge marketing blunder, and may even now be offending the corporate market that is its real bread and butter. The reason is that it is currently impossible to buy "classic" machines (XT's and AT's) in quantity. IBM seems to be saying: "Go PS/2 or go elsewhere." It will be interesting to see which way corporate America does go.

We attended a technical seminar on the internal workings of OS/2, and it's clear that the operating system has the kind of facilities that power users have been clamoring for. However, there are two big problems associated with OS/2: it's not available, and it won't let programs written for DOS 2.x and 3.x make use of the new facilities (multi-tasking and megabytes of memory).

Under the 80286 version of OS/2, you'll be able to run only a single DOS application at a time, and it will be a good two years before OS/2-specific programs start to appear. And there's not even a projected release date for a version of OS/2 that takes full advantage of the 80386. However, '386 control programs are available from other vendors (Quarterdeck Systems, The Software Link) right now that will allow you to run multiple DOS sessions. But those control programs are not true operating systems, so you don't get true multi-tasking, wherein several parts of the same program can run simultaneously, pass messages to each other and to other programs, etc.

It may turn out that OS/2 is the only major program written for the 80286! The editor of a leading computer publication claimed to have seen half a dozen 386-specific applications, and none for the 286. And one analyst stated that anyone writing for the '286 must be as brain-damaged as the chip itself!

Regardless, an intermediate class of programs (called "Family" applications by IBM) will be able to run on both OS/2 and DOS 3.3 (or higher—Microsoft has hinted rather strongly that DOS 3.30 will not be the final release), because the new versions of DOS can provide a pseudo-multi-tasking environment. However, whether any serious software will be written to conform to the "Family" API (Application Program Interface) remains to be seen.

Optical storage

Several companies (Panasonic and Kodak being among the more prominent) are displaying advanced optical-storage systems. Almost no one was talking about CD-ROM, except one pundit (and president of a company that is a major developer of programming languages) who predicted that CD-ROM will go the route of bubble memory—nowhere. The reason? Actually, there are two: (1) Because read/write optical technology is what's really needed, and (2) the difficulty of mastering (not physically producing) a CD-ROM product.

CASE

You've probably heard of CAE—Computer Aided Engineering. CASE is the corresponding discipline for software types—Computer Aided Software Engineering. It's not a big field yet, but several companies are getting involved in it commercially. The idea behind CASE is to provide an organized way of developing really large software projects that involve many people and an evolving set of design goals. CASE provides a set of graphically-oriented tools for developing design specs, translating them into simulated screens, generating code, obtaining user feedback, incorporating that feedback into the design specs, and so on. By linking all steps by computer, it is hoped that the design cycle can be shortened considerably, thereby allowing evolving user needs to influence design decisions before they are finalized. If you're just starting out and are interested in the design of large systems, check out CASE—it's the wave of the future.

KEYBOARD DEMO PROGRAM UPDATE

Dave Schubert of The Casino PCBoard BBS (609-652-6030, 300/1200/2400/9600 baud, 8/1/N) was kind enough to send the following corrections and enhancements to the keyboard demo program that appeared in the article "From Keypress to Scan Code" on page 70 of the July issue. Merge the following three lines into the program:

```
235 IF INSTR(NOPRINT$,A$)=0 THEN
      PRINT A$;" "; ELSE PRINT "  ";
1210 XBOX=19:YBOX=4:XLEN=7
      :YLEN=3
3090 DATA F1,F2,F3,F4,F5,F6,F7,F8,F9,
      F10,F11,F12
```

In line 235, note that there is a single space in the quoted string following A$, and that there are two spaces in the quoted string at the end of the line. The revised line 1210 prevents the right edge of the box from being erased, and the revised line 3090 provides for displaying the F11- and F12-key labels when using an enhanced (101-key) keyboard. Thanks, Dave. ◆CD◆

THE BROOKLYN BRIDGE AND DIREC-LINK

Life is simple with one computer. But with two or more, life gets complex, if not chaotic. The problem is this: How do you share files (not to mention printers, disk drives, and other peripherals) among several machines?

More than one fortune has been made in the computer business attempting to answer that question, but, until recently, those answers were too expensive for the hobbyist and small business.

However, things are changing rapidly, especially in the MS DOS world. Now there are many inexpensive ways to connect two (and sometimes more) computers together.

Two solutions to the problem of *connectivity* (chief buzzword of 1987) are simple hardware/software combinations that allow two PC's (desktop, laptop, or transportable) to communicate via the RS-232 port at speeds about ten times what we normally consider maximum.

There are least half a dozen "bridge" solutions on the market now; we'll discuss two of the original and more useful of them. One (Direc-Link) emphasizes ease of set up and use; the other (The Brooklyn Bridge) sacrifices easy set-up to provide greater power. We'll examine the latter first.

The Brooklyn Bridge

White Crane Systems, Inc (Suite 151, 6889 Peachtree Ind Blvd., Norcross, GA 30092, 404-454-7911) developed and markets The Brooklyn Bridge ($129.95). You use it by adding a special driver program to the CONFIG.SYS file of the master machine—the one at whose keyboard you'll be typing. For each device (disk drive(s), printer(s), clock, RAM disk, modem—any legitimate DOS device) you wish to access from the remote machine, you add an additional driver (to the master's CONFIG.SYS)

Next you run a program called BRIDGE.COM at the remote machine. Then you reboot the master. At that point you can access the devices for which you have installed drivers. A few examples should make the process clear.

Suppose you want to access the hard disk of a PC from a dual-drive laptop. First add BRIDGE.DEV to the laptop's CONFIG.SYS. BRIDGE.DEV takes care of the first few block (disk) devices—usually two floppies and a hard disk. Then run BRIDGE.COM on the PC. Now you can access the PC's floppy disks and hard disk (as drives C:, D:, and E:) from the laptop with all normal DOS commands (COPY, CD, RD, DEL, etc.).

To access a second hard disk or a RAM disk, you'd add another driver, REMOTE.DEV. To access both the hard disk and the RAM disk, you'd add two REMOTE.DEV files. White Crane also includes a program (DEVICES.COM) that displays the devices installed on your machine and the appropriate line to add to the CONFIG.SYS file.

You can also access serial and parallel ports, and the system clock, by installing a driver for each device. For example, to access the PC's parallel printer from the laptop, you'd add the following line to the laptop's CONFIG.SYS file:

```
device = remote.dev lpt1
```

Depending on your system, the installation procedure can be tricky. For example, at the office I use a single-drive clone with four network drives, a RAM disk, and serial and parallel ports. To access that machine from a laptop, the following lines were added to the laptop's CONFIG.SYS:

```
device = bridge.dev 1
device = remote.dev 2
device = remote.dev 3
device = remote.dev lpt1
```

The first line provides access to the clone's floppy disks; the second, to the network "drives" (C:, D:, E:, F:); the third, to the RAM disk (G:); and the fourth, to the printer attached to the clone. Adding those four drivers consumed only about 3.4K of available memory.

Direc-Link

Sold by the Micro-Z company (4 Santa Bella Road, Rolling Hills Estates, CA 90274, 213-377-1640) for $59.50 plus $5 for shipping, Direc-Link takes the point-and-shoot approach to file transfer. You needn't mess with device drivers, just connect the two machines electrically and run DLINK.COM on both machines. Each machine then displays a diagram of the tree structure of the current disk. You can change disks within the program.

To send a file (or a group of files), use the cursor keys to move the highlight bar to the desired subdirectory. By pressing F9, a list of all files in that subdirectory is displayed. You can mark all files, individual files, or groups of files specified with wildcard characters (* and ?) for transfer. Then press Return to send a file. You have the option of changing the name during transfer. Press Ctrl-Return to send all marked files with no further intervention.

One nice feature is that you can control both machines from the keyboard of one. Pressing Scrl-Lock toggles between local and remote modes. However, in remote mode you must watch the screen of the remote machine; each screen only displays information related to the machine it is connected to.

Another nice feature is that you can set up "script files" to automate transfer of files. You might use a such a file to transfer a salesman's orders on a daily basis.

The first time you run the program, it creates and saves a map of your directory structure. Then, next time you run the program, it loads the map without re-scanning, which saves time. You can rescan at any time if your directory structure has changed, and the program does remind you to do so each time you start it up.

We had a problem using Direc-Link on our network. It would not display the directory structure of or allow us access to read-only network "drives." However, Micro-Z promptly provided a three-byte patch that allowed us proper access.

Hands-on

Brooklyn Bridge proved invaluable in setting up our laptop machines for the reviews elsewhere in this issue. Using the XCOPY command of DOS 3.2, we were able to copy entire branch structures (directories with subdirectories) directly to the hard disks of the Toshiba and Zenith laptops—all with a single command. However, after initial set-up, we found Direc-Link easier to use, especially for transferring just one or two files.

By the way, you can copy an entire subdirectory using Direc-Link, but you must first create it on the target machine. In addition, Direc-Link works only with a single directory at a time—it will not copy branch structures in the point-and-shoot mode, although it can copy multiple directories in script-file mode.

All in all, we'd be hard pressed to say that either program is superior to the other. Brooklyn Bridge allows more flexibility, but it can be difficult to install, and its manual is not well done. Direc-Link is so intuitive that you don't need to read the manual at all. In addition, the cables supplied with Direc-Link had shielded shells and were of better construction than those supplied with The Brooklyn Bridge.

A cable is included with The Brooklyn Bridge for the purchase price; you must buy cables separately to use Direc-Link. Micro-Z sells a set (one with 25-pin females on both ends, and two 9-pin female to 25-pin males) for $32.50. So even with extra cost, Direc-Link is less expensive than The Brooklyn Bridge. For do-it-yourselfers, the manuals of both products include cable wiring diagrams. Both Micro-Z and White Crane Systems include all software on both 5¼ and 3½ format diskettes. R-E

HEATHKIT SK-203 PRINTER BUFFER

Some computer accessories are spoilers. After using one, you're spoiled—you can't imagine how you got along without it, and you can't imagine how you'd survive if you had to give it up.

Case in point: the printer buffer. Sure, you can pick up a software spooler from most BBS's, but software spoolers have problems of their own. First, they use up valuable system RAM that might be put to better use loading a spelling checker's dictionary or more data in a CAD or desktop publishing program. Second, an external device can perform tricks that are simply impossible with a software spooler.

The problem with an external buffer—until recently—has only been one of cost. However, Heathkit's new SK-203 printer buffer (shown in Fig. 1) retails for $199.95, and, although you can buy a cheaper buffer, you can't buy one with the capabilities of the SK-203 for anything near that price.

How it works

Like any printer buffer, the SK-203 has a chunk of memory that sits between your computer and your printer. The base model comes with 64K, which can be updraded to a total of 512K. The remaining features discussed below are included as standard equipment

The SK-203 has both serial and parallel inputs and outputs, and there are four ways they may be configured: (1) The parallel input can be routed to the parallel output and the serial input can be routed to the serial output; (2) Inputs and output can be

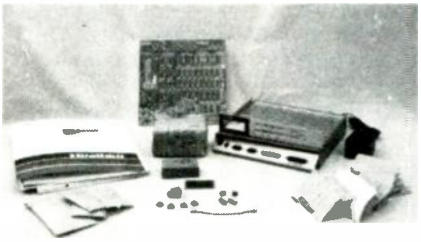


FIG. 1

FIG. 2

crossed—serial-to-parallel and parallel-to-serial; (3) Both inputs can be routed to the parallel output; (4) Both inputs can be routed to the serial output. A front-panel-mounted pushbutton, Swap (shown in Fig. 1), allows limited re-configuration without re-setting DIP switches.

The SK-203 maintains file integrity in all configurations. In other words, when two inputs are fed simultaneously (regardless of output destination), the received files are kept separate. Likewise, when multiple files are received sequentially (regardless of input), they are kept separate.

Pushbutton control

Front-panel controls include two sets (one each for the serial and parallel inputs) of Clear, Copy, P. Print (see below), Restart, and Offline pushbuttons, and the single Swap pushbutton. (See Fig. 2) Three seven-segment LED's continuously monitor the amount of free memory remaining.

Pressing Clear removes all files (received from the associated input port) from memory. Pressing Copy allows you to increment (to a maximum of 99) and decrement the number of copies of a file that will be printed. The file that will be copied is the next one received.

The P. Print switch allows you to interrupt a job in progress and send a file to the buffer that will be printed immediately Restart allows you to begin printing the current file from the beginning, in case of printer malfunction (end of ribbon, out of paper, etc.). Restart also allows you to program the timeout delay that the buffer uses to determine when one file ends and another begins. The default is six seconds. Last, Offline halts output to the associated port. Incoming data continues to be buffered while the buffer is offline.

The rear panel has two 25-pin female sockets for the parallel ports, and two 9-pin (AT-style) male plugs for the serial ports. In addition, the power switch is mounted on the rear panel, and the power jack is also accessible there. A small wall-mounted transformer powers the SK-203.

Inside are three DIP switches and a dozen or so jumper blocks that allow complete control over the serial-communication parameters (150–38,400 baud, word length, stop bits, and parity), data routing, auto form feed, handshake type and polarity, and RAM-IC size (64K or 256K).

Circuit details

Controlling operation of the buffer is an HD64180 (the Z80 upgrade made by Hitachi) running at 12.288 MHz. It's interesting that the circuit contains no UART—the microprocessor's built-in port handles the serial-to-parallel conversion. All software is contained in an 8K EPROM (2764). There are a total of 34 IC's on the circuit board (if all RAM sockets are filled).

The power cube supplies a nominal nine volts DC; the RS-232 voltages are generated by an Intersil 7662, a CMOS charge pump that uses a couple of 100-µF capacitors to generate the negative RS-232 voltage.

Building it

The kit went together smoothly. The circuit board is good quality, double sided, and has silk-screened legends marking all component locations. Order of assembly is for the most part logical. Anyone with the slightest experience in electronics assembly would have no trouble building the SK-203; expect to spend eight or ten hours in doing so. Only small hand tools are required; solder is included with the kit.

The acid test

After tracking down one assembly error (a solder bridge that totally disabled the microprocessor), we put the SK-203 to work, and it has performed flawlessly.

We have two minor complaints with the unit: (1) The lack of detailed troubleshooting information, and (2) The rather disorganized configuration instructions.

In operation, the SK-203 is a fine unit We recommend it highly. R-E

PORTABLE COMPUTERS

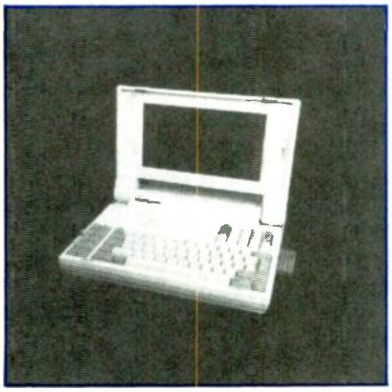
We evaluate seven portable PC compatibles.

BONDWELL 8

DATAVIEW 25

IBM PC CONVERTIBLE

JEFF HOLTZMAN, TECHNICAL EDITOR



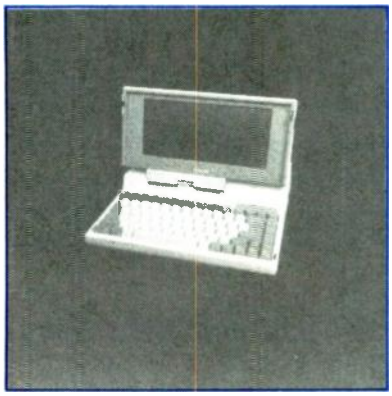
NEC MULTISPEED

For several years if you wanted to compute on-the-go, you were limited to using small machines with hard-to-read screens, small amounts of RAM, and software that was (to be charitable) serviceable, but nothing like that obtainable for a desktop machine. However, times have changed. Now you can buy machines from a number of manufacturers that run all standard PC software, in many cases faster than on a standard desktop machine.

For purposes of this review we examined seven machines with list prices ranging from $1400 to $4200. (See Table 1.) Screen displays of most battery-powered portables still can't measure up to those of a real CRT, but some (Zenith's and NEC's, for example) have improved dramatically. And the screens of several non-battery-powered portables (from Toshiba and Datavue) are every bit as good as a CRT.

To obtain objective measures of performance, we ran special benchmark tests to determine each machine's speed. To obtain some idea of each machine's subjective appeal, we had several persons evaluate each machine. All our findings are presented in tabular form below, along with comments by our reviewers.

Keyboard layouts of all reviewed machines are shown in Figs. 1–7. Of the battery-powered machines, only the NEC has a separate numeric/cursor pad, and only it has full-size function keys arrayed at the left



TOSHIBA T1100 PLUS

TOSHIBA T3100

ZENITH Z183

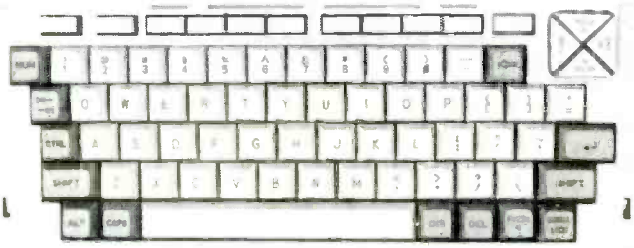


FIG. 1—Bondwell 8

FIG. 2—DatuVue 25

FIG. 3—IBM PC Convertible

FIG. 4—NEC MultiSpeed

TABLE 1—BASIC FEATURES

Machine	Price	RAM	Floppy Disk	Hard Disk
Bondwell 8	$1399	512K	1	----
Datavue 25	$3495	768K	1	10 Meg
IBM PC Convertible	$1695*	640K	2	----
NEC MultiSpeed	$2195	640K	2	----
Toshiba T1100 Plus	$2099	640K	2	----
Toshiba T3100	$4199	640K	1	10 Meg
Zenith Z183	$3499	640K	1	10 Meg

* Does not include serial/parallel adapter ($80)

side of the machine. (The DataVue's detachable keyboard also has a separate pad containing the numeric/cursor keys.) The other battery-powered machines embed the numeric pad in the main typing area; you must press a special key (usually labeled "FN") simultaneously with the desired key to access the embedded functions. In addition, most of those machines provide a separate cursor-control pad, operation of which will make you appreciate a full-size keyboard.

To get started with our evaluations, first we'll give an overview of each machine's features, and then we'll examine the objective ratings. Next we'll discuss each machine in detail, and wrap up by making recommendations.

Overview

The Bondwell, DataVue, and IBM machines all use 8088 or 80C88 microprocessors, run at 4.77 MHz, and have no turbo mode. The MultiSpeed and the T1100 Plus use full 16-bit processors and have turbo modes. The Zenith machine uses an 80C88, but provides a turbo mode. Last, the Toshiba T3100 uses an 80286 running at 8 MHz, which gives it the raw processing power of an AT-class machine (and a corresponding price tag).

All reviewed machines except, ironically, IBM's come with a version of DOS; various machines run various versions of DOS, ranging from 2.11 to 3.20. Some machines include software: BASIC, system utilities (SideKick, SuperKey), or applications programs. Table 2 shows the software included with each machine.

Type of screen (and readability) varied tremendously. The T3100 and the DataVue 25 have radiant screens that are visible under just about any lighting condition. However, those machines run only on AC power. The IBM Convertible, the MultiSpeed, and the T1100 Plus have LCD screens without backlighting, which makes them hard to

FIG. 5—Toshiba T1100 Plus

FIG. 6—Toshiba T3100

FIG. 7—Zenith Z183

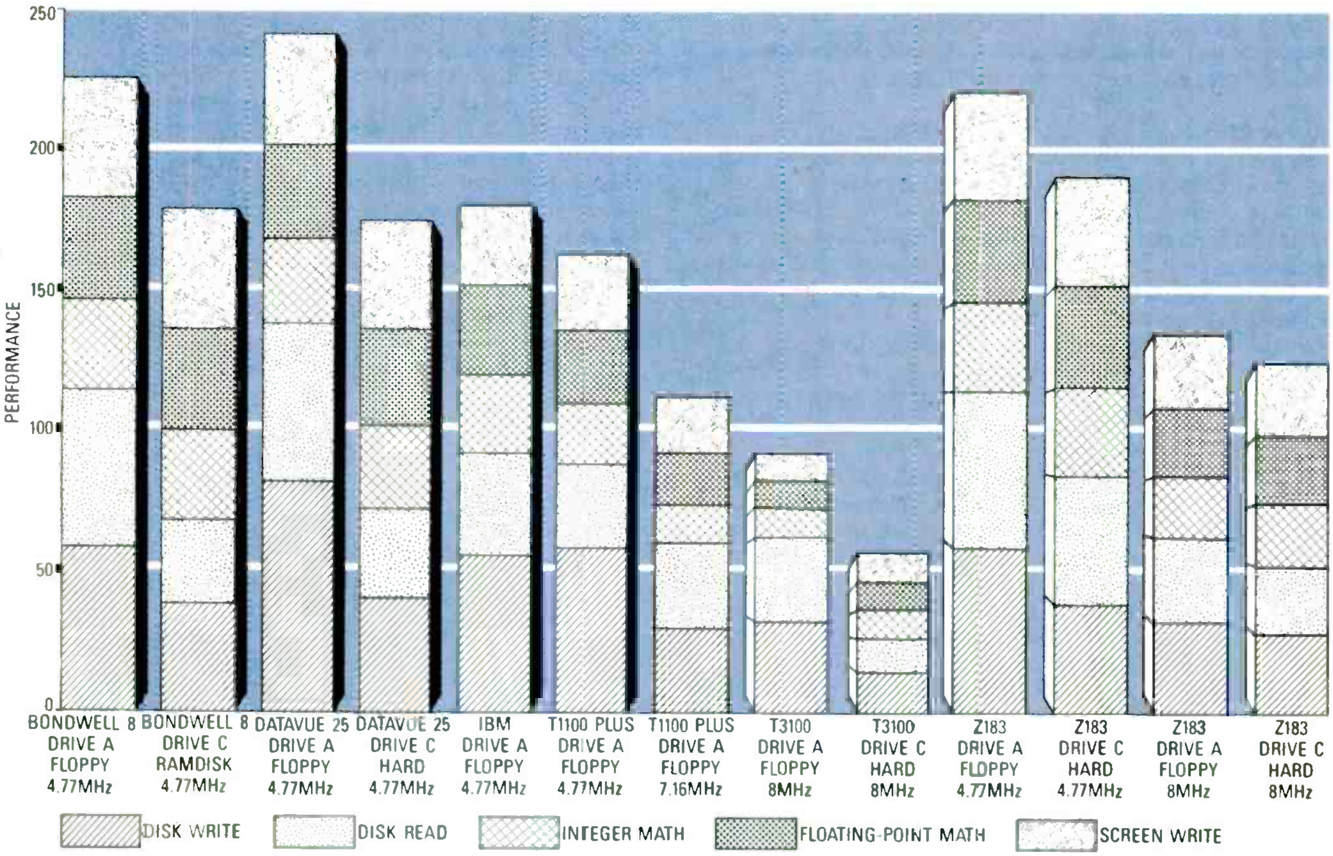


FIG. 8—Benchmark results

read, and makes their cursors hard to locate, under some lighting conditions. Their screens, however, are much more readable than those of a few years ago, so, if you haven't looked at an LCD screen for awhile, you're in for a pleasant surprise. The Bondwell has a backlit LCD screen that is more legible than the non-backlit types, but the best display (of the battery-operated machines) is provided by the Zenith.

Portable speed

Shown in Fig. 8 are the results of running five benchmark tests (similar to those used by *Byte* magazine) on each machine. The benchmarks test the speed of reading and writing sequential disk files, processing speed of both integer and floating-point math, and screen-writing speed.

No results are shown for the NEC Multispeed because the version of GW-BASIC we had in-house would not run on the Multispeed. However, the results of other benchmark programs indicate that the MultiSpeed is nearly as fast as an AT (and the T3100).

Other than the MultiSpeed, we ran all tests on each machine several times, depending on the number and type of drives, and whether the machine had a turbo mode. In addition, because the Bondwell 8 has only a single floppy-disk drive, we also ran the disk-speed benchmark on a RAM disk. (The RAM-disk program is included with the machine.)

As you can see, the Toshiba T3100 is the fastest machine by far. In fact, it was able to complete *all* tests in approximately the same amount of time it took several other machines to complete just the disk write test. Of course, the T3100 is also the most expensive of the machines we tested.

Now let's discuss each machine. Unless otherwise noted, all machines have as standard features a serial port, a parallel port, and RGB and composite-video outputs, and an external AC adapter.

TABLE 2—SOFTWARE

Machine	Dos Version	Software Included
Bondwell 8	2.11	GW-BASIC, RAM-disk, Modem8
Datavue 25	2.11	World Clock, dumb terminal
IBM PC Convertible	3.2*	Application Selector
NEC MultiSpeed	3.2	**
Toshiba T1100 Plus	3.2	Sidekick
Toshiba T3100	3.2	Sidekick, SuperKey
Zenith Z183	3.2	None

* DOS not included
** See text

Bondwell 8

At $1399, the Bondwell is the least expensive of the machines we reviewed. It's also one of the lightest, at 10.5 pounds. It has a single floppy-disk drive, a back-lit LCD screen, and a built-in 300-baud modem. The LCD's backlight can be turned off to conserve power. The machine's serial port is accessed through a non-standard nine-pin female—not male—D connector, so you may need a gender-reverser to access the serial port.

The Bondwell's screen, like that of the Toshiba T1100 Plus, is of the "squashed" variety—it has an aspect ratio of about 3:1, giving graphic images a distorted look. On the plus side, the backlighting provides contrast that is better than the non-backlit models.

Working with one drive can be inconvenient, but inclusion of the RAM-disk program partially offsets that inconvenience. However, any memory used for the RAM disk decreases the size of main memory. But that shouldn't be a problem for intended users—*not* those running large spreadsheets, databases, etc.

The machine comes with a 300-baud modem as standard equipment, and a special implementation of a public-domain communications program to operate it.

One quirk is that to format a floppy for 720K capacity, which is standard for 3½ disks, you must add "/3" to the FORMAT command. Otherwise, the disk is formatted for 360K capacity.

DataVue 25

This machine is one of two AC-only powered models we examined; the Toshiba T3100 is the other. The DataVue is the only machine we tested that comes in the "lunchbox" configuration, wherein the keyboard flips down from a vertically oriented system unit to reveal the screen. The DataVue 25 is available in a wide variety of configurations, some for very good prices, so examine the alternatives carefully.

The DataVue's screen is somewhat squashed, but it uses highly readable electroluminescent backlighting with red letters on an orange background (or vice versa). You can control screen contrast, brightness, and mode directly from the keyboard. The screen tilts through about 45°, latching in six places.

The keyboard is a lightweight battery-operated device (using two AA cells) that communicates with the main unit by infrared light. Our test unit had a maximum range of about 18 inches. To increase range, you can also connect keyboard and system unit with an optional cable.

Although the DataVue comes with a hard disk, you cannot boot from it; you must boot from a floppy and then transfer operations to the hard disk. Because DOS 2.11 is supplied with the machines, files are allocated in 8K chunks, so even a short batch file, for example, is listed in the directory as having a length of 8192 bytes. However, the hard disk has an automatic head-parking mechanism that is activated whenever the machine is turned off.

At 16 pounds, the DataVue 25 is the heaviest of the machines that we reviewed. As one of our reviewers stated, "It's portable—for Mt. T."

The documentation is well-thought-out, well-written, and well-printed. It includes a "Quick-start" section for experienced users, and more-detailed information for those needing instruction in computer and MS-DOS basics.

IBM PC Convertible

The Convertible is an odd machine that received bad publicity when it was first released. However, IBM dropped the price recently, bringing it more in line with the competition. The machine itself consists only of 640K of RAM and two floppy-disk drives. DOS is not included, nor are serial, parallel, and video ports. However, a program (called The Application Selector) is included; as shown in Fig. 9, the program is a visually oriented shell that allows users to run applications from a graphical interface. In addition, the Application Selector includes several stand-alone programs of its own, including a word processor, a telephone-list manager, a calculator, a scheduler, help screens, and various tools for formatting and copying disks. All those programs run under the Application Selector; you don't need DOS to run them. Further, the user can link his own programs to the system and run them from the main menu.

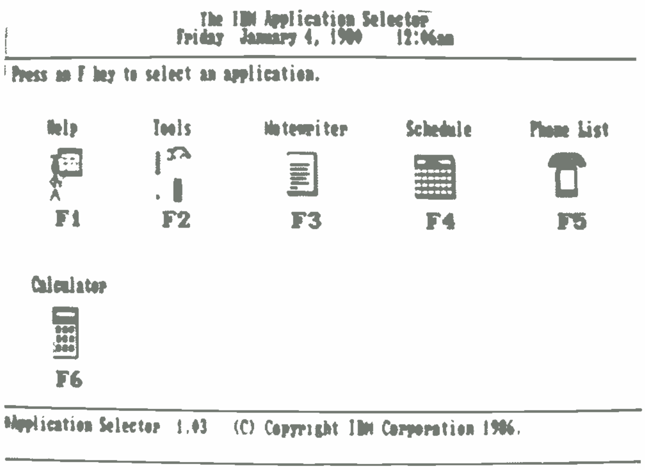


FIG. 9—IBM's application selector

The Convertible's screen is a non-backlit LCD, but it has higher contrast than all other plain LCD's we've seen. The keyboard has the best (stiffest) feel of all the portables we evaluated, but the layout has quirks of its own. (The CapsLock and Control keys are reversed, for example.)

The main unit has no provision for internal add-on hardware, but a number of modules are available that plug into the rear of the unit. (See Fig. 10.) Doing so is simple, but increases size and cost. However, for on-the-road use, the modules can be disconnected easily, thereby increasing portability.

The Convertible has a special "resume" mode that allows you to resume automatically after powering down in the middle of an application program. For example, if you're running a word-processing program and shut the power off, the next time you power up, you'll be at the same place in the same program with all your data intact.

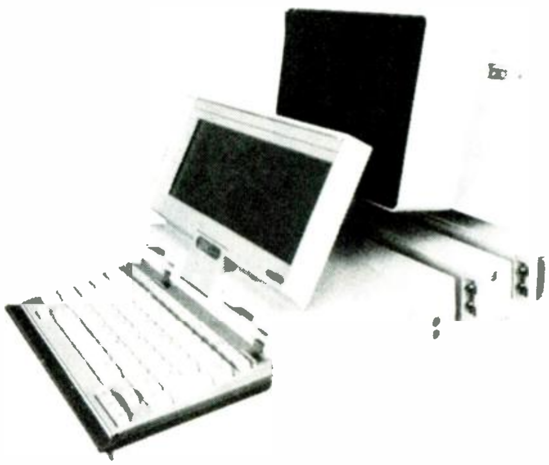


FIG. 10—IBM add-on modules

The Convertible's manual is not among the best. It is full of technical jargon ("IPL mode," for example) that tends to negate the ease of use provided by the Application Selector. The applications programs included withe the Application Selector are serviceable but limited; they are not acceptable for professional use. However, a beginner can use them for learning purposes, and graduate to more-sophisticated software when ready.

Rumors abound that IBM will introduce a new version of the Convertible with a turbo mode and a backlit screen, but, of course, those are only rumors. If the company does do so (and leaves the price alone), it will have a hot product.

NEC MultiSpeed

A fast machine with half a megabyte of ROM-based software, the MultiSpeed is highly attractive. It has a supertwist LCD screen that is eminently readable. (Supertwist screens provide higher contrast than regular screens.) Our only complaint is the fact that the friction-locked screen-tilting mechanism is difficult to adjust properly, so we usually propped the screen from the rear to obtain an acceptable reading angle.

The MultiSpeed is very fast, but it wouldn't run our benchmark program, as noted above. We noticed no other incompatibilites. Speed is switchable at the keyboard between 4.77 MHz and 9.54 MHz; the MultiSpeed uses a V30 microprocessor, NEC's version of the 8086. The V30 has a true 16-bit data bus, as opposed to the eight-bit bus of the 8088 microprocessor.

RAM has been implemented in an unusual fashion: 512K of volatile RAM, and 128K of non-volatile (battery-backed) RAM. Part or all of the latter can be configured as a RAM disk whose contents won't go away when power is removed. So, by careful configuration, you could use the MultiSpeed as a "notebook" computer in the manner of Radio Shack's low-cost non-DOS machines.

The MultiSpeed has 512K of ROM-based software, including a word processor, an outliner, a dialer, a communications program, and a set-up utility. Like that included with the IBM Convertible, the MultiSpeed's software is no match for commercial packages, but it will suffice to get a beginner started. And it can be useful on the road if you want to avoid transporting a number of floppy disks.

Toshiba T1100 Plus

Another lightweight, compact unit, the T1100 Plus compresses a fast machine in a small package. The supertwist LCD screen is readable under average lighting conditions, but the high aspect ratio (2.2:1) gives graphic images a flattened look. The keyboard's layout (which is identical to the T3100's) is not bad, but we'd prefer a stiffer feel. It's easy to add an internal modem, but the external port connectors are unprotected and are subject to damage in transit. The carrying handle is not centered, so the computer does not hang in a balanced fashion—it bumps into either your leg or external objects. Overall speed (in turbo mode) was the fastest of the machines we tested, except for the T3100 (and the MultiSpeed). Increasing the value of the T1100 Plus is the inclusion of a copy of SideKick. Documentation is excellent, for both beginners and experienced users. A separate MS DOS manual is included.

Toshiba T3100

We have no hesitation in stating that the T3100 was our favorite machine (and the most requested by our reviewers). Its gas-plasma display (shown in Fig. 11) is visible under all lighting conditions (even in a totally dark room), but also necessitates AC-only operation. The machine's speed is simply phenomenal, considering its size. The keyboard (which is identical to the T1100's) is adequate, and the hard disk is slow, even compared with the hard disk on a standard XT. But overall, the T3100 provides maximum performance in minimum space. It comes with copies of SideKick and SuperKey, and, as with the T1100 Plus, documentation is excellent.

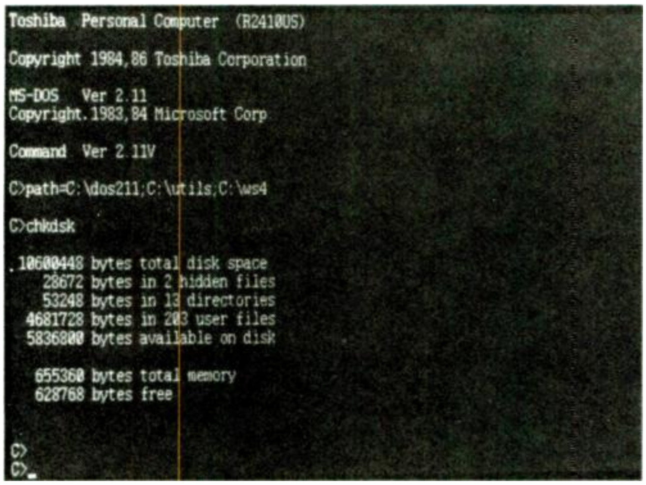


FIG. 11—Toshiba T3100's screen

Zenith Z183

More reasonably priced than the T3100 is Zenith's machine. It is a battery-powered machine that contains a hard disk, a backlit supertwist LCD screen, and a dual-speed 80C88. The machine is not the heaviest of those we tested, but it will challenge your ability to handle it and carry-on baggage simultaneously. Speed in turbo mode exceeds that of a standard PC, but the Z183 is not as fast as the Toshiba models or the MultiSpeed.

Standard equipment includes a 10-megabyte hard disk, a single 720K floppy disk, and 640K of RAM. In addition, slide controls vary screen brightness and contrast, and LED's indicate drive activity and low power.

The screen is simply wonderful, for a non-radiant type. It is legible in just about all lighting conditions, has a true aspect ratio, and is nearly as large as a nine-inch CRT. It is unquestionably the best of the battery-powered machines, and sets a standard that is sure to be emulated. Our only complaint is that at the best contrast/brightness settings for readability, the cursor becomes difficult and sometimes impossible to locate. By reducing contrast, the cursor becomes more visible, but legibility suffers.

The front-mounted carrying handle is properly centered, and a flip-down lid covers the rear-mounted ports. Slots on the left side allow insertion of a modem and a standard keyboard connector. The Z183's keyboard itself has a good feel, and a fairly good layout. The cursor pad is easier to manipulate than that on some portables. A single DIP switch sets the number of drives, turbo or standard speed (8 or 4.77 MHz), etc.

Upgrades

Since making our evaluations, several manufacturers have introduced new or enhanced models. NEC's MultiSpeed EL is identical to the standard model except for a new backlit screen that provides approximately the same readability as the Z183. The standard model can be upgraded, by the user or by NEC, for about $500; the upgrade is worthwhile if you use the machine more than occasionally.

Toshiba has introduced several new models, including a six-pound single-drive unit (with DOS 2.11 in ROM, 512K of RAM, and an 80C88), the T1000, that lists for about $1000. If the street price goes as low as usual, the T1000 will be irresistible. Toshiba also introduced a battery-powered hard-disk model, the T1200.

In early spring, President Reagan imposed trade sanctions on a number of high-tech products from Japan, and portable computers are among the hardest hit. That has led to some price increases, and to forestall further increases, several companies are considering manufacturing their machines in the U.S. NEC, for example, already has several plants employing 6000 workers in this country; gearing up for production of MultiSpeeds should not be difficult.

Recommendations

There is no single machine that is best for all persons in all circumstances. Depending on your needs and budget, one machine may be more suitable than another. Note that our tables include list prices, which vary from time to time, and which many dealers discount by 30% and even more. Shop around.

For flat-out performance, the T3100 is far and away the best machine. It's also the most expensive, and it requires AC power. If you need a battery-powered portable with a hard disk, then the Z183 is the way to go. Or, if you don't need the hard disk, the Z181 may be suitable; it's a dual-floppy cousin of the Z183.

For the budget shopper, the Bondwell 8 (or possibly the new T1000) is suitable. The IBM Convertible is a solidly built machine, and it includes "starter" software that may suffice students and beginners for some time. It also has a full range of accessories available, and the "resume" mode is a great convenience.

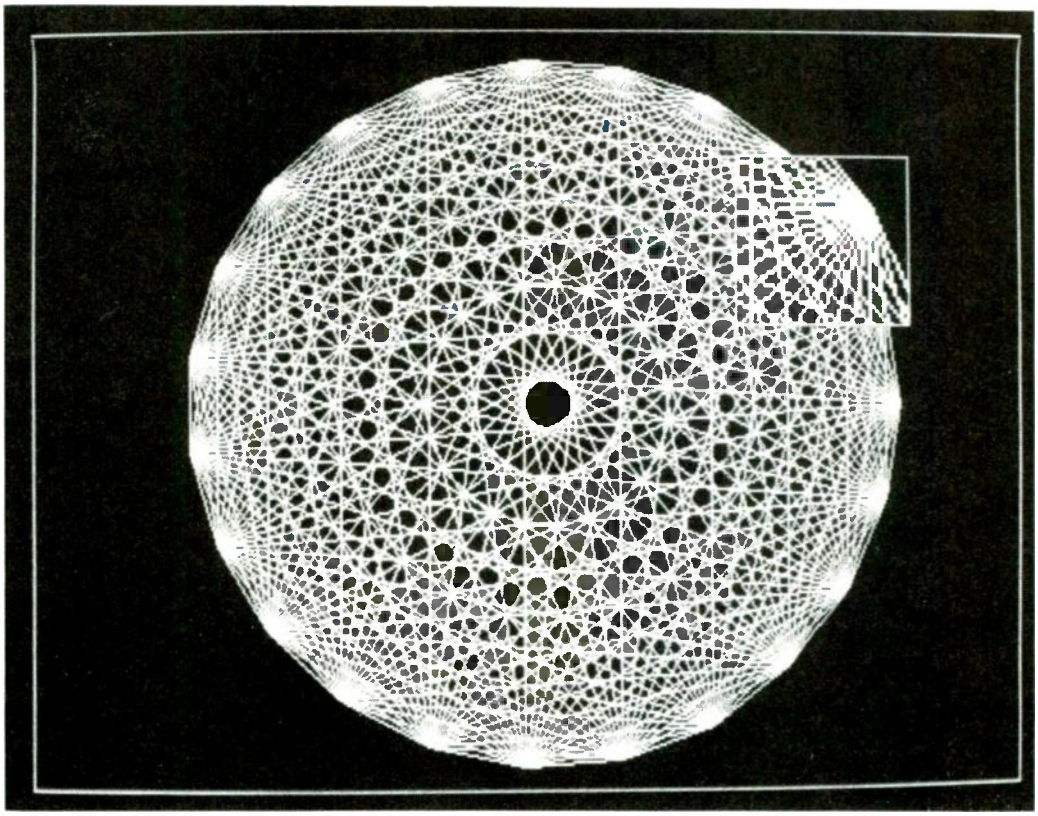
For best overall balance of power and price, you must choose between the T1100 Plus and the MultiSpeed. And due to the MultiSpeed's higher clock speed, the 128K of non-volatile RAM, and the ROM-based software, it represents the best overall value.

Credits

Our thanks to the manufacturers who generously supplied machines for review: Bondwell (47358 Fremont Blvd., Fremont, CA 94538, 415-490-4300), DataVue (One Meca Way, Norcross, GA 30093-2919, 404-564-5668), IBM (100 Summit Avenue, Montvale, NJ 07645, 800-IBM-2468), NEC Home Electronics (1255 Michael Drive, Wood Dale, IL 60191, 312-860-9500), Toshiba America (Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718, 714-380-3000), and Zenith Data Systems (1000 Milwaukee Avenue, Glenview, IL 60025).

Further thanks to our reviewers (Julian Martin, Byron Wels, Brian Fenton, Shelli Weinman, Robert Young) for their comments and evaluations.

HIGH-RES HIGH-SPEED



GRAPHICS CO-PROCESSORS

Great new graphics processors jazz up computer displays like never before.

JOSEF BERNARD

Video games used to be the only activities you needed graphics for, but that's no longer the case. Graphics are essential to CAD (Computer Assisted Design) programs, WYSIWYG (What You See Is What You Get) word processors, desktop publishing programs, and even operating-system environments including Microsoft Windows, Digital Research's GEM, and IBM's presentation manager.

The problem is that, on most desktop computers, graphics-dependent programs are slow. And as those programs become more capable and more complex, they extract a greater toll in computational overhead from the computer's microprocessor. Therefore, the microprocessor winds up spending too much time manipulating images and too little time carrying out your commands. That slowdown leads only to frustration.

For example, in high-resolution mode, the output of IBM's relatively crude CGA (Color Graphics Adapter) is composed of an array of 640 × 200 (128,000) pixels, and the position of each must be recalculated every time the display is updated fully. Doing so takes time, and, what is more important from a human-factors point of view, it also frustrates the person using the system, who can do nothing but twiddle his thumbs during the update.

More and more graphics-intensive software is becoming available these days, and, fortunately, special IC's that are specifically designed to increase graphics processing speed are also becoming available. You know that a math co-processor can drastically increase the speed with which the computer does complex math, thereby freeing the microprocessor for other tasks. In a similar manner, a graphics processor can manipulate graphic images, and doing so has two advantages: the graphics processor can do its work much faster than a general-purpose microprocessor, and it can do it while the microprocessor is working on other things.

The new generation

Display processors (NEC's 7220, for example) have been around for several years, but the new IC's offer greater capabilities. For example, Intel's 82786 is a true co-processor that, after having been instructed to perform a task, can go off on its own and do it, thereby freeing the microprocessor for other work. And Texas Instruments' TMS34010 is really a complete microprocessor with special graphics-control capabilities.

The Intel device—and most others that have been announced—is a co-processor that works in conjunction with a system's microprocessor. It has a built-in repertory of drawing operations, as shown in Table 1, and it can execute them with little or no attention from the microprocessor after the initial instruction has been given.

The TI device is more than a smart controller. And even though the operations it performs are less sophisticated than those of other graphics IC's, it is much more flexibile, so you can accomplish just about anything in software. In fact, TI has developed a library of routines that allow you to program the IC in C. By way of contrast, other graphics controllers are more or less restricted to a fixed set of commands, and in some circumstances much programming may be required to achieve the desired results.

What is it that makes those graphics devices so special? A few quotations from Intel's spec sheet for the 82786 will give you an idea (and keep in mind that the TMS34010 is just as amazing):

- Four megabytes of graphics memory
- 200-MHz CRT's
- 640 × 480 (color) or 1400 × 1400 (monochrome) resolution
- 256 simultaneous colors
- Bit-blitting (block graphics-data transfer).

A block diagram of the TMS34010 is shown in Fig. 1 The IC contains almost all that is required for a complete graphics processing and display system. Note the barrel register, a special type of shift register. In the TMS34010; it can contain a field of 32 bits, and the IC can rotate it completely in a single instruction cycle, which potentially can speed up graphics manipulations enormously. Although the TMS34010 is a 32-bit device, it can be interfaced readily to an eight- or sixteen-bit bus.

Bit-blitting and hardware windows

The new IC's are intended for use in memory-mapped graphics displays. In that type of display, each pixel on the screen corresponds to a location in the computer's memory. Conversely, the contents of each memory location determines what will appear at a given point on the display.

Several screens of images, libraries of images, of portions of a single image can be stored in RAM simultaneously. By using bit-blitting techniques, those blocks of data can then be moved or operated on as a whole almost instantaneously, making it possible to change or update a display with pre-computed graphics information—there's no need to sit around and wait while the computer recalculates all the lines and shapes that must be redrawn each time the image changes.

TABLE 1—82786 COMMANDS

Command	Opcode
LINK	02
NOP	03
DEF_TEXTURE_OPAQUE	06
DEF_TEXTURE_TRANSPARENT	07
DEF_CHAR_SET_WORD	0A
DEF_CHAR_SET_BYTE	0B
INTR_GEN	0E
ENTER_MACRO	0F
EXIT_MACRO	17
DEF_BIT_MAP	1A
DUMP_REG	29
LOAD_REG	34
DEF_COLOR	3D
DEF_LOGICAL_OP	41
ENTER_PICK	44
EXIT_PICK	45
DEF_CLIP_RECT	46
DEF_CHAR_SPACE	4D
DEF_CHAR_ORIENT	4E
ABS_MOVE	4F
REL_MOVE	52
POINT	53
LINE	54
RECT	58
BIT_BLT	64
ARC_EXCLUSION	68
ARC_INCLUSION	69
POLYGON	73
POLYLINE	74
CIRCLE	8E
CHAR_OPAQUE	A6
CHAR_TRANSPARENT	A7
BIT_BLT_M	AE
INCR_POINT	B4
HORIZ_LINES	BA

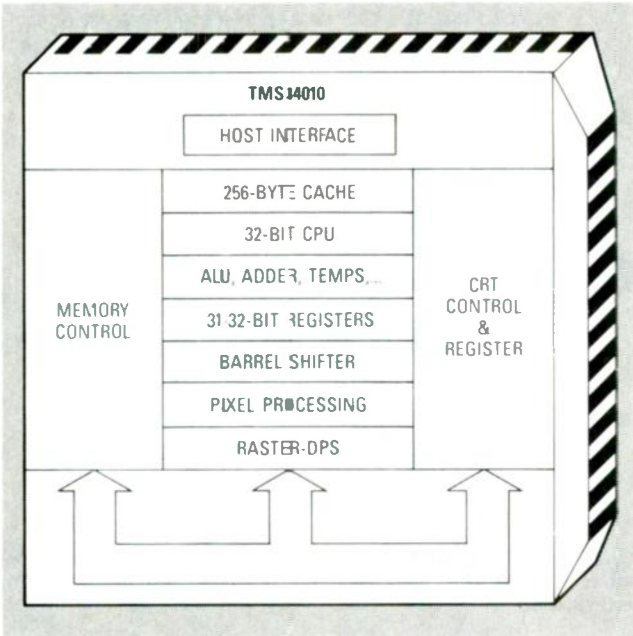


FIG. 1—TEXAS INSTRUMENTS TMS34010 is a 32-bit graphics processor, complete with its own on-board microprocessor.

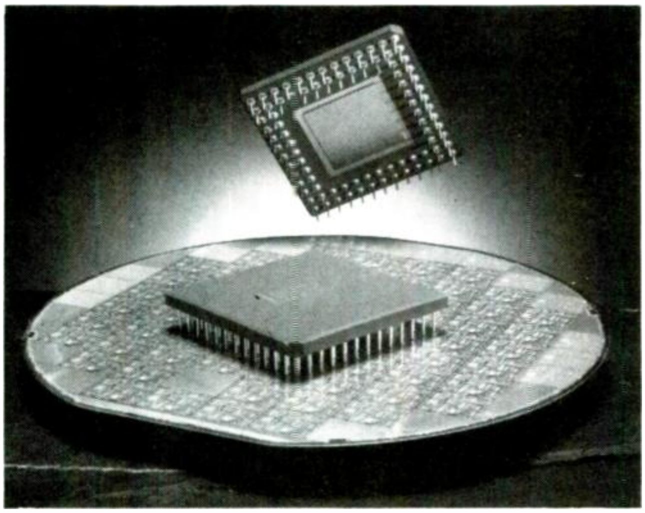


FIG. 2—INTEL'S 82786. The complexity of graphics-processor IC's requires a large number of input and output pins.

Bit-blitting is not a new technique. Commodore and Amiga machines have been using it for some time to achieve high-quality animation and graphics However, the new graphics controllers will make bit-blitting—and even more advanced techniques—available on MS-DOS systems.

Hardware windowing is one advanced technique that is available on the 82786. Rather than moving big chunks of graphics data around in memory to assemble a complete screen image, hardware windowing allows you to move *pointers* that tell the 82786 where the data is located. The graphics processor than picks up the data wherever it happens to be located. Speed is thereby increased tremendously.

Hardware overview

For all that they have to offer, the new graphics controllers are remarkably simple. They require relatively little support from other hardware, because they contain built-in registers for DMA transfers, internal controllers for video DRAM, programmable video timing, and other capabilities.

The TI processor comes in a 68-pin square PLCC (Plastic Leaded Chip Carrier) package, the Intel device in a slightly larger 88-pin package (See Fig. 2). Both are manufactured using a high-density CMOS process. Power consumption is low; the TMS34010 uses 500 mW and the 82786, 1000 mW.

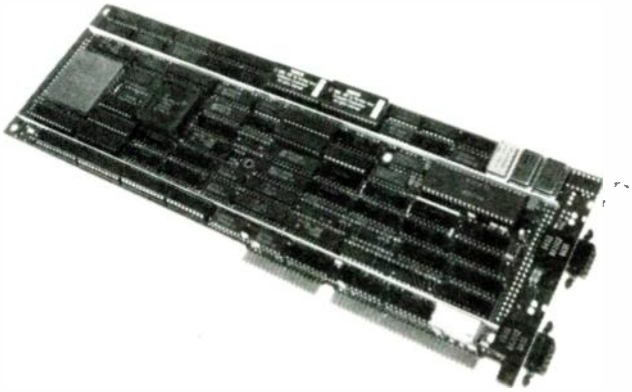


FIG. 3—NUMBER NINE COMPUTER'S SGT Pepper Graphics System uses both a TMS34010 and an 82786 in order to achieve high performance.

FIG. 4—NEW MONITOR TECHNOLOGIES allow you to see an entire page of text at a time, and make working with CAD and desktop-publishing programs easy. Shown here is the Genius, made by Micro Display Systems.

Putting them to work

There's more to using the new graphics controllers than just plugging them into a socket and turning on the computer. They require auxiliary hardware to drive a display, and, of course, software, which is usually provided in ROM.

For example, Number Nine Computer (725 Concord Avenue, Cambridge, MA 02138, 617-492-0999) in its SGT Pepper Graphic System, shown in Fig. 3, provides a firmware (software in ROM) interface called NNIOS (Number Nine Intelligent Operating System). The Pepper board actually contains both an 82786 and a TMS34010; NNIOS routes appropriate graphics commands to either, depending on which is more suitable for a given task.

The firmware interface is important because it provides a software standard, of which there are several at the present time. A standard is useful because it gives software developers an easy way to develop applications for various graphics controllers and boards without worrying about the underlying hardware.

The on-board drivers make adapting software to display hardware relatively simple. There is no need for the programmer even to know what kind of board will be used; the firmware will take care of everything else, including determining the resolution at which images will be displayed. Higher-resolution boards will provide more detail than lower-resolution ones automatically.

Black and white and read all over

It's easy to drive a monochrome display with the new graphics controllers. The primary consideration is bandwidth, and it is not difficult to produce a monochrome display capable of "swallowing" the output of a high-resolution graphics board. Many such monitors exist today; some can even display the contents of an entire page of text (with appropriate software, of course).

For example, the Genius monitor shown in Fig. 4 has a resolution of 736 × 1008, which enables it to show a full 66 lines of 80-column text. It can also do wonders with CAD and desktop publishing programs. The Genius is manufactured by Micro Display Systems, Inc., 1310 Vermillion Street, P.O. Box 455, Hastings, MN 55033, 800-328-9524.

Color displays, particularly the CRT's used, are another story. Ignoring bandwidth issues, the resolution of a color CRT is determined by the number of phosphor dots it contains, and by the size and spacing of those dots. (See Fig. 5). The more dots there are, the more detail will be possible. For example, NEC's MultiSync monitor increased the resolution possible with reasonably priced color monitors to 800 × 560. Previous monitors in the same price range were restricted to a resolution of 640 × 350.

The dot pitch of a CRT, which is usually specified in hundredths of a millimeter, refers to the spacing between phosphor elements. The finer the pitch—the smaller the number—the smaller the dots and the closer together they are. The more dots you can pack together in a given surface area, the greater the resolution you can obtain.

The CRT's used in garden-variety monitors usually have a dot pitch of 0.33 mm, which is adequate for resolving the output of an ordinary CGA card. More expensive monitors have CRT's with a pitch of 0.31 or 0.28 mm. Finer dot pitches are preferred by users of systems containing high-resolution EGA (Enhanced Graphics Adapter) and PGC (Professional Graphics Controller, until recently, IBM's highest-quality PC-based graphics sub-system) cards. But even CRT's with a 0.28-mm pitch may not be capable of doing full justice to the output of the new graphics cards embodying graphics processors.

Monitors that meet the qualifications required for really high-resolution graphics display are not cheap, and probably never will be. However, demand is increasing and manufacturing techniques are improving, so prices should decrease. But, currently, the price of a high-resolution display can easily rival that of the system that drives it.

Graphics applications

The new graphics controllers offer capabilities that greatly exceed those of the display controllers in common use today. In fact, some people believe that the new IC's do *too* much, and that their capabilities are unnecessary in the PC marketplace.

However, even though the EGA and the PGC offer much better resolution than the original IBM CGA, there are several reasons why the new graphics controllers are finding a great deal of support now, and why they will continue to do so in the future.

First is speed. If you've ever used a graphics-oriented program environment like Windows on a garden-variety PC (or clone), you know how maddeningly slow the program runs. Windows, in theory, is a terrific idea. The current version does not have the ability to run several programs simultaneously, but it does make it easy to switch among several applications at will. However, each time you switch, Windows has to recompute and redraw the entire screen. Where high-resolution graphics such as CAD images or specialized word-processing fonts—or even the Windows screen itself—are involved, redrawing the screen can take several seconds. The first time you watch it, it's fascinating. But it becomes interminably

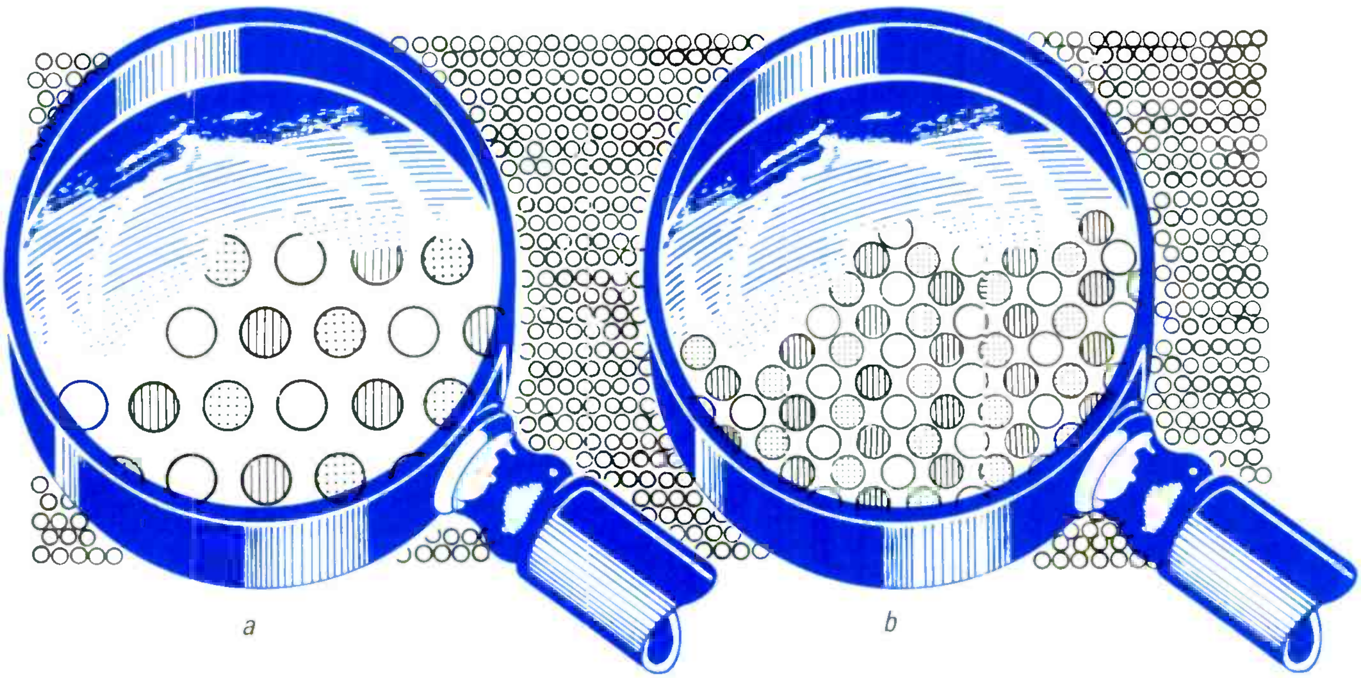


FIG. 5—RESOLUTION is determined by the number of dots, their size, and their spacing. Inexpensive monitors have relatively large dots spaced far apart (*a*). High-res monitors decrease dot size and spacing (*b*).

boring if you have to sit through it again and again.

With their bit-blitting ability, the new IC's can, depending on the amount of RAM available in a system, store several complete image screens in memory, and recall them as needed in their entirety, without having to recalculate and redraw them each time. That makes switching from one program to another (especially with a fast disk drive or a RAM disk) almost instantaneous, and that in turn makes working in a windowing environment bearable. Animation also becomes practical on a high-resolution scale, providing that the necessary RAM is available.

Display resolution

The resolution offered by EGA and even PGC boards is inadequate for some applications. Desktop publishing programs, for example, still struggle on most PC systems to show what the finished page will look like. Figures 6 and 7 show how two popular programs (Aldus' PageMaker and Xerox's Ventura, respectively) do it. As you can see, those programs try their best to show you how your layout, which may include several typefaces in several sizes, will appear; but what you see on the screen is *not* exactly what you are going to get.

That's a problem because many computer users have no patience with—or understanding of—the limitations imposed by hardware or software. They don't understand why the machine can't show them exactly what they feel they have the right to expect. If what they see isn't close to perfect, then it isn't good enough. For computers to become a more natural and accepted part of the workplace, they will have to come much closer to perfection.

The point is that, due to advances in computer hardware in general, and graphics processing systems in particular, physical page layouts will become as important as—and as easy to manipulate as—the contents of that document. Now that it can easily be previewed and manipulated without a great deal of drudgery, physical appearance will matter as much as correct spelling.

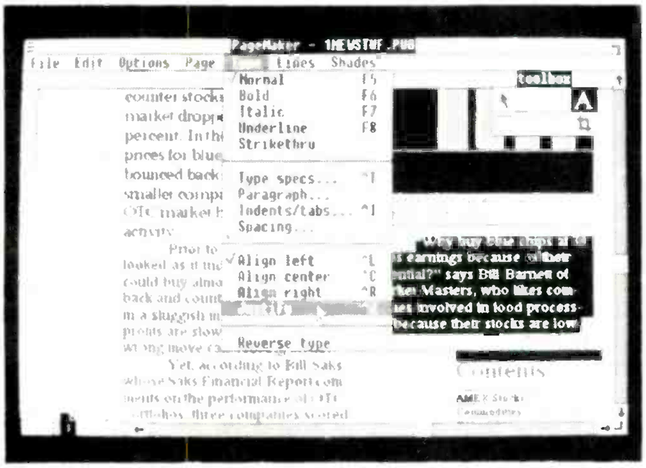


FIG. 6—ALDUS' PAGEMAKER, the original desktop-publishing program, was designed first for Apple's Macintosh, and recently has been adapted for the IBM PC family.

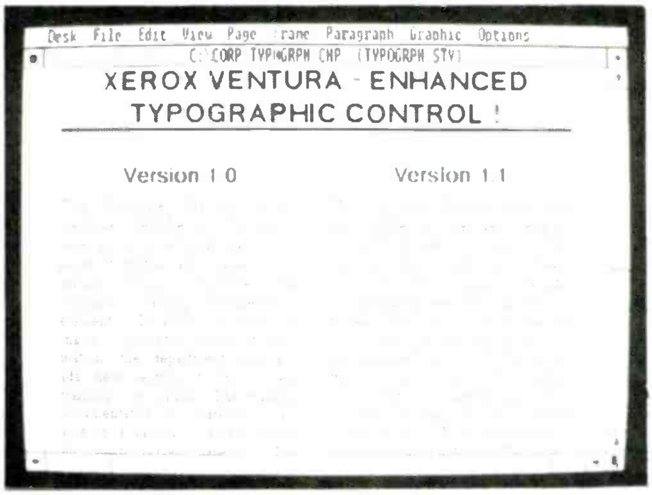


FIG. 7—XEROX' VENTURA is another high-stakes player in the desktop-publishing market. The latest version allows you to vary the spacing between letters, thereby improving readability.

R-E ROBOT

continued from page 63

ATOD takes the channel number from the top of the stack, duplicates it, and stores it (using PC!) at I/O port 150H. That sets up the analog input-channel multiplexer. The duplicate copy is used to execute the same sequence of instructions a second time. Although the first port store to 150H started the A/D converter, we would like to have a few microseconds for the MUX to settle. Starting the converter a second time ensures that the A/D converter has a clean input, one that is not full of switching transients.

SWITCH? fetches the byte of data at port 120H, masks the most significant bit (D7), and tests whether the result is equal to zero. The flag is returned on the stack.

LMTR-PERIOD writes a control byte to the configuration register of the 8253 at 100H. The 8253 is configured for square-wave output and a 16-bit frequency divisor. The next two bytes written to the 8253 will be the 16-bit divisor. LMTR-PERIOD takes an argument from the stack and divides it by 100H, leaving the quotient and remainder (/MOD). That effectively splits the word into the two 8-bit components. Each of these is stored in the 8253 timer 0 at 100H with the two-port store commands (PC!).

STOP-LEFT and STOP-RIGHT disable the motors. ENABLE-LEFT and ENABLE-RIGHT enable the motors. LFWD (left-motor forward), LREV (left-motor reverse), RFWD (right-motor forward), and RREV (right-motor reverse) each set the direction-control relays to the correct state.

That completes the program. Note that screen 32 contains no code at all, simply some explanations and definitions. It can be omitted if desired.

ROMing your code

After entering, testing, and debugging the source code, it's time to burn an EPROM. The 2764 will hold 8 screens of Forth-83 source code, more than enough. Transfer one screen at a time with the word PROGRAM as follows:

32 0 PROGRAM
33 1 PROGRAM
34 3 PROGRAM
35 4 PROGRAM
36 5 PROGRAM
37 6 PROGRAM

If you execute ROMed applications, you probably will not have your terminal attached. Until now we have invoked our applications by typing JOY at the terminal. You must include the command JOY as the last word of the last screen. Power down, remove the programmed EPROM, and install it at IC30 on the RPC board, the autostart socket for Forth-83. Press the reset switch and a few seconds later JOY will assume control of the robot.

Utility of JOY

Actually JOY is quite a bit of fun. You can sit on the robot and drive it anywhere you want to go. The values shown allow about 1 mph forward speed and slow turns. You can rotate the robot with one wheel stopped or each wheel going in opposite directions. The application is a natural for a wheelchair that needs more intelligence than a simple analog joystick could provide.

However, if you ride the robot, **be extremely careful!** Some values in the routines SPEED-CONV and DIFF-CONV will result in fast acceleration. If you are not careful, it's easy to get pitched off.

After riding, examine your chassis in the vicinity of the motor mounts. If the chassis is becoming bowed out, the torque imposed by the load is too great. Reinforce the rear with a bracket between the two sides before riding again. **R-E**

VIDEO GENERATOR

continued from page 45

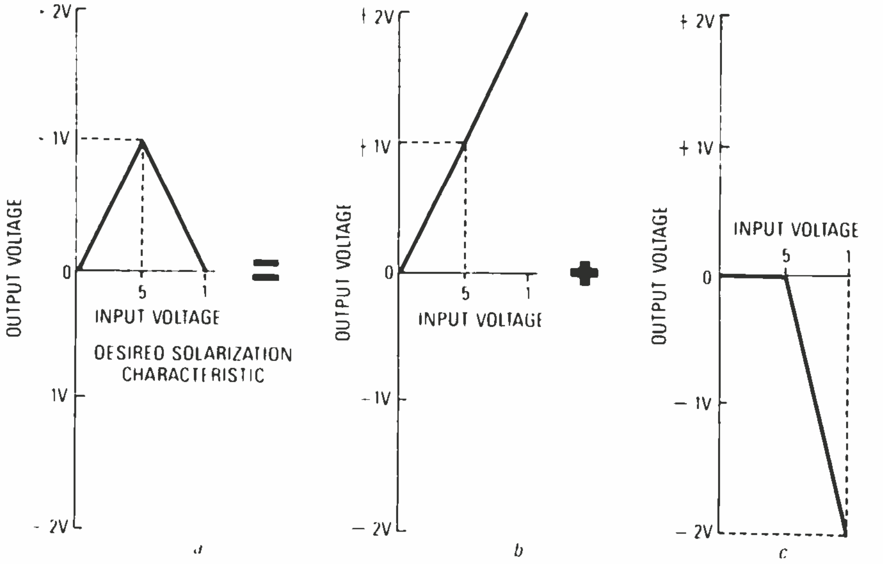


FIG.8—THE DESIRED AMPLIFIER characteristic needed for solarization, shown in *a*, can be attained by using two amplifiers having the characteristics shown in *b* and *c*. The video palette, however, accomplishes the same task using single controlled-gain amplifier.

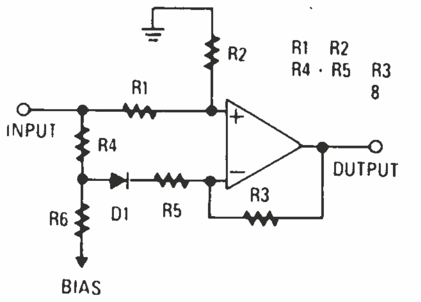


FIG. 9—BY VARYING THE FEEDBACK characteristics of an op-amp, a single stage of amplification can be made to function as a solarizer.

ally becomes forward-biased: The bias from R6 determines the level at which that occurs. When D1 conducts, resistors R3, R5, and R4 form a new feedback network that causes the amplifier gain to increase and also change polarity, which causes the output to reverse direction as the input gets larger.

Strictly speaking, R3 should equal four times R4 and R5. We got visually more pleasing results when R3 equaled eight times R4 and R5; but that is a matter of personal taste, and is left to the reader's preference. The point at which gain reversal occurs depends on R6's bias. (Optimum visual effect requires adjusting both the solarization input drive level and the foldover controls. The output level determines the picture contrast and also can be adjusted separately. We decided to use three controls in the circuit for best flexibility.

Referring back to Fig. 2, the three circuits on the effects board can be operated simultaneously to create various interesting effects. The inverted output, or the uninverted but processed luminance is eventually fed into the summing amplifier. When using the special effects, the main luminance level control is usually—but not always—set to zero. The only thing the operator must watch for is that the video levels do not exceed the sync tip or blanking levels, which can cause picture instability. Bear in mind that the summing amplifier merely combines everything: it can handle only two to three volts peak before clipping occurs.

Next time we'll show how to build, adjust, and troubleshoot the palette. **R-E**

SATELLITE TV

The international connection

BOB COOPER, JR.,
SATELLITE-TV EDITOR

THE FAR-REACHING COVERAGE OF GEO-stationary satellites has been well known, significantly documented, and somewhat troublesome to the regulators of the world since the dawn of satellite communications. After more than a decade of active involvement in the business of presenting and delivering programming via satellite, the programming industry worldwide is finally beginning to come to grips with the effects of such wide coverage.

In its most simplistic terms, a satellite transmission has two types of coverage; *intended* recipients and *non-intended* recipients. Under most national (and international) regulations, a satellite signal is considered a national or sub-national service. It is intended to be received by one or more receiving locations, each of which is known to the satellite programmer/operator in advance of the transmission being sent. Those are the intended recipients. Each country in the world has its own laws or rules regulating reception of those transmissions, or there are no laws at all. (We'll get to that situation in a moment.) The content of those laws varies widely and only the United States, Great Britain, and a handful of other countries actually recognize by law that at least some of the transmissions on satellite are open to use by non-intended recipients.

International law

In cases where laws making it "legal" to intercept transmissions not intended for you do not exist, the attitude of most nations is that it is *not* legal to do so. In other words, reception is illegal unless it has been made specifically legal by legislation/law.

FIG. 1

However, remember that satellite signals are virtually all national in nature; U.S. satellite signals are intended for U.S. users, Canadian satellites are for Canadian users, Mexican satellites are for Mexican users, and so on. In Europe, only the French presently have a national satellite service and most of the European countries share one or more common satellites (Eutelsat). There, while the satellite may be owned, operated, and shared by multiple countries, the individual channels or transponders are leased by and operated by individual countries. Therefore, under various national laws in Europe, it may be legal to receive and use one channel on Eutelsat (that one that originates in or is intended for use within the recipient's country) but not other channels on the same satellite if those channels carry programming originating in or intended for other countries in Europe.

All of that is very confusing to the layman who buys or builds a satellite-receiving system and discovers not only his own country's signals and programs but those from neighboring (or not so neighboring) countries. The science of satellite transmissions has not matured yet to the point where it is possible to build a satellite that covers only the United States.

Nor is it possible, or economical, to build a satellite for Europe where one channel covers the UK, another France, a third Denmark and so on. The signals spill outside of the intended coverage area routinely; people with the appropriate equipment can receive those foreign signals, often with great ease. Figure 1 shows the test pattern for a Caribbean superstation that transmitts on Westar 5, transponder 23. Though that station's signals are intended for reception in the Caribbean, the photo shown was taken in the U.S.

With rapidly developing domestic markets for their programs, that unintended spillover was largely ignored by programmers for nearly a decade. As an example, if a U.S. satellite programmer purchases rental or "showing rights" for a movie, it pays a negotiated fee based upon the size of its domestic market. No payment is made for viewers located outside of the U.S., and in fact the programmer has no distribution rights outside of the U.S. That means that it can not collect user fees from Bermuda even though there are unintended users there. What's more, legally the programmer must prevent the movie from being seen by those who are located outside the U.S.

Preventing reception

One method of protecting themselves from unintended viewing, either inside or outside the region where they have distribution rights, is to encrypt the signal and only accept fees from people residing within the defined viewing area. A British service called The Sky Channel, for example, encrypts their signal and closely controls the distribution of the decoders so that they are available only to viewers located within their domestic market.

Another method of controlling use to within intended regions is to seek the legal support of the governments outside of the intended viewing areas. For example, through the U.S. State Department, HBO has been successful in getting hotels and other public establishments in Jamaica to cease using HBO's programming in that country. To accomplish that, HBO enlisted the aid of an official agency within the U.S. to intercede with an official agency within the Jamaican government.

Encrypting signals is not a foolproof technique to shut off program use in non-intended areas, of course, since a decoder can be moved from an authorized location to a non-authorized location and still function. And in Europe, where the encryption technology used by satellite programmers is not as secure as it might be, (i.e. bootleg) decoders are freely offered for sale in many countries. A Swiss court recently ruled that within Switzerland it is not illegal to offer for sale or use a decoder that decrypts a French pay-television service.

Similar rulings have come from Canadian courts and they seem to be saying "It is not illegal to offer for sale (non-authorized) decoders within our country if the programming services received with the decoder are not offered in commerce here."

That sort of national attitude bothers programmers who face a form of double jeopardy when their programming is used by non-intended receivers. First, the programmers are under pressures to control the distribution of their services. Should the programmer fail to exercise due diligence (such as by encryption), he is often contractually bound to financial penalties payable to his program sources. But program sources are getting smarter and when they feel that encryption is not adequate due diligence, they are pressuring programmers such as HBO to take things a step further, as was the case in Jamaica.

Not all countries will assist the programmers with their business problems. We'll see why, and then delve deeper into the topic of international satellite reception next time. R-E

Caribbean Electronics Magazine

A brand new monthly publication called *Caribbean Electronics Magazine* intended just for people living in and around the Caribbean region is now available from Bob Cooper. If you live in the Caribbean, Florida, or Latin America (only!) and wish to receive a free sample copy, write to CEM, P.O. Box 100858, Ft. Lauderdale, FL 33310, or telephone 305-733-9955. Enclose either business card or amateur/CB QSL card as proof of your residence or business location.

SERVICE CLINIC

continued from page 30

simplest ways of hunting for an open bypass is to bridge each one with a known-good capacitor and watch the screen to see what effect, if any, the "good" capacitor has on the interference. If the trouble clears up, the bypass you are bridging is open and should be replaced.

If it happens that you can't find a defective bypass by simply bridging it with a known-good capacitor, then it's time to test the suspect capacitor under actual operating conditions. As you would expect, an oscilloscope is a top choice when it comes to making in-circuit tests. (In fact, it's tough to do the job at all without an oscilloscope.)

To use a scope to check a bypass capacitor for proper operation, you set the vertical-input selector to AC and simply touch the test probe to the capacitor's "hot" (non-grounded) terminal. If the bypass capacitor is doing the job it's supposed to be doing you will see no signal on the scope because any AC signal of necessity will have been bypassed to ground. On the other hand, however, if the capacitor is open or leaky, the screen will show some kind of AC signal component because some or all of the signal isn't being bypassed to ground.

One reason the scope's vertical input must be set for AC input rather than for DC is because an open bypass capacitor often has no effect on the B+ value. If you simply measure the B+ voltage it will usually look good because the DC trace displacement can conceal a small AC component. But if the scope cannot display DC at all, unbypassed AC—even a very small amount—will be seen, though it might be necessary to crank up the vertical gain in order to get a readable display.

On the other hand, a leaky bypass capacitor often affects the B+ value, because when a capacitor is "leaky" there is actually a relatively low DC resistance between the positive and negative leads. In a powered (active) circuit, the leakage resistance usually becomes part of an unintended voltage divider, thereby reducing the circuit voltage to some degree. Therefore, DC voltage measurements taken on the bypassed circuit will usually point directly at the defective component.

There are even some conditions in which an open bypass capacitor will affect the DC circuit voltage. For example, although an open bypass in a plate or collector decoupling network won't affect the DC circuit values, an open B+ input filter capacitor, such as C2 in Fig. 1, will result in a lower B+. That is because the input filter capacitor charges to, or almost to, the peak value of the rectified AC. If the input filter capacitor is open the rectified AC is processed by the second filter capacitor, which often follows a resistor (for instance, it follows resistor R2 in Fig. 1); hence, under load the voltage across the second capacitor does not reach the peak value, so the overall B+ value is somewhat less than normal.

Video distortion

Unlike radio oscillation, which usually is heard as squeals and howls, video oscillations caused by defective bypass capacitors often manifest themselves as small distortions in parts of the raster, as traveling wiggles, or as the *Leaning Tower of Pisa* effect, wherein parts of the picture lean to either side. When you see anything in a TV picture that looks odd or out-of-place. start bridging the bypass capacitors while you keep an eye on the picture. You'll know that you've hit the right one because when it is bridged the picture snaps to attention and turns rock-steady.

Often, normal picture detail obscures distortions caused by defective bypass capacitors. You can usually get a better idea of what's going on if you use an oscilloscope to observe a square-wave test signal, because anomalies in the squarewave are immediately apparent—nothing stays concealed when you use your oscilloscope properly. Simply start bridging the bypass capacitors one at a time until the waveform snaps to its square shape. R-E

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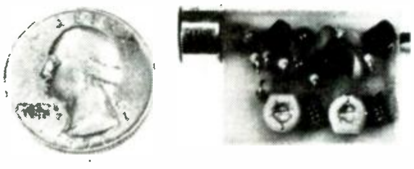

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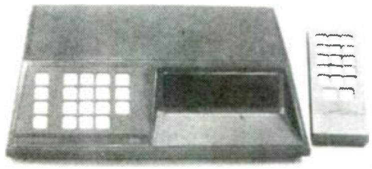

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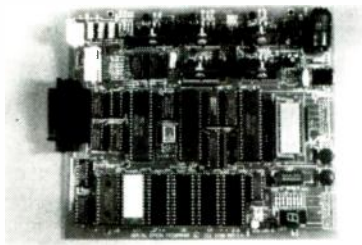

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Radio-Electronics mini-ADS

LETTERS

continued from page 16

SOLDERING TECHNOLOGY

When I received by May 1987 issue of **Radio-Electronics** the other day, I was very pleased to see the article entitled "Soldering: Old Techniques and New Technology." Much to my dismay, however, I found the article to contain errors. The thought behind the article was a good one, but some of the information was very confusing.

The charts shown on pages 47 and 49 can be misleading, which may have lead the author to believe that solder for electrical connections and electronics circuits is composed of 40% tin and 60% lead. A 60/40 tin-lead solder has an alloy designation of Sn60, and, as we learned in high school chemistry, Sn is the chemical symbol for tin. Hence, Sn60 is 60 percent tin.

Also, it should be noted that all good 60/40 solder is cored with rosin flux, and additional flux should not be added to the connection unless you are certain that the added flux is compatible with the flux in the core of the solder. An exception would be rework of a connection where the original flux has already been "boiled" away.

The author also makes a general statement that no solder can melt at a lower temperature, when, in fact, what he should have said was that no tin/lead solder can melt at a lower temperature.

As always, I am very interested in seeing articles on state-of-the-art technology. Unfortunately, that one left much to be desired.

D.A. HOPKINS
Senior Instructor, PC-Board Repair Techniques
Fort Gorden, GA

CELLULAR TELEPHONE

continued from page 55

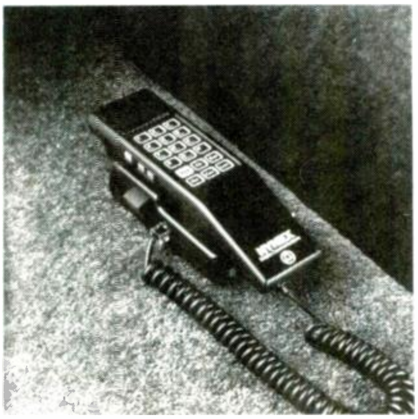
knowledge of A and B services to that indicator, causing it to flash if the service it encounters is different from the one you have selected. That notifies you that, if you have to switch services manually (perhaps you have locked into one or the other—the recommended method), that is the time to do so.

What else?

In addition to performing those invisible tasks, the sophistication of cellular phones and phone systems makes using them more convenient.

Of course, they provide such things as auto-redial, muting, and memories that can hold up to 32 phone numbers that can be dialed by just a keypress or two. But just about every phone these days has those features. Cellular phones provide even more!

A few cellular phones give you the luxury of speech recognition for hands-free dialing. It's really more than a luxury—the less your attention is diverted from your driving, the longer you're likely to be around to make more phone calls. One phone, available from AT&T, not only



THE MODEL *CDL205* is from Nynex Mobile Communications.

understands what you say to it but also talks back to you. When you pick up the handset it says, "Name please," and waits for you to tell it whom to call (it can also associate names with phone numbers). If the person you are calling is one of those stored in the phone's memory, the phone will dial the number after you speak the name. If you dial the phone manually, it will announce the digits entered as you punch them in. If the line is busy, you can later tell the phone to redial the number.

Cellular phones also use their intelligence to keep you informed of situations they encounter. We've already seen what the ROAM indicator can tell you. Another indicator, labeled NO SERVICE lights if the phone encounters no response on its control channels, meaning that there is no cellular service in the area you're in at the moment. That indicator also can be used to let you know when a call is terminated, or when a signal dropout occurs.

Because they already contain a clock circuit for the control of a microprocessor, cellular phones can also provide timekeeping services. The simplest just tell you the length of the last call you made. Others tell you how long you've been engaged in the call you're currently making (that can be quite useful, since cellular phone calls are billed on a per-minute basis). Some phones can tell you how long you've been talking, the total length of time you've used the phone (the timer can be reset to zero whenever you like), and the total number of calls you've made.

Finally, if you leave them on while you're away from them, most cellular phones are able to notify you when you return if you had a call in your absence. They can't tell you who called (although at least one firm has plans to introduce an answering machine for your car), but if you were expecting a call, at least you'll know that it probably came. **R-E**

STATE OF SOLID STATE

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

Micropower op-amp

PRECISION MONOLITHICS, INC. CLAIMS that their new OP-90 micropower op-amp sets new performance standards for similar devices. Although the OP-90's performance is comparable to that of the OP-07, it draws less than 20 μA—which is 1/200,000 the current needed for the OP-07. The OP-90's gain exceeds 700,000 (700V/mV), and common mode rejection is better than 100 dB.

In addition to its unusually low current drain, the op-amp can operate from a single-ended (single) power supply of +1.6 to +36 volts, or from a bipolar (dual) supply of ±0.8 to ±18 volts. As a single-source device, both input and output are referenced to ground and "zero-in/zero-out" (no static DC output) operation is possible. Input offset is less than 150 μV, so external nulling is not required in most applications.

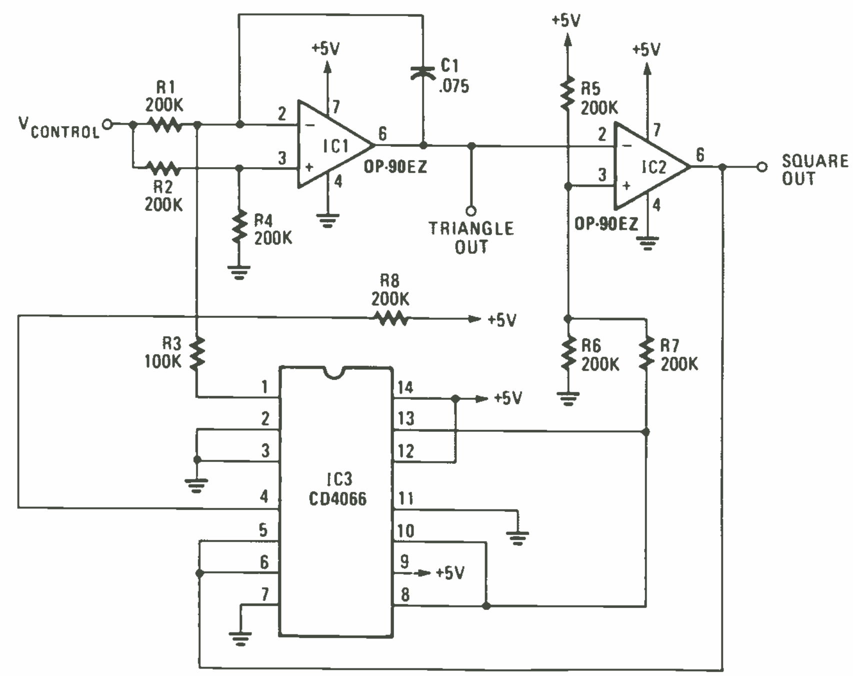


FIG. 1

The OP-90's low offset voltage and high gain enables it to provide precision performance in low-frequency micropower applications. Its exceptionally low voltage and current requirements make the device ideal for battery and solar-power operation in such applications as portable instruments, remote sensors, and satellites.

The OP-90 has the same pinout as the 741, has nulling to V−, and can be used to upgrade low-frequency equipment that presently uses the OP-20, ICL8021, HA5141, LF441, or the OPA21. It is available as the OP-90GP in an 8-pin plastic DIP with a commercial temperature range. (At T_A = 25°C, maximum offset voltage is 450 μV.) It is also available as the OP-90AZ and OP-90EZ; those are hermetic 8-pin DIP's with the former operating in the military temperature range and the latter in the industrial range. Both have $V_{OS(max)}$ of 150 μV at 25°C available. Another version, the OP-90FZ, also in a hermetic DIP; that device operates in the industrial temperature range and has 250-μV maximum voltage offset.

Figure 1 shows how two OP-90's and a CD4066 CMOS quad bilateral switch can be used to make an inexpensive precision voltage-controlled oscillator. The oscillator provides squarewave and triangular-wave outputs up to a few hundred hertz, and draws only 50 μA from a 5-volt power supply.

Op-amp IC1 is connected as an integrator. Op-amp IC2 is used as a Schmitt trigger, with resistors R5, R6, R7 and the associated internal CMOS switches setting the hysteresis to precisely 1.67 volts. The Schmitt-trigger action shapes IC1's output into a trianglular waveform of 3.33 volts peak (5.00V − 1.67V). IC2's output is a squarewave whose amplitude swing is essentially zero to +5 volts.

The output frequency for the oscillator shown in Fig. 1 is:

$$f_{out} = V_{in(volts)} \times 10Hz/V$$

however, frequency can be varied—within limits—by changing the value of integrating capacitor C1. **R-E**

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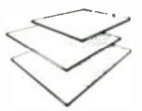

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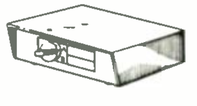

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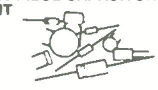

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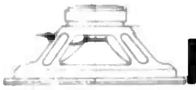

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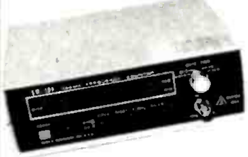

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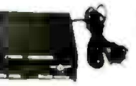

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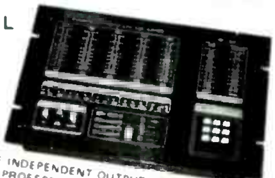

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SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interlaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION

MM5321N. $11.95

INTERSIL Also Available!

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.25	74HC175	.69
74HC02	.25	74HC221	.99
74HC04	.29	74HC240	.79
74HC08	.29	74HC244	.79
74HC10	.29	74HC245	.89
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.65
74HC32	.29	74HC273	.79
74HC74	.39	74HC373	.79
74HC75	.39	74HC374	.79
74HC76	.45	74HC595	1.19
74HC85	.79	74HC688	.79
74HC86	.39	74HC943	8.95
74HC123	.89	74HC4040	.89
74HC125	.49	74HC4049	.59
74HC132	.49	74HC4050	.59
74HC138	.49	74HC4060	1.09
74HC139	.49	74HC4511	1.29
74HC154	1.19	74HC4514	1.19
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

74HCT — CMOS TTL

74HCT00	.29	74HCT139	.59
74HCT02	.29	74HCT157	.69
74HCT04	.29	74HCT174	.69
74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
74HCT86	.49	74HCT373	1.19
74HCT138	.59	74HCT374	1.19

74C — CMOS

74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.49
74C08	.35	74C240	1.29
74C10	.35	74C244	1.29
74C14	.49	74C373	1.49
74C32	.35	74C374	1.49
74C74	.59	74C912	7.95
74C85	1.39	74C915	1.39
74C86	.35	74C920	9.95
74C89	5.19	74C921	9.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

DS0026CN	1.95	LM1458N	.39
TL074CN	.89	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.85
LM311N	.45	MC1648P	4.95
LM317T	.79	LM1871N	2.95
LM318N	.99	LM1872N	2.95
LM319N	.99	LM1896N-1	1.59
LM323K	3.95	ULN2003A	.99
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	DS26LS29CN	4.49
LM348N	.69	DS26LS31CN	1.19
LM350T	2.95	DS26LS32CN	1.19
LF351N	.39	DS26LS33CN	1.95
LF353N	.49	LM2901N	.49
LF355N	.79	LM2907N	2.49
LF356N	.79	LM2917N (8 pin)	1.55
LF357N	1.09	MC3419CL	9.95
LM358N	.49	MC3446N	2.95
LM360N	2.19	MC3450P	2.95
LM361N	1.79	MC3470P	1.95
LM380N-8	.99	MC3471P	4.95
LM386N-3	.99	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
TL497ACN	2.69	LM3909N	.99
NE540H (C540H)	2.95	LM3914N	1.95
NE555V	.29	LM3916N	1.95
XR-L555	.75	NE5532	.89
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
LM567V	.69	7815K (LM340K-15)	1.29
NE592N	.89	7805T (LM340T-5)	.49
LM741CN	.29	7812T (LM340T-12)	.49
LM747CN	.59	7815T (LM340T-15)	.49
MC1350	1.49	7905K (LM320K-5)	1.35
MC1372P	2.49	7905T (LM320T-5)	.59
MC1377P	3.19	75472	.99
MC1398P	8.95	75477	1.29
LM1414N	1.29	76477	5.95
		MC145406P	2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8 pin LP	.11	8 pin WW	.59
14 pin LP	.12	14 pin WW	.65
16 pin LP	.13	16 pin WW	.69
24 pin LP	.25	24 pin WW	1.19
28 pin LP	.27	28 pin WW	1.39
40 pin LP	.29	40 pin WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

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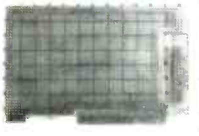


JE417 (Pictured)

- Wire Wrap
- Component Testing
- Point-to-Point Wiring
- 31/62 Connection

JE411	(6½", No Pads, Gen. Purp.)	$12.95
JE415	(6½", No Pads, PC/XT)	$14.95
JE417	(6½", Plated w/Pads, PC/XT)	$19.95

Extender Boards Designed for Troubleshooting and Testing

JE419 (Pictured)

JE419	(5¼" Extender, 22/44 Connector)	$19.95
JE421	(4¾" Extender, 31/62 Connector)	$19.95

Commodore VIC-20 and C-64 Motherboards

CV64

May have to troubleshoot or just use for spare parts.

CV20 Includes: (1) 6560, (2) 6522, (1) 6502, (2) 6116P-4, and much more!

CV64 Includes: (1) 6567, (1) 6581, (1) 6510, (1) 82-S100PLA, (1) 901227-03, (2) 6526, and much more!

CV20	(VIC-20 Motherboard)	$14.95
08903-3	(SAMS VIC-20 Schematics)	$19.95
CV64	(C-64 Motherboard)	$49.95
08906-8	(SAMS C-64 Schematics)	$19.95

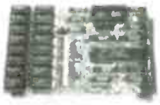
Additional Commodore Accessories

*CM-1	(300B Modem VIC-20, C-64)	$19.95
*JE232CM	(RS232 Inter. VIC-20, C-64)	$39.95
CPS-10	(C-64 Power Supply)	$39.95
CPS-128	(C-128 Power Supply)	$59.95

*Also compatible with C-128 in 64 mode only

ZUCKERBOARD

TANDY 1000 Expansion Memory Half Card



Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip.

TAN-EM512K	Includes 512K RAM	$119.95
TAN-C	Plug-in Clock option chip (only)	$39.95

SALE! 20Meg Hard Disk SALE!

T20MB	20MB Hard Disk Drive Board for Tandy 1000 .. ~~$579.95~~	$494.95
SX20MB	20MB Hard Disk Drive Board for Tandy 1000SX ~~$509.95~~	$499.95

TANDY 1000 Multifunction Board with Clock Calendar

Expand the memory on your Tandy 1000 (128K Version) to as much as 640K. Complete with an RS232 port, clock/calendar, RAM Disk, Printer Spooler and on-board DMA controller chip.

MTAN-512K Includes 512K RAM .. $199.95

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41256-120	512K RAM (18 Chips)	$ 71.10
JE1012	Baby AT Flip-Top Case	$ 79.95
JE1032	200W Power Supply	$ 99.95
JE1022	5¼" High Density Disk Drive	$119.95
JE1045	Hard Disk/Floppy Controller	$199.95
JE1003	Baby AT Motherboard (Zero-K RAM-incl. Award BIOS ROM)	$449.95

NEW! *Regular List $1,080.80*

SAVE $105.85!

JE1008	IBM™ AT Compatible Kit	$974.95
JE1059	EGA Monitor & Card *SAVE $30.00*	$569.95

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SAVE $90.35

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IBM-Case	Flip-Top Case	$34.95
JE1015	XT/AT Style Keyboard	$59.95
JE1030	150 Watt Power Supply	$69.95
JE1050	Mono/Graph. Crd. w/P.Port	$69.95
JE1020	5¼" DSDD Disk Drive	$99.95
IBM-MON	12" Mono. Green Monitor	$99.95
IBM-MB	XT Motherboard (Zero-K RAM-incl. DTK/ERSO BIOS ROM)	$99.95

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Jameco's 4.77/8MHz Turbo IBM Compatible Kit

Same as JE1004 except comes with 640K RAM, TURBO 4.77/8MHz motherboard, JE1071 multi I/O with controller and graphics, and AMBER monitor.

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JE1005 (IBM™ PC/XT Turbo Compatible Kit) . $599.95

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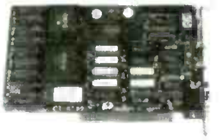
RS232HC	RS232 Serial Half Card (PC/XT)	$ 29.95
EM-100	Expansion Memory Half Card (without RAM) (PC/XT)	$ 59.95
AMBER	12" Amber Monitor (PC/XT/AT)	$109.95
PM1200B-2	1200/300Bd Half Card Modem w/out software (PC/XT/AT)	$119.95
PM1200B-2S	1200/300Bd Half Card Modem w/Mirror Sftw (PC/XT/AT)	$149.95
TTX-1410	14" RGB Color Monitor (PC/XT/AT)	$289.95

Color Graphics Card for PC/XT/AT

· Text 40 or 80 x 25 · Graphics 320 or 640 x 200 · Manual included

JE1052 .... $59.95

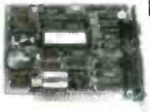
EGA Card for PC/XT/AT



· Graphics 720 x 348 · 16 out of 64 colors · Manual included

JE1055 .... $199.95

I/O Cards for PC/XT/AT



- Printer Port
- RS232 Port
- Game Port
- Manual included

JE1060 (Pictured)

JE1060	I/O for XT	$69.95
JE1065	I/O for AT	$69.95

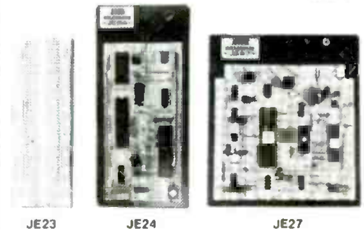
Multi I/O w/Controller & Graphics for PC/XT

· Printer port · RS232 port · Floppy controller · Graphics · Manual included

JE1071 .... $159.95

Jameco ELECTRONICS Solderless Breadboard Sockets

NEW



JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x ⅜	100	0	$ 2.49
JE21	3¼ x 2⅛	400	0	$ 4.95
JE22	6½ x 1⅜	630	0	$ 6.49
JE23	6½ x 2⅛	830	0	$ 7.49
JE24	6½ x 3⅛	1,360	2	$13.95
JE25	6½ x 4¼	1,660	3	$24.95
JE26	6⅞ x 5¾	2,390	4	$29.95
JE27	7¼ x 7½	3,220	4	$39.95

Jameco ELECTRONICS Extended 80-Column Card for Apple *IIe*

· 80 Col./64K RAM · Doubles amount of data your Apple *IIe* can display as well as its memory capacity · Ideal for word processing · Complete with instructions

JE864 $59.95

ADD-12 (Disk Drive II, II+, *IIe*) $99.95

Additional Apple Compatible Products Available

NEW! Seagate 20, 30 & 40MB Half Height Hard Disk Drives

ST225K (Pictured)

ST225	20MB Drive only (PC/XT/AT)	$274.95
ST225K	20MB w/Controller (PC/XT)	$339.95
ST238K	30MB w/Cont. (PC/XT/AT)	$399.95
ST251XT	40MB w/Cont. Card (PC/XT)	$599.95
ST251AT	40MB w/Cont. Card (AT)	$659.95

Jameco PC/XT & AT Compatible Disk Drives

JE1022 (Pictured)

JE1020	(360K Drive, PC/XT/AT)	$ 99.95
JE1022	(1.2MB, AT Compatible)	$119.95

DATA BOOKS

30003	National Linear Data Book (82)	$14.95
30005	Logic Data Book - Vol. II (84)	$14.95
30009	Intersil Data Book (86)	$ 9.95
30032	National Linear Supplement (84)	$ 6.95
210830	Intel Memory Handbook (87)	$17.95
230843	Intel Microsystem Hndbk. Set (87)	$24.95

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(Less printer)

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- **Printer Power Supply** – Item #6642 **$14.95**
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PC 8300 HOME COMPUTER
(Advanced version of the Timex 1000)

42-key mechanical keyboard (not membrane). Contains 2K of RAM. Reverse video, Z80A, 6.5MHz processor, ROM 8K BASIC. Graphics capability/sound–music, TV or monitor. Joystick input operates on 115 VAC. Includes: AC adapter, TV cable, and pair of cassette cables. Will run all prerecorded tapes for Sinclair/Timex 1000-ZX81. Mfr – Power 3000. In orig. boxes.
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Accessories . . .

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Gives your Adam fast, reliable data storage and retrieval. Can hold up to 160K bytes of information. Uses industry-standard SS/DD disks. Connects directly to your Adam memory console. Comes with disk drive power supply, Disk Manager disk and owner's manual. Mfr – Coleco, model 7817
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5¼", 1.2 Mb. AT HALF HT. DISK DRIVE

48/96 TPI (IBM® Compatible)
Double sided, single/double density; 80 track.
Mfr – Panasonic #JU-475
Item #10005 **$119.00** New

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55/100 CFM
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1" Thin: 5 plastic blades with feathered edges.
Mfr – Centaur #CUDC24K4-601
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Mfr – Centaur #CNDC24K4-601
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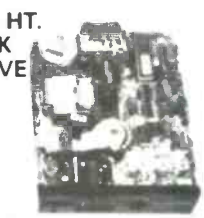
Double sided/double density, full height drive. 48 T.P.I., 80 tracks.
Mfr – Tandon TM100-2
Item #7928 **$79.00**
2 for **$150.00**

96 TPI, DS/Quad Density
Mfr – CDC #94091
Item #1893 **$99.00**

5¼" 1/2 HT. DISK DRIVE



DOS 3.2 Compatible
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Tandon TM55-4 DS/Quad
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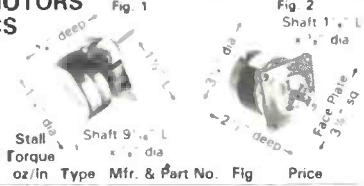

Item No.	Step Angle	Volts DC	Stall Torque oz/in	Type	Mfr. & Part No.	Fig	Price
5431	1	5	17	PM	N.A. Phillips A82310-M2	1	$9.95 ea. 2/$14.95
5275	1.8	1.8	72	PM	Superior Electric MO61-FF-6201B	2	$19.95 ea. 2/$37.50
7630	1.8	3.0	200	PM	Superior Electric M092-FT-402	2	$34.50 ea. 2/$59.50

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Illuminated cap and number lock indicators. Low profile design.
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Mfr – General Instrument
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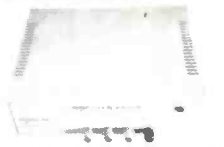

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DC Output: –5V @ .5 amp; +5V @ 3 amp; +12V @ 6 amp.
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Mfr – Motorola – Alpha Series
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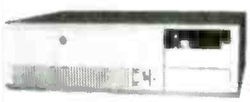
AT-STYLE COMPUTER CABINET



Contains 10 full-length expansion slots (w/guides). With room for an internal 5¼" hard disk drive. Has 3 half-height disk drive slots. Rear on/off switch, notched to hold in power supply (not incl.), and security switch w/key.
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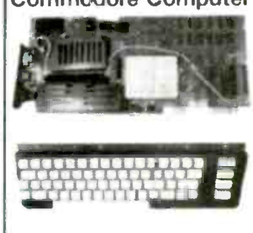
Insides of the Commodore Computer



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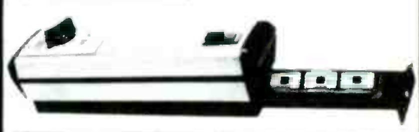

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74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
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74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
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74LS123	.49	74LS375	.95
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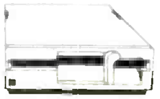

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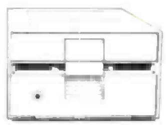

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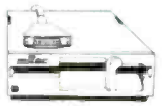

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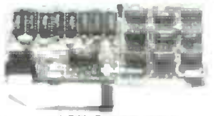

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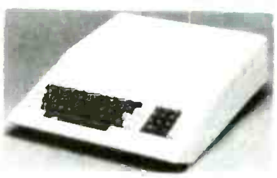


SWITCH BOXES

ALL LINES SWITCHED, GOLD PLATED CONNECTORS, QUALITY SWITCHES

2 WAY $39.95

- CONNECTS 2 PRINTERS TO COMPUTER OR VICE VERSA

AB-P *(CENTRONICS PARALLEL)*
AB-S *(RS232 SERIAL)*

3 WAY $99.95

- CONNECTS 3 PRINTERS TO COMPUTER OR VICE VERSA

SWITCH-3P *(CENTRONICS PARALLEL)*
SWITCH-3S *(RS232 SERIAL)*

NASHUA DISKETTES

NASHUA DISKETTES WERE JUDGED TO HAVE THE HIGHEST POLISH AND RECORDED AMPLITUDE OF ANY DISKETTES TESTED (COMPARING FLOPPY DISKS, BYTE 9/84)

N-MD2D	DS DD 5¼" SOFT	$9.90
N-MD2F	DS QUAD 5¼" SOFT	$19.95
N-MD2H	DS HD 5¼" FOR AT	$24.95
N-FD1	SS DD 8" SOFT	$27.95
N-FD2D	DS DD 8" SOFT	$34.95

BULK DISKETTE SALE

5¼" SOFT SECTOR, DS/DD W/TYVEC SLEEVES & HUB RINGS

$9.90	69¢ea	59¢ea
BOX OF 10	BULK QTY 50	BULK QTY 250

DISK DRIVE ENCLOSURES WITH POWER SUPPLIES

CAB-2SV5	DUAL SLIMLINE 5¼"	$49.95
CAB-1FH5	FULL HT 5¼"	$69.95
CAB-2SV8	DUAL SLIMLINE 8"	$209.95
CAB-2FH8	DUAL FULL HT 8"	$219.95

JOYSTICK GC-10 $19.95

- SET X-Y AXIS FOR AUTO CENTER OR FREE MOVEMENT
- FIRE BUTTON FOR USE WITH GAME SOFTWARE
- ATTRACTIVE, SOLID, PLASTIC CASE
- INCLUDES ADAPTOR CABLE FOR IBM, APPLE II, IIe

POWER STRIP $9.95

JDR PART #: POWER-STRIP

- 15 AMP CIRCUIT BREAKER
- 6 RECEPTACLES
- 6 FOOT POWER CORD
- PILOT SWITCH

WITH SURGE PROTECTION

JDR PART #: MT-660

$12.95

DISKETTE FILES

5¼" DISKFILE	3½" DISKFILE
HOLDS 70	HOLDS 40
$8.95	$9.95

BUILD STEVE CIARCIA'S INTELLIGENT EPROM PROGRAMMER

AS SEEN IN BYTE, OCT 86

- STAND-ALONE OR RS-232 SERIAL OPERATION
- MENU SELECTABLE EPROM TYPES NO CONFIGURATION JUMPERS
- PROGRAMS ALL 5V 27XXX EPROMS FROM 2716 TO 27512
- READ, COPY OR VERIFY EPROM
- UPLOAD DOWNLOAD INTEL HEX FILES
- PROGRAMMER DRIVER USER MODIFIABLE

Kit includes PCB & all components except case & power supply

$199

CALL FOR VOLUME QUOTES

CIRCLE 178 ON FREE INFORMATION CARD

20 MEG HARD DISK DRIVE ON A CARD $389!

NEW! EVERYTHING-IN-ONE CARD

MCT-MGMIO $119.95

- HERCULES COMPATIBLE MONOCHROME GRAPHICS, 720 x 384 PIXELS
- 1 STANDARD SERIAL PORT INSTALLED, OPTIONAL 2nd PORT AVAILABLE
- 1 PARALLEL PORT AND REAL TIME CLOCK/CALENDAR INCLUDED
- SUPPORTS BOTH DS/DD & DS/QD WHEN USED W/DOS 3.2 OR JFORMAT

QUALITY IBM COMPATIBLE MOTHERBOARDS

TURBO 4.77 / 8 MHz $129.95

JDR PART #: MCT-TURBO

- 4.77 OR 8 MHz OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- DYNAMICALLY ADJUSTS SPEED DURING DISKETTE OPERATION FOR MAXIMUM THROUGHPUT AND RELIABILITY
- CHOICE OF NORMAL/TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

STANDARD MOTHERBOARD $109.95

JDR PART #: MCT-XTMB

80286 6 / 8 MHz $499.00

JDR PART #: MCT-ATMB

- 8 SLOT (2 EIGHT BIT, 6 SIXTEEN BIT) AT MOTHERBOARD
- HARDWARE SELECTION OF 6 OR 8 MHz
- 1 WAIT STATE
- RESET SWITCH, FRONT PANEL LED INDICATOR AND KEYLOCK SUPPORTED
- SOCKETS FOR 1 MB OF RAM AND 80287 ON BOARD
- ON BOARD BATTERY BACKED CLOCK OPERATES WITH PC-DOS OR MS-DOS

3½" FDD KIT BY TOSHIBA

JDR PART #: FDD-3.5 KIT

- 720K FORMAT, DOS 3.2 COMPATIBLE
- ALLOWS DATA INTERCHANGE WITH NEW IBM MACHINES
- MOUNTING HARDWARE FOR 5¼" SLOT
- FACEPLATES FOR BOTH AT & XT

$149.95

IBM COMPATIBLE FLOPPY DISK DRIVE

JDR PART #: FDD-360

GOOD QUALITY DRIVES BY MAJOR MANUFACTURERS SUCH AS QUME, TANDON & CDC

- 5¼" HALF HEIGHT
- 360K STORAGE CAPACITY
- DS/DD
- 48 TPI

$69.95

IBM XT STYLE COMPUTER CASE

AN ATTRACTIVE STEEL CASE WITH A HINGED LID FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS

- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
- CUT-OUT FOR 8 EXPANSION SLOTS
- ALL HARDWARE INCLUDED

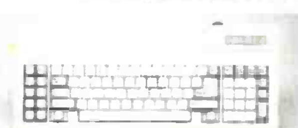
$34.95

XT STYLE SLIDE TYPE CASE $39.95
AT STYLE SLIDE TYPE CASE $89.95

BUILD YOUR OWN 256K XT COMPATIBLE SYSTEM

XT MOTHERBOARD	$109.95
PRO-BIOS (A $20 VALUE)	FREE!
256K RAM	$26.55
130W POWER SUPPLY	$69.95
FLIP-TOP CASE	$34.95
MCT-5150 KEYBOARD	$59.95
360K DRIVE	$69.95
FDD CONTROLLER	$34.95
MONOGRAPHICS CARD	$59.95
FORTRONICS MONITOR	$99.95
TOTAL:	$566.15

IBM COMPATIBLE KEYBOARDS



MCT-5060 $59.95

- IBM AT STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE

MCT-5339 $89.95

- IBM ENHANCED STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- 12 FUNCTION KEYS
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

MCT-5150 $59.95 XT STYLE LAYOUT

MCT-5151 $79.95 KB5151™ EQUIVALENT

EASYDATA MODEMS

All models feature auto-dial/answer/redial on busy, Hayes compatible, power up self test, touchtone or pulse dialing, built-in speaker, PC Talk III Communications software, Bell Systems 103 & 212A full or half duplex and more.

INTERNAL

EASYDATA-12H $99.95 1200 BAUD HALF CARD

EASYDATA-12B $119.95 1200 BAUD 10" CARD

EASYDATA-24B $199.95 2400 BAUD FULL CARD

EXTERNAL

NO SOFTWARE INCLUDED

EASYDATA-12D $119.95 1200 BAUD

EASYDATA-24D $219.95 2400 BAUD

MCT DISPLAY CARDS

MCT-EGA $179.95

100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS

- COMPATIBLE WITH IBM EGA, COLOR GRAPHICS AND MONOCHROME ADAPTORS
- TRIPLE SCANNING FREQUENCY FOR DISPLAY ON EGA, STANDARD RGB OR HIGH RESOLUTION MONOCHROME MONITOR
- FULL 256K OF VIDEO RAM ALLOWS 640 x 350 PIXELS IN 16 OF 64 COLORS
- LIGHT PEN INTERFACE

MCT-CG $49.95

COMPATIBLE WITH IBM COLOR GRAPHICS STANDARD

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- SUPPORTS RGB, COMPOSITE MONOCHROME & COLOR AND AN RF MODULATOR OUTPUT
- 320 x 200 COLOR GRAPHICS MODE
- 640 x 200 MONOGRAPHICS MODE
- LIGHT PEN INTERFACE

SHORT SLOT

MCT-MGP $59.95

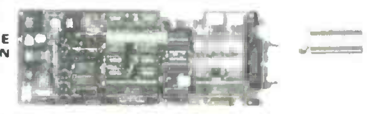
COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- PARALLEL PRINTER PORT, CONFIGURABLE AS LPT1 OR LPT2
- 720 x 348 GRAPHICS MODE
- LOTUS COMPATIBLE
- CAN RUN WITH COLOR GRAPHICS CARD IN THE SAME SYSTEM

MCT DEVELOPMENT TOOLS

MCT-PAL PAL PROGRAMMER $269.95

ONE ARRAY LOGIC CHIP CAN REPLACE 4-5 TTL ICs



- PROGRAMS 20 & 24 PIN PALS FROM TI, NSC & MMI
- EASY TO USE MENU-DRIVEN SOFTWARE ALLOWS PROGRAMMING, VERIFICATION READING, MAP BUILDING & BURNING THE SECURITY FUSE
- READ AND SAVE BURN PROFILES IN JEDEC FORMAT ON YOUR DISK

CUPL STARTER KIT $49.95

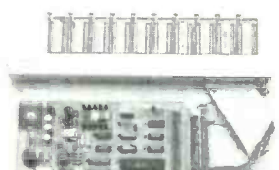
MCT-MP MICROPROCESSOR PROGRAMMER $199.95

PROGRAMS 8741/2/8/9 PROCESSOR CHIPS

- EASY TO USE MENU-DRIVEN SOFTWARE SUPPORTS READ, WRITE, BLANK CHECK AND VERIFY OPERATIONS
- PORT ADDRESS SELECTION IS USER CONFIGURABLE
- SAVE AND RESTORE PROGRAM IMAGES ON DISK
- INCLUDES SOFTWARE FOR STANDARD HEX AND INTEL HEX FORMATS

MCT-EPROM EPROM PROGRAMMERS $129.95

PROGRAMS 27xx AND 27xxx SERIES EPROMS UP TO 27512



- SUPPORTS VARIOUS MANUFACTURERS FORMATS WITH 12.5, 21 AND 25 VOLT PROGRAMMIMG
- MENU-DRIVEN SOFTWARE ALLOWS EASY MANIPULATION OF DATA FILES
- SPLIT OR COMBINE THE CONTENTS OF SEVERAL EPROMS OF DIFFERENT SIZES
- READ, WRITE, COPY, ERASE CHECK AND VERIFY WITH EASY ONE KEY SELECTION
- INCLUDES SOFTWARE FOR STANDARD HEX AND INTEL HEX FORMATS

4 GANG PROGRAMMER $189.95
10 GANG PROGRAMMER $299.95

MCT PRODUCTS CARRY A ONE YEAR WARRANTY

CIRCLE 179 ON FREE INFORMATION CARD

1200B MODEM $99.95 FOR IBM W/ SOFTWARE 2400B MODEM $199.95

MULTIFUNCTION CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-MF $79.95

ALL THE FEATURES OF AST'S SIX PACK PLUS AT HALF THE PRICE!

- 0-348K DYNAMIC RAM USING 4164s
- INCLUDES SERIAL PORT, PARALLEL PRINTER PORT, GAME CONTROLLER PORT AND CLOCK/CALENDAR
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR

MCT-ATMF $139.95

ADDS UP TO 3 MB OF 1 BIT RAM TO THE AT

- USER EXPANDABLE TO 1.5 MB OF ON-BOARD MEMORY (NO MEMORY INSTALLED)
- FLEXIBLE ADDRESS CONFIGURATION
- INCLUDES SERIAL PORT AND PARALLEL PORT
- OPTIONAL PIGGYBACK BOARD PERMITS EXPANSION TO 3 MB

ATMF-SERIAL 2nd SERIAL PORT $24.95

MCT-ATMF-MC $29.95 PIGGYBACK BOARD (ZERO K INSTALLED)

MCT-MIO $79.95

A PERFECT COMPANION FOR OUR MOTHERBOARD

- 2 DRIVE FLOPPY DISK CONTROLLER
- INCLUDES SERIAL PORT, PARALLEL PORT, GAME PORT AND CLOCK/CALENDAR WITH BATTERY BACK-UP
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR

MIO-SERIAL 2nd SERIAL PORT $15.95

MCT-IO $59.95

USE WITH MCT-FH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OT LPT2 (x378 OR x278)
- CLOCK/CALENDAR WITH A BATTERY BACK-UP

SHORT SLOT

IO-SERIAL 2nd SERIAL PORT $15.95

MCT-ATIO $59.95

USE WITH MCT-ATFH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPTA OR LPTB (x378 OR x278)
- GAME PORT
- USES 16450 SERIAL SUPPORT CHIPS FOR HIGH SPEED OPERATION IN AN AT

SHORT SLOT

ATIO-SERIAL 2nd SERIAL PORT $24.95

RAM CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-RAM $69.95

A CONTIGUOUS MEMORY SOLUTION FOR YOUR SHORT OR REGULAR SLOT

- SHORT SLOT, LOW POWER PC COMPATIBLE DESIGN
- CAN OFFER UP TO 576K OF ADDITIONAL MEMORY
- USER SELECTABLE CONFIGURATION AMOUNTS OF 192, 384, 512, 256 & 576K, USING COMBINATIONS OF 64 & 256K RAM

SHORT SLOT

MCT-ATRAM $149.95

A POWER USER'S DREAM. 4MB OF MEMORY FOR THE AT

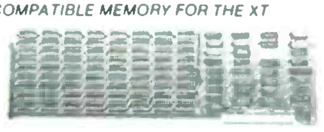
- USER EXPANDABLE TO 2MB OF ON-BOARD MEMORY
- USES FULL 16 BIT PARITY CHECKED MEMORY, 64K OR 256K DYNAMIC RAM
- FLEXIBLE STARTING ADDRESS, ROUND OUT CONVENTIONAL MEMORY TO 640K & ADD EXTENDED MEMORY ABOVE 1MB

MCT-ATRAM-MC $39.95 2MB PIGGYBACK BOARD (ZERO K INSTALLED)

MCT-EMS $129.95

2MB OF LOTUS/INTEL/MICROSOFT COMPATIBLE MEMORY FOR THE XT

- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- USES 64K OR 256K DYNAMIC RAM (NO MEMORY INSTALLED)
- USE AS EXPANDED OR CONVENTIONAL MEMORY, RAMDISK OR SPOOLER
- SOFTWARE INCLUDES EMS DEVICE DRIVERS, PRINT SPOOLER AND RAMDISK



MCT-ATEMS AT VERSION OF THE MCT-EMS $139.95

Seagate

HARD DISK SYSTEMS

20 MB $339 30 MB $399

Systems include half height hard disk drive, hard disk drive controller, cables and instructions. Drives are pre-tested and warranted for one year.

Seagate 40 MB AT DRIVE

FAST 40ms ACCESS TIME

NEW! 1/2 HEIGHT

$599

DISK CONTROLLER CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-FDC $34.95

QUALITY DESIGN OFFERS 4 FLOPPY CONTROL IN A SINGLE SLOT

- INTERFACES UP TO 4 FDDs TO AN IBM PC OR COMPATIBLE
- INCLUDES CABLING FOR 2 INTERNAL DRIVES
- USES STANDARD DB37 CONNECTOR FOR EXTERNAL DRIVES
- SUPPORTS BOTH DS/DD AND DS/QD WHEN USED W/ DOS 3.2 OR JFORMAT

MCT-HDC $89.95

HARD DISK CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL

- IBM XT COMPATIBLE CONTROLLER SUPPORTS 13 DRIVE SIZES INCLUDING 5, 10, 20, 30 & 40MB
- OPTIONS INCLUDE THE ABILITY TO DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES
- INCLUDES CABLING FOR 1 INTERNAL DRIVE

MCT-RLL $119.95

GET UP TO 50% MORE STORAGE SPACE ON YOUR HARD DISK

- INCREASES THE CAPACITY OF PLATED MEDIA DRIVES BY 50%
- RLL 2,7 ENCODING FOR MORE RELIABLE STORAGE
- TRANSFER RATE IS ALSO 50% FASTER: 750K/sec vs 500K/sec
- USE WITH ST-238 DRIVE TO ACHIEVE 30+ MB IN A HALF HEIGHT SLOT

NEW!

MCT-FH $139.95

STARVED FOR SLOTS? SATISFY IT WITH THIS TIMELY DESIGN

- INTERFACES UP TO 2 FDDs & 2 HDDs
- CABLING FOR 2 FDDs & 1 HDD
- FLOPPY INTERFACE SUPPORTS BOTH DS/DD & DS/QD WHEN USED WITH DOS 3.2 OR JFORMAT
- ALL POPULAR HDD SIZES ARE SUPPORTED, INCLUDING 5, 10, 20, 30 & 40MB
- CAN DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES

MCT-ATFH $169.95

FLOPPY AND HARD DISK CONTROL IN A TRUE AT DESIGN

- AT COMPATIBLE, CONTROL UP TO 2 360K/720K OR 1.2MB FDDs AS WELL AS 2 HDDs USING THE AT STANDARD CONTROL TABLES
- SUPPORTS AT STYLE FRONT PANEL LED TO INDICATE HD ACTIVITY
- 16 BIT BUSS PROVIDES RAPID DATA TRANSFERS
- FULLY SUPPORTED BY AT BIOS

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1200B MODEM $99.95 FOR IBM W/ SOFTWARE 2400B MODEM $199.95

BARGAIN HUNTERS CORNER

300 BAUD MODEM FOR IBM

INCLUDES ASCII PRO-EZ SOFTWARE

NOW ONLY $29.95

720K FLOPPY DISK DRIVE

BY MITSUBISHI

- ★ 5¼" HALF HEIGHT
- ★ 96 TPI
- ★ 100% IBM COMPATIBLE
- ★ DOUBLE SIDED/QUAD DENSITY

ONLY $99.95

SPECIAL ENDS 8/31/87

PAGE WIRE WRAP WIRE

PRECUT ASSORTMENT
IN ASSORTED COLORS $27.50
100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

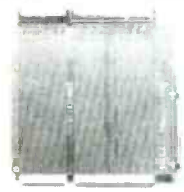
SPOOLS

100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

EXTENDER CARDS

IBM-PC	$29.95
IBM-AT	$39.95



WIRE WRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE
WITH GOLD-PLATED EDGE-CARD FINGERS

XT

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
IBM-PR2	AS ABOVE W/ DECODING LAYOUT	$29.95
AT		
IBM-PRAT	LARGE +5V & GROUND PLANES	$29.95
S-100		
P100-1	BARE - NO FOIL PADS	$15.15
P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75
APPLE		
P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
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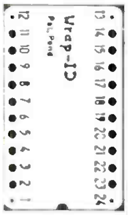
SOCKET-WRAP I.D.™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC, SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



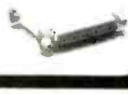
ID WRAP 24

FRAME STYLE TRANSFORMERS

12.6V AC CT	2 AMP	5.95
12.6V AC CT	4 AMP	7.95
12.6V AC CT	8 AMP	10.95
25.2V AC CT	2 AMP	7.95

25 PIN D-SUB GENDER CHANGERS

$7.95

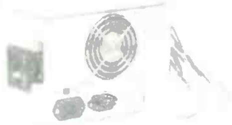


SWITCHING POWER SUPPLIES

PS-IBM $69.95
- FOR IBM PC-XT COMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A
  -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY

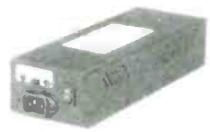
PS-IBM 150

PS-IBM-150 $79.95
- FOR IBM PC-XT COMPATIBLE
- 150 WATTS
- +12V @ 5.2A, +5V @ 16A
  -12V @ .5A, -5V @ .5A
- ONE YEAR WARRANTY



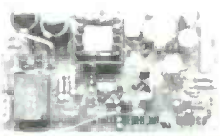
PS-AT $89.95
- FOR IBM PC-AT COMPATIBLE
- 220 WATTS
- +5V @ 22A, +12V @ 8A
  -5V @ .5A, -12V @ .5A
- 1 YEAR WARRANTY

PS-AT



PS-A $49.95
- USE TO POWER APPLE TYPE SYSTEMS. 79.5 WATTS
- +5V @ 7A, +12V @ 3A
  -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR

PS-A



PS-1558 $34.95
- 75 WATTS, UL APPROVED
- +5V @ 7A, +12V @ 3A
  -12V @ 250ma, -5V @ 300ma

PS 1558

CAPACITORS

TANTALUM

1.0μf	15V	.35	.47μf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001μf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01μf	50V	.14	.1μf	50V	.18
.047μf	50V	.15	.47μf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1μf	25V	.14	1μf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

DATARASE EPROM ERASER $34.95

- ERASES 2 IN 10 MINUTES
- COMPACT-NO DRAWER
- THIN METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

¼ WATT RESISTORS

5% CARBON FILM ALL STANDARD VALUES
FROM 1 OHM TO 10 MEG. OHM

10 PCS same value	.05	100 PCS same value	.02
50 PCS same value	.025	1000 PCS same value	.015

RESISTOR NETWORKS

SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	.59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	.99
DIP	14 PIN	13 RESISTOR	.99

SPECIALS ON BYPASS CAPACITORS

.01 μf CERAMIC DISC	100/$5.00
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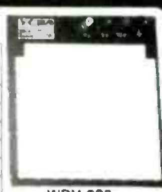

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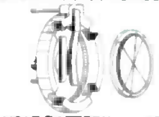

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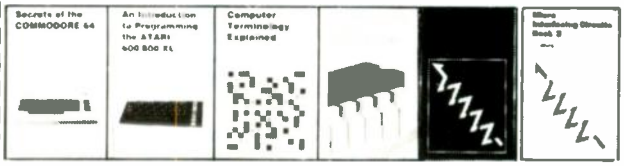

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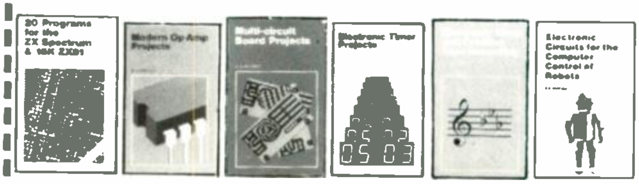

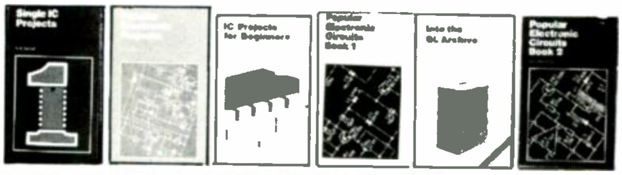

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