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CIRCLE NO. 6 ON FREE INFORMATION CARD

1979 Edition
Illustrated are typical case configurations and schematic symbols for various solid-state components. Those at right are for diodes and rectifiers: directly below, for transistors and solid-state control devices; and below right, for integrated circuits and seven-segment light-emitting diode displays.
THE “SILENCER” dynamic noise filter described here can eliminate tape hiss, record-surface noise, and atmospheric radio noise. Consequently, it is an ideal add-on device for stereo hi-fi systems. Moreover, it does not require encoding and decoding.

The device is essentially a voltage-controlled low-pass filter whose cutoff or break frequency is continually changing to accommodate program material and shut out any detracting noise. It only filters when noise and hiss are audible, when program material is at a low level or absent. The phenomenon of masking is utilized. That is, high-level signals mask noise that would be objectionable if program material level were low. When such masking occurs, the whole signal is passed. When there is no masking by program material, however, the filter extends the bandwidth only as far as required by the music. Beyond this, the high-frequency noise is attenuated. The frequency at which the filter begins rolling off to attenuate high-frequency noise is called the "break frequency."

About The Circuit. The Silencer circuit constantly analyzes incoming signals for amplitude, frequency, and persistence. These factors determine the bandwidth at any instant, as well as how quickly the variable low-pass filter changes. Attack and release times vary with the music, thus eliminating a "pump and wheeze" effect of noise modulation.

The device has a continuously variable threshold control, with front-panel LEDs calibrated to indicate "Low," "Mid," and "High" break frequencies. The filter's break frequencies vary between 1.5 and 20 kHz with a roll-off slope of 9 dB/octave (maximum). The Silencer is a single-ended stereo device, making it ideal for use with tapes, records, and tuners for playback and record purposes.

The unit connects either in the auxilli-
ary mode or in the tape loop of your audio amplifier. On the back panel are IN and OUT jacks for the tape loop; the front panel also has a TAPE monitor button, and a system DEFEAT.

The block diagram of Fig. 1 shows the functions of the dynamic noise filter. The voltage-controlled low-pass filter is composed of IC1A and IC1B, as shown in the schematic of Fig. 2. (The components to the left of the dashed line make up one stereo channel; only one is shown in the schematic for clarity.) The gain of op amp IC1A is approximately R3/R5. At low frequencies, the capacitive reactance of capacitors C4 and C5 is very high, making the output of IC1B look like a low impedance source. The gain of IC1A is then:

\[ A = \frac{R3}{R5} = 10,000 \text{ ohms/1000 ohms} = 10 \]

At higher frequencies, however, the impedance of C4 and C5 decreases; IC1B generates an output and bootstraps R5. This bootstrapping effect causes R5 to look larger. Therefore, gain A becomes smaller and the filter attenuates the high-frequency energy.

To vary the breakpoint of the filter, FET Q1 has the ability to shunt the signal at the non-inverting input of IC1B to ground. Figure 3A shows the filter with the FET open and the high frequencies attenuated, while 3B illustrates the filter's action with the FET shorting the signal to ground. The control signal applied at the gate of the FET allows the bandwidth of the low-pass filter to be self-adjusting for any frequency. This allows high-frequency signals and subtle harmonics of fundamental bass frequencies to be passed, while unmasked noise is attenuated.

The circuits represented by the shaded blocks of Fig. 1 are the dynamic analytical controls. They automatically judge the program material, adjust the bandwidth to accommodate it, and change the attack and release times to maximize the masking effect and minimize noise modulation. The control signal is applied to the gate of Q1. It's determined by the (1) spectral content, (2) amplitude, and (3) persistence of the incoming signal.

The spectral content is sensed by the high pass weighting filter, a network made up by R8, R29, R30, R31, C6, C17, and IC2A. This network is driven by the output of IC1B, which actually determines the quiescent operating point of the low-pass filter. Amplitude is determined by threshold control, R27, a 100K-ohm front-panel potentiometer. This pot sets the voltage divider for the positive input to IC2A, and the dc level for IC2A's output. The dc output level determines the quiescent operating point of the FET. The dynamic operation of the FET is adjusted by the ac control signal, allowing it to follow the program material. The ac component of IC2A's output is determined by sensing the signal's amplitude on the output of IC1B.

The persistence log amp is formed by R33, D2, and C20. It checks the correlation coefficient of the signal, and adjusts the attack and release time of the low-pass filter to minimize any noise modulation problems. Variable attack and release times allow for the most effective masking of the noise.

The anti-log amplifier IC2B also senses the control voltage output of IC2A. This signal is then rectified and filtered by D4 and C21, and is then used to drive threshold comparators IC2C and IC2D. These amps drive the logic network of D5, D6, and D7, which drives the display. The 10K-ohm trimpot, R37, is used to calibrate the LEDs. The red LED indicates a break frequency of 1.5 kHz, the yellow, a break frequency between 1.5 and 20 kHz, and the green that the filter is opening up above 10 kHz.
PARTS LIST

C1, C3, C9, C11, C21—1-µF 50-volt axial-lead electrolytic capacitors.
C2, C10—0.005-µF disk ceramic capacitors.
The following are 100-volt Mylar capacitors:
C4, C5, C12, C13—0.022-µF
C6, C14, C17—0.001-µF
C7, C15, C20—1-µF
C8, C16—0.01-µF
C18, C22, C23, C24—1000-µF 35-volt radial-lead electrolytic
D1—33-volt Zener diode
D2 through D7—1N914 signal diode
D8 through D11—IN4002 rectifier
F1—1/2-ampere fuse
IC1, IC2—µA4136 quad op amp (Fairchild)
J1-J8—RCA phono jacks
LED1—Red (Fairchild FLV 110 or equivalent)
LED2—Yellow (Fairchild FLV 410 or equivalent)
LED3—Green (Fairchild FLV 310 or equivalent)
Q1, Q2—Matched pair of 2N5458 JFETs.
The following are 1/2-watt, 5% tolerance resistors:
R1, R13, R26—47,000 ohms
R2, R14, R35, R43, R44—4700 ohms
R3, R15, R33, R38—10,000 ohms
R4, R16—100 ohms
R5, R17—1000 ohms
R6, R18—39,000 ohms
R7, R19, R45, R46—2200 ohms
R8, R20, R29—15,000 ohms
R9, R21—11,000 ohms
R10, R22, R36, R39, R41—100,000 ohms
R11, R12, R23, R24, R34—1 megohm
R25—22,000 ohms
R28, R32—470,000 ohms
R30—680,000 ohms
R31—130,000 ohms
R40, R42—27,000 ohms
Other resistors and controls:
R27—100,000-ohm potentiometer with switch
(RTS FR-GC-XM 450 or similar)
R37—100,000-ohm thumbwheel trimpot
R47, R48—10 ohms, 1/2 watt, 5% tolerance resistor
S1, S2—DPDT switches
S3—110-V, 2-A switch (part of R27)
T1—22-volt center-tapped, 50-mA transformer
Misc.—Ac line cord, knob for threshold pot, buttons for switches, suitable enclosure, hardware, hookup wire, solder, etc.
Note—The following items are available from Logical Systems, 3314 "H" St., Vancouver, WA 98663 (Tel. 206-694-7905). Complete 318 Silencer kit, including 6063 extruded aluminum chassis and hand-finished black walnut end pieces, $129.00. Also available separately: Etched and drilled circuit board, $15.00; individually tested and matched 2N5458 FETs, $3.50. Washington state residents please add 5% sales tax.
**Construction.** This unit is most easily constructed using a printed-circuit board. Complete etching and drilling guides are shown in Fig. 4A, with the component guide shown in Fig. 4B. Proper orientation of parts is very important. Take careful note of how FETs Q1 and Q2 are mounted as well as op amps, diodes, and electrolytic capacitors. Also observe that the dynamic characteristics of the FETs must be matched. Moreover, when choosing op amps, it is important to make sure that the one chosen for the detection circuit, IC2, has an open-loop gain of at least 50 dB at 10 kHz. Op amps in the parts section were chosen for their excellent noise figures.

The unit is designed to fit into a custom aluminum extrusion, held by the eight screws in the wood ends. Any suitable enclosure will work, however. The circuit board itself measures 6" x 9". The RCA phone jacks, front-panel switches, and threshold pot are circuit-board mounted for ease of construction and minimum noise. LEDs may be circuit-board mounted or attached to your front panel and then wired. If you choose not to use the furnished printed-circuit guides, make sure that the power supply is as far away as possible from the rest of the circuit to eliminate stray hum.

**Calibration.** Calibration should be done before you fully enclose the unit. To calibrate, connect the noise filter into your amplifier's or receiver's auxiliary or tape input. Find a low-level noise source—an erased magnetic tape would be ideal. If you don't have tape facilities you may use the inside groove of an LP record. Increase the amplifier's gain so you can hear the noise very well.

Start with the Silencer's threshold pot turned fully counterclockwise and slowly turn the control knob clockwise. You will hear the noise change character and become more objectionable. Return to the position where the noise-content change just begins (listen several times so you will be able to identify this point). With the threshold knob in this position, adjust R37, the thumbwheel trimpot, so that the red LED lights. You should adjust the pot so that it is at the point where only a slight adjustment will cause the yellow LED to light.

In conclusion, this easy-to-build noise-reduction system will be a helpful and versatile addition to any stereo hi-fi system, cleaning up signals from any source.

---

**OPERATING SPECIFICATIONS—“SILENCER”**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hiss Reduction</td>
<td>15 dB at 10,000 Hz</td>
</tr>
<tr>
<td>Max. Filter Slope</td>
<td>9 dB/octave</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>20 to 20,000 Hz ±0.5 dB</td>
</tr>
<tr>
<td>Minimum Bandwidth (Filter Closed)</td>
<td>1500 Hz</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>Output noise greater than 100 dB below max. output, 20 to 20,000 Hz</td>
</tr>
<tr>
<td>S/N Ratio</td>
<td>Better than 85 dB below 2 V ac output 20 to 20,000 Hz</td>
</tr>
<tr>
<td>THD</td>
<td>Less than 0.1%, at rated output, 20 to 20,000 Hz</td>
</tr>
<tr>
<td>IM Distortion</td>
<td>Less than 0.01% at rated output 60/7000 Hz mixed 4:1 typically less than 0.005%</td>
</tr>
<tr>
<td>Rated Output</td>
<td>2 V ac into 10,000 ohms</td>
</tr>
<tr>
<td>Max. Output</td>
<td>10 V ac into 10,000 ohms</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>47,000 ohms, single ended</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>100 ohms</td>
</tr>
<tr>
<td>Power requirements</td>
<td>110/120 V, ac 50/60 Hz, 8 W</td>
</tr>
</tbody>
</table>

Note: All measurements made with filter bandwidth open maximum except where specified (This is the worst-case condition.)

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1979 Edition
How light-emitting diodes work and some tips on where to use them

By Walter G. Jung

In just a few short years, the light-emitting diode (LED) has found its way into innumerable circuits and devices as a "state" indicator. Not too long ago, there was only one type of LED (red); but today there is such a wide variety from which to choose that selection can become confusing.

What is a LED? A LED is a pn-junction semiconductor device specifically designed to emit light when forward biased. This light can be one of several colors—red, amber yellow, or green—or it may be infrared and thus invisible. The schematic symbol for a LED is shown in Fig. 1. It is similar to the symbol for a conventional diode except that the arrows are added to indicate light emission.

Electrically, a LED is similar to a conventional diode in that it has a relatively low forward voltage threshold. Once this threshold is exceeded, the junction has a low impedance and conducts current readily. This current must be limited by an external circuit, usually a resistor.

The amount of light emitted by the LED is proportional to the forward current over a broad range, thus it is easily controlled, either linearly or by pulsing. The LED is extremely fast in its light output response after the application of forward current. Typically, the rise and fall times are measured in nanoseconds. Because of this fast response, LED's make excellent high-speed switched sources of light for

To correct this, let's take a look at what a LED is, how it works, what electrical and optical characteristics are available, and how to make the best use of them.

Fig. 1. Schematic symbol for LED is standard diode with arrows for light output.

Fig. 2. Response of the human eye to various types of LED light emissions.
use in multiplexing, strobing, and optical communications systems.

LED's are small in size compared to conventional incandescent lamps; and, in fact, a LED actually consists of a tiny "chip" a few thousandths of an inch across mounted in a relatively large plastic package. As you might expect, a LED is also very light in weight.

Because of their low operating voltage and low current drive requirements, LED's consume very little power—about 30 mW (20 mA at 1.6 V being typical). Consequently, LED's generate little heat. A side benefit of the low power requirement permits interfacing LED's with most digital and linear IC's or low-power transistor stages.

A LED does not "use itself up," and has little wearout mechanism, so very long life can be expected. Some manufacturers predict 100,000 hours or more, which amounts to over 11 years of continuous use. On a practical basis, once wired in and operated within specified ratings, a LED should last forever.

Characteristics. It was once said that LED's came in three colors—red, redder, and reddest; but recent advances in semiconductor technology have changed the picture greatly. The early red LED's were made of gallium-arsenide phosphide (GaAsP) compounds. These are still the most inexpensive types available. Gallium phosphide (GaP) is now used to produce green, yellow, and red LED's.

The relative sensitivity of the human eye to the standard LED emission wavelengths is shown in Fig. 2. Note that the eye is most sensitive in the green area with the peak at 0.56 microns. The GaP red emission is at 0.69 microns, while GaAsP red is at 0.66 microns.

The light output of a LED tends to be monochromatic—of a single color (wavelength). The light output of LED's is usually specified in candelas, a measure of intensity; though sometimes it is specified in foot-lamberts, a measure of intensity per unit area.

Interpreting Data Sheets. To use a LED properly, you must have some understanding of the data sheets. A few illustrations from typical data sheets are shown in Fig. 3.

The simple curve in Fig. 3A shows that LED light output increases linearly with forward current up to 50 mA, which, incidentally, is a typical continuous maximum current for plastic-packaged devices. Figure 3B is a current/voltage characteristic, showing the "knee" where conduction starts (in this case, at about 1.65 V, which is typical for a GaAsP diode). A GaP diode has a higher knee voltage (2 to 3V), but the curve's general shape is similar. Note that the diode current increases rapidly above the knee, which is why current limiting must be used to prevent damage to the diode.

The lensing arrangement of the diode package makes a big difference in how bright the LED appears off axis. As shown in Fig. 3C, the light can be formed into a narrow beam (as for the MV5024) or it can be wider (as for the MV5025). The beam-width used depends on the application. For example, a narrow-beam LED is correct for an optical communicator, but it is not good for a panel lamp since it will not catch the eye off to one side.

Even with a constant-current drive, temperature plays a role in the light output of a LED, as shown in Fig. 3D. However, for most hobby applications, this is not an important consideration unless a high-temperature environment is contemplated.

As a general rule, the LED should always be operated within recommended values. Maximum current can be exceeded on a peak basis as long as the average current is within specifications. The reverse voltage applied should be watched—3 volts is the usual maximum. A clamping diode can be used to prevent voltages that are too high.

Package Styles. Although LED's are manufactured in a wide variety of packages, only a few of the configurations have become favorites. One of the most popular packages is the T-1 3/4, a ¼"-diameter, high-dome, epoxy-encapsulated style. The Monsanto MV5020 series is typical of this type. It is intended for front panel or pc board mounting, and is available with a clear lens (MV5020), a diffused lens (MV5022), a plain red lens (MV5021), or a diffused red lens (MV5023). An uncolored, clear lens produces a point source of light, while a clear diffused lens softens the effect. A red lens aids contrast if the ambient light is high. A diffused red lens softens the beam and widens the angle of visibility, often desirable features.

These LED's are shipped in a plastic clip for insertion in a panel. The leads
are square and can either be soldered or wire-wrapped. The cathode lead is identified by the flat side on the plastic base, though in some cases the cathode is identified by a shorter lead. Green and yellow LED's that complement the MV5020 red series and have the same packaging are the MV5222 and MV5322, respectively.

The Fairchild FLV 100/101/102/108 series of "button" LED's are in small plastic packages similar to the TO-106 outline, but with only two leads. The respective part numbers correspond to a point source (FLV 100), diffused wide angle (FLV 101), red diffused area source (FLV 102), and an uncolored version (FLV 108) of the FLV 102. All of these packages benefit from the contrast enhancement provided by a black case. Although these units are best suited to PC board mounting, a plastic panel-mounting clip is available.

Another useful type of LED is the Texas Instruments TIL209/TIL209A, a red LED is a miniature 1/2"-diameter T-1 lamp size. It has a diffused red lens and is visible over a wide angle. The TIL209 has round leads, while the TIL209A has square leads. A companion green LED (TIL211) is also a diffused source. TI is currently working on yellow LED's, which should be available soon.

Hewlett-Packard has a series of red LED's which have a built-in current-limiting resistor. This eliminates the need for an external limiting circuit. Two models that operate from a 5-volt supply (can be driven by TTL) are the 5082-4860, a red diffused unit in T-1 ¾ size, and the 5982-4468, a clear diffused unit in T-1 size. The 5087-4860 can be panel-mounted and has wrap leads.

Litronix has also incorporated a current limiter in a LED package to operate over a wide variety of supply voltages. These devices come in T-1 ¾ and T-1 sizes. They have red diffused lenses. The RLC-200 is usable at voltages up to 12.5 V maximum, while the RLC-210 works up to 16 volts.

**Driving LED's.** A LED can be driven by either an ac or dc source, requiring a current-limiting resistor in either case. The two basic driving circuits are shown in Fig. 4. The equations show how to determine the value of the limiting resistor.

In Fig. 4A, the positive of the voltage source is connected to the LED's anode, so a forward current, \( I_f \), flows. The current depends on \( V \), the LED forward voltage drop (\( V_f \)), and the value of \( R_I \). The forward voltage drop varies between 1.6 and 3 volts, depending on the type of LED and can be determined from the published data sheets. As an example, assume that the LED requires 20 mA, has a \( V_f \) of 1.6, and the voltage source is 5 V. Then \( R_I = (5 - 1.6)/0.02 = 170 \text{ ohms} \). (180 ohms would be the nearest standard value.) Check the required wattage of the LED.

---

**REFERENCES ON LED'S**

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*Manufacturers' Literature:
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  * "Application Notes,” Monsanto
  * "Optoelectronics at Work,” Motorola
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*Manufacturers' Addresses*

  * Chicago Miniature Lamps. 4433 N. Ravenswood, Chicago, IL 60607
  * Dialight, 60 Stewart Ave., Brooklyn, NY 11201
  * Fairchild Microwave & Optoelectronic Div., 464 Ellis St., Mountain View, CA 94040
  * General Electric Co., E. Nela Park, Cleveland, OH 44101
  * Hewlett-Packard Co., 620 Page Mill Rd., Palo Alto, CA 94304
  * Littronix, 19000 Homestead Rd., Cupertino, CA 95014
  * Monsanto, 10131 Bubb Rd., Cupertino, CA 95014
  * Motorola Semiconductor Products, 5005 E. McDowell Rd., Phoenix, AZ 85036
  * National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051
  * Opcoa, 330 Talmadge Rd., Edison, NJ 08817
  * Texas Instruments, Dallas, TX 75222
  * Xciton Corp., 5 Hemlock St., Latham, NY 12110

---

**Fig. 4.** Calculation of series current-limiting resistor for dc shown at (A); for ac, shown at (B).
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Low-power logic such as CMOS cannot drive LED's directly so a buffer such as a CD4049 or CD4050 must be used, but current is limited. A solution is to use an emitter-follower buffer as shown in Fig. 5C. A beta of 100 for Q1 will reduce the drive current required to 200 µA, which is compatible with the 4000A series of CMOS. The circuit in Fig. 5C is an example of OR logic since the LED is lit for a logic one on either A or B. Limiting resistor R1 should be selected to match the supply voltage. An npn transistor could also be used for Q1 by connecting the collector to the supply with the LED and R1 in the emitter circuit. A basic asset of CMOS is its very high noise immunity, so a slightly reduced output swing from the gate in Fig. 5C is not a real detriment as far as driving other CMOS inputs is concerned. There are no fanout restrictions.

So far, we have discussed only on-off types of LED drives. A linear driver is shown in Fig. 5D. An op amp is used to make the LED current precisely proportional to the input modulation signal. Potentiometer R3 determines the dc bias current in the LED since the voltage at the rotor of R3 also appears across R1. If R3 is centered, R1 "sees" 7.5 volts and the current through the LED is 20 mA. The audio signal, through Q1, modulates the dc bias signal to control the LED current proportionally. This circuit could be used as the transmitter end of lightbeam communicator. It is simple, inexpensive and easy to set up, and none of the components is critical.

Some Applications. A pulser that is useful for on-off modulation of visible or IR LED's is shown in Fig. 6. A 555 timer IC is used as an astable oscillator which provides a 10-µs pulsed output every 10 ms (a 100-Hz rate). The circuit can be frequency modulated by applying an audio signal to pin 5. Resistor R3 sets the peak LED current to about 200 mA, and, since the duty cycle is only 0.001, the LED is not overloaded.

Using a narrow-beam IR LED (such as the Motorola MLE60) in this circuit and a silicon detector at the receiver, an invisible light-beam communication link can be constructed.

A sensitive polarity (or null) indicator is shown in Fig. 7. The circuit uses an op amp to achieve a very low input-voltage threshold. Since the input signal is applied to the op amp noninverting input (+), the op amp output is positive when the input is positive and negative when the input is negative. A positive input lights the green LED, and a negative signal lights the red LED. The LED's can be separate devices, or a dual unit such as the Monsanto MV5491 (red/green) LED can be used.

The input threshold is the offset of the op amp used. For a 741, it is ±6 mV or less. There are no loading effects since the input draws very little current. If the added sensitivity is not needed, the op amp can be omitted and the LED's driven directly through R2. This is a useful option if the source impedance is low.

The circuit shown in Fig. 8 uses two high-gain comparators to determine whether a critical voltage is between two limits. In the circuit shown, the limits are +4 and +6 volts. The two comparators are wired as OR gates, so that the LED is energized if either comparator output is low. This would occur if V_in were less than +4 V or more than +6 V. Using this general idea, different reference voltages can be used to monitor almost any voltage level.

Conclusion. Of course, we have not covered all of the possible uses for the various types of LED's. Hopefully, some ideas have been generated. Others can be obtained from the references given in the accompanying box.
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1979 Edition
A DIGITAL STOPCLOCK FOR SHORT AND LONG EVENT TIMING

Times events to 10 hours in 0.1-second intervals.

BY MICHAEL S. ROBBINS
WOULD you like to know precisely how long a recording session runs; how long it takes to make one lap around the track; or how long that new amplifier has been cooking on the bench? Here is a new six-digit stopclock that can do it—counting and displaying elapsed time up to ten hours by tenths of a second.

The heart of the stopclock is the new National Semiconductor MM5309 PMOS integrated circuit. It is identical to the MM5311-5314 series of clock IC's with one important exception. The "hold" pin has been replaced by a "reset" pin, which allows all of the counters to be reset to zero. This means that all of the on-chip counters can be reset to zero as required in a stopclock.

In this project the 5309 is used with three other IC's to provide 0.1-s counting with stop, start, and reset controls. Power is provided by a 12-volt transformer, and either 60- or 50-Hz line power can be used. Although the 5309 has outputs for either a 12- or a 24-hour display, in this case we use only a 10-hour display with the initial zero blanked and the sixth digit used for displaying tenths of a second. (For example, the display is 09:00:00.0 instead of 09:00:00.0.)

The complete schematic of the stopclock is shown above and on the opposite page.

Fig. 1. Complete schematic of stopclock is shown above and on opposite page.
Fig. 2. Etching and drilling guides with component layout diagrams for the two pc boards.
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for additional transistors to drive the 0.1-s display (DIS6), the outputs of IC3 are connected through D9 through D15 to the outputs of IC4. Since IC4 is off due to the leading-zero blanking interval when it would normally display the 10's of hours, this time slot can be used for the 0.1-s display. Thus, the H10 output of IC4 is used to turn on and off IC3 and enable DIS6.

Now, what happens when the H10 10's of hours display is supposed to be on as it normally would be after a 9:59.59 count? Without IC1, DIS6 would display a random character. One NAND gate in IC1 is used to detect this random digit and reset IC2 and IC4 to zero. In this manner, the stopclock is reset 0.2 second after the 10:00:00 count pulse, thus producing an effective timing range of 9:59:59 counts.

The other two gates in IC1 are connected as an RS latch to turn on and off the time base. Operating S2 causes pin 9 of IC1 to drop to zero. Diode D7 is then forward biased, preventing the ac signal from reaching IC2 and IC4. Operating S1 raises pin 9 to about 12 volts and effectively removes D7 from the circuit, allowing the ac timing signal to reach the counters, and the count changes every 0.1 second.

Jumper Z1 between pins 13 and 14 of IC4 causes the input sections of IC2 and IC4 to divide by six for use on the 60-Hz power line. For 50-Hz operation, no jumper is needed.

Construction. The stopclock is best assembled on two printed circuit boards, the etching and drilling and component placement guides for which are shown in Fig. 2. The circuit is split between the main and display boards as shown by the two sections in Fig. 1.

Leaving installation of the IC's until last, wire the main board as shown, taking care to properly orient the filter capacitor, diodes, and transistors. Note in Fig. 3 that some resistors mount upright. Install Molex Soldercons® or regular IC sockets in the locations for the IC's, but don't install the IC's just yet.

Next, wire the display board as follows. First install and solder the resistors into place on the foil side of the board. Trim away excess lead lengths. Then install and solder into place the displays, DIS1 through DIS6, on the blank side of the board. Interconnect the two boards with lengths of hookup wire connected between similarly labelled pads on both boards. Solder 5" (12.7-cm) lengths of hookup wire to the pads identified in Fig. 2 by the letters H through L.

Fasten the display board to the main board with two small L brackets, threaded spacers, and machine screws; and mount another pair of spacers at the back of the main board. Then mount the entire assembly inside the chassis box, via the spacers, with four machine screws and lockwashers. Glue a red acrylic filter behind the front panel of the chassis box over the display "window." Then mount TS1 and TS2 on the rear panel of the box and S1, S2, and S3 on the top.

Connect and solder the free ends of the wires coming from holes H and I to the lugs of TS1 and the free ends of the J, K, L, and M wires to lugs 3, 6, 4, and 5, respectively of TS2. Solder 5" lengths of hookup wire to each of the lugs on TS2 and wire them to the switches as shown in Fig. 1. Label TS1 12 Volts ac and lugs 3 through 6 on TS2 STOP, START, RESET, and GROUND, respectively. Then label switches S1, S2, and S3 STOP, START, and RESET, respectively.

Practicing the usual precautions for handling MOS devices, install the IC's in their respective locations via the Soldercons or sockets. Make certain that you orient them properly. (On the case of each IC is a dot for easy identification of pin 1.)

Operation and Use. When power is first applied to the stopclock, random numbers will be displayed. Depressing RESET switch S3 resets all displays to zero. When START switch S1 is momentarily closed, the stopclock should begin counting at a 0.1-s rate and the DIS6 digit should be a blur. Let the stopclock run for a few minutes. Then hit STOP switch S2. The display should immediately grind to a halt and remain locked onto the last count after releasing S2.

To be of any use as an events timer, the stopclock must be stopped and started in a manner that produces meaningful information. The simplest approach would be to use the switches on the top of the cabinet to initiate the count and stop it. For remote operation, an identical set of pushbutton switches can be connected to TS2 (paralleling S1, S2, and S3) via a cable. The best way by far of tripping and stopping the count is to let the event being timed operate the stopclock.

Bear in mind that each of the three circuits operated by the pushbutton switches in Fig. 1 is held at +12 volts by R1, R2, and R3. To enable an input, the bottom ends of these resistors must be connected to ground. Therefore, any external switching device connected to TS2 must have an on resistance of less than 100 ohms and an off resistance in excess of 10,000 ohms. In the momentary-on condition, the external switching device must be capable of handling 12 mA of current.

As shown in Fig. 4A, relay contacts operated by some remote device can be used to trip any one or more of the S1, S2, S3 functions. The circuit is closed by applying energizing power to the relay coil. If the relay is a latching type (mechanical or electrical), some means must be provided to open its contacts after each closure.

Optoelectronic couplers make ideal interfaces for the stopclock whenever the controlling circuit is at a different voltage from that used in the timer's circuit or has potentially damaging spikes. An optoelectronic coupler consists of a light source (usually a LED) and a light sensor (usually a phototransistor) facing each other in a light-tight case. The source and sensor are electrically isolated from each other. The Motorola 4N28 optoisolator, one of the more common types available, is shown connected to TS2 on the stopclock in Fig. 4B. A separate optoisolator circuit can be used on each of the START, STOP, and RESET inputs. Each is separately tripped by momentarily applying a dc voltage to the source circuit.

The circuit in Fig. 4C can be used to...
measure running (or on) times. Resistor $R$ should be selected to limit the current through the diode to about 40 mA. For example, to measure the running time of a battery-powered cassette recorder that has a 12-volt dc motor, the value selected for the resistor in ohms is equal to $(V-1.2)/A$, where $V=12$ volts and $A=40$ mA. In this case, $R=270$ ohms. The circuit connects across the tape recorder’s motor.

The length of time it takes a vehicle (including toy trains and cars) to traverse a prescribed distance is often of interest. Light-beam tripping is a convenient way of starting and stopping the count. The circuit for accomplishing this is shown in Fig. 4D. Almost any type of light source, including an ordinary flashlight, can be used in this scheme. Depending on the distance between the light source and phototransistor, it may be necessary to use lenses to focus the beam. (Lenses may not be necessary in timing toys unless the distance is more than a few inches.) Although a Motorola MRD450 phototransistor is specified in the diagram, the value of the resistor can be adjusted to allow the circuit to accommodate just about any other phototransistor.

---

**Fig. 4.** Stopclock can be operated by a relay (A); an optoisolator (B and C); or a phototransistor (C).
Getting Started with Op Amps

A solderless socket, a handful of parts, and you are ready to experiment with these versatile devices.

By Sol D. Prentsky
VOM. The output voltage across the 2000-ohm load should be at least two-thirds of the ±9-volt supply (at least 12 volts peak-to-peak).

When S1 is closed, an audible tone should be heard from the speaker, and the measured potential should drop to about 6 volts p-p. Bear in mind that the average meter indication with a VOM will be about half the peak-to-peak value. The oscillator frequency is determined by the \( R_2 - C_1 \) time constant. If you change the value of either (or both) component, the frequency will change accordingly.

This test circuit can handle many different types of op amps. In addition to the internally compensated op amps, of which the 741 is an example, the tester will also work with externally compensated op amps without circuit changes because the use of a compensating capacitor is not necessary in this setup. The LM107, 741, MC1556, CA3100S, and HEP-6052P are examples of internally compensated op amps, while the LM101A, NE531, 709, 748, and HEP6053P are examples of externally compensated op amps.

Because the dual in-line package (DIP) IC's have two parallel rows of leads, they are easy to insert into the solderless socket. If you have round metal-can op amps, you can form the leads into the correct in-line configuration with the aid of long-nose pliers; work carefully. Fig. 2 illustrates how the circuit is breadboarded.

**LED Experiment.** The light-emitting diode, or LED, is a natural companion for the op amp. The LED requires only about 1.6 volts at 20 mA for proper operation, which is well within the output capabilities of the op amp. The circuit shown in Fig. 3 uses an op amp to pulse a LED at a visible rate. This circuit can also be used as a clocking oscillator for digital circuits so that countdown action can easily be followed.

The basic circuit in Fig. 3 is similar
to that shown in Fig. 1, except that the value of C1 has been greatly increased to slow down the repetition rate to about 1 Hz (1 pps). Display circuit A shows the addition of a conventional silicon diode and a LED (any color) that will pulse on with each positive-going portion of the oscillation pulse. The variation shown in circuit B employs two differently colored LED's. Arranged with silicon diodes, the LED's pulse on and off in step with the op amp's oscillator signal. (Note: some of the older type green and yellow LED's require more drive current than do red LED's, which means that they might not glow as brightly. If you use the newer GaP green or yellow LED's, you will encounter no difficulty in glow light level.) The two-color circuit can also serve as a polarity indicator for other circuits, if you assume the red LED to be on for one polarity and the green LED on for the other polarity.

Microphone Amplifier. The basic simplicity of op-amp amplification is shown in Fig. 4. The two modes—low- and high-impedance modes—correspond to the two differential op-amp input connections. In using a single-ended input for a microphone, you have a choice of using either the inverting (−) or non-inverting (+) input. In either case, the closed-loop gain is substantially the same and is determined by the ratio of R1 to R2.

The choice of input is determined by the greatly differing input impedances for each connection. In circuit A, the input impedance is approximately the same as the value selected for R1. Hence, for this mode, you can make the input impedance any reasonably low value (by selecting the proper value for R1) and determine the required gain by selecting the appropriate value for R2. In circuit A, the gain is R2/R1 = 240,000/1200 = 200 or 46 dB.

If you need a high-impedance input, in the range of hundreds of megohms, feed the input signal to the non-inverting (+) input as shown in circuit B. If you wish to use a crystal or ceramic microphone in this mode, you must shunt it by about 1 megohm to provide a dc path for the bias on the + input. The load in both circuits is a 2000-ohm earphone because of the limited ability of the op amp to supply substantial output current.

At these high gains, the 741 op amp will cover only the speech frequencies. For extended bandwidth, you will have to use an externally compensated 748 op amp in place of the 741. For loudspeaker operation, replace the earphone with an equivalent value fixed resistor and use this signal to drive an audio amplifier.

If you want to make a simple audio mixer for two or more signal sources (microphones, turntables, tape recorders, receivers, etc.), use a separate P1 for each source in the Fig. 4A circuit in a summing mode.

In Conclusion. There are almost unlimited number of relatively simple op-amp experiments you can perform, many of which have been published in these pages in the past. Most such experiments can be assembled and tested for educational purposes or modified as the experiment progresses. They can be taken apart and reassembled in only a few seconds using the solderless-socket breadboard approach.

While in this article we have stressed the use of the solderless socket as a breadboarding system for linear (op-amp) circuits, this does not preclude their use in digital IC experiments and projects. Using one of the largest sockets, you can breadboard a complete logic system in only minutes.
BUILD A
DIRECT-DRIVE
TURNTABLE

BY GEORGE MEYERLE

FEATURES AUTOMATIC
PITCH CONTROL AND
METER-READOUT "STROBE"

A Hi-Fi turntable isn't something you would ordinarily expect to see as a construction project in an electronics magazine, but here's a turntable system you can build yourself. It's chock full of electronics, and its direct-drive design is the apple of the audiophile's eye today. In addition, it features two remarkable innovations: an automatic pitch control and a direct-readout meter for checking speed accuracy.

Unlike turntable designs which use idler-rim drive or belt drive, the direct-drive turntable does not employ speed-reducing devices to rotate the platter. Consequently, there are no idler wheels to flatten or belts to fray and stretch over a period of time. The servo-controlled motor, operating directly at a precise speed of 33 1/3 or 45 rpm, connects directly to the platter. Such a slow rotational speed reduces vibration and rumble. At 33 1/3 rpm, the main rumble frequency is below 10 Hz. Direct drive also permits use of a single bearing, reducing wow, flutter and rumble caused by multiple bearings.

Using electronic circuitry to control a direct-drive motor produces a host of benefits. For example, speed accuracy is maintained even in the face of line frequency changes, which can occur from time to time. Moreover, you can adjust the pitch higher or lower. And should there be an unusually heavy force applied to the platter of this turntable while it's rotating — say, by a record-cleaning brush — you can quickly achieve precise speed by switching on the automatic pitch control.

About the Circuit. The turntable employs a direct-drive brushless dc motor that has one main sleeve bearing and
PARTS LIST

C1 - 4.7 µF, 10%, 10-volt electrolytic capacitor  
C2 - 0.015 µF, 10%, 50-volt polyester film capacitor  
C3 - 47 µF, 10%, 10-volt tantalum capacitor  
C4 - 1 µF, 10%, 10-volt tantalum capacitor  
C5, C6 - 330 µF, 10-volt electrolytic capacitor  
C7, C9 - 220 µF, 35-volt electrolytic capacitor  
C8 - 1000 µF, 35-volt electrolytic capacitor  
C10 - 22 µ F, 10%, 50-volt polyester film capacitor  
C11 - 1 µ F, 10%, 10-volt tantalum capacitor  
C12 - 1000 µ F, 50-volt disc capacitor  
D1 through D5, D8 - 1N4148 diode  
D6, D7 - 100-volt, 1-ampere rectifier diode (1N4002 or similar)  
IC1 - MC1732CL integrated circuit (Motorola)  
IC2, IC3 - 747 operational amplifier integrated circuit  
J1, J2 - Dual phono jack assembly  
M1 - Zero-center, ±75 µA meter movement  
The following resistors are 2-watt unless otherwise noted:  
R1, R2, R3, R4 - 100,000 ohms, 10%, carbon film  
R4 - 220,000 ohms, 10%, carbon film  
R5, R6, R35 - 12,000 ohms, 10%, carbon film  
R7 - 10,000 ohms, 2%, metal film  
R8, R15, R16 - 100,000 ohms, 10%, carbon film  
R9, R11, R32, R33 - 12,000 ohms, 2%, metal film  
R10, R13 - 1200 ohms, 10%, carbon film  
R14 - 1000 ohms, 2%, metal film  
R15 - 22,000 ohms, 2%, metal film  
R16 - 22,000 ohms, 10%, carbon film  
R17 - 10,000 ohms, 2%, metal film  
R18, R22, R27 - 560 ohms, 10%, carbon film  
R19 - 2400 ohms, 2%, metal film  
R20 - 390 ohms, 2%, metal film  
R21 - 100,000 ohm trimmer potentiometer  
R23, R24 - 2500-ohm trimmer potentiometer  
R25 - 39 ohm, 10%, 5-watt resistor  
R36 - 2500 Ohm potentiometer  
S1 - 3-pole, 3-position rotary switch (or toggle equivalents)  
S2 - Spst switch  
T1 - 16-volt, 100 mA wall-plug transformer with line cord  
Misc. - Direct-drive, brushless de motor with integral circuit board assembly; printed circuit board for control circuit; motorboard; turntable base; control panel; acoustic-isolator springs (8); wire nuts (6); control knobs (3); 6-32 x 1" machine screws and nuts (3); No. 6 x 4" woodscrews (2); double-sided tape; hookup wire; solder; etc.

Note: The following items are available from Netronics Research & Development Ltd., 333 Litchfield Rd., New Milford, CT 06776: Complete turntable kit, including all parts and Audio-Technica Model AT-100511 universal tonearm No. 450D for $159.95; complete kit less tonearm (motorboard minus tonearm holes) No. 350D for $130.00 plus $3.00 postage and handling; dust cover for above No. 40-004 for $12.00 plus $1.50 postage and handling; motor with cast platter and rubber mat No. 99-001 for $65.00; control circuit pc board No. 99-007 for $5.90; meter movement No. 99-004 for $6.50; auto pitch control switch (S2) No. 99-004 for 90c. When ordering complete kit, add $2.50 for postage. Connecticut state residents, please add sales tax.

Fig. 1. The control circuit for the turntable motor. The tachometer signal is converted to square waves, differentiated and fed back to the motor. The oscillator and filter for the power supply are also located on the control board assembly.
a ball-type bottom bearing. A preassembled 11-transistor circuit board is housed inside the motor's case. It is connected to an external electronic control circuit board assembly via a color-coded cable system. The circuit assembly inside the motor housing contains all of the circuitry required to rotate the motor and provides a means by which the accuracy of the motor's speed can be monitored.

The motor's brushless action is accomplished by using a high-frequency oscillator, the output of which goes to a series of commutator coils that initiate and sustain motor rotation. A tachometer coil assembly generates a signal that is a function of the speed of the motor's rotor. This control signal is fed back to the speed control circuit to provide constant regulation.

The external control circuit is shown in Fig. 1. The tachometer signal from the motor goes to stage A (IC2A), which converts the pulses into square waves. The output of stage C is, therefore, proportional to the speed of the motor. Independent of temperature or line voltage, this output is then coupled back to the motor control board through R19. Once the motor has been set to a desired speed, via R36, the electronic feedback system tracks to maintain this speed.

A zero-center meter movement is connected between the output of stage C and the rotor of 33 1/3-rpm potentiometer R23. When this potentiometer and pitch potentiometer R36 have been properly set, the direct-drive motor locks onto exactly 33 1/3 rpm and the meter's pointer remains at the zero-center index mark on its scale.

If for any reason, such as record loading or other sources of friction, the speed of the motor deviates from 33 1/3 rpm, the meter will begin to indicate off the zero mark. The meter itself is calibrated for ±5% motor speed deviation range (both sides of the zero index mark). You can compensate for speed changes by operating the speed adjust potentiometer and recentering the meter's pointer. However, there is a far easier and faster way to accomplish the same end that makes this turntable different from other turntables.

Stage D in the control system is what sets this turntable apart. Note that op amp IC3B is connected as a differential amplifier directly across the meter terminals. Because this stage has a gain of about 20,000 and is operated wide open, a change of only a few millivolts at its input ports generates a maximum output. The change in millivolts will barely be revealed by the meter's pointer, which will remain virtually fixed at the zero mark.

If S2 is closed (AUTO PITCH CONTROL ON), the output of stage D will be fed to the motor speed control board for instant use. The correction factor in this mode is so fast that it insures an almost perfect pitch. Even the slightest change in motor speed is immediately corrected automatically and the motor will rotate at a predetermined speed to keep the meter's pointer on zero center and the inputs to the differential amplifier will be exactly the same.

With automatic pitch control switch S2 set to OFF (open), speed adjust potentiometer R36 can be used to fine tune the turntable speed for exact pitch, slightly above or below 33 1/3 rpm, if there have been any slight frequency changes during the manufacturing stage between the original recording and the final retail disc. You can also tune a disc for your own instrument if you wish to play along with the music.

Note that only the rectifier/filter part of the power supply is on the control circuit board assembly. The 16-volt transformer plugs into a wall outlet and only the low ac voltage is routed to the turntable's electronics package. This insures a very low hum level to be picked up by the phonograph cartridge.

This turntable employs a second set of acoustic isolators that are resonant about 2 Hz below the resonant frequency of the main platter system. The result is excellent isolation from acoustic coupling sometimes experienced from loudspeakers.

**Construction.** The actual-size etching guide and components placement guide for the printed circuit board to be used in the turntable are shown in Fig. 2. Mount the components on the board exactly as shown, taking care to properly orient the electrolytic capacitors, diodes, transistor, and IC's. Use a low-wattage soldering iron with fine tip and apply only enough heat to assure good electrical and mechanical connections. Carefully inspect each solder connection for cold soldering and solder bridges between closely spaced conductors. When you are satisfied that the board is properly wired and soldered, temporarily set it aside.

The motorboard, which measures roughly 17" × 10" (43 × 25 cm), consists of two 3/4" (1.9-cm) thicknesses of high-density particle board glued firmly together to form a monolithic sandwich. The upper layer of the sandwich has a 5/8" (12.7-cm) hole cut into it, while the lower layer has a 3 1/2" (8.9-cm) hole centered within the hole in the upper layer. The motor drops into the motorboard through the top hole, its mounting flange resting on the lower layer's upper surface. Then three 6-32 × 1" machine screws and nuts anchor the motor into place. Mount the tonearm and its rest post in their respective locations on the right side of the motorboard. Slip the turntable platter onto the motor's spindle and check to make sure that it rotates without brushing against the motorboard.

The base of the turntable must be large enough to accommodate the motorboard and leave enough room to house the control electronics package in front. It must also be deep enough to clear the motor or permit the rear end of the motor's housing to sit in a cutout in the bottom panel. Use #6 woodscrews to mount four isolation springs near the corners of the motorboard. Turn over the base and, in like manner, mount four more isolation springs near each corner of the base.

Mount the AUTO PITCH CONTROL (S2) at the left end of the control panel. Then, using double-sided tape, mount

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**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wow</td>
<td>0.02% rms (weighted)</td>
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<tr>
<td>Flutter</td>
<td>0.04% rms (weighted)</td>
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<tr>
<td>Rumble</td>
<td>≤-60 dB RIAA/RRLL</td>
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<tr>
<td>Drift (APC on)</td>
<td>0.01%</td>
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<tr>
<td>APC accuracy</td>
<td>0.01%</td>
</tr>
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<td>Speed control</td>
<td>±5% (33 1/3 &amp; 45 rpm)</td>
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<tr>
<td>Suspension</td>
<td>Dual resonant</td>
</tr>
<tr>
<td>Motorboard weight</td>
<td>5½ pounds (2.5 kg)</td>
</tr>
<tr>
<td>Platter</td>
<td>180 kg/cm² moment of inertia, non-ferrous</td>
</tr>
<tr>
<td>Pitch control</td>
<td>Five-turn, three-ball planetary potentiometer for precision accuracy</td>
</tr>
</tbody>
</table>
the meter movement in a rectangular cutout in the control panel so that its scale is easy to read. This done, mount the control circuit board assembly to the panel via the PITCH control (R36) and MODE switch (S1). Check to make sure that the adjustment slots of the 33 (R23), 45 (R24), and APC (R26) trimmer potentiometers line up with the holes in the control panel.

Referring back to Fig. 1 and Fig. 2, complete wiring the system. Do not solder the wires coming from the motor housing directly to the pc board pads. Instead, solder lengths of prepared hookup wire (preferably color coded for easy identification) to the board, twist together the free ends of the hookup wires and the appropriate motor wires, and screw onto each twisted connection a wire nut. Solder a 1" (2.54-cm) long piece of solid bare wire to the pads marked CAL on the circuit board. Then solder the leads from the outboard low-voltage transformer's output to the pads marked AC.

Next, connect and solder the cartridge leads coming
The turntable performance was exactly what you would expect of a first-quality unit. Checks with a frequency counter confirmed that the indicated nominal speeds were exact, within the ±0.1% accuracy of our four-digit counter's display. The meter indications for vernier speed control were within 5% of full-scale and on the nose at the zero-center index mark. Line voltage variations had absolutely no effect on the speed of the turntable or meter indications.

The unweighted rms wow was 0.02%, essentially the residual of our test record and meter. The flutter measured 0.04%. The unweighted rumble was -31 dB, principally in the lateral plane. With RRLL audibility weighting, the rumble was -58 dB.

The turntable took a little longer to reach its final speed than do most turntables. We timed it at about 7 seconds to come up to 33 1/3 rpm and 11 seconds to come up to 45 rpm. With the Auto Pitch Control set to ON, the turntable required about 14 seconds to reach a locked-in condition at both speeds.

The turntable's unique double-suspension isolation system proved to be very effective in preventing acoustic feedback. We confirmed this when we made our standard test for isolation from the mounting surface, as a function of frequency. This was by far the best turntable we have tested in this manner. Its most sensitive point was at about 35 Hz—at least as good as the best turntable we previously tested. Its isolation at higher frequencies, where most acoustic feedback problems occur, was typically 20 to 40 dB better than other turntables.

User Comment. Without considering cost, our tests revealed that this turntable performs essentially on a par with other direct-drive, commercially made turntables. Its wow, flutter, and rumble are as good as most direct-drive turntables and better than most belt-driven units.

The turntable's speed stability was exceptionally good, with none of the warm-up drift that is typical of direct-drive or other electronically controlled turntables. This drift is usually small enough to be negligible, but in the case of this turntable it was undetectable. The range of the pitch control is greater than average, and we especially like the APC system. It gives the user the rock-stable, accurate frequency of a synchronous motor with the advantage of being able to set the "synchronous" speed to one's own taste.

The chief drawback to the turntable was the long start-up time. On the other hand, the platter can be left running while changing records or stopped manually at any time. Hence, there is no need to shut the turntable off during a playing session. Because of the soft base suspension, one must be careful when operating the controls to avoid jarring the motorboard. But in normal operation, the tonearm's finger lift or cueing lever are the only active controls, and they pose no problems in this regard.

We did not perform tests on the Audio-Technica tonearm that was mounted on the turntable's motorboard. From past experience with it, we know that this is a smooth-handling tonearm that should be compatible with any good phono cartridge. The turntable can accommodate any separate tonearm, of course.

This turntable gives every audiophile the opportunity to own a truly state-of-the-art direct-drive disc player for a fraction of the usual cost by allowing him to wire the electronics and assembling the mechanical section.

**Setup and Use.** Set the motorboard assembly into the base so that it rests on its isolation/support springs. Slip onto the motor's spindle the turntable platter and rubber mat. Place a bubble level on the platter to make sure that it is level.

Preset all potentiometers on the control board to their mid-positions. Plug the turntable's line cord into an ac outlet and set the MODE switch to 33 and the Auto Pitch Control switch to OFF. Illuminate the strobe pattern on the edge of the turntable platter with a fluorescent or neon light source. Adjust the 33 control on the bottom of the motor housing so that the second set (from the bottom) of strobe marks is approximately stationary. Then adjust the Pitch Control until the pattern is exactly stable. Adjust the 33 CAL (R23) control so that the meter's pointer rests on the zero index on the scale.

Set the MODE switch to 45 and adjust the 45 CAL (R24) control until the bottom set of strobe marks on the platter are stationary. Put the MODE switch back in the 33 position and set the Auto Pitch Control to ON. Adjust the APC calibration control (R26) for a zero indication on the meter. Set the Auto Pitch Control to OFF.

Lightly twist together the two bare calibration wires on the circuit board. This will speed up the motor by 5%. Adjust METER CAL potentiometer R21 (this pot is not accessible through a hole in the front panel) until the meter's pointer indicates exactly ±5%. Untwist the calibration wires and orient them so that they do not touch each other or any part of the circuit.

(Note: The calibration procedure is best performed during the hours when commercial power demands are at their lowest, such as during a weekend. This will ensure that the power-line frequency is at its closest to the ideal 60 Hz.)

Turn off the power by setting the MODE switch to OFF and disconnect the power from the ac receptacle. Remove the turntable platter and mat. Then fit the control panel in place in the turntable's base and fasten it down with two No. 6 woodscrews. Reinstall the platter and mat and check again with the bubble level to make certain the turntable is level. If necessary, repeat the adjustment procedure from the point where you trim the Pitch Control to obtain an exactly stable 33 1/3 rpm speed when viewing the strobe marks on the platter.

Put the turntable where you want it in your system and connect the feed cables between it and your audio amplifier. Check again to make sure the turntable is level. It is now ready to be used for playing discs.

Whenever you turn on the turntable from a cold start or switch from one speed to another, wait about 10 seconds for the speed to stabilize before lowering the tonearm onto the disc's surface. (Monitor the motor; when the pointer rests on the zero, or center, index, the turntable is operating at the proper speed.)

The most convenient way of operating the turntable is by leaving it in the automatic mode. In this mode, the speed of operation will be as close to perfect as your calibration can make it. When the turntable is operated in automatic, the assumption is that the disc was cut at an exact 33 1/3- or 45-rpm speed. If you find that the pitch appears to be off, however, you can set the Pitch Control to OFF and bring it back on-pitch by adjusting the Pitch Control. You can adjust up to ±5% pitch error in this manner.

(Editor's Note: The author is pursuing patent protection for concepts described in this article. However, readers may build it for personal use.)
CIE has a terrific idea for a few people who know what they want.
If you want success in electronics... if you want the skills people are glad to pay for... find out about CIE training. It's a terrific idea that can get you on your way to success in electronics troubleshooting.

Let's face it, learning valuable new skills isn't something you just breeze through. Especially in a modern technological field like electronics troubleshooting. You've got to really want success if you're going to build your skills properly.

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POWER SUPPLY

One IC makes blow-out-proof selectable voltage supply.

INTEGRATED circuits available to the electronics experimenter usually require ±15 volts (for op amps) or +5 volts (for TTL digital logic). Anyone who has done much experimenting with these devices knows the necessity for a good regulated power supply.

While it is not difficult to design and build a power supply for either of these voltages, the easiest and cheapest way to get a good supply is to use a voltage regulator chip, the 78XX series made by Fairchild. This IC looks like a conventional three-lead plastic power transistor; and, when coupled with a bridge rectifier and filter capacitors, it can deliver 5, 6, 8, 12 or 15 volts at currents ranging up to 1 ampere.

Besides providing excellent regulation, the IC is internally protected from excessive load current or heat dissipation. Even if a heat sink is not used, it will not burn out since the power supply shuts off when it gets too hot and turns on again when it cools down.

Circuit Design. The basic circuit is shown in Fig. 1. Note that transformer T1 has two independent 7½-volt secondaries which can be connected either in series for the 15-volt supply or parallel for 7½ volts (at more current) for the 5-volt supply. Diodes D1 through D4 form a conventional bridge rectifier, with C1 as a filter.

In the 15-volt version, the voltage at the input to the the regulator is about 117 VAC.

Fig. 1. Same circuit is used for either supply. Components and jumpers must be changed.

PARTS LIST

BP1, BP2—Five-way binding post (red and black)
C1—2000-µF, 15-volt electrolytic capacitor (for 5-volt supply)
1000-µF, 25-volt electrolytic capacitor (for 15-volt supply)
C2—0.22-µF Mylar capacitor
C3—35-µF, 25-volt electrolytic capacitor
D1-D4—Silicon rectifier diode (1N4003 or similar)

F1—1/4-ampere fuse and holder
IC1—5 volts—7805; 12 volts—7812
6 volts—7806; 15 volts—7815
8 volts—7808
S1—Spst switch
T1—Dual 7½-volt ac secondary, 500-mA transformer (Triad F-152XP or similar)
Misc.—Suitable chassis, optional neon indicator lamp, line cord, mounting hardware.

Note: The following are available from Northwest Engineering, 801 Duchess Rd., Bothell, Wash. 98011: printed circuit board (N004A-PCB) at $5.00; IC1 (N004A-REG) at $3.10; kit of board and board-mounted components (N004A-FK) at $17.50 (specify voltage output). Kits are sent postpaid in continental USA.
21 volts dc; in the 5-volt version, the dc input is about 10 volts. The output for the former is between 14.4 and 15.6 volts with variations of less than 0.15 volt for load changes of 5 to 500 mA. For a 5-volt output, the load can be 1 ampere, which can drive up to 50 TTL devices.

Construction. The printed circuit board shown in Fig. 2 is the same for either type of supply, with the following exceptions: For a 15-volt supply, connect a jumper between points A and B, use a 7815 IC, and use a 1000-μF capacitor for C7. For a 5-volt supply, connect jumpers between points A and D and between B and C, use a 7805 IC and use a 2000-μF capacitor for C7.

To assure stable operation, the input to the IC is bypassed by C2; C3 improves the overall transient response of the supply.

When mounting the IC, bend it over so that the mounting lug (in electrical parallel with the common pin) can be attached to the negative portion of the foil pattern (the large area). This is where a heat sink should be used to provide the best current rating. Use a 1½" by 3" piece of aluminum for the heat sink and attach it and the IC mounting lug to the PC board with a bolt going through a properly sized hole drilled in the board.

The prototype power supply used two 15-volt sections, and one 5-volt version with each terminated at its own 5-way binding posts on the front panel. Use a red binding post for the positive side and a black post for the negative. Do not use the chassis at any point as a common.

Fuse F1 is mounted on the rear panel, with the power on-off switch on the front. If desired, a conventional 117-volt neon power indicating lamp can be connected across the primary of T1.

Any type of chassis can be used to support the three supplies. If you need 6-, 8-, or 12-volt supplies, use the 15-volt circuit and select the desired 78XX regulator integrated circuit.
ENJOY PRIVATE MESSAGES

WITH A VOICE SCRAMBLER

Low-cost IC circuit makes message unintelligible without a similar unit

BY JOSEPH B. WICKLUND JR.

Would you like to be able to keep unauthorized people from listening to your private communications? Thanks to recent advances in integrated circuit technology, it is possible to build a low-cost voice scrambler that will make your message unintelligible to anyone who doesn't have a compatible unscrambler. Of course, voice scramblers have been around for many years, but most of them are too expensive or too difficult to use (or both). This circuit is easy to build, is reliable, and can be used as either the scrambler or unscrambler.

(Continued on page 42)

**Fig. 1. Block diagram and waveforms show how the scrambler works.**

- (A) is incoming signal;
- (B) is sum and difference;
- (C) is output after filtering.

Unscrambling is shown in (D) and (E).

ELECTRONIC EXPERIMENTER'S HANDBOOK
PARTS LIST

B1, B2—9-volt battery (see text)
C1, C9, C10, C19, C20—0.1 µF Mylar capacitor
C2, C12—3000-pF, 5% capacitor
C3, C13—1200-pF, 5% capacitor
C4, C14—6800-pF, 5% capacitor
C5, C15—300-pF, 5% capacitor
C6, C16—100-pF, 5% capacitor
C7, C17—39-pF, 5% capacitor
C8—20-pF, 5% capacitor
C11—0.22-µF, Mylar capacitor
C18, C21, C22—35-µF, 25-volt electrolytic capacitor
IC1, IC2, IC6, IC7—741 op amp
IC4—2208 multiplier (Exar)
IC8—555 timer
R1, R3, R6, R11, R25, R26, R29—R30—100,000-ohm, 1/4-watt, 10% resistor
R2—27,000-ohm, 1/4-watt, 10% resistor
R4—56,000-ohm, 1/4-watt, 5% resistor
R10, R13—300,000-ohm, 1/4-watt, 5% resistor
R14—30,000-ohm, 1/4-watt, 5% resistor
R15—62,000-ohm, 1/4-watt, 5% resistor
R16—180-ohm, 1/4-watt, 10% resistor
R17—5000-ohm trimmer potentiometer
R18, R20—10,000-ohm, 1/4-watt, 10% resistor
R27, R28—20,000-ohm trimmer potentiometer
S1, S2—Dpdt switch
Misc.—Suitable chassis (Bud SC2132), battery holders and connectors, mounting hardware, suitable input/output jacks, etc.

Note—The following are available from Northwest Engineering Co., 801 Duchess Rd., Bothell, WA 98011: Pcb board (N007-PCB) at $8; IC4 (N007-MULT) at $9.25; Kit of pcb board and board mounted parts (N007-PK) at $34.50. All postage paid in U.S. via parcel post or UPS.

Fig. 2. Complete schematic of Scrambler.
Fig. 3. Actual-size foil pattern for scrambler is shown at left; component layout at right.

**How Scrambling Works.** The block diagram in Fig. 1 shows how the scrambler works. The incoming audio signal is filtered to remove all frequency components above 3 kHz as shown at (A). The signal is then used to modulate a 3.5-kHz oscillator signal, with a linear four-quadrant multiplier as the modulator. The output (B) of the multiplier includes the sum and difference frequencies and any remaining 3.5-kHz carrier, leaving only the difference frequencies as shown at (C).

It is interesting to note that, in the output, the voice channel from 300 to 3000 Hz is contained in a single-sideband signal from 3200 to 500 Hz. It can be recorded or transmitted like any other voice signal, but the frequency spectrum of the output is an inversion of the input. (For example, an input frequency of 300 Hz is 3200 Hz in the output and an input of 2500 Hz is 1000 Hz in the output.) The inversion thus makes the voice message unintelligible.

When the scrambled signal is coupled to the input of a similar unit, the signal is re-inverted and the original audio comes out in unscrambled form as shown at (D) and (E) in Fig. 1.

**Circuit Operation.** The complete schematic of the voice scrambler is shown in Fig. 2. Integrated IC1 is used as a high-input-impedance buffer amplifier to prevent loading on
the signal source. Resistors \( R_2 \) and \( R_3 \) control the gain of the buffer. An active low-pass filter with a cutoff frequency of 3000 Hz is provided by \( IC_2 \) and \( IC_3 \). The shape of the filter is controlled by the feedback components \((R_4-R_7 \) and \( C_2-C_7)\) and the circuit is designed to provide a four-pole Chebyshev filter characteristic with 1 dB of ripple in the passband and a sharp roll-off. Integrated circuit \( IC_5 \) is a stable square-wave oscillator operating at a frequency determined by \( R_{16}, R_{17}, \) and \( C_9 \). Potentiometer \( R_{17} \) is used to adjust the oscillator frequency so that two or more units can be matched. The oscillator output is attenuated by resistors \( R_{18} \) and \( R_{19} \) and modulated by the output of \( IC_3 \), the filtered input signal. The balanced modulator is \( IC_4 \). Trimpots \( R_{27} \) and \( R_{28} \) provide balancing adjustments for the modulator. When they are properly adjusted, only the sum and difference frequencies of the two inputs will appear at the output. Integrated circuits \( IC_6 \) and \( C_7 \) form a low-pass filter to pass only the desired output signal.

The output of \( IC_7 \) can be used to drive load impedances as low as 2000 ohms. It can be used with most amplifiers, for speaker applications, or a set of 2000-ohm headphones.

**Construction.** To ensure that the active filters are properly tuned, it is recommended that 5% resistors and capacitors be used for the critical components \((R_4-R_7, R_{21}-R_{24}, C_2-C_7, \) \( \text{and } C_{12}-C_{17})\). The gain-controlling resistors for the multiplier \((R_{10}-R_{13})\) should also have 5% tolerances.

Although the circuit can be wired point-to-point on perforated board, it is preferable to use a pc board such as that shown in Fig. 3. Be sure to observe the notch codes on the IC’s and the polarities of the electrolytic capacitors so that they are properly installed.

In using a pc board, note that 8-pin DIP 741 op amps are required. If point-to-point wiring is used, other versions of the 741 (round, 14-pin DIP or dual) can be substituted.

Mount the batteries in holders in any convenient location in the chassis. If desired, the power can be obtained from an external supply between ±6 and ±15 volts. The supply voltage is not critical as far as circuit operation is concerned, but the maximum input signal level and the overall gain will vary for different supply voltages. The gain can be adjusted by changing the values of \( R_3 \) (raising it to increase the gain) and \( R_{18} \) (lowering it to increase oscillator signal level).

The input and output connectors on the front panel must be chosen to suit the application.

**Adjustment.** For the proper operation, the oscillator should be adjusted to 3500 Hz. If an accurate counter or oscilloscope is available, \( R_{17} \) can be adjusted while monitoring the output of \( IC_5 \) (pin 3). An alternate method of adjustment based on the accuracy of the lowpass filter can be used if necessary. With the input shorted to ground and \( R_{17} \) turned fully counterclockwise, adjust \( R_{28} \) to get an output of 0.15 volt on an ac voltmeter. Now adjust \( R_{17} \) until the output voltage falls to 0.026 volt. The oscillator is now adjusted to approximately 3500 Hz.

To balance the multiplier, it will be necessary to adjust \( R_{27} \) and \( R_{28} \) while monitoring the scrambler output with an ac voltmeter or a set of headphones. With no signal input, adjust \( R_{28} \) for minimum output (near the middle of its range). To adjust \( R_{27} \), it is necessary to disable the oscillator by shorting across capacitor \( C_9 \). With an input signal of about \( \frac{1}{2} \) volt (1000 to 3000 Hz), adjust \( R_{27} \) for minimum output signal. The scrambler is now ready for use.

**Use.** A crystal microphone can be connected to the input of the scrambler with the output (with unity gain) connected to the MIC input of a tape recorder or transmitter. If headphones are used, the scrambled signal is connected between the recorder preamplifier and speaker amplifier (or receiver detector and audio amplifier).

The multiplier portion of the circuit can be used as a single-sideband modulator. The multiplier can be modified to operate with carrier frequencies as high as 5 MHz. Pins 13 and 14 of \( IC_4 \) should be shorted to pin 4, with \( R_{10} \) through \( R_{13} \) removed, a 5100-ohm resistor connected between pins 4 and 15, and pin 2 connected to pin 16. With \( IC_5 \) removed, the desired carrier signal can be coupled into pin 4 (using about 1 volt). The output of \( IC_4 \), from pin 15, can be coupled into a SSB filter to remove the unwanted sideband.

The multiplier can also be used as a variable-gain amplifier, or remote volume control. If the oscillator is removed, the gain of the multiplier can be controlled by varying the dc level on pin 5 of \( IC_4 \) from 0 to 5 volts. One way to accomplish this is to include a 100,000-ohm potentiometer in series with a 100,000-ohm resistor across the positive supply. Remove \( IC_5 \), \( R_18 \), and \( R_19 \). Connect \( C_10 \) from \( IC_4 \) (pin 5) to ground. Connecting the wiper from the potentiometer to \( IC_4 \) (pin 5) will provide the desired variable voltage. For wide-band or hi-fi use, remove the two active filters. A control range of 50 dB can be obtained with low distortion.
ANY different designs for digital logic test probes have appeared in the past few years. Most tend to favor a specific logic family, with TTL getting the most attention. Few, if any, are capable of checking ECL and MOS devices and circuits. The logic probe described here is designed for testing virtually all the logic families currently in use, including RTL, DTL, TTL, ECL, and MOS devices and circuits.

The universal logic probe, while larger than "ordinary" testers, is also completely self-contained. It has its own built-in battery power supply to simplify test hookups. (Most popular test probes derive their power from the circuit under test.)

An important factor to be considered in logic probe design is frequency response. Most testers will not respond to high frequencies. Thus extremely short duration pulses are lost and, in some cases, cause signal degradation in the circuit being tested. The universal probe solves this problem by being able to respond to frequencies in excess of 10 MHz. Furthermore, it will check for a logic 1 or logic 0 within 5 mV of a set value.

**About the Circuit.** The tester is made up of two parts: a small case containing all of the electronics (including two controls that permit you to preset the logic levels) and a probe assembly with attached cable. The probe itself contains a 7-segment LED display. The ground lead is attached to the body of the probe for easy connection to the circuit being tested.

The heart of the circuit is dual differential comparator integrated circuit IC1 in Fig. 1. The IC1A half checks for a logic 1. Its pin-8 output is held low until the input on pin 5 from the probe is 5 mV (or greater) above the voltage applied to pin 6. The latter is determined by the setting of R5 and ranges from -1 V to +5.25 V dc. When the input is greater than the voltage applied to pin 6, the output of the comparator sends Q1 into conduction to cause a 1 to be displayed.

The 0 part of the circuit operates in the opposite manner. The input on pin 13 must be more negative than the preset voltage on pin 12, determined by R4 and ranges from -1 V to +5.25 V dc. When the input is greater than the voltage applied to pin 13, the output of the comparator sends Q2 into conduction to cause a 0 to be displayed.

**Fig. 1. Dual comparators sense the voltage at probe tip.**

**PARTS LIST**

B1, B2—9-volt battery
B3, B4—1.5-volt battery (AA cell)
C1—10-pF, 10-volt capacitor
C2, C3—0.1-µF, 10-volt capacitor
D1, D2—1N751A zener diode
D3 to D6—1N34 diode (or similar)
D7—1N753A zener diode
D11—Seven-segment LED display ( Monsanto MAN-3 or similar)
IC1—72720 dual differential comparator
Q1, Q2—2N3904 transistor (or similar)

The following resistors are 1/4 watt:
R1—1000 ohms
R2—10 ohms
R3—40 ohms
R4—10,800 ohms
R5, R9—8000 ohms
R6, R9—8000 ohms
R7—18,000 ohms
R8—5000 ohms
R11—6.8 ohms
R5, R8—10,000 ohm miniature potentiometer

Misc.—Length of three-conductor shielded cable, plastic felt-tipped pen, cement, needle tip, knobs (2), press-on type, battery connectors, chassis, mounting hardware, etc.
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by the setting of \( R_8 \). The range here is from \(-2 \text{ V}\) to \(+3 \text{ V dc}\). When this section of the comparator turns on, \( Q_1 \) saturates, and the 0 portion of the display is illuminated.

Diodes \( D_3 \) and \( D_4 \), in conjunction with capacitors \( C_2 \) and \( C_3 \), ensure that, once the indicator is activated, it will remain on long enough to be seen, even with reasonably high pulse repetition frequencies. Resistors \( R_2 \), \( R_3 \), \( R_5 \), and \( R_6 \) provide current limiting for the display. Diodes \( D_5 \) and \( D_6 \) form a gate that allows testing the indicator before operation. Diodes \( D_1 \) and \( D_2 \) protect the IC inputs. Resistor \( R_{10} \), with \( D_7 \), converts the 18 V from batteries \( B_1 \) and \( B_2 \) to \(-6 \text{ V}\) and \(+12 \text{ V}\) for the IC. Batteries \( B_3 \) and \( B_4 \) provide the higher current required for the seven-segment display.

**Construction.** The tester can be assembled on a printed circuit board using the actual-size etching and drilling guide shown in Fig. 2. However, if care is exercised, the circuit could be assembled on perforated board using point-to-point wiring.

Mount the board and batteries in an enclosure approximately 11/2" by 3" by 51/2" as shown in Fig. 3. Note that part of the box is used to store the probe and cable when not in use. The two potentiometers and switch are mounted on one end of the chassis with appropriate identifications made with press-on type.

The probe can be made from a used plastic felt-tipped pen case as shown in Fig. 5. Using a three-conductor shielded flexible cable, identify the leads as 0, 1, and tip. Make the tip lead long enough to go through the end of the plastic case. Cut an opening on the side of the case slightly smaller than the LED display. Feed the 0 and 1 leads through this hole. On the display, interconnect segment leads A, B, F, and G. Solder the 0 lead to this combination. Solder the 1 lead to the E segment. Connect the display common to the coax shield. Feed the shield lead through a small hole below the read-out and wrap it around the plastic case. Feed the tip lead through the front opening on the case. Seat the display in place and cement it securely. Fabricate a needle tip and solder it to the probe tip lead. Cement this in place.

When assembly is complete, connect a voltmeter between the rotor of potentiometer \( R_5 \) and ground. Rotate this potentiometer between its two extremes and mark the 1-volt calibration points on the front panel at the rotor of \( R_5 \). Do the same for \( R_8 \). Don't forget to indicate the polarity. Also make sure that the rotor of \( R_8 \) is always more negative than the rotor of \( R_5 \).

**Operation.** To check a logic circuit, determine the high and low voltages for the 1's and 0's of the circuit being tested. Set the two potentiometers accordingly. Attach the probe ground to the circuit ground. Place \( S_1 \) in the test position (T). The display should indicate both a 0 and a 1 (which looks like the letter P). Place \( S_1 \) in the operate position and touch the probe tip to the circuit being tested. A logic 0 or a logic 1 should be properly displayed; or, if the circuit is transitioning between 0 and 1, both sections of the display will light. If the display remains blank, the test point is operating somewhere between 1 and 0, which means something is wrong.
BUILD A

Wide-Range Photometer/Enlarger and Exposure Meter

Valuable darkroom accessory
covers broad spectrum of light intensities
and exposure time ranges

If you do any type of photographic enlarging, contact printing, light-intensity measuring, etc., you need a photometer/exposure-time meter. Here is a high-resolution instrument with 0.01-, 0.1-, 1.0 and 10-foot-candle (ft-c) ranges that are usable down to 0.0005 ft-c. Neutral-density filters can be used to extend the upper range to 10,000 ft-c.

Exposure-time ranges include 0 to 25, 50, and 100 seconds at any multiple or intermediate range desired. A calibration control accounts for differences in paper speed and other factors. And a number of contrast ranges assist in paper grade selection.

The assembled instrument features an illuminated meter scale, and a high-stability operational amplifier IC that has instant-on, zero drift, and immunity from line-voltage variations. A high-speed linear cadmium-sulfide photocell is used to sense the measured light.

About the Circuit. In the simplified light-measuring circuit shown in Fig. 1A, as the light intensity on PCI increases, the photocell's resistance decreases. This causes an increase in the input current, I_in. The feedback current in light-range resistor R produces a voltage, V_f, across this resistor which is the same as V_m. Consequently, M1 indicates in direct proportion to the intensity of the light.

In the basic time-measuring circuit...
shown in Fig. 1B, PC1 is placed in the op amp’s feedback circuit. Calibration potentiometer R14 presets the input current—and feedback current—to a fixed level. With a decrease in light intensity striking PC1, the resistance of the photocell increases and the input and feedback currents remain equal and unchanged, but the feedback and output voltages increase. Thus, the meter indications are in equal and unchanged, but the feedback and output voltages increase. The meter indications are in equal and unchanged, but the feedback and output voltages increase. The meter indications are in

Meter movement protection is provided by the limiting (saturating) action of the op amp, while C5 prevents rapid pegging of the meter’s pointer. Capacitors C1 and C3 minimize the amplifier response to any ac present on the signal leads.

Construction. Except for S1, S2, S3, R14, M1, and T1, all components can be mounted on perforated board with push-in solder clips. Use a socket for IC1. Install C1 and C2 close to the IC socket. (A completely wired board assembly is shown in Fig. 3.)

Select an enclosure that is large enough to accommodate the meter and other front-panel controls, with enough depth to permit mounting the board assembly and T1. Start assembling the system by machining the enclosure’s front panel to accept the controls and meter movement, and mount the parts in their respective holes. Do not forget to install phone jack J1 on the front panel. Note that a two-circuit phone jack and plug are used. Only the tip and ring contacts of the plug (and their respective jack contacts) are used for the PC1 lead connections. This is necessary because the photocell’s leads must not be connected to ground. If you wish, use two-conductor shielded cable between P1 and PC1, leaving the shield “floating” at the PC1 end and connecting to the barrel contact on P1. The meter scales (0-25 and 0-100) must be properly labeled to provide the appropriate meter readings. This can be accomplished with the aid of a dry-transfer lettering set. Carefully remove the snap-on cover from the meter movement and label the scales as shown in the lead photo. While the cover is off the movement, you can install the optional illumination lamps (11 and 12). Uniform scale illumination can be obtained by installing a bright reflective metal strip above the meter scales.

Use a well-subdivided scale for calibration potentiometer R14. Either

---

**PARTS LIST**

- **C1**—0.02-µF, 25-V disc capacitor
- **C2**—0.1-µF, 25-V disc capacitor
- **C3**—0.22-µF, 25-V disc capacitor
- **C4**—1000-µF, 35-V electrolytic capacitor
- **C5**—50-µF, 15-V electrolytic capacitor
- **D1**—D2—6.2-V, 1-W zener diode (HEP103 or similar)
- **R1**—2200-ohm.
- **R2**—100-ohm.
- **R3**—47K ohm.
- **R4**—62K ohm.
- **R5**—4700-ohm, 1/2-W, 5% resistor
- **P1**—Miniature phone plug
- **M1**—0.50-microampere, 4-in. dc meter
- **PCI**—Linear high-speed photocell (Clairex CL705HL) (Do not substitute)
- **PC1**—Linear high-speed photocell (Clairex CL705HL) (Do not substitute)
- **R19**—500,000-ohm carbon pc-type potentiometer
- **R20**—1-megohm carbon pc-type potentiometer
- **RECT1**—1-A, 200-V PIV bridge rectifier (HEP176 or similar)
- **S1**—Single-pole, four-position, shorting type rotary switch
- **S2**—Dpdt slide switch
- **S3**—Spst slide switch
- **T1**—12-V, 0.3-A filament transformer (Radio Shack 273-1385 or similar)
- **Misc.**—Perforated board; fleca clips; case 3" x 4½" x 6½" (Vector W30-66-46); miniature shielded cable: line cord: dial plate: knobs: IC socket: ¼" phenolic sheet: 22-megohm carbon resistor: 15,000-ohm carbon resistor: etc.

* The following are available from Electronics Distributors, Inc., 4900 N. Elston Ave., Chicago, IL 60630; meter (F64 less lamps), meter scale illumination kit (F71).
a panel-mounted dial plate or a rotating dial flange can be used. Identify the front-panel controls with dry-transfer lettering.

Mount PC1 between two pieces of thin phenolic board, allowing the sensitive surface of the cell to protrude through a hole in the upper board. The protrusion should be about \( \frac{1}{16} \) in. \((1.59 \text{ mm})\) above the board’s surface. After properly mating the boards, remove PC1 and spray the outer surfaces a flat (matte) white paint.

Connect and solder the two inner conductors of a thin two-conductor shield cable to the leads of PC1. (Do not connect the shield to the photocell.) Insulate the solder joints with electrical tape. Place PC1 in position and secure the two pieces of board together, with the cable sandwiched between them. A metal finger loop can be mounted on one end of the assembly for ease in positioning the sensor.

Connect the free end of the microphone cable to P1. The shield goes to the barrel contact, while the inner conductors go to the ring and tip contacts.

Power transformer T1 can be mounted to the bottom or one wall of the enclosure with machine hardware. Connect its primary leads to a two-lug, non-grounding type terminal strip. Route the line cord through a rubber-grommet-lined hole drilled through the rear wall of the enclosure. Connect it to S3 and T1 as shown in Fig. 2.

**Adjustment and Calibration.** Using clip leads, connect a milliammeter in series with R12. If necessary, adjust the value of \( R12 \) for an indicated current of approximately 70 mA. Install R13 and measure the voltage drop at the meter lamp terminals; it should be 6.3 volts across both lamps. If not, adjust the value of R13. Check that there are about 20 volts dc across C4, and about 6 volts across D1 and across D2.

To adjust the bias current of IC1, set S2 to TIME, R14 to maximum resistance, and remove R1 from the circuit. Connect about 44 megohms of resistance (two 22-megohm carbon resistors in series) to a phone plug and insert it into J1. Then, adjust R16 until M1 indicates zero. If this cannot be accomplished, replace R10 with a resistance between 3900 and 7500 ohms. Alternatively, you can increase (or omit) R11 for a broader range.

The next adjustment compensates IC1’s input offset voltage. With 44 megohms plugged into J1 and all other conditions as above, connect a 15,000-ohm, 10-percent resistor across pin 2 (input) and pin 3 (ground) of IC1. Adjust R15 for a zero indication on M1. If this is not possible, slightly increase the value of R5 and decrease R4, or vice versa. Maintain the sum of R4 plus R5, at 8000 ohms or more.

Upon removing the 15,000-ohm resistor, M1 should remain at zero. If not, repeat the input bias and offset adjustments. Install R1 and check to see that there is a 0.3-volt dc drop across R2. Adjust R1 or R2 if necessary.

The final adjustments are made to calibrate the foot-candle ranges. The nominal resistance of PC1 is 28,000 ohms at 2 ft-c and 56,000 ohms at 1 ft-c. Set range potentiometers R17 through R20 about halfway through their travels and set S2 to LIGHT. Connect a 5600-ohm resistor to a phone plug and insert it in J1. This simulates the ideal resistance of PC1 at 10 ft-c.

Set S1 to the 10-ft-c range and adjust R17 until M1 indicates full-scale. Similarly, use a 5600-ohm, a 560,000-ohm, and a 5.6-megohm resistor, respectively, to calibrate the 1-, 0.1-, and 0.01-ft-c ranges while adjusting the corresponding potentiometers. The simulating resistors used should have 5-percent or better tolerances. If an accurate photometer is available, you can use it to calibrate the light ranges.

Although neutral-density filters can be used to extend the light ranges, filters using film negatives are satisfactory for non-critical use. Using the enlarger as a light source, focus it and remove the film from the carrier. Place PC1 on the enlarger easel and set S1 to the 1-ft-c range. Stop down the lens until M1 indicates 1 ft-c. For the X10 multiplier, select a portion of unwanted negative that, when placed over the sensor, causes the meter to indicate 0.1 ft-c. Affix the film to a thin blackened washer or disc that fits over the top of the photocell. Place the glossy side up to protect the emulsion from scratches. Selected film bits should be uniform and without detail.

**Application.** Measure light with S2 set to LIGHT and S1 set to the desired range. Measure time with S2 set to TIME and R14 set to a previously determined calibration setting for the particular application. The calibrating procedure for R14 accounts for paper speeds, mode of operation, time scale in use, and processing factors. This is performed once for each set of conditions and recorded for future use. When calibrating or using the instrument, all darkroom lights must be off. Avoid directly illuminating PC1 by the meter’s lights.

Select an average negative and make the best possible print in the conventional manner using test strips. As an example, let us assume the best print required 15 seconds of exposure at f/8 aperture. For the integrated light method, you will need a 2½-in. \((6.35-\text{cm})\) square piece of ground glass as a light scatterer. With the enlarger undisturbed, place PC1 at the center of the projected image and set S2 to TIME. Hold the light scatterer up to the enlarger’s lens. Then adjust and record the settings of R14 that result in 15 seconds indication on the 25-, 50-, and 100-second scales where possible. Also, record the data on the projection paper in use.

To use the exposure meter at a later date, set R14 to the recorded setting for the particular paper and time scale. At almost any lens aperture and print magnification, use the light scatter and observe the required exposure time. You can select the exposure time desired by varying lens aperture (or vice versa). A blackened paper tube...
from a 35-mm film carton positioned over the sensor checks or eliminates the effect of stray light. During exposure, S3 can be switched off.

Calibrate R14 with the lens aperture set to one or two stops larger than the exposing aperture of the test print when using the instrument with small lamp enlargers. In the example, open the lens one full stop to f/5.6. Calibrate R14 for 15 seconds indication on each time scale where possible. Using this mode of measurement, observe exposure time at any selected aperture and close down one stop before exposing. Alternatively, you can halve the indicated exposure and expose at the measuring aperture.

The spot method determines exposure time at print shadows without the use of a light scatterer. To calibrate, place PC1 at important print shadows (bright portion of the projected image) and adjust R14 until the meter indicates 15 seconds on each time scale. To use this mode, set R14 as recorded for the paper and time scale, place PC1 at the print shadows, and observe the required exposure time.

Contrast measurements use the light scales to determine the ratio of light levels at the bright and dark portions of the image. The table gives various contrast ranges with the setup requirements. Because it is used most frequently, set up the 0-to-25 range with S2 on LIGHT and S1 on the 0.1-ft-c range. Place PC1 at the darkest area of the image and adjust the lens aperture until M1 indicates 40 percent of full-scale. Advance S1 one decade to the 1-ft-c range. Note that M1 now indicates 1 on the 0-to-25 scale.

Move PC1 to the brightest area of the image and read image contrast directly on M1. Middle contrasts of 8 to 15 indicate the use of normal-contrast paper. By keeping notes, relate contrast measurements with the required paper grade.

The integrated light method, preferably used with negatives of average balance, requires either a correction or recalibration of R14 for negatives of predominantly light or dark scenes. The spot method, capable of handling almost any negative, assumes that projected print shadow areas are larger than the photocell's diameter.

By installing a photocell in the tip of a probe, you can take measurements on contact print boxes, viewing screens, etc. For camera applications, choose between the LIGHT and TIME scales. The TIME scales can be interpreted in any convenient manner, such as 0 to 2.5, 5, and 10 seconds or 0 to 250, 500, and 1000 milliseconds, and easily converted to fractional shutter speed if desired.

Bear in mind that CdS cells exhibit a memory effect related to previous light history. Therefore, avoid exposing PC1 to sunlight or bright room lights prior to use. Also, response time increases with decreasing light levels. So, allow time for the meter indication to settle at very low light levels. Long-term meter drift proved to be nonexistent in use, but you can check meter zero by setting S2 to LIGHT and removing P1.

**WHAT DO YOU KNOW ABOUT TRANSFORMERS?**

**BY ROBERT P. BALIN**

1. Assuming no losses, the output voltage between A and B is ___ volts.

2. Assuming no losses, secondary current I₂ is ___ mA.

3. The 100-ohm secondary load will look like ___ ohms to the primary voltage supply.

4. If the two 150-ohm windings are connected as shown, the output impedance between A and B will be ___ ohms.

5. Taking into account the way the windings are connected and their polarity markings, the output voltage between A and B will be ___ volts.
THE WHEEL of fortune has always been one of the favorite games of chance. Perhaps it is because of the fascination of watching the wheel go around and around and not knowing where it will stop. You can build an electronic roulette which has little red lights going around and around, stopping eventually at a completely randomly selected number between 1 and 16. Players can select their number for each spin of the wheel, watch the lights, and collect their winnings if the light stops on their number. Like a mechanical wheel, the lights go fast at first and then slow down gradually before stopping at the winning number.

**Circuit Operation.** As shown in Fig. 1, a clock oscillator (IC1) operates at about 100 Hz when the SPIN pushbutton is depressed. When the switch is released, a time constant in the circuit causes the oscillator to slow down to a stop in about 10 seconds. The output of the clock is conditioned for the TTL logic by transistor Q1.

To understand how the 16 LED's are operated, note that the combinations of numbers 1 and 9, 2 and 10, through 8 and 16 are driven by the output of the first flip-flop and the 8-bit shift register. However, the selection of which of the eight combinations is in the circuit at one time is made by the state of the second flip-flop. As the clock delivers pulses to the first flip-flop, the digital one level is propagated from 1 through 8 on the LED's.

At the eighth clock pulse, the output of IC3 operates a one-shot (IC2). This causes the output flip-flop to change states, so that the second eight LED's are selected. Simultaneously, the first flip-flop and the shift register are...
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Fig. 1. Etch jog and guide above: component layout below.

Fig. 2. Complete schematic. LED array (left) is connected to lettered terminals on IC3 and IC4 (above).

Fig. 3. Etching and drilling guide above: component layout below.

Photo shows how LED’s were arranged on top of the enclosure.

**PARTS LIST**

- **B1**—9-volt battery (6 C cells)
- **C1**—0.22-µF capacitor
- **C2**—0.001-µF capacitor
- **C3**—100-µF, 15-V electrolytic capacitor
- **C4**—0.03-µF capacitor
- **D1**—5.6-V zener diode
- **IC1**—Function generator (566)
- **IC2**—Quad 2-input NAND gate (7400)
- **IC3**—8-bit shift register (74164)
- **IC4**—Dual JK flip-flop (74107)
- **LED1** to **LED16**—Light-emitting diode
- **Q1**—Silicon npn transistor
- **R1, R3-R5**—10,000-ohm, ¼-W resistor
- **R2**—1500-ohm, ¼-W resistor
- **R6**—39-ohm, ¼-W resistor
- **R7**—2700-ohm, ¼-W resistor
- **R8**—180-ohm, ¼-W resistor
- **S1**—SPst switch
- **S2**—Normally open SPst pushbutton switch
- **Misc.**—Suitable enclosure, press-on type, C-cell holders, insulated wire, mounting hardware, etc.

**Construction.** The circuit can be assembled on perforated board or on a pc board such as that shown in Fig. 3. Be sure to observe the polarities and coding on all components and use a low-power soldering iron. Note that there are three jumpers on the board.

The prototype was housed in a plastic enclosure 6½” × 3¾” × 2”. As shown in the photo, the cover of the box was drilled for the 16 LED’s arranged in a circle. The holes should be just large enough to fit the tops of the LED’s. The lights can be identified at random using press-on type. The two switches can be mounted on the cover as shown.

Since the project has a current drain of about 100 mA, six C cells, in holders mounted on the bottom of the enclosure, can be used. This allows about 10 mA for the LED’s. Any color can be used for the LED’s, but it is advisable to have a few extras so that they can be selected to have all 16 glow with about the same brilliance.

Reset In this way, the same logic is used for all 16 LED’s. The complete schematic is shown in Fig. 2.

**Electronics Experimenters Handbook**
DURING the summer months, when power demands peak, brownouts are an all too common occurrence. As power companies cut back on the amount of voltage delivered to the ac outlets in your home, the picture on your TV receiver is likely to shrink and lose color, your lights might dim slightly, and some of your appliances may have difficulty operating on the unaccustomed low voltage. Some electrically operated appliances can even be irreparably damaged if they are operated on too low a voltage.

Most people just grit their teeth and try to bear with the inconveniences of the brownout situation. This is one way to approach the problem, but a more practical approach would be to use a device that will restore the line voltage level to normal. This is exactly what the Power Guard is designed to do. It is completely automatic. As the line voltage begins to fall below a predetermined level, the Power Guard compensates for the reduction by boosting the voltage available at its output. Then, when the power company restores normal service, the Power Guard switches itself out of the line, to remain ready to go into action again when the next brownout occurs.

About the Circuit. A voltagesensing circuit that operates a relay, causing it to switch a transformer in and out of the ac line is the heart of the Power Guard (see Fig. 1). The sensing circuit is made up of the voltage divider formed by R1 and R2, neon lamp 11, and silicon controlled rectifier SCR1.

When switch S1 is set to ON, line voltage is applied across the R1/R2 divider network. Assuming that this potential is greater than 105 volts ac, 11 will fire. This, in turn, indicates that the power available at the wall outlet is at a "normal" level. By adjusting R2, the line potential at which 11 is triggered can be varied.

When 11 comes on, it applies current to the gate of SCR1, triggering the silicon controlled rectifier into conduction and energizing relay K1. When this happens, the relay's lower set of contacts places output receptacle SO1 directly across the ac line. Capacitor C1 across the solenoid of K1 eliminates the possibility of relay chatter that would normally be caused by the rectified voltage coming through SCR1.

When a brownout occurs and the line voltages drops below the value predetermined by the setting of R2, 11 extinguishes and removes gate current from SCR1. This causes the SCR to cut off on the next zero crossing of the line voltage and deenergizes K1. This, in turn, switches the secondary of T1 into the circuit, which is designed to add the primary and secondary voltages. This "boosted" voltage is then delivered to SO1. The magnitude of the voltage boost depends on the secondary voltage of T1 at the reduced line voltage. The point at which the boost comes into play depends on the setting of R2. (Note also that, when the boost circuit is operating, 12 comes on to provide a visual indication that line voltage is down.)

Tracking, the opening and closing of the relay's contacts caused by minor changes in line voltage, is eliminated by 11. The reason for this is that the neon lamp's firing voltage is higher than that required to maintain it in the ionized state. So, while the lamp requires about 110 volts to fire, it will not extinguish until the line voltage drops to 105 volts.

CONSTRUCTION

THE POWER GUARD

Boosts voltage and eliminates TV picture shrinkage during summer brownouts

BY JULES H. GILDER
Since most electrical appliances and electronic instruments are designed to operate properly on line voltages ranging from 105 to 125 volts, no change in performance will be noted until the line drops below 105 volts. Using this as the trigger point, you can add between 10 and 20 volts to the potential available during the brownout, and the system will automatically adjust itself to the varying conditions as they occur.

Construction. The circuit of the Power Guard is very simple. Hence, it can easily and conveniently be assembled on a piece of perforated epoxy-fiberglass or phenolic board. The transformer can then be mounted on the floor of a metal case large enough to accommodate it and the board assembly without crowding. Don’t forget to leave room for SO1 to mount on the front of the case and for the line cord exit hole and fuse holder on the rear of the case. If you build a 15-ampere Power Guard, you should have no difficulty mounting all of its components in a standard (preferably steel) metal case measuring 9" × 7" × 6" (22.9 × 17.8 × 15.2 cm).

Since you will be working directly with line voltages, it is very important that you check all wiring carefully before you apply power. Make certain you use a three-wire line cord and connect the neutral (green) lead to chassis ground via a large solder lug and to the third contact on SO1. It is best to use an autotransformer for T1. However, if you can’t locate one, you can substitute an ordinary filament transformer. If you do use a filament transformer, you must take care to assure that the primary and secondary are properly phased to provide a boost in voltage. (The transformer’s secondary must also be rated at a greater current than would be drawn by any load plugged into SO1.) To determine the proper phasing, wire the transformer as shown in Fig. 2 and measure the potential at the “output” leads. Transpose the secondary leads and again measure the output voltage. The connection scheme that yields the higher voltage is the proper phasing setup.

Setup and Use. To use the Power Guard properly, it is necessary to first adjust R2 so that the system triggers SCR1 at the correct voltage level. The simplest way to adjust R2 is to plug the Power Guard into a variable transformer and decrease the potential applied to the system’s power plug to 105 volts. If you don’t have access to a variable transformer, a filament transformer connected as a “bucking” instead of “boosting” autotransformer can be used.

When the potential is 105 volts, adjust R2 so that T1 just extinguishes. At this point, the relay in the system should not be energized, and the booster winding in the Power Guard should be in the circuit. If you measure the voltage at SO1 it should be between 110 and 120 volts ac.

Once R2 has been adjusted for the proper triggering level, it need not be touched again. The Power Guard is ready to use.

Appliances can be permanently plugged into SO1 and the Power Guard’s switch set to OFF when no brownouts are expected. Then, during the months when you can expect brownouts, just flip the switch to ON.

**PARTS LIST**

- C1 - 40-microfarad, 200-volt electrolytic capacitor
- D1 - Silicon rectifier (1N4001 or similar)
- F1 - 15-ampere fuse (3AB, 15A)
- I1, I2 - NE-2H neon lamp
- K1 - 117-volt dc relay with dpdt contacts rated at 20 amperes or more
- R1 - 56,000-ohm, 1/2-watt resistor
- R2 - 100,000-ohm trimmer potentiometer
- R3, R4 - 100,000-ohm, 1/2-watt resistor
- S1 - Heavy-duty dpdt power switch rated at 25 amperes or more
- SCR1 - 200-volt silicon controlled rectifier (HEP-R1211 or similar)
- SO1 - Three-contact chassis-mounting ac receptacle
- T1 - Autotransformer (Allied Electronics Cat. No. 705-0144 16-ampere or 705-0104 8-ampere type) or high-current filament transformer (See text)
- Misc. - Metal chassis box; heavy-duty three-wire line cord with plug attached; fuse holder for Fl; perforated board and solder clips; machine hardware; hookup wire; solder; etc.

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**Fig. 1. Voltage-sensing circuit switches transformer in and out of circuit to keep voltage up during brownout.**

**Fig. 2. Circuit to determine proper transformer phasing.**
HOME EMERGENCY LIGHT for "BLACKOUTS"

- Automatic "on" when ac power fails
- Full-wave battery-charging circuit
- Doubles as lantern flashlight
- Compact, neat design

WHEN a power blackout occurs, one is likely to get caught in the dark without ready access to a flashlight or candle. Here is a hand emergency light to solve the problem, minimizing possible injury and fear due to darkness.

This emergency light goes on automatically whenever ac power is interrupted for one second or more, providing several hours of light before a recharge is needed. (The 1-second delay is built in to prevent flickering.) In addition, the system includes a battery charger which maintains full charge on ordinary nickel-cadmium batteries. It can also double as a portable flashlight and is designed into a neat, small package.

This home safety device is simple to build, requiring easy-to-get parts and modification of an inexpensive lantern-type flashlight.

How It Works. The schematic of the emergency light is shown in Fig. 1. Transformer T1, RECT1 (a full-wave bridge rectifier), and filter capacitor C1 form a low-voltage dc power supply. When line voltage is applied to the circuit, LED1 glows. Current through LED1 is limited by R1. The power supply provides charging current for battery B1, two NiCd cells. Diode D1 prevents the battery from discharging back through the LED. Charging current is limited by either R3 or R4. When switch S1 is in the SLOW position, R3 allows 33 mA to flow into the battery. When S1 is placed in the FAST position, R4 provides 100 mA, which charges B1 more quickly.

The dc voltage also energizes relay K1. Since the relay coil is energized under normal (line voltage-on) conditions, it might tend to get very warm. To keep the coil cool, resistor R2 is placed in series with it, lowering the amount of continuous current flow. The path between the battery and the light bulb (11) is controlled by the relay contacts. Under line-on conditions, no current can flow through the bulb.

When the line power drops out, however, the relay coil is de-energized, and the contacts complete the circuit between the battery and the light bulb. The bulb automatically lights up, providing emergency illumination. To prevent the emergency light from flashing on and off whenever the line voltage drops for a fraction of a second (for example, when your refrigerator compressor kicks in), we take advantage of the fact that it takes about one second for the voltage across C1 to decay to the point where the relay drops out. The exponential properties of the RC circuit smooth out any instantaneous variation in line voltage.

The flashlight is a self-contained unit which connects to the power supply through a three-conductor power plug-jack combination. When independent flashlight operation is desired, switch S2 takes over the relay's switching operations by pro-
Fig. 1. Schematic of the emergency light. Power failure causes K1 to drop out, supplying power to I1.

PARTS LIST

B1—Two General Electric GC-3 1.25-volt, 1.2 A-hour nickel-cadmium batteries
C1—1000-μF, 16-volt upright electrolytic capacitor (Radio Shack 273-958 or equivalent)
D1—1-A, 50-PIV silicon rectifier
F1—1/4-A fuse (Buss AGC 1/4 or equivalent)
I1—Three-conductor power jack (Cinch-Jones S303AB or equivalent)
K1—6-volt SPDT relay (Radio Shack 275-004 or equivalent)
LED1—Light emitting diode (Sprague ED-123 or equivalent)
PL1—Three-conductor power plug (Cinch-Jones P303AB or equivalent)
R1—120-ohm, 1-watt resistor
R2—220-ohm, 1/2-watt resistor
R3—150-ohm, 1/2-watt resistor
R4—51-ohm, 2-watt resistor
RECT1—2-amp, 50-PIV bridge rectifier (Radio Shack 276-1151 or equivalent)
S1—SPDT miniature toggle switch
S2—SPST pushbutton switch (furnished with lantern)
T1—6.3-volt, 300-mA filament transformer (Radio Shack 273-1384 or equivalent)
Misc.—Chassis box 4" x 3¼" x 6" (Radio Shack 27-252 or equivalent), lantern (Sears 4841, Ray-O-Vac L295 or equivalent), fuse clips (Buss 5682-41 or equivalent), metal battery holder (Radio Shack 270-1439 or equivalent), piece of 1" wood 4½ x ¾ aluminum angle stock, 1/4-inch metal spacers, printed circuit or perforated board, line cord, rubber grommets, metal battery holder, wood screws, machine hardware, brass shim stock, adhesive-backed decorative vinyl, dry-transfer lettering, hookup wire, solder, etc.

Fig. 2. Etching and drilling guide for pc board is below; component placement at right.

Construction. The emergency light is composed of two units: a portable flashlight and the base/recharger which it plugs into.

Components forming the recharge circuit should be mounted on a printed circuit or perforated board. Etching and drilling and component placement guides for pc board fabrication are shown in Fig. 2. Mount the components on the board, paying close attention to the polarities of C1, D1, the leads to LED1, and RECT.(Align the rectifier so that the dot on the top of the case faces north. The pin facing north is the +dc output. South is negative, east and west are the ac inputs from the secondary.) Fuse F1 can be mounted either on the back panel using a panel-mount holder, or on the circuit board using standard fuse clips. The clips require 4-40 mounting hardware. The two 4-inch (10-cm) leads should be connected from LED1 to the appropriate pads on the circuit board. Three 4-inch (10-cm) leads should be run from the board for S1, and three 10-inch (25.4-cm) leads for PL1. Drill holes in the utility box for pc board standoffs, rubber feet, LED1, S1, and the line cord. Insert the line cord through its hole using a grommet or strain relief and connect its leads to the transformer primary. Then mount the circuit board in the utility box using ¼-inch (0.64-cm) metal spacers.

The prototype uses Cinch-Jones three-conductor power connectors, but substitutions are OK. Drill two mounting holes in the wood block and a hole for PL1's leads through the cover of the utility box. Install a grommet in the hole for the leads.

Plug PL1 is mounted on a 3/8" x 5/8" x 3/8" (8.9 x 8.9 x 1.9 cm) block of wood, which is covered with walnut grained adhesive-backed vinyl. Drill holes on the bottom side for mounting hardware (make sure these don't go all the way through), PL1, and the top two metal guide rails (completely through the block). These rails should be fashioned from ¼" x ½" (1.9 x 0.32 cm) aluminum angle stock. Round the corners of the aluminum, and drill two holes for securing hardware. Position
the rails so that they accept the flashlight you choose to use (the one in the photo is a Sears model), and then drill holes into the top of the wood block to match those in the guide rails. Give the rails a brushed appearance by rubbing them lengthwise with fine steel wool under running water. Then attach the rails to the block with ½” (1.25 cm) roundhead wood screws.

Secure plug PL1 to the wood block and attach the appropriate leads from the circuit board. Mount the block on the top of the utility box’s cover, lining up the holes you previously drilled. Secure the block to the cover with roundhead wood screws.

Final assembly of the base/recharger may now be accomplished. First, label the front panel as shown in the photo using dry-transfer letters. Then apply several light coats of clear acrylic spray. This will prevent the photo from being worn off. After the spray has dried, secure S1 in its mounting hole. If your LED1 has no mounting collar, use a ¼-inch (0.64-cm) O.D. rubber grommet to keep the LED secure. Slip the cover onto the utility box and secure it with the hardware provided for this purpose. This completes the assembly of the base/recharger.

It is necessary to modify the hand lantern that you choose. Disassemble the lantern, and find the “molding line” running down the middle of the housing. This can be used to accurately center the power jack J1. Cut a hole in the bottom of the housing that conforms to the power jack you will install. Use a very sharp safety knife to cut the plastic. Drill holes for the mounting screws for the jack and for a metal battery holder. Rather than soldering inside the lantern housing, prewire the components outside the housing as shown in Fig. 4. Replace the light bulb with a lower voltage unit (see accompanying box).

Do not solder the light bulb lead to the brass rivet on the back of the bulb’s nylon retainer nut. Instead, remove the compression spring and solder the lead to one loop of spring. Then replace the spring and feed the wire through the hole in the rivet. To make bulb replacement more convenient, install a small in-line connector in the lead between the spring and terminal of jack J1. A U-shaped clip which fits around the barrel of the lamp socket is furnished with the lantern. Solder two leads to the clip, one of which is connected to terminal 3 of J1. Connect the other to S2 as shown in the schematic. Note that S2 is the lamp’s original ON/OFF switch. Fasten the U-shaped clip to the lamp socket base. Complete the wiring of J1 and S2, and then install two 1.25-volt NiCd batteries in the metal holder. Reassemble the lantern.

Testing. Make one final check of all wiring before applying power to the unit. Then, setting the lantern aside, plug the line cord into a wall socket. A distinct click should be heard as the relay is energized, and LED1 should glow. If all is well, plug the lantern into the base/recharger. If it lights up, switch it off with S2. (If this doesn’t turn J1 off, disconnect the line cord and recheck all wiring.) Allow the batteries to charge for about ten minutes with S1 in the FAST position. Then simulate a power failure by disconnecting the line cord. The lantern should light up after a one-second delay. If the lantern checks out OK, plug the line cord back into the wall socket, and allow the batteries to charge for at least 16 hours.

Operation. The lantern should be placed where fail-safe illumination is most needed. After the initial charge (with S1 in the FAST position), use the SLOW charge rate, as this will offer extended battery life and slightly lower consumption.

SELECTING AN INCANDESCENT BULB.

The battery power source used in the emergency light holds a power capacity of 1.2 ampere-hours at 2.5 volts (when fully charged). This means that it can keep a 1.2-A current flowing for one hour. Alternatively, it can sustain a 0.6-A current for two hours, 0.3-A for four hours, and so forth. Obviously, the smaller the current drain from the power source, the longer the flow can continue. You will have to decide for yourself how long you will need the light to function before the NiCd cells are completely discharged.

If you live in an area plagued with frequent (but brief) power blackouts, this discharge time is not too important. Alternatively, if your neighborhood gets rare (but prolonged) power losses, duration of the power source should be extended.

These factors will dictate your choice of lantern light bulb. The type PR-2 light bulb, which draws 0.5 A at 2.4 volts, will discharge the battery source in about 2 hours and a quarter. If you choose a PR-4 bulb instead, the NiCd cells will last about 45% longer, since it draws only 0.27 A at 2.3 volts. Although the PR-4 will produce less light than the PR-2, many builders will prefer it because it is easier on the supply. If even longer duration (and a lower light level) are desired, you can choose a less demanding bulb type or add current-limiting resistors in series with the bulb.

Fig. 3. Base with recharger is shown without cover. Flashlight plugs into socket on wooden block.

Fig. 4. Modifying flashlight is best done by reworking outside the flashlight housing.
BUILD A LOW-COST

1-Hz to 1-MHz

Frequency Counter

A FREQUENCY counter can be as useful in working with electronic equipment as an oscilloscope, yet it is often the last piece of test gear the hobbyist and experimenter buys. The main reason for this save-for-last attitude stems from the fact that commercially made counters are relatively high priced. Now, however, the easy availability of inexpensive "surplus" IC's and low-current LED displays makes it possible for you to build a low-cost, three-digit frequency counter with a range from 1 Hz to about 1 MHz. By shopping carefully (see the ads at the back of this magazine), you should be able to build your frequency counter for just about $25 to $30.

Circuit Operation. A frequency counter consists of a wave shaper that "conditions" the input signal to give it the clean-edged waveform necessary to trigger the decade counting units. The outputs of the counters drive numeric displays. The entire operation is controlled by a time base that enables the counter for a precise period of time. During the enable in-
interval, all events present at the input are counted and totalized. At the end of the count interval, the counts are stored and displayed. The counter is then inhibited from accumulating more counts until the display period ends. Then the frequency counter is reset and a new count cycle begins.

The complete circuit of the frequency counter is shown in the schematic. The input circuit can be modified according to the availability of components. Just keep in mind that the input should have a reasonably high impedance and that the input of the IC2 decade counter should have a clean positive-going leading edge.

Integrated circuit IC1 is a Schmitt trigger that conditions the input signal and converts it to logic levels suitable for the IC2 through IC4 counter chain. The tenth input count to IC2, at pin 1, generates a “carry” pulse at pin 5 to toggle IC3. At the instant the carry pulse is generated, IC2 causes DIS1 to display a 0, while IC3 causes DIS2 to display a 1. When a tenth input pulse is applied to the input of IC3, a carry pulse toggles IC4 and DIS2 displays a 0 and DIS3 a 1. In this circuit, the carry output of IC4 (pin 5) can be used to turn on the decimal point of DIS1 to indicate an overrange condition.

The timing starts with half of the dual timer (IC5). Switch S1 enables either a 1-s or a 1-ms timing interval. During this interval, the second half of IC5 generates a 2- or 3-second display interval during which the counters are disconnected from the input and the display system is unblanked. At the end of the display, a reset pulse initiates the timing/counting interval.

Construction. Except for the input binding posts, switches, and displays, the entire circuit can be assembled on a piece of perforated board using point-to-point wiring. The only critical area of assembly is around Q1 and the input of IC1, where high-frequency signals will be present. Mount Q1 and IC1 at the end of the board nearest where the input jacks will be mounted on the case.

The displays, switches, and input binding posts should mount on the front of the enclosure. Mount the displays side by side in a slot just large enough to accommodate them and cement them in place. Then mount the binding posts and switches and complete circuit wiring according to the schematic diagram.

Calibration. You can use any frequency counter of known accuracy and a signal generator to make all frequency adjustments. Simply set S1 to the Hz position, drive the counter with some fairly low-frequency signal, and adjust the setting of R6 for the correct indication. If you are using a highly accurate frequency counter to monitor the output of the signal generator, adjust R6 so that the displayed numbers on both counters are the same. Repeat the procedure with a high-frequency signal.

If you do not have access to a highly accurate frequency counter, you can calibrate the dial of any audio signal generator using a 60-Hz source and Lissajous pattern (on an oscilloscope). Then use the outputs as a reasonably accurate signal source to calibrate the frequency counter.

If you have an older signal generator whose dial has a high degree of inaccuracy, you can build the low-cost frequency counter into it. Then you will always know at exactly what frequency the generator is operating.
TORNADOES, hurricanes, and other severe weather disturbances often strike in the middle of the night or at times when most people are not normally listening to the radio or watching TV. Consequently, they receive no advance warning and are unaware of the impending danger.

Residents of areas where disturbances often occur have taken to listening to transmissions from the National Weather Service stations operating on 162.40 or 162.55 MHz in most parts of the country. The receivers used for this purpose generally range from low-cost battery-powered units to vhf/FM scanners. There are also some expensive receivers with special circuitry to alert police stations, etc., to a forthcoming severe-weather announcement by the NWS.

The under-$15 circuit described here will enable you to duplicate the special alert provisions of the costlier NWS receivers. It decodes the 1050-Hz warning tone used for the alert (when it occurs) and automatically activates the normally quiet receiver. This puts your low-cost unit in the same class as the professional weather warning systems.

Circuit Operation. The circuit (Fig. 1) is essentially a controller for relay K1, whose normally open contacts are between the receiver audio output transformer (secondary) and the loudspeaker. Thus the speaker is normally disconnected and resistor R1 provides a substitute load. Capacitor C1 is used to isolate diodes D1 and D2, which provide signal clipping to prevent overdrive of IC1. Capacitor C2 isolates the diode clip-
per from IC1, since any dc component at the input to IC1 could cause false decoding.

Trimmer potentiometer R2, in conjunction with C5, determines the decoding frequency (1050 Hz) while C6 determines the bandwidth and C7 sets the decoder timing. When not decoding, the output of IC1 (pin 8) is high. When IC1 receives a tone within its locking range, the output drops low. This output is applied to one input of a gate in IC3. The output is also coupled through C8 to trigger IC2, a 555 timer.

The timer is required because false alarms can be produced by random receiver noise or voice announcements which occasionally are at 1050 Hz. Since the signals producing false alarms are usually of short duration, but the real alert tone is transmitted for at least 15 seconds, some form of timing circuit is needed.

The output of IC1 is connected to pins 2 and 4 of IC2. When a pulse appears, IC2 resets and starts its timing cycle. Resistor R5 and capacitor C10 set the length of the cycle (about 10 seconds). When IC2 times out, its output (pin 3) goes low and is applied to the input of IC3. When (and only when) the two inputs of IC3 are both low, its output goes high.

As long as the 1050-Hz tone is not present at the input of IC1, the circuit idles, with SCR1 not conducting and the relay deenergized. When the 1050-Hz signal is received from NWS, the output of IC1 goes low and IC2 starts timing. At the end of the timing cycle, the output of IC3 goes high and SCR1 starts to conduct through the relay coil. Then the loudspeaker is connected to the receiver’s audio output and the weather bulletin is heard. Diode D4 reduces the back emf generated across the coil and D5 prevents damage due to application of reverse power supply. Pushbutton switch S1 is used to reset the decoder and turn off the speaker.

Construction. Parts placement is not critical and the circuit can be assembled on perforated board or a pc board. Sockets for the IC’s are suggested. Do not install the IC’s before reading the following instructions on tuning. Any enclosure of suitable size can be used.

The circuit operates from a 6-12 volt dc supply. In the nondecoding state, the current requirement is about 12 mA at 6 V. If your receiver power supply is in this voltage range, uses a negative ground, and can tolerate the current drain, you can power the alarm circuit from this source. If you have a battery-operated receiver, build a low-power dc supply between 6 and 12 volts.

If you have a transformer-operated, tube-type receiver, consider picking off the 6.3-volt filament supply (if one side is grounded) and using a silicon rectifier diode and a filter capacitor (about 1000 µF).

Testing. Start with the IC’s out and the circuit not connected to the receiver.

Install IC1 in its socket and connect a dc voltmeter between pin 8 and ground (positive side to pin 8). Turn on the dc power and note that the voltmeter indicates close to the supply voltage. Connect an audio signal generator ground to the circuit ground and the hot side to the TRANS terminal on TS1. With the relay deenergized, you should now have a signal on the input of IC1.

Set the signal generator as close as possible to 1050 Hz. Adjust R2 until the voltmeter reading drops to near zero, indicating that IC1 is decoding. Remove the signal generator, and the voltmeter should go back to the supply voltage reading. Perform this step several times to make sure that IC1 is operating with each application of 1050 Hz. Turn off the audio generator and the dc power.

Remove IC1 from its socket and install IC2 in its socket. Connect the dc voltmeter between pin 3 of IC2 and ground. Turn on the dc power. Connect a jumper to circuit ground and touch the other end to pin 2 of IC2. Note that the voltmeter reading is the supply voltage. After about 10 seconds, the voltmeter should drop back to near zero, indicating that IC2 has
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**INSTALLATION**

Connections to the weather receiver will vary depending on the receiver. Some typical connections are shown in Fig. 2. Note that a 1:1 8-ohm transformer is used for isolation in case the chassis of the receiver is used as the positive side of the supply (especially if you use the receiver power supply for the alerting circuit). The isolation transformer is also used in case the circuit is OTL.

If the receiver is used for other than weather reception, install a switch across the SPKR and TRANS terminals on TS1. Then be sure the switch is open to use the alerting circuit.

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**INSTALLATION**

Connections to the weather receiver will vary depending on the receiver. Some typical connections are shown in Fig. 2. Note that a 1:1 8-ohm transformer is used for isolation in case the chassis of the receiver is used as the positive side of the supply (especially if you use the receiver power supply for the alerting circuit). The isolation transformer is also used in case the circuit is OTL.

If the receiver is used for other than weather reception, install a switch across the SPKR and TRANS terminals on TS1. Then be sure the switch is open to use the alerting circuit.

**Operation.** Turn on the weather radio. Tune it to your local NWS station and allow it to warm up so that it doesn’t drift (assuming it doesn’t have afc). Depress S1 and you are ready to receive an alert warning. Since the speaker is now silent, you can turn up the volume to make sure that, if the alarm comes during the night, the sound will be sufficient to awaken you.

If you leave the receiver and the alerting circuit on 24 hours a day, it will be triggered between 10 and 11 a.m. each weekday when the NWS test signal is transmitted.

When a severe weather alert is broadcast, it is repeated every 10 minutes until the alert is over. This means the alarm will sound each time until you shut down the system.
The rolling of dice is one of the oldest games known to man. In ancient times, dice were actually carved out of bones, with various characters on the six sides. Today, we have electronic dice. Though some of the character of the game may be lost in the transition from rolling the bones to pushing a button, the chances of winning and losing are still the same (sometimes better, since there are no mechanical irregularities to modify probabilities). Also, electronic dice can be used in the dark and don't emit rattling noises that can be disturbing to some people.

The electronic dice device described here is easily built and comes in a neat, simple package. It makes an ideal game for children and grownups whatever their ages.
Circuit Operation. As shown in Fig. 1, three of the six inverters in IC5 are interconnected with C1 and R2 to form a clock oscillator running at about 1 MHz. A fourth inverter in IC5 is used as a buffer to drive the first die circuit (IC1). This IC is a divide-by-12 counter consisting of a divide-by-2 (not used) and a divide-by-5 (used). The outputs of the counter are decoded by one inverter in IC5, two NAND gates in IC3 and two AND gates in IC4. The decoded outputs then drive directly the six LED's which form the face of one die.

The output (carry) from the first die is used to drive the second die circuit formed by IC2 and the remaining face of one die.

The decoded outputs then drive directly the six LED's which form the face of one die.

The output (carry) from the first die is used to drive the second die circuit formed by IC2 and the remaining elements of the other IC's.

When the roll switch, S2, is operated, the clock oscillator is coupled to the first die, and its circuit runs through its states at a rate of 1 million times per second. The second die runs through its states at about 166,000 times per second. When S2 is released, the LED indication is truly random, with the same probability as an actual pair of theoretically perfect dice would have.

Construction. Neither the circuit layout nor lead dress is particularly critical, but an effort should be made to minimize the length of the lead between the 1-MHz oscillator and the first counter (IC1). If desired, a pc board can be made, using the etching and drilling guide shown in Fig. 2.

There are two ways to mount the LED's. The first is to mount them directly on the pc board in their designated places, making sure that their tops are at least 3/16" to 1/4" above the tops of the integrated circuits. Then the top cover of the enclosure must be drilled so that the seven LED's for each die protrude through the holes. The pc board can then be mounted on the top cover using suitable mounting hardware. The LED's should be selected (by connecting them to a 5-volt dc source through a 180-ohm, 1/2-watt resistor) to make sure that they all glow with about the same brightness.

The pc board fits in the plastic case given in the parts list. When the top of this case has been drilled for the LED's, it is covered with a red antiglare filter that obscures the unlit LED's. This makes the face of each die clear.

The batteries (in their holder) are secured to the bottom of the case and a piece of foam rubber is placed on top of the batteries so that the pc board and LED's make a tight fit when the case is closed. The foam rubber keeps things from moving about. Of course, with this approach, the pc board need not be attached to the cover. In the prototype, nickle-cadmium cells were used. Although their initial price is high, they can be recharged many times.

The second way of mounting the LED's involves drilling the top cover and attaching the LED's to it with epoxy. Then lengths of insulated wire can be used to interconnect the LED's and the pc board.

Operation. When the power switch is first turned on, the dice should illuminate in combination. This initial state is determined primarily by the mismatches in the thresholds of the IC's and will vary with the IC's. Therefore, this "start-up" state is not random and should not be used as a "throw" of the dice.

When the roll pushbutton is depressed, all 14 LED's should go on. Some will be brighter than others due to the differences in their duty cycles. When the button is released, the display will be a random roll.

A ROLL-DOWN CIRCUIT

While testing the electronic dice, we experimented with finding a way to produce a "roll-down" similar to the effect obtained when regular dice are thrown. This can be done by using the circuit shown here to replace the three-inverter oscillator portion of Fig. 1.

The output of the UJT is coupled to pin 9 of IC5, while pin 8 of IC5 is connected directly to the junction of R1 and pin 1 of IC1. The R1 of the original circuit is required because the 7405 (hex inverter) has an open collector on its output transistor. Note the new position of the roll pushbutton.

When the roll switch is pushed, the UJT forms a conventional oscillator with a frequency determined by R1 and C4, whose values can be changed as desired. When the switch is released, the dc supply is removed from the timing circuit and C4 is included in the circuit. As the charge on C4 leaks off, less and less voltage is applied to the timing circuit and the oscillator frequency drops. This causes the dice display to "slow down" and, as the voltage drops to almost zero, the dice stop rolling. Reclosing the roll switch will start the roll again. The value of C4 can be changed to vary the duration of the roll-down time.

—The Editors
COMMUNICATING on a light beam is fairly common with light-emitting diodes ("Experimenting With Light-Beam Communications," POPULAR ELECTRONICS, April 1975, p. 40), but for longer distances and greater efficiency, a laser light source is recommended. With the system described here, it is possible to get a range of more than one kilometer (3300 ft). Since it uses a PIN photodiode in the receiver, the system can be operated in daylight or darkness without an expensive infrared filter.

Though most light-beam communicators use amplitude or intensity modulation, this system employs pulse-frequency or pulse-rate modulation (PFM or PRM). This type of modulation is almost immune to transient atmospheric effects and noise from interfering light sources. Also, the output signal from the PFM receiver is constant in amplitude over the entire communicating range, while that from an AM system becomes progressively weaker as range is increased.

State-of-the art communicator uses pulse modulation to achieve a possible range greater than 3000 feet.

BY FORREST M. MIMS

Transmitter. As shown in Fig. 1, a modular amplifier (AMP1) boosts the voice signals from a dynamic microphone. In a pulse-frequency modulator (Q1 and Q2), Q2 is a UJT connected in a relaxation-oscillator mode. With no input from AMP1, Q1 is saturated (with very low emitter-to-collector resistance) and Q2 oscillates at a frequency determined by the time constant of C2 and R6. When an input is present on the base of Q1, the frequency of Q2 is varied in direct proportion to the amplitude of the modula-

1979 Edition
Fig. 1. A commercial modular audio amplifier modulates a UJT oscillator to drive the laser.

**PARTS LIST (TRANSMITTER)**

- **AMP1**—Modular audio amplifier (Radio Shack 277-1240 or similar)
- **B1, B2**—9-V transistor radio battery
- **B3**—67/2-V battery (Eveready 457 or similar)
- **C1, C2**—0.01-µF capacitor
- **C3**—0.005-µF capacitor
- **C4**—0.01-pF, 100-V capacitor (disc or paper only)
- **D1**—Laser diode (see table at right)
- **J1**—Microphone jack
- **Q1**—2N2907 transistor
- **Q2**—2N2647 UJT
- **Q3**—Selected npn switching transistor (see text)
- **R1**—10,000-ohm potentiometer
- **R2**—5000-ohm potentiometer
- **R3**—4700-ohm, ½-W resistor
- **R4**—200-ohm, ½-W resistor
- **R5**—15,000-ohm, ½-W resistor
- **R6**—390-ohm, ½-W resistor
- **R7**—120-ohm, ½-W resistor
- **R8**—100-ohm, ½-W resistor
- **R9**—1000-ohm, ½-W resistor
- **R10**—5000-ohm, ½-W resistor
- **R11**—100-ohm, ½-W resistor
- **S1**—Dip switch
- **S2**—Split toggle switch
- **Misc.**—LMB B-H 643 enclosure, lens, battery retainers and clips, brass tubing, telescope, mounting hardware, 200-ohm dynamic microphone, epoxy, pc board, solder, etc.

**SUITABLE LASERS**

<table>
<thead>
<tr>
<th></th>
<th>RCA</th>
<th>RCA</th>
<th>RCA</th>
<th>LDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power output (W)*</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
<td>6</td>
</tr>
<tr>
<td>Threshold current (A)</td>
<td>4</td>
<td>4</td>
<td>1.5</td>
<td>8</td>
</tr>
<tr>
<td>Peak current (A)</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>

*Typical power output at peak forward current.

Note: The prototype laser has been successfully operated with all three of the RCA lasers listed above.

Addresses: The manufacturers will provide current prices and specifications upon request. Write to RCA, Electronic Components, Box 1140, New Holland Pike, Lancaster, PA 17604; Laser Diode Laboratories (LDL), 205 Forrest St., Metuchen, NJ 08840.

The resulting PFM signal across R8 triggers a laser drive circuit comprised of relaxation oscillator C4, Q3, R10, and D1. Transistor Q3 is an npn switching transistor operated in a nonconventional avalanche mode. A charge is placed on C4 through R10 until the breakdown voltage of Q3 is reached. The capacitor then discharges through Q3 and the laser. The pulse is very fast (50 ns) and high in current (5 to 10 A) to fire the laser. The cycle then repeats. The large current surge does not mean that the battery has to supply 5 or 10 amperes. The surge comes from the charge stored on the capacitor.

Transistor Q3 oscillates independently of the modulator even when the center frequency is determined by the setting of R2.

Photo shows layout of prototype transmitter. Mounting for boresighting telescope is at top.
the latter is in the relaxation mode. However, with an input, the oscillation varies with the signal. Potentiometer R2 adjusts the carrier frequency to achieve the best modulation. A carrier of about 20 kHz gives the best results for the circuit used here. This is much higher than the 6 or 8 kHz required for acceptable voice transmission and assures good quality for both voice and music.

The transmitter is assembled on a printed circuit board as shown in Fig. 2. All components can be installed after the board is prepared, with the exception of Q3 and the laser diode. Transistor Q3 must be selected by using a test jig such as that shown in Fig. 3, which measures breakdown voltage. Ideally, a 15-MHz oscilloscope should be used to measure the current delivered by the transistor under test. This is done by measuring the pulse voltage across R3 in the test circuit. Since this is a 1-ohm resistor, the voltage measured is equal to the current.

If a 15-MHz scope is not available, a lower-bandwidth scope, connected across C1, can be used to measure the transistor's breakdown voltage. The graph in Fig. 4 can be used to determine the peak current delivered by the transistor.

Not all transistors will oscillate in the test circuit. For best results, try common npn switching transistors such as 2N914, 2N2222, 2N3643, 2N4400, 2N5188, HEP50, etc. Select a transistor that gives a peak current between the laser's threshold and peak allowable currents (as specified by the manufacturer). High currents give high output power. Install the transistor on the pc board and note its current for future reference.

Several lasers can be used, as listed in the table. Do not install the laser yet. Instead, connect an infrared LED (SSL-55C, TIL31, TIL27, etc.) in the circuit for preliminary testing. This permits you to get the circuit operating properly without the possibility of damaging the laser diode.

Receiver. In the receiver (Fig. 5), infrared radiation from the laser strikes PIN photodiode D1 and generates a current which is amplified by IC1. Capacitive coupling between amplifier stages blocks dc signals from ambient sunlight and other light sources. The output of IC1 can be fed directly to an earphone for AM operation. For PFM, however, a threshold discriminator is necessary. The monostable multivibrator composed of Q1 and Q2 forms the threshold circuit. When an amplified pulse from IC1 exceeds the trigger threshold of the multivibrator (a few tenths of a volt), Q2 delivers a pulse of constant width and amplitude. This can be picked up at the collector of Q2, but best results are obtained by adding an amplifier (AMP1) for loudspeaker operation.

The pc board for the receiver is shown in Fig. 6. Use care when installing the IC to avoid bridging the copper portions.

Receiver sensitivity can be improved somewhat by the addition of potentiometer R7, which can be adjusted to reduce the threshold of the multivibrator and permit detection of weak signals. (There is no provision for R7 on the pc board. It can be added by removing a short section of foil from the negative line to Q1 and Q2 and soldering the potentiometer's leads across the gap.)

The photodiode used in the prototype was a high-quality EG & G device costing about $15. This diode has a highly linear response and can be operated in broad daylight. Less expensive detectors (even ordinary silicon solar cells) can also be used; but light baffles, shields, or an infrared filter will be necessary for daylight operation.

Assembly. Check the pc boards for errors and then mount them in suitable enclosures. The enclosures noted in the parts lists were used in the prototype because the hinged lids permit rapid access to the batteries and pc boards.

Assembly the receiver first. Use a chassis punch or nibbling tool to cut a hole in one end of the cabinet for the lens. A 2" plastic lens was used in the prototype, but most any simple lens can be used as long as its focal length is 4 1/4" or less. The larger the lens, the better its light gathering power.

Use L brackets to mount the pc board in the enclosure with the photodiode at the exact center of the lens opening. For the lens given in the parts list, the diode should be exactly 4 1/4" from the inside cabinet wall in which the lens hole is cut.

Mount the threshold adjust pot (R7, if used), gain control (R15), and power switch (S1) on the end of the case opposite the lens opening. Use appropriate mounting hardware for the
Fig. 4. Breakdown voltage of driver transistor versus peak current through the laser diode.

Speaker AMP1, and the two 9-volt batteries. Scraps of pc board 1" x 3" make good battery retainers. Use rubber grommets as standoffs for AMP1. Complete receiver assembly by wiring the various components to one another. Then mount the lens using a flexible adhesive such as Dow Corning Silastic. The plastic lens mentioned in the parts list can be mounted by bending its shoulders with a hot soldering iron.

There are two steps to the transmitter assembly. First, prepare appropriate mounting holes for the controls, hardware, and lens tube assembly. A 9/16" hole should be adequate for the lens tube. Then install all components and batteries except the laser pc board. Make the necessary connections to the board but don't mount it.

Install an infrared LED (note proper polarity) instead of the laser. Test the receiver by pointing it toward a line-powered incandescent lamp. If the receiver is properly aligned with respect to the lamp, a 120-Hz buzz should be heard from the speaker.

Now point the transmitter LED toward the receiver lens and turn on the power. Talk into the microphone or place it near a radio while adjusting R2. It should be possible to get good-quality audio from the receiver. If not, make sure the transmitter LED is properly aligned with respect to the receiver. Then try adjusting R7 in the

Fig. 5. The receiver uses a special photodiode for maximum sensitivity and range. Amplified signal toggles a multivibrator used as pulse detector. The commercial amplifier drives a speaker.

PARTS LIST (RECEIVER)

AMP1—Modular audio amplifier (Radio Shack 277-1240 or similar)
B1,B2—9-V transistor radio battery
C1 to C4—0.01-µF capacitor
C5—500-pF capacitor
C6—0.002-µF capacitor
C7—0.1-µF capacitor
D1—SGD-040B PIN photodiode
(EG&G; available from Cramer Electronics, 85 Wells Ave., Newton, MA)

02159, for 815 plus postage; see text)
1C1—CA3035 amplifier array (RCA)
Q1,Q2—2N718 npn switching transistor (or equivalent)
R1,R10,R12—10,000-ohm, 1/4-W resistor
R2—200,000-ohm, 1/4-W resistor
R3—500,000-ohm, 1/4-W resistor
R4—100-ohm, 1/4-W resistor
R5—500-ohm, 1/4-W resistor
R7—500-ohm potentiometer (optional, see text)

R9,R13—100,000-ohm, 1/4-W resistor
R11—150,000-ohm, 1/4-W resistor
R14—15,000-ohm, 1/4-W resistor
R15—10,000-ohm potentiometer
S1—Dpst toggle switch
Spkr—8-ohm miniature speaker
Misc.—LMB B-H 643 enclosure, lens, battery retainers and clips, mounting hardware, cement, solder, pc board, etc.
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receiver. If no signal is heard, check the transmitter wiring. Also, the LED may be bad, Q3 may not be oscillating, or one or more of the batteries may be weak.

If the receiver oscillates, it may be necessary to reduce the gain of the amplifier by increasing R3 or R4 somewhat. Adding R7 may also help eliminate receiver oscillation.

Proper operation of the system is obvious since a slight misalignment of the transmitter with respect to the receiver will cause loud noise and oscillation from the receiver and then silence. This illustrates the PFM mode of operation. Unlike simple AM systems, a PFM light-beam communicator gives constant receiver amplitude at all ranges out to the threshold cut-off point.

**Final Transmitter Assembly.** When the system is operating properly, remove the LED from the transmitter and install the laser. Mount the laser with its glass window on the back side of the pc board and secure it in place with a #8-32 nut. The plane of the laser junction should be parallel with the narrow side of the pc board. (See Fig. 7.) Next, carefully bend the laser’s flying lead so that it goes into its mounting hole. Make sure the lead doesn’t short against the laser mounting stud.

**CAUTION:** Do not connect a VOM to the laser diode. The small amount of current delivered by the meter will destroy the laser chip.

With the laser in place, test the system again. If it works properly, a 1/2" length of brass tubing (available from hobby shops) is carefully soldered to the back of the pc board with the laser chip at the exact center. Cut a slot from the tube as shown in Fig. 7 to prevent possible shorts. If the tube is not soldered properly the first time, try again until it is centered and level. This tube becomes the laser lens receptacle.

Next use two 7/16" standoffs to mount the laser pc board in the cabinet. A telescoping lens tube made as shown in Fig. 7 is inserted in the tube receptacle. Use a simple lens with a diameter of 12 to 15 mm and a similar focal length. Use epoxy to secure the lens in place.

**Optical Alignment.** Both transmitter and receiver must be aligned with infrared light for best results. This is no problem with the receiver if the lens called for in the parts list is used since its infrared focal length is 4 1/4". For other lenses, add perhaps a quarter of an inch to the visible focal length.

Alignment of the transmitter is more difficult due to the small size of the laser source. An approximate alignment can be made by placing the lens a millimeter or so farther from the laser chip than the visible focal length of the lens. An approximate alignment will give a broad beam suitable for communications up to about 1000 feet. For long ranges, the beam must be made nearly parallel by adjusting the lens for as small a beam spread as possible. This is easily done if an infrared image converter is available. Surplus sniperscopes are ideal for

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**SAFETY CONSIDERATIONS**

The GaAs laser used in this system has a peak optical power output of a few watts if operated at maximum current. That is a lot of light compared to the output of low-power helium-neon lasers; but the optical pulses are brief so that the average power is far less than that of most helium-neon devices.

According to the U.S. Air Force School of Aerospace Medicine, GaAs lasers emitting 10 watts per pulse are not capable of producing detectable eye damage. Three principal factors contribute to this safety margin: the absorption of the infrared in the eye’s vitreous humor, imperfect focusing of the infrared, and the laser’s low average power.

Nevertheless, a few basic precautions must be followed to insure utmost safety:

1. As with any source of bright light, do not look directly into the laser beam.
2. Avoid pointing the laser at shiny surfaces (mirrors, unpainted metal, etc.) because reflected light can be as potentially dangerous as direct light.
3. Do not point the laser in a direction in which bystanders might look into the beam.
4. Turn off the laser transmitter when it is not in use, to preserve its life and that of the battery.

---
this purpose, but they are expensive. Kodak makes infrared-sensitive phosphor screens which glow orange when struck by a beam from an IR laser or LED. These screens cost about $25 (a lot less than electronic image systems). Write Special Product Sales, Kodak Apparatus Div., Eastman Kodak Co., Rochester, NY 14650 for details and prices.

Align the laser lens by pointing the beam at a white card (or the phosphor screen) at least 3 feet away and focus the lens for the smallest spot size. Use the infrared viewer to see the spot if the white card is used.

When the optimum focus point for the lens is found, use white glue to secure the lens in place and prevent need for realignment.

**Telescope Alignment.** Range tests of a few hundred feet are relatively straightforward, but long-range operation requires the addition of an alignment telescope for the transmitter. You can use any spotting or rifle telescope of 3X to 10X as long as it has a cross hair. For the sake of economy, in the prototype, an inexpensive 10X pocket telescope was obtained from Radio Shack for about $3 (Cat. No. 63-844). (Also available from other electronics outlets.) A cross hair was added by cementing two human hairs to a 3/8" washer which was then cemented to a shoulder inside the telescope eyepiece section.

The telescope must be boresighted with the laser. Make an adjustable mount similar to the one shown in Fig. 8. Use two sections of pc board for the mounting platform. Solder three nuts to the back of one board and use springs to permit adjustment.

Aligning the telescope is fairly easy if a phosphor screen or infrared viewer is available. The transmitter is mounted on a tripod with an appropriate nut and the laser is caused to illuminate a fixed spot at least 50 feet away. The telescope is then aligned until the crosshair falls on the target. Recheck the laser to make sure it still illuminates the target and alignment is complete. Perform the alignment at night for fast results and use a flashlight to illuminate the target when the telescope is being used.

**Range Testing.** When the telescope is boresighted with the laser, the system is ready for long-range testing. Begin by mounting the laser on a tripod and pointing the telescope at a fence post, car, or other object at least 1000 feet away. Place the microphone near a radio to get a continuous audio signal. Proceed to the target site, and point the receiver toward the transmitter. It will be necessary to move the receiver about until the optimum detection angle and point are found. If no signal is received, the laser beam has probably crossed the telescope field of view at a point beyond the range of the initial alignment target. Therefore, proceed a few feet toward the telescope side of the laser until the signal is received. An infrared viewer is helpful in finding the brightest spot in the projected beam (which is only a few feet across at 1/2 mile).

The prototype communicator has been used to achieve a range of 3380' (1.03 km). This could be increased to well over a mile by increasing the laser current, reducing the transmitter beam width, or increasing the receiver lens size. For example, the prototype uses a laser with a threshold current of 4.1 amperes. While the laser can be operated at a top peak of 10 A, transistor Q3 delivers only about 5 A. Therefore, the laser output is only a few hundred milliwatts, while more than a watt would be available at 10 A. With the full 10-A current, the optical-communication range equation shows that range would be slightly more than doubled.

Similarly, a diverging beam of light follows the inverse square law, so doubling the diameter of the receiver lens from 2 to 4 inches will double the range.

9 Uses for the 69¢ Wonder

Tested experimenter circuits that can be built with the 703 monolithic amplifier.

A BUCK doesn't go very far these days. But it will still buy a lot of electronics. For example, for just 69¢, the readily available 703 integrated circuit (an emitter-coupled i-f/r-f amplifier) can be used in a multitude of circuits that require a minimum of parts.

The 703 is a highly stable, limited-gain chip that can be made to operate at frequencies of up to 150 MHz. Its efficient internal biasing system is easy to use and reduces power supply requirements and stage decoupling demands. For less than a buck, it's an experimenter's dream.

With this in mind, we present the following nine projects you can build around this popular IC. Three of the projects can be used alone; the remaining six can be used for experimenting or as add-ons to existing electronic devices.

High-Input-Impedance Amplifier. This circuit, shown in Fig. 1, will deliver up to 20 mW of audio output power at the secondary of T2. With a power gain of 30 dB, this circuit can be used as a high-gain preamplifier, a driver amplifier, or a low-power output stage. The transformers provide impedance matching. As such, they can be selected to suit the specific application intended for the circuit.

RC-Coupled A-F Amplifier. With only two resistors and three capacitors, the 703 becomes a high-gain RC-coupled audio amplifier as shown in Fig. 2. The 2200-ohm output resistor can be replaced by 2000-ohm headsets or an output transformer (see Fig. 1 for hookup). Note that the input impedance of this amplifier is low—only about 200 ohms.

Code Practice Oscillator. The code practice oscillator circuit shown in Fig. 3 is another minimum-component project. The output can be a small transformer for feeding a small speaker, or it can be a headset load. The frequency of the tone is determined by the value of the feedback capacitor. To make an oscillator with "warble," use two capacitors...
of different values and switch one in and out of the circuit. For an electronic siren, connect a 4700-10,000-ohm resistor between pin 8 of the 703 IC and the key and a 100-200-µF capacitor from pin 7 to pin 4.

455-kHz i-f Amplifier. In Fig. 4 is shown the schematic of a 455-kHz i-f amplifier made from four readily available components. By cascading several of these high-gain i-f amplifiers, you can make a complete i-f strip for use in a receiver project. The internal bias and limited-gain features of the 703 reduce the need for coupling when several stages are cascaded.

R-F Amplifier. The Fig. 5 r-f amplifier, designed to operate from 500 kHz to 1000 MHz, has its input and output circuits tuned by LC networks. As shown in the short accompanying table, the value of C in both cases must be selected for the frequency range desired. The tuning capacitors should be small trimmers to permit tuning for maximum response at a given frequency.

Crystal Oscillator. A 1-30-MHz crystal oscillator is easy to build when using a 703 IC (see Fig. 6). The values of C1, C2, and L are determined by the crystal and the operating frequency. Capacitor C2 is the most critical component; it must be selected to provide just enough feedback for stable operation. Inductor L is used for bias decoupling and, in some cases, can be replaced with a 220-ohm resistor.

AM Wireless Microphone. The wireless microphone in Fig. 7 is designed to transmit voice signals by radio up to about 100 ft to an AM broadcast receiver. Here, the 703 IC is used as an oscillator and audio amplifier. Only a small transistor radio speaker is needed as a microphone. For use as a phone-oscillator, replace the speaker with a 50,000:1000-ohm transformer, and connect the high-impedance winding to the phono cartridge.

27-MHz CB Converter. With the circuit shown in Fig. 8, you can listen to CB calls on your AM broadcast-band receiver. The 27-MHz CB signals picked up by the antenna are converted in this circuit to a range of frequencies your BCB receiver can accommodate. The IC in this case functions as a reflex converter, operating both as a mixer and a local crystal-controlled oscillator. The circuit is simple to build and get to working if care is taken with layout and component leads are kept short. For improved selectivity and sensitivity, you can add the r-f amplifier circuit shown in Fig. 5 to the output of the converter.

Photoelectric Control. The 703 IC can even be used as a dc amplifier as demonstrated by the photoelectric control shown in Fig. 9. This circuit has a 5000-ohm sensitivity control potentiometer that permits you to "tune" it to respond to a suitable light source 5 to 10 ft away. A small, sensitive relay must be used to drive whatever signaling load you desire. The current drain for this circuit is very small, making the photoelectric control ideal for battery operation.


**Precision Matching of RESISTORS**

Home experimenter technique for matching resistors to better than 0.5%

**BY JAMES DEMAS**

**Precision** matching of resistor values is extremely important in such circuits as bridges and differential amplifiers. At first glance, you might think that an easy way to match values is to use expensive 1% or better precision resistors. A close look at the situation, however, will reveal a basic flaw in this plan. If you use 1% resistors, one resistor might be 1% higher and the other 1% lower than the nominal value required. Hence, the matched-pair tolerance would be 2%.

Ordinarily, when you need closely matched resistor pairs, the absolute resistance value is not as important as how close the values are to each other. Closely matched resistors whose absolute values are "in the ballpark" of those required will usually suffice for a given application.

While commercial manufacturers generally use expensive laboratory-type equipment, the home experimenter must find a more economical means for matching resistors. Fortunately, all he needs is a high-impedance multimeter, a 0-to-30-volt power supply, and a 10-turn potentiometer. The meter should have a 10-megohm or greater input impedance and a sensitive low-voltage range, preferably 0.6 volt or less full scale. Almost any value for the potentiometer’s resistance between a few hundred and about 50,000 ohms will do for this test circuit.

**Resistance-Ratio Method.** The Wheatstone bridge that you must set up with the meter, power supply, potentiometer, and resistors to be matched is shown in the schematic diagram. With this setup, you can easily obtain resistance ratios that will permit you to match resistors to better than 0.5%.

The resistors to be matched in the diagram are R1 and R2. These will form one voltage-divider leg of the bridge, while the potentiometer (R3) will form the other leg. When using this circuit, with R1 and R2 in place, adjust R3 for a null, indicated by the meter reading as close as possible to zero on the most sensitive range. This balances the bridge.

Interchange R1 and R2. If the values of R1 and R2 are identical, transposing the two resistors will not affect the meter reading. However, any difference in the resistances will unbalance the bridge and cause the meter to read some positive or negative voltage above or below the null point by an amount proportional to the ratio of the two resistor values.

The resistances of R1 and R2 are related by the formula

\[ \frac{R_2}{R_1} = \left(1 + \frac{\Delta E^*}{E} \right) \left(1 - \frac{\Delta E^*}{E} \right) \]

where \(R_1\) and \(R_2\) are the values of the resistors to be matched, \(E\) is the power supply voltage, \(E_2\) is the meter reading after transposing the resistors, and \(E_1\) is the initial meter reading after nulling. The formula applies only if the power supply and meter are connected as shown. Also, \(E_2\) and \(E_1\) have polarity signs that must be carried into the calculations.

A sample calculation of how to use the formula is instructive. Assume two 175,000-ohm resistors are compared using an 18.5-volt supply potential. The initial null is at \(-1.0 \text{mV}(E_1)\) and the final voltage (\(E_2\)) is \(-1.96 \text{V}\). This yields

\[ \Delta E = \frac{-1.96 \text{V} - (-0.0001 \text{V})}{18.5 \text{V}} = -0.1059 \]

\[ \frac{R_2}{R_1} = \frac{1 + (-0.1059)}{1 - (-0.1059)} = 0.8086 \]

This means that the value of \(R_2\) is lower than that of \(R_1\) by 1 - 0.8086, or about 19.1%.

For matching resistor values greater than 5000 ohms, use an 18- or a 27-volt supply potential. For resistors of less than 5000 ohms, use a 9-volt supply potential. Resistances of less than 1000-ohms should not be matched by this procedure because of their excessive power dissipation.

Another point to keep in mind is that, when the values of \(R_1\) and \(R_2\) exceed about 50,000 ohms, the first equation will be in error, owing to the meter’s inherent loading effect on the circuit. This results in a \(\Delta E\) measurement that will be too small. To correct for the error, replace the \(\Delta E\) entry in the formula with

\[ \Delta E = \frac{R_m}{R_{in}} \frac{0.5R_1}{R_m} \]

Where \(R_{in}\) is the input impedance of the meter. Finally, because of noise pickup and the magnitude of the correction term, resistances greater than
Matching the Resistors. There's an obvious—but usually impractical—procedure for matching resistors: select one resistor from a batch having the same nominal value and proceed to measure ratios until you hit on a close match. A more practical procedure would be to trim one resistance to make it equal to the other.

The initial trimming is of two types. In series trimming, the lower resistance is increased by adding in series with it another resistor of the proper value. In parallel trimming, the larger resistance is decreased by connecting a resistor of the proper value in parallel. Series trimming is preferred where possible. When the lower-value resistor is a standard or reference that cannot be modified, however, you have no alternative but to employ parallel trimming.

In series trimming, if $R_2$ is greater in value than $R_1$ (you can always change your reference to make $R_2$ the smaller resistance), the necessary series resistance for $R_1$, designated $R_n$, can be calculated by using the formula

$$R_n = R_1 \left( \frac{R_2}{R_1} - 1 \right)$$

The absolute value of $R_1$ may not be known, requiring that you use the nominal value for computation. The closest commercially available value for $R_1$ can be used. These two error sources, however, usually prevent the trimmed pair from being perfectly matched. But the matching will still be much better than if you just took two precision resistors of the same nominal value and used them.

With parallel trimming of the larger-value resistor, trimming resistor $R_n$'s value can be computed by

$$R_p = \frac{R_2}{R_1 - 1}$$

Again, $R_2/R_1$ is greater than 1, and the nominal value of $R_2$ is used in the calculation. This procedure works well if $R_2/R_1$ is not too close to 1.00. As the ratio approaches unity, $R_n$ becomes prohibitively large. Hence, with parallel trimming, use an $R_n$ that is slightly lower in value than that calculated from the equation. This makes $R_2$ a little lower in value than $R_1$. Then series trim as discussed above for any final adjustment of the ratio.

If the match is still inadequate, further trimming will make it approach the ideal. With series trimming, if $R$ is too low, add another resistor of lower value in series with $R_1$ and $R$, to correct the value. If $R$, is too large, the combination of $R$, and $R_1$ is greater than $R_2$. Several solutions are possible. Series trim smaller resistance $R_2$. Alternatively, connect a suitable resistance in parallel with $R_2$—NOT the series combination of $R$, and $R_1$—to reduce it to the correct value.

The required parallel trimming resistor, $R_p$, for $R_1$ is calculated by

$$R_p = \frac{R_2}{R_1 - 1}$$

where $R_1/R_2$ is just the inverse of the original ratio determined for the resistor pair, and $(R_1 + R_2)/R_2$ is the ratio determined after the first trim.

The most economical type of resistors to use for matching are 10% composition types. Using 10% composition resistors and the matching procedure outlined above, you can be sure of better than 1% matching for less than the cost of two 5% resistors. Absolute accuracy will be sacrificed, however. But if you buy your resistors all at one time and from the same place, they will usually be from the same batch. Resistors in a given batch are usually closely matched.

Matching composition resistors to better than 0.5% is possible, but such resistors have poor inherent long-term stability, especially for values exceeding 1 megohm. Stability can be improved by operating the resistors well below their rated power and by burning them in before matching. Once matched, treat the resistors as you would semiconductor devices. Don't overheat them and use a low-power soldering iron and heat sinks on the leads.

For the highest possible stability, wire-wound, oxide, and metal-film resistors are recommended.
GUITAR SOUND INTENSIFIER

By Ken Lang

THERE are few families with young-sters (or young-at-heart oldsters) that don’t have guitars these days. The instrument may be the familiar acoustic type, whose shape and size have not changed much during its long history, or it may be a solid body electric type. With a smaller body, the electric guitar relies entirely on electronic amplification for its sound—and it is probably today’s largest selling equipment.

The solid-body electric guitar has a resonant wooden section instead of a resonant box. Magnetic pickups are mounted inside the body under the metal strings. Without the nuances of body size and shape to provide differences in tone, most solid-body guitars sound pretty much alike. The combination of pickup, strings and electronic resonance provides a pure inductance, which contributes little to sound character and causes peak emphasis at one particular frequency (with attendant ringing and hangover). The subtle string overtones get lost because they can’t compete with the sound output at circuit resonance.

Of course, special effects can be added to electric guitars, but a means of really changing the coloration of the sound is more desirable. Such a change can be achieved by adding this Guitar intensifier.

It has its own volume, bass, and treble controls and can be mounted in the cavity of many solid-body electric guitars. Having independent tone-control arrangements, this approach gives the user a variety of tonal colorations and produces a wide frequency response. There is no loss of high-frequency overtones at low volume settings, but the GI provides the instrument with more “punch.”

Circuit Operation. The signal induced in the guitar pickup (Fig. 1) is coupled through $S1$ and $C1$ to the base of $Q1$, a preamplifier. Potentiometer $R12$ is a volume control, while $R13$ and $R14$ provide bass and treble control.

The complete bass cut-and-boost circuit is composed of $R5$, $R13$, $R6$, $C3$, and $C4$. The treble cut-and-boost consists of $C5$, $R14$, and $C7$. The contoured...
signal is then applied to Q2, which is coupled to J1 through C8.

When S2 is placed in the bypass position, the transistor amplifier is turned off and the input signal goes through only the volume, bass, and treble controls.

**Construction.** The complete circuit can be assembled on a small pc board as shown in Fig. 2. If the unit is to be mounted in the cavity of a solid-body guitar, be sure all components are mounted so that they take up a minimum of height.

The value of R15 must be selected so that it prevents distortion due to overloading of the first stage. Because of variations among guitar pickups, this resistor can be any value from zero to 10,000 ohms.

After determining that the amplifier operates with S2 in the bypass position, connect the loose end of R4 to ground and place S2 in the position. If you get distortion, start by using 2200 ohms for R15. If the distortion continues, try 4700 ohms. Continue to increase the resistance if necessary.

Set the amplifier volume and tone controls as you normally do. Then play the guitar and test the operation of volume control R12, bass control R13, and treble control R14. The results should be very noticeable. Tone response is tailored by adjusting the bass and treble controls for a broad range of coloration. The wider frequency response gives both slashing chords and softly picked solo notes. The attack is fast and the sound is clean. Chord sustain is excellent. ☀️
There has long been a need for an inexpensive, easy-to-use bench instrument that could measure the voltage levels of signals at frequencies into the MHz range. Now, for less than $25 you can build a broad-band voltmeter that accurately measures from dc to frequencies over 20 MHz at amplitudes up to 90 volts in five overlapping voltage ranges.

The heart of this meter is a thermal converter similar to the type used in professional instruments to perform voltage calibrations to frequencies of 1 GHz. The converter is essentially a straight wire heater, which is connected in series with the current to be measured, and a thermocouple that measures the mid-point temperature of the heater. The thermocouple generates a dc voltage that is approximately proportional to the square of the current. (Fig. 1).

The important characteristic of the thermal converter is that its response is relatively independent of waveform and frequency variations. The unit used in this voltmeter is designed to operate between dc and 10 MHz with excellent accuracy and up to 65 MHz with only a 3% error. To get accurate results at, say, 65 MHz, a more sophisticated construction of the converter would be required.

**How It Works.** As shown in Fig. 2, R1 through R4 make up a voltage divider, with values selected to limit the voltage across TC1, the thermal converter, to 0.45 V. The dc output of TC1 is connected to the noninverting input of operational amplifier IC1, which is connected as a dc amplifier. Resistors R5 and R6 determine the gain of IC1, whose output drives M1 a 50-μA meter. Potentiometer R7 is used to calibrate the circuit and the meter, while R8 is adjusted to set the zero point of the meter movement.

**Construction.** With the exception of the circuit involving the input voltage

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**Fig. 1. Output of thermal converter varies with the square of the input. Use this curve to calibrate meter.**

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**BUILD A $25 HIGH-FREQUENCY VOLTOMETER**

Measures up to 90 volts from dc to beyond 20 MHz.

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**BY THOMAS H. SEAR**

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**ELECTRONIC EXPERIMENTER’S HANDBOOK**
divider and TC1, where r-f signals may be present, and all leads should be kept as short as possible, there are no special precautions to be observed in wiring the voltmeter. However, it is advisable to keep the r-f and dc portions separated as much as possible to avoid pickup.

The IC and resistors can be mounted on perforated phenolic board, with the five connectors, meter, switch, and two potentiometers on the front panel of a suitable enclosure. The resistors in the voltage divider are standard 5% units, R1, R3, and R4 being made up of two resistors either in series or parallel, to obtain the required value. The closer you can come to the required value, the better the accuracy of the meter. A precision resistance measuring bridge can be used to get even better accuracy.

**Calibration.** Before turning on the power, be sure that the meter needle is at its zero mark, using the mechanical zero adjustment on the meter itself if necessary. Set R7 to its center position, turn on the power (S1), and wait a few minutes for the circuit to stabilize.

Then adjust R8 to set the meter pointer to zero.

Because TC1 is a thermal device, it will generate a slight output due to the ambient temperature. It will also indicate above zero following each measurement until it returns to the ambient temperature. For this reason, R8 should not be used to adjust the zero after each measurement. Use R8 only after the temperature has stabilized for 5 or 10 minutes.

With the power on and the meter zeroed, connect a known dc voltage to the appropriate input jack. The 22.5-volt input (J2) is recommended because calibrating on that range will distribute the voltage divider errors more evenly. Wait about 10 seconds for TC1 to stabilize. Then adjust R7 to obtain the correct meter reading as determined by the graph in Fig. 1. The calibration will be as good as the degree to which the input voltage is known. (Three fresh 1.5-volt dry cells will provide a calibration voltage very close to 4.8 volts.)

**Caution.** Although the circuit is conservatively designed to protect TC1, the device can be easily damaged by excessive current. Even brief currents of 5 mA or more in the input divider circuit can burn out TC1. Always start measurements using the 90-V range and move down to the lower ranges only if the meter indication is 5 divisions or less. Never connect a voltage to an input jack when you know the voltage is higher than the range for that jack. Also, never change the amplitude or frequency of the input signal without first reducing it to zero since transients could damage the thermal converter.

**Use.** Always remember to allow the voltmeter to warm up for a few minutes.

Keep in mind that the meter's repeatability may be an order of magnitude better than most instruments to which you may compare it. To avoid confusion, set this meter to a reference indication and then compare it to another instrument. This voltmeter is very sensitive in the upper third of the scale, and a small voltage change that may not be noticed on a conventional multimeter can amount to several divisions on this meter.
BUYING YOUR own computer is a lot like buying hi-fi equipment. You’re shopping for a system, not a single component. And the options available to you are much the same in both cases. You can start with a complete, multi-purpose system of awesome complexity or start small and build your system from that minimum. Moreover, you can build that minimum system from a number of different pieces or as one unit that is essentially complete in itself.

Still, the differences between hi-fi and computer systems are profound. Computers can perform a far wider range of tasks than hi-fi systems, so they require a much wider range of peripheral equipment in order to perform them. And where interconnecting a hi-fi system is as simple as plugging the cables from the turntable into a jack marked PHONO, connections for a computer are more complex. You not only need to have precisely the right kind of input or output for a given peripheral device, but you must program the computer to communicate properly with that peripheral.

The most important parts of a computer system are the MPU (Microprocessor unit), memory, I/O (input/output), cassette interface and recorder, power supply, video output, and CRT screen. Others, which are just becoming common in home systems, include a printer, a floppy-disk system, a modem for data communications by telephone, and device controllers.

There’s almost no limit to the number of ways these system components can be packaged. The MPU, memory, I/O
and power supply are usually packaged together. Keyboard, video output and CRT screen (or keyboard and printer) are often packaged together as a "terminal," but it's also fairly common for the keyboard, video output and sometimes the CRT to be incorporated as part of the computer itself. All the other parts can be found built into some computers or external to others.

Your choice of a beginning system will be affected by your budget, your level of computer knowledge, and the list of components you must begin with for your particular application. So it's well to begin by learning what those system components are, and what they do.

Parts of a Computer System. The best-known part of the computer system is, naturally enough, the part that does the actual computing. In a home system that will be a single integrated circuit called a microprocessor. But a microprocessor alone is useless without the other parts that make up a true computer system. And the most basic of these parts are the MPU (where the computing is, naturally enough, the part that does all the actual computing. In a home system, this MPU is called an "executive" or "operating system" program, with each word stored in a separate, numbered location.) Most of the time, the computer works in sync with one another.

Memory. The "scratchpad" registers of the MPU are only a tiny fraction of the memory the computer needs. There's no room in there to store, for example, the program that tells the computer what to do. And frequently the computer needs some place to store its register contents for a while in order to fill those registers with other data. Where there is a lot of data to be handled, the computer needs someplace to store that, too.

Most of these requirements are filled by a type of memory called RAM, or Random Access Memory. The contents of RAM can be changed by the computer at any time, which makes it very simple to revise programs or data whenever required. Unfortunately, when you turn the power off, the contents of RAM spontaneously scramble themselves. When you next turn the computer on again, whatever programs and data you have stored in RAM are irretrievably lost. The contents of RAM can be lost in other ways, too. For instance, an incorrectly written or entered program can accidentally overwrite portions of itself. So, while some RAM is absolutely necessary, something more than RAM would be extremely useful. And two other types of memory—ROM and mass storage—are available to do the job.

ROM stands for Read-Only Memory. Unlike RAM, it's non-volatile; that is, it doesn't forget or scramble contents when the power is turned off. And the computer can't rewrite its contents, either. All the computer can do is read what's already there. This makes ROM a perfect place to store programs which the computer will need all the time. The most common application of ROM is storing monitor programs (also called "executive" or "operating system" programs), which the computer needs frequently in order to communicate with its I/O devices, and how to understand what it receives from them. In some personal computers, a "high-level language"—usually BASIC—is also stored in ROM to enable you to communicate with the computer on your terms.

Some ROM's ("masked ROM") are programmed at the time of manufacture, and can never be changed. Others, called PROM (Programmable ROM), EPROM (Erasable PROM) or EAROM (Electrically Alterable ROM) can be erased and reprogrammed. But you can't just change a single item as you can in RAM; instead, you have to erase the whole PROM (usually by exposure to a strong ultraviolet light, like a sunlamp) and reprogram it with a special "PROM programmer" attachment.

Both ROM and RAM are organized similarly. Data and program steps are stored in individual "words." (Most home computers use 8-bit words, called "bytes"; a few use 12-bit or 16-bit words, with each word stored in a separate, numbered location.) Most of the time, the computer works its way through these locations in sequence, acting on whatever it finds at each address before proceeding to the next one. Often, though, what it finds at a given address is an instruction to jump somewhere else in memory, whereupon it jumps and starts reading through memory in sequence from that point.

About the minimum amount of RAM or ROM you'll find on even the simplest, most limited computer is 256 bytes, or sometimes 512 or 1024 ("1K") bytes. But most computers have at least 4K of RAM or more, in 4K or 8K increments.

Mass Storage. Both RAM and ROM store programs and data within the computer itself. But RAM and ROM are too expensive to serve as permanent storage for all but the most frequently-used programs. Since it takes a fairly long time to enter most programs by hand, it's very useful to have some comparatively inexpensive way of storing these programs in a form the computer can read directly. Several such systems are available.

The oldest mass-storage system is punched paper tape. Many programs are sold on paper tape, since many computer hobbyists have Teletype terminals with built-in paper tape facilities, and because paper tape readers are inexpensive. But paper tape punches (unless included in a Teletype) are fairly expensive, and are always noisy. Also, both reading and punching paper tape is a comparatively slow process.

Therefore, most computer hobbyists use audio cassette interfaces, which record data and programs on ordinary tape recorders, using ordinary tape which can be erased and reused when necessary. This is faster than paper and inexpensive as well. The only drawback is that there are several different cassette data formats, and a computer set up for one such format can't make head or tail out of a tape in another format, even if it's from an otherwise identical computer. Faster still, but more expensive, are floppy-disk systems, a form of magnetic recording using disks of magnetically coated material rather than tapes.

It takes a bit longer to load a program from a floppy disk than to run one in ROM, longer still to load it from a cassette, and quite a bit longer to load one from paper tape. But these mass-storage media have some advantages, too: If you have more programs than can fit in your computer's memory at once, you must use mass storage to save the programs you're not currently running. It also makes it easier to upgrade your software, trading in an 8K BASIC, perhaps, for a 12K or 16K BASIC with more features. And it allows you to use different programs whose address space overlaps, provided you don't use both of them at once.

I/O can come in an even greater variety of forms. Most home computers have either built-in I/O devices with which you can communicate directly, "ports" for connection of external I/O...
devices, or some combination of the two.

Built-in I/O devices take only a limited number of forms. For input, some computers have arrays of switches, others have calculator-like keypads, and still others have typewriter-like keyboards. For output, the range is from binary LED displays (lights that indicate the status of each "bit" of information in a computer word or memory address), usually associated with switch-array or keypad inputs, to digital LED's like those on a calculator (usually found with keypads) to video outputs that display several lines of letters and numbers on a built-in or external TV screen. Many home computers have built-in cassette interfaces, too. Though the cassettes function as a sort of memory, the interfaces that work with them are classed as a type of I/O.

Not all I/O involves letters and numbers, though. There are growing numbers of device control interfaces that can switch external devices on and off under program-controlled conditions. With such interfaces, your computer could, for instance, turn lights on and off while you're away to make it look as if someone were home.

More sophisticated interfaces between the computer and the real world are proportional controllers, using analog-to-digital (A/D) and digital-to-analog (D/A) converters. Most "real-world" information and processes are analog—the temperature, for instance, rises and falls continuously, rather than in discrete digital steps that the computer can understand. An A/D converter makes it computer-readable. Similarly, a D/A converter turns digital signals into varying voltages for proportional—not strict on/off—control of external devices.

There are also telephone interfaces, called "modems" (short for modulator-demodulators), which allow your computer to communicate by phone with other computers and remote terminals. External modems require an I/O port built into the computer. But there are also modem boards that fit directly into some computers.

I/O ports come in two varieties: parallel and serial. In a parallel port, each of the 8 bits in a character passes through its own line to the computer. In a serial port, the 8 bits pass through a single pair of wires one at a time, often with added bits to indicate where each character begins and ends. Parallel ports are usually faster and cheaper, but are impractical for long runs between devices because they require so many wires. Serial ports require only two wires, but are slower. There are two common types of serial ports, the "20-mA current loop" and "RS-232," each requiring a different plug pattern and voltage level. However, most serial ports (and most serial devices, except for Teletypes, which are 20-mA) can be wired for either standard.

Software. Though computing power is sometimes referred to as "intelligence," computers are dumb machines, which cannot do a thing without being told, in extreme detail, precisely what to do and how to do it. Without these programs of instruction, a computer is far less useful than a $4.95 calculator; its power and utility rest as much on its programs as on the hardware that those programs control.

The most important such program is the monitor or operating system. This program tells the computer where to go for information, what form to expect it in, and how to output it. A monitor will also tell the computer how to output, or "dump," sections of its memory contents to show what programs and data are stored there, and how to execute those programs. More sophisticated monitors will have additional features useful in writing, editing and debugging programs, such as "breakpoint" routines that stop the program at a specified step to see if it's reached that step without mishap, "search" commands that can find any byte or combination of bytes, and commands to move memory contents from one location to another.

Usually, this program is stored permanently in ROM memory. The computer is then ready to use as soon as it's turned on. Some computer monitor programs are on cassette tape or paper tape, which cannot be loaded in until the computer is first hand-fed a short program called a "bootstrap," which tells it how to read the tape. But ROM monitor boards are usually available as accessories for these computers.

Two other very important programs are assemblers and high-level languages. Using just a monitor, you have to program in machine code. This requires that you must learn the computer's own, rather roundabout ways of performing even simple tasks ("multiply 2 x 3," for instance, could require 7 commands or so on a typical home computer system). You must also learn to communicate in the computer's own vocabulary, a rather arcane mixture of C9's, DB's, and the like. An assembler lets you write these programs in more comprehensible form, using such abbreviations as "IN" for input, and "ADD" for addition (though you still have to do things the computer's way rather than your own). The assembler program translates your instructions into the computer's vocabulary.

High-level languages, such as BASIC (the most popular in home use), let you talk to the computer in a form more closely resembling human communication. You can then devote much more of your time to telling the computer what you want done, and far less time to telling the computer how to do it. A BASIC program for dividing 2 by 3, for example, is: "PRINT 2/3." The "interpreter" then tells the computer what sequence of steps it needs to do to accomplish this.

Assemblers and interpreters, particularly the latter, require a great deal of memory in which to run. The more elaborate the program, and the more it can do for you, the more memory it takes. One computer manufacturer, for example, offers BASIC in versions occupying 4K, 8K, 12K and 16K of memory, each with more features than the last. Assemblers and short interpreters are sometimes available in ROM, but usually have to be loaded from a paper tape, cassette, or disk.

When buying programs, make sure they're compatible with your system. Most programs are designed to run in a given block of memory addresses, and will not run if relocated unless they're modified. You must have RAM memory at those addresses, and this RAM must not be occupied by other programs which will be in use at the same time (such as the monitor or disk operating system, in a few systems).

Programs written in BASIC or other high-level languages pose another problem. BASIC programs on tape or disk can only be used with the BASIC interpreters or compilers they were designed for; other BASICS will be unable to read these programs properly, if at all. A printed program, however, can be manually entered from the keyboard with any BASIC that has all of the commands that program uses.

Computer Types. Home computers run a wide gamut of designs. But basically, they fall into one of 6 main classes: 1. Intelligent Terminals. These include a microprocessor (the part that does the computing), some memory, a typewriter-like keyboard, and either a built-in video screen or an output to feed an optional,
accessory screen. Such computers are ready to use as soon as you plug them in. But they all provide for later expansion by the addition of more memory, other terminals, printers and so on. (Some of them, however, are easier to expand than others.) These are ready to use for data processing applications, games, teaching yourself programming and, in some cases, graphics.

2. Micro-Mainframes. These are designed to become the bases of larger systems than the intelligent terminals. Therefore, they are less complete (keyboard, video output or display, and ROM monitors are usually extra costs), but have more room for expansion.

There are two basic types of mainframes: those with a full quota of front-panel switches and controls, and those with few external controls except for power and reset switches. The front-panel controls let you program directly into the machine without any external terminals or keyboards, but the process is painstakingly slow; front panels are more useful in trouble-shooting programs, checking them step-by-step to see where troubles, if any, lie. Most front panels use arrays of LED's and switches, each corresponding to a single bit of data or address. A few, however, have calculator-like keypads and numerical displays, which make them simpler to use.

"Turnkey" computers—those without front-panel controls—are automatically programmed to work with such "peripherals" as external terminals or keyboards and displays. That's a major timesaver. But turnkey computers require those peripherals in order to be of any use at all in most applications.

Both front-panel and turnkey mainframes are built to hold a number of accessory boards for system expansion. Such boards might typically include more memory, additional input/output (I/O) ports for communication with such devices as printers or additional terminals, modems for communication via telephone with other computers and terminals, and a host of other devices.

Mainframes are, obviously, adaptable to virtually any purpose you have in mind; you can even adapt some of them to perform several tasks at once. This adaptability is only gained at the expense of higher cost, but there's quite a spread between the prices of the most and least expensive mainframes. And you can reduce the first cost by buying one stripped down to the bare essentials of MPU, memory and I/O (sometimes all available on one board) to keep the first cost low.

Many of these mainframes share the same "bus," the pattern of wires that the boards plug into and the pattern of signals and voltages they carry. Most common in the home computer field are the S-100 bus, which originated with the Altair 8800, and the SS-50 bus, which originated with the Southwest Technical Products 6800. There are other bus types, too, which are rarely compatible with each other. (Bus compatibility is indicated in the product directory that follows.) Some of the lines on the S-100 bus have never been officially defined, however, and may be used for different purposes by different manufacturers. Before buying S-100 equipment from several sources, it pays to check by writing to the manufacturers involved to see whether the equipment will all work harmoniously.

3. Single-Board Systems. These are both more and less complete than mainframe computers. They usually come complete with keypads for input and either binary or digital LED displays for output—features which most mainframes lack—but are usually supplied as bare boards with neither power supply nor case, features found as a matter of course in both mainframe and intelligent-terminal computers. (Some of the intelligent terminals are also available without case and power supply, as single board units.)

Single-board systems are often sold as computer trainers, and they are very useful for learning about computers. All circuitry is accessible, and the keypad and display simplify programming in machine language. They're also useful for dedicated (single-purpose) applications, such as controlling machinery or house systems, since they're so inexpensive.

Moreover, some are designed expressly for this purpose, including on-board relays. They can be expanded, too, by the addition of more memory and connection of external terminals. But the amount of expansion that can easily be accommodated is rather limited.

4. Single-Board MPU's. As with single-board systems, these come with neither power supply nor case (and cases are frequently not available). But they do not include keypads or LED displays. Some have on-board interfaces for use with external terminals. Most provide for easy connection to additional boards with more memory, more I/O and other functions—easier, in many cases, than with single-board systems. In several cases, whole families of plug-together boards from several manufacturers have grown up around certain manufacturers' computer boards.

These boards were mostly designed for use by engineers in evaluating specific microprocessors for inclusion in their own companies' products. As a result, they're built to industrial, heavy-duty standards (which raises their cost, frequently beyond that of single-board systems, even though the latter do more). And their instructions tend to be oriented toward the engineer, with more technical background and less hand-holding than instructions aimed at the non-engineer and hobbyist.

Conclusion. Sales of personal computers for home, experimental, and small-business uses are burgeoning. With prices ranging from well under $100 to many thousands, virtually everyone can enter this exciting field at any level. The following product directory will give you a full picture of the type and variety of personal computers on the market today.
### EXPANDO-32 KIT
- Dynamic RAM's, can be expanded in 8K increments up to 32K.

<table>
<thead>
<tr>
<th>Size</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>8K</td>
<td>$179.00</td>
</tr>
<tr>
<td>16K</td>
<td>$255.00</td>
</tr>
<tr>
<td>24K</td>
<td>$325.00</td>
</tr>
<tr>
<td>32K</td>
<td>$400.00</td>
</tr>
</tbody>
</table>

### EXPANDO-64 KIT
- Dynamic RAM's, can be expanded in 16K increments up to 64K.

<table>
<thead>
<tr>
<th>Size</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>16K</td>
<td>$260.00</td>
</tr>
<tr>
<td>32K</td>
<td>$279.00</td>
</tr>
<tr>
<td>48K</td>
<td>$325.00</td>
</tr>
<tr>
<td>64K</td>
<td>$425.00</td>
</tr>
</tbody>
</table>

### FLOPPY DISK INTERFACE
- JADE FLOPPY DISK (Tarbell board) Kit: $175.00
- Assm. & Tested: $250.00
- S.D. Computer Products: $179.00

### MOTHERBOARDS, S-100 STYLE
- Kit: $85.00
- Assm. & Tested: $99.00
- Bare Board: $135.00
- 13-Slot with front panel slot Kit: $95.00
- Assm. & Tested: $110.00
- Bare Board: $140.00
- 22-Slot Assm. & Tested: $140.00

### STATIC RAM BOARDS
- JADE 8K Kit: $125.95
- Assm. & Tested: $149.95
- RAM 65 (250ns) Kit: $139.75
- Assm. & Tested: $149.75
- JADE 8080A Kit: $169.75
- Bare Board without parts: $25.00
- 16K - Uses 2114's (lo power) Assm. & Tested: $375.00
- Assm. & Tested: $325.00
- Mem2 Kit (250ns) Bare Board: $285.00
- 16K Static with memory management Assm. & Tested: $390.00
- JADE 8080A Kit: $300.00

### EXPANDING AND MOTHERBOARDS
- $117.00 (16K any EPROM)
- $99.50 (1K RAM, uses 2708 or 1702)
- $99.50 (16K any EPROM, uses for expanding APPLE II)
- $59.95

### FLOPPY DISK DRIVE
- JADE INTERFACE $49.95
- JADE 8080A Kit: $295.00
- Single-density 5 1/4", 31 track drive.

### JADE 8080A
- Kit: $100.00
- Assm. & Tested: $149.95
- Bare Board: $30.00

### JADE Z80
- Kit: $125.00
- Assm. & Tested: $185.00
- Bare Board: $35.00

### SHUGART DRIVE DRIVES
- SA 400 $295.00
- SA 801R $495.00
- DM 2700 $750.00

### JADE COMPUTER PRODUCTS
- Cards Welcome
- Cash, Checks, Money Orders, and Credit Cards accepted. Add freight charge of $2.50 for orders under 10 lbs. Add 5% sales tax on all parts delivered in California. Discounts available at OEM quantities.
The listing covers only computers and those peripherals and module boards made by a manufacturer for its own computers and not fitting other makes. Modules, peripherals and accessories made for those computers by other companies, or fitting several makes of computer, will be found in the appropriate sections of this directory.

Wherever possible, we have indicated mutual compatibility among products of different manufacturers by one of the following bus symbols: (AP) - Apple II (DG) - Digital Group, (EX) - Motorola EXORLQisor M6800, (H8) - Healtkit H-8, (8) = Inteltex 8, (IEE) = IEEE-488 bus, (KM) = Kim-1, (LS) = LS-11, (MB) - Intel SBC Multibus, (PT) = PET, (RS) = Radio Shack TRS-80, (S1) = S-100 (Altair) bus, (SS) = SWTP 68K 30-pin I/O bus, (UB) = DEC Unibus.

ALPHA MICRO SYSTEMS

AM-100 16-Bit CPU

(S1) MPU board implementing WD-16 16-bit processor on S-100 bus. Supports most S-100 peripherals, including static memory, I/O and video. MPU features 11-digit floating-point arithmetic in hardware, eight 16-bit general registers, real-time clock, multiple-level DMA and vectored interrupts; up to 10 times the throughput of most 8-bit systems. Software provided includes: AMOS operating system with time-sharing, multi-tasking, multi-user, disk-management and memory-management (to 256K bytes) capabilities, device-independent I/O structure, macro assembler, ALPHABASIC with special business features, ALPHALISP, ALPHAFORTH and ALPHAPASCAL... $1495

ANDROMEDA SYSTEMS

11/B COMPUTER SYSTEM

(LS) LS-11 MPU, turnkey system; 20K words (54K bytes) RAM, expandable to 28K words; dual floppy-disk system with 512K bytes on-line; includes Lear-Siegler ADM-3a 80-char × 24-line CRT terminal; RT-11 OS; FORTRAN, FOCAL, and BASIC available. 8-slot quad card cage, serial interface, power supply... $5317

11/B-LA36. With DECwriter LA36 instead of ADM-3a... $9002

APPLE COMPUTER

APPLE II

(AP) 6502-MPU computer with built-in keyboard, 6K BASIC and 2K monitor in ROM, 4K-48K RAM, interfaces for cassette (1500 char/sec), color video (text, graphics, or mixed) and video-game paddles or joysticks. Video output, 40 characters x 24 lines, upper-case; normal, inverse, or flashing, full cursor control. Graphics 40 x 48 resolution (40 x 40 with four lines text) in 15 colors; high-resolution graphics (requires 12K memory). 280 x 192 (280 x 160 with four lines text) in black, white, and two colors. Apple BASIC has special color, graphics, and game commands. Assembled, in case. Weight 10 lb. With 4K/16K/32K/48K... $970/$1115/$1495/$1795

Apple II Board. Same, less case, power supply, and keyboard. With 4K/16K/32K/48K... $645/$870/$1170/$1470

Parallel Printer Interface card. ROM firmware answers BASIC commands; allows up to 255 char/line, upper/lowercase, special symbols; printers up to 5K char/sec; interfaces to most printers through parallel port... $180

Communications Interface Card. RS-232 port with PROM firmware on card; for use with serial peripherals and modems; passes lower-case or converts to upper-case, at user's option. 110 or 300 baud; half-duplex... $180

High-speed Serial Interface Card. Similar to C.I card, but 75-19.2K baud: switch-selectable speed, line length, auto line feed, carriage return delay... $195

Applewriter II Firmware Card. Has expanded Microsoft floating-point BASIC in firmware, 9-digit arithmetic, large function library, 3 data types, fixed-point or scientific notation, string operations, and high-resolution graphics: user-programmable error messages: will run in 4K RAM, 16K required for high-resolution graphics... $100

Applesoft II on cassette... $20

Programmer's Aid #1 Firmware. ROM-based library of routines for: high-resolution graphics; program renumbering and linking; tape verification; music; RAM tests; machine-language program relocation... $50

Prototyping/Hobby Card. For user's custom circuits; includes system bus description... $24

Disk II Floppy-Disk Subsystem. Interface cards, mini-floppy drives. (Company handles up to 7 cards, 14 drives.) Holds up to 116K bytes (formatted) per disk, sector-softsectored. With one drive and controller... $495

Printer II. Printer interface plus Centronics P1 printer, 80 char/line, 150 lines/min., dot-matrix, electric-discharge on aluminum, 4.75" paper... $695

Printer IA. Interface plus Centronics 779, 132 char/line, 60 char/second, dot-matrix, impact, paper to 8.5"... $1445

Memory Expansion Modules. 4K/16K... $75/$300

BYTE

(B1) Chassis only, with motherboard and power supply. no MPU. See Accessories section for details... $229

CGRS MICROTOCH

SYSTEM 6000

(S1) 6502-MPU computer system using S-100 bus. Modular system, all parts available separately.

6000 Level I: Tutorial. 6502 MPU, 256 bytes RAM; front panel with 7-segment hex displays, single-step, memory protect. Kit/wired... $200/$240

6000 Level II: Introductory. All features of Level I, except 1K RAM, plus TTL support logic for S-100 interface. Kit/wired... $260/$330

6000 Level III: Standard. All Level II features except front panel, plus I/O board with T.I.M. "Terminal Interface Monitor" ROM for use with terminals; S-100 motherboard; power supply (+16V @ 1A, -8V @ 10A) Kit/wired... $370/$470

6000 Level IV: Advanced. Level III features plus front panel; 2K RAM, Kit/wired... $500/$600

6000 Level V: Professional. Level IV features plus cabinet and EXOS extended operating system firmware. Kit/wired... $795/$995

6000 Level X: Turnkey. Keyboard input and video output; no front panel. 1K RAM, "VIP" operating system with screen control; other features as for Level V Kit/wired... $2250

6000 Level XI: Portable. Similar to Level X, but in portable briefcase; power supply +16V @ 1A, -8V... $895

6A. S-100 motherboard, with room for additional cards. Kit/wired... $745/$995

MPU BOARDS

6502-MPU boards for S-100 systems...

Level I. MPU with 1-MHz crystal clock; power-up restart circuitry, 50-pin front-panel connector, slow-memory and S-100 interface logic. Bare board kit/wired... $50/$150/$190

Level II. Similar, plus 2K E.V. 4K 2708 EPROM. Kit/wired... $220/$280

2-MHz option. For above boards and computers, $50

Note: Compatibility listings for other S-100 boards are available from CGRS Microtech.

CENTRAL DATA

2650 COMPUTER SYSTEM BOARD

2650-MPU computer, including 80-character, 16-line video output, 300-baud Kansas-City-standard cassette interface, 1024-byte PROM supervisor with basic ROM and diagnostic routines, PROM and expandable on-board to 4096 bytes. Includes 64-character uppercase character generator, space for additional 64-user-created characters, 750 bytes user-available RAM. Requires independent MBUS interface bus. Wired to PROM population. Wired... $275

Kit... $225

S-100 Bus Motherboard. Expansion board for 2650 computer, accepts Altair-bus memory or I/O boards... $110

Kit... $95

Software Editor/Assembler and BASIC, on cassette. Each... $28

Editor/Assembler, BASIC, Debugger, Character Generator Program... $20 each

12K BASIC, Assembly Language Package $30 ea.

COMMODORE

PET COMPUTER 2001

(PT) IEE 6502-MPU, self-contained computer, includes built-in keyboard with 64-character ASCII uppercase

plus 64 graphics-related characters; 9-in. video display for graphics, 40 character × 25-line alphanumeric, or both; 8K RAM memory, expandable to 32K, 12K ROM including 8K BASIC interpreter and 4K operating system; built-in audio-cassette recorder (file management system in BASIC); interfaces for additional recorder and IEEE-488 instrument interface bus. Wired... $495

4K/8K... $595/$795

2020 PRINTER

(PT) Prints up to 80 char/line on 8½" roll or fan-fold paper; prints complete PET alphanumeric and graphic character set; 120 char/sec; can be programmed to print extended characters or unique characters such as corporate logo... $695

C2NT Second cassette recorder... $100
**COMMODORE/MOS**

**KIM-1 MICROCOMPUTER** (KM) 6502 MPU, single-board computer with 1.1K RAM, 2K ROM monitor, 20-ma serial interface, 23-key control and hex data-entry keypad (terminals provided for additional, remote keypad). Six-digit LED hex display of address and data, audio cassette interface, 15 I/O lines, interval timer under software control. Can be used as stand-alone microcomputer (requires 5V @ 1.2 A, 12 V @ 100 mA), or expanded with modules below. Assembled $245

**KIM-3** 8K static memory

**KIM-4** Motherboard Interfaces KIM-1 with up to six system expansion modules, with all required buffering (motherboard not required to interface KIM-1 with a single expansion board). Includes +5 V, +12 V, regulators (external power supply required). $119

**KIM-5** Firmware resident assembler/editor $198

**KIM-6** Prototyping board, wirewrap, for user-defined system expansion $39

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**COMPTRONICS**

**1080 F-8 MICROCOMPUTER** (S1) F-BMP-4 microcomputer. Includes FAIL-SAFE Bug Program Storage Unit, Static Memory Interface, 2K RAM, 2.0-MHz crystal, 1K EPROM, 4K EPROM sockets. Connectors for S-100 memory expansion, 1 serial and 4 parallel I/O ports. Controls memory page select, memory protect, I/O or terminal select, high-speed paper tape select, monitor/user-program select, reset. Requires +5, +12 V dc. Kit/wired $239/$275

**COMPUCOLOR**

**8080-MICROCOMPUTER** 8080A-MPU computer with 3-key rollover, 4K to 32K RAM, built-in mini floppy (5") disk drive. Disk controller has 4-drive capability. With 4 single-sided drives, 32K/64K RAM. Kit/wired $90

**COMPUCOLOR II** 8080A-MPU intelligent terminal type computer with 8-color integral display on 13" CRT. Typewriter keyboard with 3-key rollover, 4K RAM, similar to Z-80, but with built-in mini floppy (5") disk drive. Disk controller has 4-drive capability. With 4 single-sided drives, 32K/64K RAM. Kit/wired $239/$275

**CROMEMCO**

**SYSTEM THREE** (S1) Z-80A-MPU with dual-disk drive (4-drive controller), 8K RAM with bank select (expandable to 512K), 30A power supply, 21-board capacity, jump-on-reset to 1K PROM monitor; includes serial (110-7600 baud) and parallel interface. Rack Mount Frame, $5990

Option 001. Front-panel PROM programmer for 2708 $495

Option 002. Additional dual-disk drive $2395

Option 003. Additional 16K memory $795

Z3-WCB. Walnut floor cabinet, 29" x 21" x "30". $595

Z3-CAB. Aluminum cabinet with foldaway handles. 13" x 20" x "26". $195

Software available: 16K Z-80 BASIC, FORTAN IV, Z-80 macro assembler and linking loader.

**Z-1** (S1) Z-80 MPU computer with front panel controls and indicators. 8K capacity (2708), 32-A power supply, 8K RAM memory, RS-232 serial interface, 1K monitor, Wired $2495

**Z-2** Similar, but without front panel. Power-on jump circuit begins automatic program execution when power is turned on. Rack-mount design (cabinet option) with 60-A power supply for cards and other peripheral cards. Stabilized Blitz-Bus motherboard design to reduce ground-current noise. Kit/wired $595/$995

**Z-20** Similar to Z-2, but with built-in mini-floppy (5") disk drives. Disk controller has 4-drive capability. With one drive, Kit/wired $1495/$2095

Z20-FDD. Additional disk drive $495


Z2-WCB. Walnut floor cabinet $595

**SYSTEM TWO** (S1) Consists of Z-20 with 2 drives. RS-232 interface, 32K RAM, 5-color printer interface.

**Model CS-2** $3990

**SINGLE CARD COMPUTER** (S1) Z-80 MPU plus 8K 2716 PROM; 1K RAM; serial (RS-232 or 20 mA) port; 24 bits parallel I/O; vectored interrupts; 5 programmable timers. Requires +8 V @ 1.4 A, +18 V @ 70 mA; -18 V @ 25 mA. SCC. Kit/wired $395/$495

**MCB-116** 12-command monitor and 3K CONTROL BASIC in two 2716 PROMS. MCB-290 Z30-CPU MPU replacement only, no on-board memory or I/O. See Module Boards section. Kit/ wired $225/$395

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**DIGI-KEY**

**NIBBLER** (S1) MCM-600 microcomputer. Includes NIBL BASIC resident assembler in ROM, 2K RAM (expandable to 28K), 110-baud TTL serial I/O. On 44" x 64" board with 72-pin edge connection, includes manual. Wired $150

Power-supply board. Provides 5V @ 1 A and ±12 V @ 100 mA for NIBBLER, also converts TTL serial I/O to both 20-mA TTY and RS-232 $40

**DIGITAL MICROSYSTEMS**

**DSC-2 MICROCOMPUTER** Z-80 MPU standard, 64K optional; dual-density disk system with two 6" drives built-in (double-sided optional), expandable to four drives; CP/M included; includes RS-232 serial interfaces; real-time clock, no backplane. With 2 single-sided drives, 32K/64K RAM $4955/$6090

With 2 double-sided drives, 32K/64K $5695/$6795

With 4 single-sided drives, 32K/64K $7040/$8145

**DIGITAL SERVICE & DESIGN**

**DSB 1802** Z800-MPU microcomputer system. Uses SS-50 bus (but compatible with 6800 MPU or SW/T compatible serial I/O which use 6800 MPU for baud-rate generation). Full 65K addressing; all EF flags. Q and N outputs. D-Bus lines brought out to bus 2708. 8K (2716) EPROM memory, ±5V and ±12V regulators; RS-232 or TTY interface option. All modules sold as bare boards with edge connectors. Kit/wired $27

**DSB 1802-1/0 I/O network card; supports 9 cards** $29

**DSD S6011** Serial Card $12

**DSD S6055** 5-slot motherboard $29

**DSD 2114-16K** 16K RAM card* $27

**DSD P212** Parallel I/O card $12

**DSD C I/O-2M** Cassette interface $12

**DSD 1802 Package** of one each of the above, with documentation $125

**CDP1802CD** CPU $20

**MPO42** Baud-rate crystal $4.50

**RTS1-62-Y1** Cassette motor relay $2.80

**WYN 1802** DSD monitor in Z-80 version $30

- "Fully compatible with 6800 SS-50 systems.

**DIGITAL SPORT SYSTEMS**

**INFORMER 2** Two-piece computer: one disk/mainframe unit, one keyboard console. Requires TV set or video monitor. Includes: 32K RAM, 2 serial RS-232 ports; 2K PROM, floppy controller and mini drive, power supply; BASIC on disk; 63-key keyboard; TV interface. $1695

16K RAM addition $385

4-port serial board $65

4-port parallel board $321

PROM board (holds up to 8K) $97

Additional mini-floppy drive $550

PROM board (for 2738) $256

RS-232 add-on for original serial port $33

Game and business software available on disk.

**UC2000 MICROCOMPUTER** (S1) 8080A-MPU, terminal-type microcomputer. (Available without MPU if desired). Mainframe includes: 12" 144-cps video monitor, 8-slot microcomputer with customizing area; 1A power supply; blower; standard keyboard; cabinet with room for mini-floppy drive. System A. As above, no cards $995

System B. With 8080A MPU, Video interface (96- 12" lower/uppercase ASCII, 64 char. x 16 li., graphics capability); cassette interface (bi-phase or K.C.) $2266

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**The Publisher**

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**NOTICE TO READERS**

We consider it a valuable service to our readers to continue, as we have in previous editions of this guide, to print the price set by the manufacturer or distributor for each item described as available at presstime. However, almost all manufacturers and distributors provide that prices are subject to change without notice.

We would like to call our readers attention to the fact that during recent years the Federal Trade Commission of the U.S. Government has conducted investigations of the practices of certain industries, in fixing and advertising list prices. It is the position of the Federal Trade Commission that it is deceptive to the public, and against the law, for list prices of any product to be specified or advertised in a trade area, if the majority of sales of that product in that trade area are made at less than the list prices.

It is obvious that our publication cannot quote the sales price applicable to each trading area in the United States. Accordingly, prices are listed as furnished to us by the manufacturer or distributor. It may be possible to purchase some items in your trading area at a price that differs from the price that is reported in this edition.
DYNABYTE

Z-80-MPU. 12-position card cage and shielded backplane, regulated 30A power supply, case aluminum enclosure (wood enclosure tops optional), 32K RAM, 2 serial RS-232, 1 parallel I/O ports, vectored interrupts, real-time clock, EPROM programmer.

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB8-1</td>
<td>$2195</td>
</tr>
<tr>
<td>DB8/2</td>
<td>Similar, with 5-inch mini-floppy; dual density floppy disk controller allows addition of double-density drives.</td>
</tr>
</tbody>
</table>

DB8-1: Two drives single-sided: $4395
DB8-2: Double-sided: $5195
DB8-4: Similar, but with double-density 8" floppy: $2995
DB8-4/1: Two, single-sided drives: $2995
DB8-4/2: Two double-sided: $3595

PZ8. SELF-CONTAINED COMPUTER

Z-80 MPU single-board computer for S-100 bus. Can include MPU, 2 RS-232 serial and 1 parallel I/O ports 1K static RAM, 4K EPROM with programmer; vectored interrupts, real-time clock, reset jumper.

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>PZ8-1</td>
<td>$555</td>
</tr>
<tr>
<td>PZ8-1X1</td>
<td>1K RAM option: $40</td>
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<tr>
<td>PZ8-1X2</td>
<td>2K EPROM: $55</td>
</tr>
<tr>
<td>PZ8-1X3</td>
<td>4K RAM: $40</td>
</tr>
<tr>
<td>PZ8-1X4</td>
<td>2 serial ports: $75</td>
</tr>
</tbody>
</table>

BASIC CONTROLLER

Single-board computer for high-level programming of control applications. Uses Z8L basic BASIC. Has all facilities of PZ8 except S-100 bus, plus 8-bit status-light port, four 7-S A relays, four 5-A relays, 32 flag outputs, 32 sense inputs, cassette I/O with file handling, 64-char-16-line video interface, 8K RAM, expandable to 16K.

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tr>
<td>BCI-1</td>
<td>$1095</td>
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<tr>
<td>BCI-X2</td>
<td>Power supply: $85</td>
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<tr>
<td>BCI-X2</td>
<td>Power supply: $85</td>
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<tr>
<td>BCI-X3</td>
<td>Additional 4K RAM: $110</td>
</tr>
<tr>
<td>BCI-X4</td>
<td>Application program cassettes: $12</td>
</tr>
</tbody>
</table>

E & L

MMD-1 MINI-MICRO COMPUTER

8080A MPU educational microcomputer system with built-in breadboard sockets; comes with Bugboard self-teaching training course. Features octal keyboard and binary display, power supply, 256-byte PROM operating system (expandable to 512 bytes); 512-byte RAM (expansion available). Kit/asssembled: $375/$525

<table>
<thead>
<tr>
<th>Price</th>
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<tbody>
<tr>
<td>$2582</td>
</tr>
</tbody>
</table>

System D. With 16K RAM, extended keyboard, 1 floppy $3649
System E. RS-232 printer interface, dual floppy, all System C features $4665
MII0-1. Firmware monitor $66
Option 001. 230V 50 Hz operation $25
Option 002. RS-232 and 20/60 mA interface $160

ELECTRONIC TECHNOLOGY

ETC-1000

5602-MPU computer accepts wide variety of processors (Z-80, 8080A, M6800, and F8) for alternate or multiprocessor use. Basic system includes 6502 control processor, 256-byte ROM (expandable on processor board to 4K), 1K RAM, eight-digit LED display, hex and control function keys, eight I/O device-control lines, two serial 1/O lines, and interrupt system with eight levels, plus choice of two power supplies. Space in cabinet for up to 16 expansion options, such as additional MPU's, ROM, RAM, peripheral controllers and external interface modules for real-time control. Memory map option allows expansion to 4M. Other options include 220-V and low-voltage power supplies, bus expansions, and peripherals. Wired $775 1006S. Stretch chassis option for above (32-slot) $100

1003. B-A power option $75
1011. Power-on restart, user-addressable $55
1013-1. Battery backup $270
1031. Altair-compatible bus extension for use of Altair-compatible computers using DTC-ETC with 1006S $2195

1095. Cassette I/O $65
1104. 4K RAM $235
1126. 8K RAM $385
1465. 16K ROM module $215
1407. 8080A MPU with 1K private RAM, ROM $325
1216. 6800 MPU with control ROM $255
1411. 8K MPU with ROM and 1K RAM $325
1413. 6502 MPU with ROM and 1K RAM $345
1414. Z-80 MPU $299
1415. Z-80 MPU with 1K RAM, 1K RAM for additional 1K ROM $525
1145. 8K interface, 16 x 64 characters $385
1525. Alphabetram keyboard $125

ETC-1000/32K DISK SYSTEM

Similar to computer-multiplexing options 1003, 1005, 1120 (4), plus 2-channel EIA Communications Interface, programmable writing-protection, and dual-drive IBM-compatible disks and controller with DTC; includes 32K RAM, 50K disk storage, keyboard, 8-digit display, cassette I/O $5680

ENVIRONMENTAL TECHNOLOGY

LITTLE BIT

Single-board microcomputer designed for controller-type applications. On 4.5" x 6" card with 44-pin edge connector, features 32 bidirectional, TTL I/O lines; 2 daisy-chained external interrupt lines; automatic power-on restart; 1K EPROM, 64 bytes RAM; 2 software-programmable interrupt timers; crystal clock; on-board regulators (5V regulator can supply up to 300 mA, for operating external circuit); over-temperature protection and current limiting.

10154. With 1K 2708 EPROM: $153
10728. With 4K 2732: $153
10626. Little Bit More: 320 bytes RAM, 2K EPROM, 40 I/O lines: $240
10742. Mighty Byte: 8K EPROM, 1K-64 RAM, 48 I/O lines: $240
10668. Universal Display, 6-digit LED: $59
10692. Hex keyboard: $59

EXIDY

SORCERER

Z-80 MPU intelligent-terminal type computer, with keyboard and video output. Memory 8K RAM, expandable to 32K; 4K ROM standard, ROM cartridges up to 16K available. Dual cassette I/O at 300 or 1200 baud, remote motor on/off, RS-232 serial I/O at 300 or 1200 baud; edge-card connection for 100-number expansion unit. Video output: 30 lines x 64 char (1920 char/screen), full 128-character ASCII set, 64 pre-defined and 64 user-defined graphic characters (all 128 may be user-defined); 512(h) x 240(v) graphic resolution; automatic scroll, delete character, erase end-of-line, end-of-screen, clear screen, full cursor control; $895

Exidy 12 video monitor: $299
16K RAM expansion: $299
PIC-1 PROGRAMMABLE CONTROLLER

For 6802 or 6502 MPU. Compact (4½ x 6½”) board for control applications. Has provision for RAM (256-384 bytes), 2K EPROM, crystal, choice of interface devices, 16 I/O and 4 handshake lines, 2 hardware interval timers, serial-parallel/parallel-serial face devices, 16 I/O and 4 handshake lines, 2 hardware interval timers, 2 input/output lines, 5 heavy-duty relays, TTY and cassette interfaces; programmable–frequency square waves, external-pulse counters; may be linked in multiple-board systems; accepts 2706 or 2716 EPROM. Comes with extensive 6802 test program listing, short 6502 test program, both available on EPROM.

PIC-1 Bare board and documentation $29
PIC-1ES65. 6502 EPROM $15
PIC-1ES88. 6802 EPROM $15

SMARTS II

Z-80 MPU computer with built-in floppy drive, 32K RAM, 2K PROM and color video interface (64 char x 16 l) with sound, separate 63-key (upper-lower-case) ASCII keyboard. Memory expandable to 512K RAM, 8K PROM (16K PROM with optional interface); 2.5-MHz clock; S-100 bus, 6 cards; video 7 x 9 matrix, 8 colors (expandable), limited graphics, floppy-disk system expandable to 3 min drives, two standard-size disk drives optional; includes one RS-232 interface, expandable to 4; “Game I/O” for up to 6 joystick/stick, power supply 8V (8.1A, 12V in, 4A, 12V in) $1595
1RS32. Serial add-on I/O port $31
1KPRM. 1K PROM add-on $18
8KPRM. 8K PROM board (less PROMS) $62

GIMIX

GIMIX GHOST 6800

6800-MPU system with S5-50 bus. Has fifteen 50-pin slots plus eight DIP-switch-addressable, 30-pin I/O slots configurable to 4 or 8 decoded addresses; DMA capability through cycle-stealing or halt; separate crystals for CPU and baud-rate generator; sockets for 4K 2706 PROM; DIP-switch-addressable for SWTP or MSI software. In cabinet with keylock power/reset switch, cooling fan, video board, GMBUG 2K 8K ROM monitor; 2-port buffered parallel I/O board; 8K RAM (upgradeable to 16K on-board); space and power for dual mini-floppy (not included). Options include: 3 independent software-programmable timers; 8K additional RAM with or without software-programmable RAM address, write protect, disabling, accessible, 8K, no options $1195
CPU timer option $53
8K added RAM (16K total) $156
8K added RAM with software control $229

HEATH

H8 (188)

Computer with 8080A MPU, 1K ROM monitor for load-debug and front-panel operations; front panel with octal keypad and digital display. With 10-slot cabinet using Heath 50-pin bus, power supply capable of handling up to 32K of memory and two I/O interfaces; programmable speaker andLED status lights. Kit, with wired and wired CPU, BASIC, assemblers, editor and debug programs on audio cassette. Requires H8-1 memory board (see Module Boards) to operate. Kit $375
WH-8. Wired version $475

"Minimum System" B8 with 8K RAM, serial I/O, cassette interface, H9 video terminal, and cassette recorder/player $1221
"Recommended" System. Similar, but with 16K RAM. Extended BASIC on cassette $1439

H11

Computer with LSI-11 11-bit MPU accepting PDP-11 software. 4K x 16 dynamic RAM expandable to 20K, 6-slot backplane; power supply with switching regulators and full circuit protection; I/O interface; DEC software package with editor; PAL-11 assembler, linker, on-line debugger, I/O executive, BASIC and FOCAL. Kit, with assembled MPU $1295

WH-11. Wired version $1656
H11 System One. Includes H11, 8K RAM, parallel interface, serial interface, H9 video terminal, H10 paper tape reader/punch $2461
H5-11. Computer System Similar, but with LA36 DE decoder writer II printing terminal instead of video terminal $3300

M-16 EXTENDED ARITHMETIC CHIP

Adds hardware arithmetic instructions to LSI-11, including fixed-point x, + and extended shifts, plus floating-point +, -, x, /, DIP 40-pin package plugs into socket on LSI-11 boards $159

MICROPROCESSOR TRAINER

6800-MPU computer kit designed for circuit-training purposes. Includes 1K ROM monitor, 6-digit hex LED display, 17-key hex keypad, 256 bytes RAM (expandable to 512), breadboarding socket, 8 buffered LED's for display of breadboard logic states. DIP switches for binary input to breadboard, power supply +5, -12V, all buses buffered and terminated on front panel, provision for 40-pin external connector for extending memory and I/O. Kit ET-3400 $190
ET-3400 Combination of ET-3400 trainer and EE-3400 microprocessor training course includes additional 256 bytes RAM (512 bytes total) plus additional electronic components including PIA interface chip and 1406 digital/analog converter $270

IASIS

i7301

8080 MPU, single-board computer with built-in hex keyboard and display, 1K PROM monitor (space for 2K), 1K RAM, two I/O ports plus audio cassette interface. LEDs signal end of tape read or write operations. Requires +5 V, +12 V (only -5 V derived internally); power supply optional. Computer is built into a 500-page, looseleaf programming course manual; computer board has plexiglass cover with cutout for keys. Wired $450
5-PAC Set of 6 software cassettes $75

IMSAI

I-8080 TABLE-TOP COMPUTER

(51)

8080A MPU system includes clock, tri-state bus drivers and control-signal timing, Plug-in front panel control board with large, paddle-handle address/data switches and LED masks; color-coded switches allow kit-version switches to be color-coded. Options include: 28-pin 16-bit motherboard, aluminum cabinet, many mechanical options (fan, connectors, cables) available, many S-100 hard disk and software options available. Power supply delivers 8 V up to 28 A, ±16 V and 3A. I-8080 (PCS 80/10). Kit/wired $699/$931
I-8080-0EM (PCS 80/11). Without front panel. Kit/wired $529/$749
RM. Rack-mount option $20
FM. Cooling fan $29/$39

I-8080/15 TOP TABLE TOP 0885 SYSTEM

(5) Similar to I-8080-0EM, but with 8085 MPU, 10-slot terminated and regulated motherboard, MPU board includes 256 bytes RAM, 1K ROM, parallel and serial I/O ports. Kit/wired $799/949

I-8080/30 SYSTEM WITH CRT

(51) Similar to I-8080/15, but with 5" CRT built into cabinet front, video interface (upper/lower-case), and KB-1 intelligent keyboard (see Peripherals section). Kit/wired $1199/$1499

I-8080/34 DISK SYSTEM

(51) Similar to I-8080/30, but with CRT replaced by one mini-floppy drive. Kit/wired $1649/$1999

I-8080/40 DISK

Similar to I-8080/30, but with dual mini-floppies. Kit/wired $1995/$2245

I-8080/100 SYSTEM

(5) Consists of I-8080/30-50 CRT system, 16K RAM, Tarbell-standard audio cassette recorder interface and 8K cartridges, BASIC, CASSETTE Operating System, 2 parallel, 1 serial port, all cables. Kit/wired $1886/$2670

I-8080/200 SYSTEM

(5) Consists of I-8080/34 disk system, 16K RAM, video output, DOS, intelligent keyboard. Kit/wired $2610/$3357

VDP-80 VIDEO DATA PROCESSOR

6855 MPU, integrated computer system with 12" CRT, ASCII keyboard with numeric keypad, control keyboard and cursor controls, dual floppy disks, 32K RAM, all interfaces, in single cabinet. Disk system uses PerSic drives, single or double density, 1-megabyte capacity expandable to 4M, RAM expandable to 196K, serial and parallel ports, IMSOD software included.

VDP-80/1000. Wired $6995
VDP-80/1050. With 64K RAM. Wired $7745

VDP-40

Similar to VDP-80, but with 514 mini-floppies, 9" CRT (80 x 24 display), 2K ROM monitor system expandable to 4.5 megabyte disk storage. Wired with 32K/64K RAM $4495/$5295

8048 SINGLE-BORARD COMPUTER

Programmable computer and process controller. 22 I/O lines, 5 heavy-duty relays, TTY and cassette interface, 24 key hex keypad, 9-digit hex LED, requires PS-3A power supply.

8048CC-EROM. EROM version. Kit/wired $499/$549
8048CC-ROM. ROM version. Kit/wired $299/$349
8048RAM. 1K RAM expansion for 8048 - $315/$345
PS-3A. 5-V, 3-A open-frame power supply for 8048CC. Wired $99

IMSAI EXPRESS CONTROL COMPUTER

Similar to 8048, but with cabinet, power supply, software and documentation. Wired $499

INDUSTRIAL MICRO SYSTEMS

COMPUTER

8080A MPU, 2 serial ports with independently-adjustable baud rates, real-time clock with maskable interrupt; vectored-interrupt logic; 2708 EPROM, 32K-64K RAM with memory-mapping; 2 Shugart 8015 floppy drives with controller; 110/220-V operation, 110/220-V, 5-0032. With 32K, Wired $3432
With 48K $3736
With 64K $4040

INTECOLOR 8031

(18)

8080A-MPU system with integral 13-color CRT display, built-in mini-floppy drive, detachable key- board. Intelli-8 bus structure. Includes: 31 internal
Write and run machine language programs at home, display video graphics on your TV set and design microprocessor circuits—the very first night—even if you’ve never used a computer before!

**ELF II featuring RCA COSMAC microprocessor**

**$99.95**

as FORTRAN and BASIC must be translated into machine language before a computer can use them. With ELF II you build a solid foundation in computing so you’ll really know how things work—don’t leave the big, expensive things to others.

Video output also makes ELF II unique among computers selling for such a low price. Attached to your TV set, ELF II becomes a fabulous home entertainment center. It’s capable of playing endless hours of colorful video action of all ages! ELF II can create graphics, alphanumeric displays andcredible high-resolution electronic music! No special software is required.

No additional hardware is required to connect ELF II to your TV. Just plug ELF II into your antenna terminals instead, simply use a low-cost RF modulator (to order one, see coupon below).

With 5,400 instructions (connectors not included) allows you to expand ELF II as your needs for power grows. It’s small, compact and extremely portable, yet it can do such remarkable things.

**ELF II Expires in A Giant!**

Thanks to ongoing work by RCA and Netronics, ELF II add-on’s are among the most advanced anywhere. Plug in the GIANT BOARD® and you can record and play back programs, edit and debug programs, communicate with remote devices through modems, create all types of strange devices that happen (by luck or design) to get to ELF II to solve special problems such as operating a laser printer or analyzing radar returns from your home-built space craft. Add 4k RAM board and you can write longer programs, store more information and even extend new capabilities.

Expanded, ELF II is perfect for engineering, business, industrial, scientific and personal financial applications. Nothing else is available and ELF II is backed by such an extensive research and development program that it’s the future!
MICROPRODUCTS

SUPERKIM (KM) (AP)
6502-MPU, single-board computer with detachable hex keypad and 6-digit hex display. Modeled after Commodore/MOS KIM-1, but with more RAM, EPROM and programmable area in approximately same size. Software-compatible with KM-1; compatible with most KM-1 and Apple II hardware interfaces; can use Apple II as software development system. Includes: 4K RAM sockets, 1K RAM, 2K KIM ROM monitor, 4 EPROM sockets for 16K 2732, or 8K 2716; power-on reset; interface and jacks for cassette (KIM-compatible); serial RS-232 interface; on-board regulator, rectifier and filters, requires only 12V ac, C.T. 6/2A; 110V ac, 1A. Provided, can support up to 9 b-directional 8-bit parallel ports with handshaking, 8 counter timers; 8 latched priority interrupts; software re-settable; DMA possible; EPROM addressable anywhere from 0000 to FFFF; large prototyping area for A/D chips, etc. $395

MICRO DATA SYSTEMS

MDS-690A SINGLE-BOARD COMPUTER (S1)
8080-MPU (uses 8080 instruction set), but also compatible with upcoming Motorola 6809, with 16-bit internal registers, hardware multiplication, 16 addressing modes, and 5x throughput of 6800. Has 2400-baud cassette interface; 1K RAM, 10K ROM space, 16 I/O lines plus 4 control lines, provision for RS-232 interface; Dama capability; MONBUG, 1K PROM monitor is software-compatible with MICROBUG but will interface with memory-mapped video and graphics cards, has "memory window" for examining and altering memory contents, interrupt-driven keyboard routines, video handler with cursor control.
Kit/wired ........................................... $198/$258

MDS-2 SYSTEM (S1)
Includes MDS-690A MPU, power supply, motherboard, video/graphic card and custom keyboard, in hand-finished redwood case.
Kit/wired ........................................... $659/$749

MDS-1, MDS-2 with 8K RAM. Kit ................................ $699

MIDWEST SCIENTIFIC

MSI 6800 (S3)(S5)
6800-MPU computer using SS-50 bus architecture. Includes power supply (5 V @ 20 A, +15V @ 3 A); CPU with 4K EPROM, 128 bytes RAM, reset-vertex PROM, baud rate generator, MSIBUS monitor (MIKBUG-compatible); interface adapter board with eight I/O slots (S3) strappable for 4 or 8 decoded addresses per slot; 16-slot (S5) motherboard, 8K RAM, serial interface, Dama capability; MONBUG 1K PROM monitor is software-compatible with MICROBUG but will interface with memory-mapped video and graphics cards, has "memory window" for examining and altering memory contents, interrupt-driven keyboard routines, video handler with cursor control.
Kit/wired ........................................... $198/$258

Group 1 Package For users having their own terminals. Includes MSI 6800 with 16K RAM, audio-cassette interface, MSI tape BASIC. Kit/wired ................................ $690/$1400

Group 2 Package Includes MSI-6800 with 32K RAM, dual-drive floppy disk, MSI Disk Extended BASIC Interpreter, MSI BASIC Compiler, CRT terminal, high-speed printer. Kit/wired ..................................... $6393/$7330

MINITERM ASSOCIATES

SYSTEM 8000-A (S1)
Z-80-based system with eight-slot card-cage and motherboard, 16K dynamic RAM (no wait @ 4 MHz), 90-key keyboard, 10-A power supply, mini-floppy interface for up to three drives, one mini-floppy drive, software and firmware. Wired. $2699

MODERN MICROCOMPUTERS

TERMINAL COMPUTER (S1)
8085-MPU computer with built-in 9" CRT monitor, keyboard, 32K RAM, single or dual floppy disks. Upper/lower-case ASCII; separate numeric keypad; 24x16 x 80-character display; Micropolis disk drives and extended BASIC. Includes business software: will customize as required. Features: 10-slot 8-100 motherboard; 53-key keyboard with 2-key rollover; power supply for +8V @ 15A, +18V @ 3A each; two cooling fans; beige or blue cabinet.
With 1 floppy (143K on line) ................ $3250
With 2 floppy (630K) ......................... $4500
With dual floppy, 1.2 megabytes ........... $4950

MORROW COMPUTER & ELECTRONIC DESIGN

MEC SYNAPSE/10
8080-MPU computer with 8K RAM, 8K EPROM, 48 parallel I/O lines, 2 independent serial ports, priority interrupts, real-time clock, fancooled 30W power supply in self-contained metal enclosure. Designed for data acquisition, industrial control, communications interfacing, etc; custom versions available in quantity. Quantity 100, ea ........................................... $1800

NETRONICS

ELF II
1802 MPU, single-board, animated graphics computer, on five-slot motherboard. With hex keypad, video 64 x 32 graphics display output, 256-byte RAM. 60-terminal ELF bus for expansion of memory (to 64K) and I/O. Requires 6-V ac Kit ........................................... $100
Power Supply. (6.3 V ac, 5 A) ................. $5

ELF II GIANT BOARD
Plug in expansion board with cassette, RS-232/TTY and 8-bit parallel I/O; decoders for 14 I/O instructions; system monitor/editor. Kit ........................................... $40

4K STATIC RAM
Addressable to any 4K page; chip-select circuit available. Original (256 bytes) has been replaced with 1024x8 RAM; requires an add-on card to convert to 2048x8. Price $25. Kit/wired ........................................... $90

PROTOTYPE (KLOUGE) BOARD
Accepts up to 36 IC’s, all sizes, space for on-board regulator. Kit/wired ........................................... $17

ELF II FULL ASCII KEYBOARD
Kit ........................................... $65

EXPANSION POWER SUPPLY
5-A, powers entire Elf II; required if adding RAM options. Kit ........................................... $35

CASE FOR ELF II with all expansions $30

NORTH STAR

HORIZON-1
Z-80 MPU computer with mini-floppy disk drive, 4-MHz processor. 1K RAM, 1 serial I/O port, and North Star extended disk BASIC and DOS. Motherboard has slots for up to 12 S-100 boards (3 slots used in normal configuration); serial I/O, real-time clock and disk power on motherboard; other ports may be added to motherboard. Power supply 8V @ 15A, +16V @ 5 A; panel space for up to 3 mini-flop- py drives. Options include serial and I/O ports on motherboard, 1K PROM (on processor board), additional disk drives. With three 100-pin connectors on motherboard, space for 9 more. In wood or blue metal cabinet.
Horizon-1, Kit/wired ................................ $1599/$1989
Horizon-2, similar, except with 2 drives $1999/$2349
HRZ-OCK, Chassis, cabinet, processor, serial I/O, three 100-pin edge connectors, motherboard and power supply only. Requires additional boards to become usable. Kit/wired ........................................... $559/$579
HRZ-BIO, Additional serial I/O. (Available assembled only when ordering as part of assembled Horizon). Kit/wired ........................................... $39/$59
HRZ-P10, 8-bit parallel I/O, as above. Kit/wired ........................................... $39/$59
HRZ-DIV, Add-on drive to convert Horizon-1 to Horizon-2. Kit/wired ........................................... $400/$450
MDS-DIV, Third drive for Horizon-2 ........................................... $400/$450

HRZ-CABLE, Cable set for use with MDS-DIV. Kit $49

NORTHWEST MICROCOMPUTER

NMS 85 DESKTOP COMPUTER
8080A-MPU (3-MHz) computer with built-in CRT and keyboard, provision for built-in disk. Base system includes desk-top cabinet; MPU, CRT (24 in. x 80 char), 32K RAM, serial and parallel ports; Wired $3445

NMS 85/P
Similar, but with dual-drive, double-density floppy (1 megabyte) and 2 floppy (2 megabytes) with DMA data transfer (double-sided optional); 54K user RAM plus 1K system RAM, 103-key Hal-effect keyboard; two serial ports, two parallel ports. Software includes CP/M, disk BASIC, Fortran and PASCAL compiler/interpreter, wood cabinet ........................................... $7495

NOVAL

NOVAL 760 DESKTOP COMPUTER
Z-80 MPU computer with CRT, keyboard, printer and tape system; flip-up mounting in wood desk. Computer features 32K RAM, 3K PROM, additional 4k display RAM, eight I/O ports, black & white display screen; drawer-mounted ASCII keyboard with user-assignable keys, dot-matrix printer, Plotter, computer-controlled cassette system at 2500 bits/sec; 26 x 32-char graphics, using 8 x 8 matrix graphics characters; color capability for use with eXternal monitor. Wired ........................................... $3795

THE NUCLEUS

CPU/SERIAL BOARD
(S1)
8080A MPU board with on-board RS-232/20-mA serial port, 110-9600 baud, usable with and without front panel; two ports data rate selectable. $9000. Wired ........................................... $195

OHIO SCIENTIFIC

CHALLENGER
6502-MPU computers using Ohio Scientific OSI 48-line bus, Microsoft BASIC in ROM or on disk, PROM monitor. Additional, non-6502 MPU's available on some models. Assembled.
C2-6 Model 500. Single-board computer; includes 8K BASIC in ROM, 4K RAM, serial port, PROM monitor.
C2-6 Challenger II. All features of Model 500 MPU boards, plus serial port, large cabinet, power supply, 8-slot backplane with 7 slots op for expansion. $545
C2-6P Challenger II-P. Similar, but with audio cassette interface, cooling fan, keyboard and Model 540 video board (upper/lower-case, 160 graphics characters); 4-slot backplane with two free slots; requires video monitor or modified TV, accepts cassette recorder for program storage. In integrated, single cabinet ........................................... $598
C2-8P Challenger II-P. Similar to C2-4P, but with greater expansion capability; larger cabinet, heavy-duty power supply, 8-slot backplane, keyboard in remote console ........................................... $825
C3-51 and C3-OEM Challenger III. Contains Z80 and 6502 MPU's in addition to 6502 on disk. MPU selector software, parallel port, 1-megabyte memory management, scratchpad RAM for user-programmed interrupt vectors, and dual floppy-disk drives. Exten-sive applications and business software available. Specify C3-51 (in two matching cabinets) or C3-OEM (integrated into a single, larger cabinet) ........................................... $3690
C3-6B. Similar to C3-OEM, but with addition of 74-megabyte Winchester-type hard disk drive. 48K static RAM, 16-slot motherboard with only 7 slots

ELECTRONIC EXPERIMENTER'S HANDBOOK
occupied; with rack, OS -65U multiple -terminal op- erating system and one CRT terminal $13,000

Hinged cabinet top: $25
50 Hz; 110/220-V constant-voltage supply: $45

POLYMORPHIC

POLY-88
8080 MPU, in cabinet with five slots, A-power sup- ply; up to four independently powered chassis may be plugged together; memory may be left on while boards in other cabinets are shut off for debugging. MPU board includes on-board, real-time clock, eight-level vectored interrupts, 512 bytes of RAM, up to 3K PROM (2708 type) including 1K monitor; optional internal I/O port Mini-cassette and Printer interfaces fit on MPU card. Reset switch.

System 6. Same, in kit form, fit terminal monitor and cassette recorder: $1.575
System 12. Same as System 16, less TV monitor, cassette recorder, and memory. $1,175
System 2. System 12 in kit form, less keyboard and fan: $735
Cabinet. With five-slot backplane and power supply and reset switches. Kit/wired: $235/$355

Printer Interface Card. (Fits POLY-88 only). RS-232 or 20 mA wired: $65/$80
Cassette Interface. (Fits POLY-88 only). Kansas-City standard (300 or 600 baud) or Poly-Phase (1200 or 2400 baud). Kit/wired: $65/$85

PROCESSOR TECHNOLOGY

SOL-20 TERMINAL COMPUTER
8080 MPU computer system in housing with built-in keyboard. Includes 16-line, 64-character video in- terface, RAM, 1K ROM monitor, 85-key keyboard with upper and lowercase, cursor keys and arithmetic keypad; 1200 baud/second C7S5 cassette interface, 16K RAM, 1K PROM (space for 1K PROM), 5-slot backplane 8.6-A power supply, fan, room for five expansion module U.C. boards. With BASIC (6K) and two video-game programs on cassette, SOLOS personal computer module Kit/wired: $825.00/$1095

Solo-20/32 With 32K RAM: $2150/$2395

Sol System III-A. Includes Solo 20/16, P797-11 video monitor, RQ-413 A cassette recorder, Extended Cassette BASIC. Wired only: $2495

Sol System III-A. Includes Solo 20, 32 otherwise similar to I-A: $2795
Sol System III. Includes Solo 20 with 50K RAM. Helios dual-drive floppy disk system, P792-82 tape monitor. Extended Cassette BASIC. Wired only: $5995
SOL-PC SINGLE BOARD COMPUTER
8080 MPU, plus: 2K RAM, 1K PROM (space for 1K more), video display as above, serial and parallel in- terfaces, keyboard interface, SOLOS personality module Kit/Wired: $575/$745

BOOTLOAD PERSONALITY MODULE
2K PROM program loads EPROM from disk (Included in System III or IV). $100
SOLO-HYTYPE PRINTER INTERFACES
Interfaced Diablo Hytype printers to SOL Parallel Data Interface connector, software drivers included. Specify Solo Hytype for Diablo 2000 series, II for Diablo 1300...

QUAY
8080 MPU TWO-BOARD SYSTEM

Z-80 MPU (2.5 MHz), 1K RAM, 4K EPROM (2708) sockets, EPROM programmer, PROM monitor, serial (RS-232 or 20 mA) I/O with automatic baud-rate setting, parallel input for (parallel keyboard input, monitor provides software echo to user-supplied Processor-Technology VDM-1 video interface). May be used as a stand-alone computer, as MPU for S-100 computer (2 piggyback boards, requires only one bus connector); strapable for use without front panel; but provided with connectors for Altair and Impal front panels. Wired: $350

SOL-20 TERMINAL
Complete system, including 80AI, 8K static memory, 12-slot motherboard with connectors and 18A power supply, wood-grain cabinet, 2.5K BASIC in 2708 PROM, chassis fan...

QUAY 8000 COMPUTER

 Tracker Technology...

ADVANCED Electronic Music Products.... effects devices to computer controlled modular synthesizers. Select from experimenter's kits, step-by-step product kits or fully assembled professional equipment.

3.5-5 A, +28 V or 0.5 A; 105-125V ac Or 47-63 Hz; with power cord, switch, fuse, wood-grain base, provi- ded cassette recorder, and memory. Wired...

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90 SERIES WORK STATIONS

90F/MPS SINGLE-BOARD FLOPPY SYSTEM

- 1802 MPU, single-board computer; 256-byte RAM
- Color video output
- Cassette interface
- 1200 baud communications
- 2K bytes RAM
- 4K bytes EPROM

90F/MPS-1

- 12K bytes RAM
- 8K bytes EPROM

90F/MPS-0

- 4K bytes RAM
- 2K bytes EPROM

Z-80-MPU, single-board system with resident floppy disk controller.

SUPER ELF

- 8080A MPU, single-board computer with on-board floppy disk controller
- 512-byte RAM
- 2K bytes EPROM

90 SERIES WORK STATIONS

S-100 systems above.

MODULAR BUSINESS COMPUTER

- Has 8085 terminal, 64K RAM, 2K ROM, 8K EPROM
- With 16-digit accuracy
- Includes Level II BASIC with string variables, video graphics

SPACE BYTE

- 8085 CPU
- Single-board computer for S-100 bus

SOUTHWEST TECH. PRODUCTS

- Based on Motorola 6800 MPU and its family of support devices
- Chassis, motherboard, memory card
- With 2K bytes of eight-bit static RAM, serial-20mA

SILVER SPUR

- Z-80-MPU computer in compact keyboard housing
- Basic system includes 4K ROM with monitor and display, battery backup option made possible by CMOS circuitry
- With 4K bytes RAM, 2K bytes EPROM

RADIO SHACK

- TRS-80 MICROCOMPUTER
- Z-80-MPU computer in compact keyboard housing
- Basic system includes 4K ROM with monitor and display, battery backup option made possible by CMOS circuitry
- Byte input and output ports; continuous and single-step operation; breadboarding space for use circuits

CDP161602. Kit $249

ROCKWELL

- AIM 65 Printing Computer
- Single-board computer with built-in 20-character alphanumeric display and 24-column dot matrix printer
- 546-key terminal-style keyboard

TOS-M68B

- Same as business system above, but with addition of 2716 EPROM's; on-board dc-to-dc high-voltage supply; requires 0.4A while programming

MP-8 EPROM PROGRAMMER OPTION

- Plugs into socket near top edge of motherboard, for programming 2716 EPROM's; on-board dc-to-dc high-voltage supply; requires 0.4A while programming, 0.15A when idle

SDDS TECHNICAL DEVICES

- TO-7000-MPU
- Incorporates SWTPC processor and 8K RAM boards, plus console board with SWTPC-compatible I/O, in attachable case
- Can hold up to 16K RAM, 8K EPROM, console board includes hexadecimal keypad and display, plus indicators, 6 I/O slots

TOS-M68B Kit/wired $750/$895

SOUTHWEST TECH. PRODUCTS

- Based on Motorola 6800 MPU and its family of support devices
- Chassis, motherboard, memory card
- With 2K bytes of eight-bit static RAM, serial-20mA

SYSTEM B

- Includes TOS-M68B with 40K RAM, dual floppy disks with 12-megabyte storage, CT-64 terminal with upper/lower-case and full control character decoding (see Peripherals section for details), DOS and BASIC with random and sequential files, in desk with laminated plastic surface

SPACE BYTE

- 8085 CPU
- Single-board computer for S-100 bus
- Runs 8080 instructions at 3.75MHz, uses 450-rpm motors
- With 16-digit accuracy

MODULAR SOFTWARE DEVELOPMENT SYSTEM

- Same as business system above, but with addition of 2708/2716 EPROM programmer software, includes FDOCS III, 8080 and Z-80 macro assemblers, utilities, OS and 3870/FX cross assembler, optional Disk Extended BASIC, CP/M, FORTRAN-80, and

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MP-8 EPROM PROGRAMMER OPTION

- Plugs into socket near top edge of motherboard, for programming 2716 EPROM's; on-board dc-to-dc high-voltage supply; requires 0.4A while programming, 0.15A when idle

SOUTHWEST TECH. PRODUCTS

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BIZPAK $5995

SYNTERTEK

VM-1
6502-MPU, single-board computer with on-board double-function keypad and 6-digit hex display. Has 4K ROM monitor, 1K RAM (expandable on-board to 4K), total system max 65K, 3 user PROM/RAM (2316/2322/2711e) expansion sockets, interfaces for audio cassette recorder (8 byte/sec KIM-1 compatible, 18 byte/sec high-speed, 20mA Teletype and other interfaces with automatic baud rate selection; TV controller board interface, application port with 25 bi-directional TTL lines and expansion capability, and system expansion bus. Other features include: 5 on-board programmable interrupt timers; 28 double-function keys, including up to 30 "special" functions, some user-definable; audible keypad response; option boards plug in directly; complete KIM-1 compatibility, including plug-ins to KIM motherboards; it can be used as a card-cage interface, requires only 5V power; has output line for oscilloscope single-line display, assembler, editor and BASIC firmware available. Software allows write-protect of selectable memory areas, decimal point prompt on hex display, break and breakpoint, debug. Wired. $269

SUPER JOLT

Single-board computer with 6502 MPU, 1K RAM, 32 bi-directional I/O lines, DMA capability, sockets for 2K PROM or 4K ROM (1K DeBug Monitor supplied), 20 mA and RS-232 serial interfaces, interval timer, 4 interrupts. Wired. $375

JOLT SYSTEM CARDS

JOLT 3K PROM. Wired. $149

JOLT 4K RAM. Kit/kit. $199/205

JOLT Universal Card Blank. Drilled for 14-, 16-, 24- or 40-pin sockets. $40

JOLT Tiny BASIC. Resides in 2304 bytes of memory. PROM version requires two 2K PROM cards (nine PROM's) Paper tape/PROM. $25/$275

TANO

OUTPOST

Terminal-type computer with full ASCII keyboard, 2480 CRT display; 32K RAM, 6800 MPU, mini-flippery disk drive and controller. $1995

TECHNICO

SUPER STARTER SYSTEM

Based on T9900, 16-bit MPU single-board computer with 1K PROM, 512 bytes RAM, EPROM programable serial (RS-232/230) I/O on-board. Expandable to 2K RAM, 2K PROM, 2K EPROM on-board, to 65K total memory with expansion boards. Peripheral boards available include 32K-byte memory, 1K chip parallel CRT, 2K chip audio/mini-cassette recorder, keyboard, floppy disk, power supply, interface board, chassis with limited or full front panel, CRT, printers. Kit/wired. $299/$399

TEXAS INSTRUMENTS

TIM900/100M

Based on TIM900, 16-bit MPU. Single-board computer with 1K, 16-bit words of EPROM with T9BUG monitor, 256 x 16-bit RAM, expandable on-board to 4K x 16 EPROM, 512 x 16-bit RAM. Parallel and serial (RS-232/230 mA) I/O, two programmable intemal timers, 15 external hardware interrupts, external expansion board and rear socket for prototyping. Will work with TIM990/4 prototyping system. Hexadecimal/microfom, four chassis and other peripherals to come. Requires power supply (under 2 A @ 5 V). $8929

TIM900/101M

Tim 900B. Has two serial ports, 1K (x 16) EPROM, 1K (x 16) RAM. $525

VECTOR GRAPHIC

VECTRONIC 1
8080 MPU, 18-slot computer (with six connectors installed). 20-A power supply, whisper fan, PROM/RAM board with 1K RAM, room for 2K 1720A ROM, 512-byte monitor for use with Tarbell cassette and Atari, IMSAI, or Polyorphic I/O boards. Kit/wired. $619/$849

WINTERK

WINCE MICRO-MODULES
68000-MPU, modular system, consisting of the following:

Wince Control Module. 68000-MPU board with 128 bytes memory, 16-bit parallel I/O port, space for up to 512 bytes RAM, one serial and two parallel ports. Minimum configuration (128 bytes, one port). $149 Maximum configuration (512 bytes, three ports). $349/459

VECTOR MZ

Similar to Vector 1, but with Z-800 MPU, two quadri
dimensional Micropolis mini-flippery disk drives and controller. 2-Kar Trimmer I/O board with 1 serial, 2 parallel ports, 32K RAM, 12K PROM/RAM board with extended monitor, complete DOS and extended disk BASIC. Wired. $3750

MEMORY WORD PROCESSOR

Consists of Vector 1 with drive, Hitachi 12" CRT monitor, Diablo HyTerm printer with 160/20 serial print mechanism, word-processing software, disk BASIC. Wired. $8600

VECTOR 2

Z-80 MPU system with built-in keyboard, 10-slot S-100 motherboard; 32K FlashRAM; PROM/RAM board with extended monitor; Flashvideo video board with 64K x 16, display, expanded graphics; power supplied for ±5 V @ 12 A, ±12 V @ 4 A; 72-key keyboard with numeric keypad and user-definable keys. Wired. $1455

VIDEObRAIN

VB-101 HOME COMPUTER

F-16 MPU computer with integral alphanumeric keyboard, video r-l interface, real-time, time-of-day clock with alarm; two joysticks. Program entry through ROM cartridges; requires no user programming, but allows up to 8K program cartridge/ROM, system expansion bus. Available. System 100. With Financier cartridge $500

Expander 1. Interfaces VB-101 to audio cassette recorder, storage or data or user programs, plus RS-232 port for communication with printers and modems $175

Expander 2. Acoustic coupler/modem, for use of VB-101 as computer terminal. $325

CM01 Timeshare Cartridge. For use in accessing data banks and limeshared systems. $80

VB-59 Programmable. Structure BASIC, programming language. $125

OTHER SOFTWARE

Money Management Series: Finance, money-management, budget and data-base programs. $70/$80

Education Series: Math, music, art, history and vocabulary cartridges. $20/$40

Entertainment Series: pinball, tennis, checkers, blackjack, football and others. $20/$45

WESTERN DATA SYSTEMS

DATA HANDLER

6502-MPU computer with variable-speed clock. 512 bytes memory, one parallel I/O port, 80 char x 25 lines on monitor or TV with direct video input. $2289

Dust Cover. Hunged plexiglass dust cover with cutouts for switch and keypad access. $19

PRO/E1 Expansion Board. Includes 4K RAM expandable to 16K, 2K EPROM (expandable to 8K) with resident cassette operating system and video drivers; 50-char x 2-line video display with r-l modem, for use with standard TV set, can display 160 x 25 lines on monitor or TV with direct video input. P/E1 Kit/wired. $298/$324

P/E1-4K. Additional 4K RAM. $56

2716 EPROM Programmer. Connects to Pro/E1 and Data Handler parallel port. Kit. $45

WYLER

8080-MPU SYSTEM

Totally modular, on 34" x 44" plug-boards. Mount in card files with seven from 28 slots, including 19" rack-mount versions, or 84-slot card drawer for 19" rack. Single options include ROM and EPROM memory; parallel, serial, analog, IEEE-488 and opto-isolator I/O; priority interrupt; time clock; full-service parallel adapters for DEC PDP-11; power supply, paper-tape reader, interface modules; plus a wide variety of plug-compatible individual logics modules. Price depends on system configuration.

ALPHA COMPUTERS

Z-800 MPU with 8-slot mainframe including power-on clear, NMI, and reset circuitry; front-panel reset switch with LED pilot light; internal DIP switch replaces front-panel sense switches; slot space for ribbon cables; rear-mounted power switch; power supply (under 2 A @ 5 V), 12 V (1.6A), 5 V (1.6A), 3.3 V (0.4A); power supply requires no user programming; 2 slots for switch and keypad access. $8929

Alpha 1. With 2 serial I/O ports, 1K RAM (expandable to 2K on-board), 2K Zapple monitor in ROM; 4K EPROM space, 1 audio cassette interface, parallel port, 8K BASIC. $1579

Alpha 2. Similar, but with 16K additional RAM; software includes BASIC, Zapple text editor, Text Output Processor, Macro Assembler. $1579

Alpha 3. Similar to Alpha 2 but with 32K 25-page two-page video display and keyboard port instead of 16K RAM; video driver routines in EPROM; upper/lower-case display with character blink and inverted, 160 x 75 graphics mode with 64 graphics characters. $1469

Alpha 4. Similar to Alpha 3, but with 16K additional RAM. $1925

Alpha 5. Similar as Alpha 3, but with 32K additional RAM instead of 16K. $1939

Alpha 5 Plus. Similar to Alpha 4, but with 32K additional RAM. $2289
COMPUTER PERIPHERALS

ALF PRODUCTS
AD8 MUSIC SYNTHESIZERS
Computer-operated synthesizer system consisting of up to 8 single-tona synthesizer boards plus an intelligent controller or S-100 bus adapter. All synthesis boards independently programmable. Facilities include 256-level volume control, 256-level envelope-parameter control; 128 frequencies (8 octaves, 12 pitches/octave, 4 pitches/octave of external input); mono or stereo output under computer control. 8080 software available.

AD8 System: Intelligent controller/motherboard, interfacing via ribbon cable to one or more AD8 synthesizer boards, and to SIMP-A (Standard Interface for Micro Peripherals) interface in computer.

10-5-4. Synthesizer board for AD8 system. Kit/wired $225/$265

ANDERSON JACOBSON
AJ 841 I/O PRINTING TERMINAL
I/O Selectric terminal with RS-232 or parallel interface, ASCII code. Impact printer, interchangeable typefonts, 14.9 char/sec printout; may be used off-line as stand-alone printer. Requires 128 ASCII control; 47-key keyboard; upper-case alpha lock; prints 88 characters (upper/lower-case); 130 char/line; paper widths to 14.8", half/full duplex; require EBCD or Comma-spacing (select Selectric) typefaces. Factory-refurbished $995

ARTISAN
85 MICROCALCULATOR BOARD
Hardware scientific-calculator board, interfaces through 8-bit bi-directional parallel port. Accepts instructions from processor, outputs 14-digit results to processor for storage or display; software driver requires less than 256 bytes. Includes logs, trig functions, polar/rectangular conversions, multiple storage registers, p, e, metric/U.S. conversions, mean and standard deviation, square root. Removable 14-digit display on board. With display and interface cable $189

PTR PRINTER
110 char/s, impact type, 81/2"W standard paper; compatible with power supply, enclosure, parallel interface. Kit/wired $945/$795

FL1 MINI FLOPPY
Dual 5" mini-floppy drive; cabinet, power supply; S-100 controller card; EXDOS-M 6502 DOS, Kit/wired $995/$1195

FL2 FLOPPY
Dual Persci 277 8" drive; cabinet; power supply; Persci 1070 controller card; CGRS S-100 adapter card; EXDOS/TIM DOS/terminal monitor (6502). Wired only $2495.

ATV RESEARCH
MICRO-VERTER
Interfaced computer video signals to any unmodified TV with UHF reception, avoids low-band VHF interference for video signals in computer circuits. Tunable over 4 UHF channels. Usually requires no direct connection to antenna terminals. Color-compatible (Apple-approved). Operates 1000 hours on 4 AA batteries (not supplied). MXV-500 $35

PIXE-PLEXER
Modulator/2-f-oscillator for interfacing computer video signals to VHF TV channels 2-6. Accepts analog or digital signals. May be operated as monochrome character display or as multiplexer-modulator for color-difference plus audio-subcarrier inputs. Uses 3.5 MHz color-subcarrier, 4.5-MHz audio subcarrier with varactor diode modulator for FM sound insertion. Circuit board 1.5" x 3". Requires +15V or

-12V/+5V, max current 50 mA; no power supply or case provided. PXV-4500. Kit $24.50
Pixe-Verter. Similar to Pixe-Plexer, but without audio and 3.58-MHz color subcarriers or color-difference inputs. PXV-2A. Kit $8.50

Note: Use of above devices may not meet FCC requirements.

AXIOM
EX-901 MICROPRINTERS
Stand-alone, dot-matrix printers: 80, 40 or 20 char/line; electro-sensitive paper, 120 lines/min, 96-char ASCII, expandable to 256-char input buffer, expandable to 2K, 3, software selectable character sizes, may be mixed on same line; software selection of reverse print. EX-901 P: Parallel ASCII input. $395
EX-901S. Parallel and RS-232/20-mA serial input; 50-1200 baud. $495
EX-901 HS. High-speed serial input, 50-9600 baud. $549
EX-901S. Serial and parallel. $655

EX-810 GRAPHICS PRINTER
Full-graphics dot printer using electrostatic sensitive paper; prints 8192 dots/sec, up to 512 dots/row; can also function as 80-col alphanumeric line printer with speeds up to 60 char/sec; parallel input, 5-V, 100-mA output available for external computer; paper width 5" $795

EX-820 MICROPLIOTER
Similar to EX-810. Three, software-controlled horizontal dot resolutions up to 128 dots/in, 96-char ASCII, expandable to 256 char with user-programmable fonts; serial and parallel input, 528-char input buffer, expandable to 2K, 3, software selectable character sizes, can be mixed on same line; can mix alphanumericics and graphics on any line; vertical dot resolution 65 dots/in; provision for automatic histogram generation $795

BO-SHERREL
M-1 SHORT-HAUL MODEM
Asynchronous transmission; for local communication; max data rates vary with distance, from 9600 baud under 2 miles to 600 baud under 10 mi (reduced distances by factor of 3 if shielded cable used); optical-coupler isolation; RS-232. Wired, in cabinet $1194
M-1 card system: Card frame fits 15" rack, occupies 7" rack space, will accommodate 15 M-1 cards. Card frame $300
M-1 cards $125

M-2 SYNCHRONOUS SHORT-HAUL MODEM
Similar to M-1, but for full-duplex, synchronous communication. Range/data-rates from 1 mile/9600 bits to 4 miles/2400 bits $395

BYTE
BYTE-TTY
Stand-alone TV typewriter card; video signal output. ASCII keyboard input, parallel computer I/O, 32-char x 32-line (16 lines visible); scrolling; may be modified for 64-char x 16-line and serial I/O connection by DIP switches. Requires +5V & 1.5A. (6) $12V @ 100mA. $175

CALIFORNIA COMPUTER PRODUCTS
CALCOMP 142M FLOPPY DRIVE
Single-sided drive for 8" floppy disk. Capacity (IBM 3740 format) 243K bytes, unformatted, 401K bytes single-density, 802K double-density. Hard-sector capacity 325 Kb side (double-density). Switch selectable hard or soft sectoring. Includes jump-er and switch-selected options. Requires +24V dc, 1.5 A, +5 V, 1 A, 90-127 V ac, 60 Hz, 1.7 A. $625

CALCOMP 143M FLOPPY DRIVE
Double-sided. Capacity (IBM 3740 format) 486K bytes, unformatted, 921K bytes single-density, 1.86M double-density. No hard-sector option $750

1143M FLOPPY DISK DRIVE CONTROLLER
Intelligent controller for up to four 142M or 143M drives. On-board intelligence: 1K buffer memory.

Choice of 26, 15 or 8 sectors/track; word, byte or serial transfer. Accepts up to two host adapters simultaneously.

1143M controller $860
With S-100 or RS-232 interface $1110
With LSI-11 interface $1310

CENTRONICS
MICROPRINTER
Non-impact, discharge printers; 5x8 dot matrix characters, 150 lines per minute, uses aluminized paper 4.75" wide requires no toners or ribbons; 96-character upper/lower-case ASCII, software selection of 5, 10 or 20 char/in., acceptable characters and underlining; only 4 moving parts; 5 lines/in. vertical; audio alarm for paper empty; auto motor control turns motor off when no data received; available in serial and parallal versions.

Pair-parallel interface. TTL-compatible I/O, 7-bit ASCII. Wired $495
Serial, RS-232C; with parity selection; switch selectable 50-9600 baud; 1620-char buffer. Wired $595

CGRS MICROTECH
AUDIO INTERFACE
Adds audio-cassette mass storage to RS-232 port or terminal w/extension port. For Centronics or Tarbell Bi-Sync tapes. Bare board/kits $10/$30/$50

COMMODEORE
PET 2020 PRINTER
See under "Computers."

PET 2127 CASSETTE RECORDER
See under "Computers."

COMPUTORCOLOR
8001 COLOR TERMINAL
8001A-MPU intelligent color terminal with Intellitect-8 bus structure; 19 color CRT; keyboard in separate housing; Includes 4K RAM refresh memory $1650

8001G COLOR GRAPHICS TERMINAL
Similar to 8001, but with special color graphics package. Includes graphics plot hardware and software, 8-color background selection, 64 standard ISASCII characters, page playoff, color and numeric keypads $2750

Special options: See Computers section.

COMPUTERWARE, INC.
10-MEGABYTE DISK SUBSYSTEM
(S1) (S2) (S3) (S4) "Mid-cartridge" drive with S-100 or M6800 EXOR-converter controller and interface. Removable hard disk is in 2-by-8, 11-square cartridge, disk diameter 10.5". Capacity 5 megabytes per surface, 10 megabytes/disk (unformatted); direct-drive motor, no belts or pulleys; servo tracking; auto head-unload if power fails. Includes power supply, controller and either interface; cabinets and rack-mounts optional $6995

CONNECTICUT MICROCOMPUTER
RS-232-TO-CURRENT-COOP/TLA ADAPTER
Board with circuits converting RS-232 to 20-mA current loop signals, and 20-mA to current-loop. AllowsTTY ports to drive RS-232 terminals and vice versa. Easily modified to adapt RS-232 to TTL instead of 20-mA. $975

ADA 400S with solder-pad connections $25
ADA 400B with barrier-strip connections $30

ELECTRONIC EXPERIMENTER'S HANDBOOK
IEEE-488 TO RS-232 ADAPTER
Adapts IEEE-488 bus (e.g., Pet) to RS-232, output only. Use as RS-232 printer adapter for Pet, etc. ADA 1200B. Wired, less power supply, case or RS-232 connector ........... $99 ADA 1200S. With power supply, case, and connector........... $169

CROMEMCO

JOYSTICK CONSOLE
Joystick (2-axis) with speaker and amplifier, plus four user-defined pushbutton switches. Joysticks +2 V each axis, spring return to center. For games, graphics, and similar applications. For use with Cromemco D-7A or similar analog interfaces. Joystick console. Kit/wired ........... $65/$95

3100 CRT TERMINAL
Solid-state capacitive keyboard; separate numeric and cursor keypads. 80 char x 24-line display; upper/lower case; remote video output jack, auxiliary I/O port. RS-232 interface. With 10-foot cable ........... $1595

3101 CRT TERMINAL
Similar, but also has 16 software-assignable function keys; local editing mode; screen formatting including dual-intensity characters, blinking characters, protected fields; block-transfer mode transmits entire screen of characters to computer .......... $1955

3779 DOT-MATRIX PRINTER
60 char/sec; 12" platen. Continuous-variable character pitch allows up to 132 char/line; tractor feed ........... $2495

3703 DOT-MATRIX PRINTER
180 char/sec; 18" platen; 132 columns. Form feed, bi-directional printing, double buffering; tractor feed ........... $1495

3355 DAISY-WHEEL PRINTER
55 char/sec; 15" platen. tractor feed and friction platen ........... $3995

P1 PRINTER INTERFACE
(51)
Interfaces one daisy-wheel, one dot-matrix printer to S-100 bus .......... $195

WFD MINI DISK DRIVE
5" mini-floppy drive; soft-sectored IBM format; 92 KB/side. Operates from F4DC Disk Controller ........... $495

PFD DUAL DISK DRIVE
8" floppy drive; holds two disks, 256 KB each (512 KB total); soft-sectored IBM format; includes power supply and cables, oiled-walnut case. Kit/wired ........... $1995/$2495

SOFTWARE DISKS: FORTRAN IV, 16K BASIC, Z-80 assembler, Dazzler games; specify 5" or 8" drives. Over 400 pages. A collector's item, featuring The Basics from the first 16 issues of BYTE and SCELBI's classic library of books. Your microcomputer bookshelf is incomplete without this priceless edition.

ECONOMY TERMINALS
ET1 Displays 24 lines of 80 characters, upper-case AS-

CIRCULAR: NO 20 ON FREE INFORMATION CARD

1979 Edition
CIT (transmits upper and lower) on 12-in. CRT. RS-232 and 20-mA interfaces; 63-key keyboard, scroll and page modes; 16 selectable baud rates to 19,200; blinking underline cursor, addressable; automatic repeat on all keys; tab fixed every eight characters; 2K RAM, 11/2K ROM, 1 serial port. Wired ...$1045

ET2 Small, but with 2K operating system ROM, 2 serial ports, full 128-character ASCII upper/lowercase; added 4-key configuration pad (local, page/scroll, caps lock, print port); auxiliary port for printer; choice of inverse, half-intensity, or blink. ...$1145

ET2/D Similar to ET2, but with detachable keyboard with numeric pad, 4-key configuration pad. ...$1295

ET4 Similar to ET2, but with 6K ROM, 4-32K RAM, 3 serial ports, five additional alternate character sets, limited graphics, choice of 40/80/132 char. lines. ...$1295

EDUCATIONAL DATA SYSTEMS OF VA

LIGHT PEN
For interactive graphics, allows user to "write" on screen. Requires 8080 system with TTL parallel input and memory-mapped video board (Procesor Tech, Polymorphic, Merlin, etc.). Two software drivers. 760-byte driver uses high-speed, 4-way search to find where pen is pointing, has predefined tables for video boards mentioned above, coding in instructions for other boards; 300-byte driver sets slower, two-dimensional Wash-transform search; both drivers return pen address in HL register. Wired ...$32

ELECTRONIC PRODUCT ASSOCIATES

IMP-1A PRINTER (EX) (S1)
Line printer, 40-column, bidirectional, 5 x 7 dot matrix impact type, 50 characters per second with 80 char/sec bursts. Prints 12-char/inch on 3 1/2-in paper. $1450

IMP-EAX Interface for EPA Micro-68b computer. $22

IMP-EXOR Interface for EXORcisor. (S1) IMP-ALT/1M5 Interface for Affair, etc. ...$79

FLOPPY DISK
Floppy disk systems for 6800 MPU. IBM-compatible format, 250 bytes per disk. With cabinet and power supply. ...$295

Single-Drive System ...$295

Dual-Drive System ...$3295

ELECTRONIC SYSTEMS

T.V. TYPEWRITER
Stand-alone TVT board. Composite-video output, 64-character lower-case ASCII character set, 16 lines x 32 char (can be modified for 64 char) on-screen, plus 16 lines in off-screen memory. Addressable cursor, blink, auto scroll, erase to end-of-line or end-of-screen. On-board ASCII parallel ports for keyboard and computer input; special memory output port for computer inspection of on-board memory contents. Requires +5V (±1.5A), -12V (±30 mA) Part No. 106. Bare board/board with parts ...$39/$145

Part No. 800. Similar, but 128-character upper/lower-case ASCII set, 24 lines x 60 char., reverse characters selectable. Bare board with parts ...$39/$160

UART & BAUD RATE GENERATOR

Converts serial to parallel and parallel to serial, on-board parallel generator for baud rates 110, 150, 200, 300, 1200 and 2400, TTL compatible. 44-pin edge connector. Requires +5,-12V. Part No. 101. Board/board with parts ...$12/$35

Edge connector ...$4

RF MODULATOR
Converts video to Channel 2-3 rf signal. On-board regulated power supply; Apple-approved. Requires 12V ac-adapter, or +5V dc. Part No. 107. Bare board/wi...$76/$135

RS/223/ITF INTERFACE
Converts RS-232 to 20mA current loop, and vice versa, using two separate circuits. Requires ±12V. Part No. 600. Bare board with parts ...$49.5/$7

RS/232/ITF INTERFACE
Converts TTL serial to RS-232, and vice versa, using two separate circuits. Uses 10-pin edge connector. Part No. 232. Bare board with parts ...$49.5/$7

TAPE INTERFACE
For recording and playing Kansas-City standard tapes on low-cost audio recorders at up to 1200 baud. TTL-serial digital I/O, audio I/O connects to recorder mic in and headphone out. No coils. Requires +5V, low power drain. Part No. 111. Board/with parts ...$67.5/$27.50

MODEM
Originate/answer modem, for full or half duplex at up to 300 baud. No coils. TTL serial I/O connection; for 8-ohm speaker and crystal mike. Uses XR FSK-demodulator. Requires +5V. Part No. 109. Bare board with parts ...$76.5/$27.50

ESCON PRODUCTS

SELECTIVE CONVERSION KIT
(51) Converts IBM Selective typewriters into computer printers. Requires no drilling or cutting; does not affect typewriter profile or operation. Use with S-100 interface. Requires 30 V dc (±2 A), power supply available. E-A. Mechanical parts, solenoids and instruction manual for installation in typewriter. Kit $250

E-B. Power supply and solenoid-drivers. Kit wired ...$120/$195

E-C. S-100 interface card. Kit wired ...$135/$220

E-T. Complete set, Kit form ...$456

EXPANDER
"BLACK BOX" PRINTER
Prints 10 char/sec, 80 char/line, upper-case ASCII set, on 81/2-in paper. For friction or sprocket-fed pa... wired. ...$396

Cover ...$30

F&D ASSOCIATES

EPROM PROGRAMMER
For 2704/2708 EPROMs. Software timing and control; requires 3 ICs, 6 transistors plus power supply. Designed primarily for SWTCP 6800, but can be adapted to I/O ports of other MPU's. With software for SWTCP system with console. EPB-2. Bare board and documentation ...$29

GEORGE RISK INDUSTRIES

GR1756 KEYBOARD
5-key, dc-level and pulse strobe signals for easier affect typewriter profile or operation. Uses S-100 interface, printport; auxiliary port for printer; memory-mapped video board (Procesor Tech, Polymorphic, Merlin, etc.). Two software drivers. 760-byte driver uses high-speed, 4-way search to find where pen is pointing, has predefined tables for video boards mentioned above, coding in instructions for other boards; 300-byte driver sets slower, two-dimensional Wash-transform search; both drivers return pen address in HL register. Wired ...$32

GRI 711 KEYBOARD
Similar to 756, but with separate numeric and cursor control pad; automatic repeat on all characters; built-in power supply options; parallel buffered output via D-25 connector, in two wire steel-enclosure. Wired ...$150

GRI 716 HEX KEYPAD
Fully-encoded hex keypad, 2-key rollover, latched data outputs, full debouncing, user-selectable logic, data and strobe signals. Kit/wired ...$25/$75

GHOST POWER CONTROL SYSTEM
Allows remote device on/off control, manually or with any computer. Following modules may be used alone or together:

GHOST RELAY DRIVER BOARD
Controls up to 31 GE RR8 relays; scanning circuitry determines relay status; usable with any computer; up to 4 boards (124 relays) can operate from one 20A current loop sensor. Provision for manual control as normal low-voltage switching system, even without computer. System fits in 30x12-in. electrical cabinet. Relay driver board ...$449

GHOST OPTO-ISOLATED INPUT BOARD
Detects up to 24 different switch closures. Input voltages from 5 to 24V, FIFO buffer memory, switch debouncing; self-scanning. For remote-control device monitoring via any 8-bit parallel input port with handshake lines. Can mount to and draw power from SS-50 bus if available ...$39

16-BUTTON REMOTE 2-WIRE KEYBOARD SYS (S5) Allows remote control from any number of keyboards, using only one #24, twisted-pair phone line (up to 1 mile distance). When one keyboard is in use, others are locked out. Tone Receiver Board powers and controls the keyboards, and converts their signals into binary format. Receiver board with 8-bit parallel input port with handshake lines; can mount to and draw power from SS-50 bus, if available. Tone Receiver Board (one required) ...$249

16-button keyboard (O-A, ..., Z) ...$39

GRE PRINTERFACE II
Dot-matrix printer with S-100 interface. Character set features upper/lower-case, with/without descenders, enhanced characters, superscripts and subscripts, foreign punctuation, page boundaries, and optional APL characters. Character throughput more than 50 char/sec; 80-column; longer lines automatically wrap around; 7x9 matrix; x 8/11 roll paper, impact; auto-reversing ribbon drive with re-inking rollers. Can be configured to emulate almost all serial and parallel-interface boards; had onboard control processor with 156 bytes RAM, 1K ROM (neither addressable by CPU), custom character sets can be field programmed into ROM with included character assembler. With interface, printer mechanism, power supply and cables ...$985

HEATH

H9 CRT TERMINAL

756MF. Mounting frame ...$9

GR 711 KEYBOARD
Similar to 756, but with separate numeric and cursor control pad; automatic repeat on all characters; built-in power supply options; parallel buffered output via D-25 connector, in two wire steel-enclosure. Wired ...$150

Electronic Experimenters Handbook
1979 Edition

H10 PAPER TAPE READER/PUNCH

Uses standard 1-in wide paper tape (roll or fanfold); reads at 50 char/sec; punches at 10 char/sec; punch and read circuits are independent and operated simultaneously; code mode for tape duplication; power supply, parallel TTL interface.

Kit $350

WH17 FLOPPY-DISK SYSTEM

Mini-floppy disk system for Heath H8 computer. Controller circuit board plugs into H8 mainframe.

SMF-3 Wired $165

SERIAL PRINTER

Daisy-wheel character printer, 45 char/sec; 120 char/line; interchangeable fonts; parallel input, impact.

PTR-45A Wired $2400

PTR-45A-TF. With tractor-feed option $2600

LINE PRINTER

Impact printer; 300 lines/min; requires serial or DMA interface; solid characters; tractor feed.

PTR-IX60, 80 char/line. Wired $2610

PTR-300B, 122 char/line. Wired $3656

(S1) LIF. S-100 DMA interface. Kit/wired...

$39/9/$599

MINI LINE PRINTER

Dot-matrix printer-44 col; 55 char/sec; uses standard paper, no parallel interface.

AP-44 Kit/wired $499/$599

DASY-WHEEL PRINTER TERMINAL

Hard-copy terminal with tractor feed, keyboard, 45 char/sec; 132-col; HType II mechanism; six-ft. cable; requires serial I/O.

HCT-45A-TF. Wired $299

MODEM/AcouSTIC COUPLER

Available in 300- and 1200-baud versions.

MMD-300A. 200-baud. Wired $299

MMD-1200A. 1200-baud. Wired $995

FLOPPY-DISK SYSTEMS

Dual PerSci floppy drive, single-density format, (IBM-compatible), with power supply, in table-top cabinet, with DIO non-DMA Disk Interface.

PCS-80/25A Wired $2170

PCS-160A. Same, but double-density $2955

PCS-80/29A. Expansion unit for PCS-80/25A, with drives, power supply, cabinet, no interface $1995

PCS-80/26B. Expansion for PCS-80/25B $2095

PDC-A. Same as PCS-80/25A, less cabinet and power supply $1770

PDC-B. Same as PDC-A, but double-density $2170

RM. Rack Mount for PCS-80/25 or 26 $20

DMMO. Dual 5.25-in floppy option, will mount two PCS-80 floppy or computer cabinets, in two configurations, with single cover for both; includes tilt bracket for convenient position of 1KB-1. $50

TAPE DRIVE SYSTEMS

Available for 7 or 9 tracks; 800, 1600 or 800/1600 BPI; 7", 8½" or 10½" reel sizes. From $6974

INTELLIGENT BREADBOARD CONSOLE

Connects to any S-100 computer for design of digital logic circuitry. Requires 6-bit parallel I/O ports; provides access to 48 lines of TTL I/O; with power regulators, LED level indicators; 6 component strips, sockets for forty 16-pin IC's.

BBC-5 Kit/wired $435/$625

BBC-3. Same but with three component strips; requires three I/O ports, accesses 24 lines I/O. Kit/wired...

$325/$532

BBCM. Expands BBC-3 to BBC-5. Kit $135

INDUSTRIAL MICRO SYSTEMS

FLOPPY-DISK SYSTEM

In portable, self-contained enclosure with Shugart 801R drive. Superseded S-100 controller compatible with Altair BASIC and CP/M, 110/220-V operation; fused ac and dc.

61-0041 $1045

61-0051. Similar, but in 19" rack mount with slides expandable to 3 drives (unloaded slots covered); cooling fan...

$1170

61-0061. Same as 6001, but less slides, and with wood enclosure sides. Wired...

$1215

61-0201. 2-drive rack-mount enclosure with power supply and cides; for Shugart 800-series, PerSci 277 drives...

$305

61-0360. Desk top version, with wood sides...

$385

INOTRONICS

INOVELX 410/420 FLOPPY DRIVES

Full-size (8") floppy drives; mount 2 horizontally or 4 vertically in standard rack; single and double-density (3200 and 6400 characters per inch), unformatted capacity 400K/800K per diskette. Available in IBM-compatible, soft-sectored (410) and hard-sectored (420) versions; 220/240V and 100/115V 50 Hz versions also available.

INOVELX 410...$495

INOVELX 420...$505

INOVELX 420-246. Triple-voltage power supply for two-drive system $110

3400 DUAL DISKETTE SUBSYSTEM

Includes two InnoveX 410 or 420 drives, power supply, rack-mount enclosure (16.7" panel height) with power-regulator, ac filter, fan, mounting for controller or interface board.

3400V, With Controller for LSI-11...

$2955

3409-D. Double-density version $3165

INDUSTRIAL DATA SYSTEMS

IP-125 IMPACT PRINTER

Impact dot-matrix (7x7) printer with integral microprocessor control, built-in diagnostics, and serial and parallel data interfaces; built-in diagnostics program; full 96-char ASCII upper/lower-case; uses roll, fan-fold or single sheet plain paper up to 8½" in. wide; standard line printer, 10 col./in.; parallel, serial and RS-232C with selected baud rate (300 to 19200 baud). Wire line RS-232 interface, double-wide character set, 8-bit parity, 120- or 240-baud char. buffers in standard configuration; includes three I/O ports, accesses 24 lines I/O, sustained print rate 100 char/sec; sustained throughput to 50 char/sec; standard, optional to 80 char/sec; re-inking ribbon mechanism, ribbon life 104 hr. Other options include: graphics options (preferably for IP-225); feed with automatic paper-boundary skip (standard on IP-225); 1024 and 2048-char. line buffers. In table top consoles with front-panel line-feed, paper, test and power control interface. Kit $799

PTR-225. With tractor feed, form-feed, and automatic page-boundary skip...

$949

INTEGRAL TECHNICAL SYSTEMS

PEN-4K (PT)

Self-contained, self-powered 8K RAM addition for PET; with financial, math, algebra software...

$279

INTERTEC

CRT terminal with 12" screen, 80 char × 24 lines, 25 line for status messages. ASCII 128-char set, upper/lower-case, 11 special graphics symbols; 8-character constant, extendable only fields; blinking, underline, reverse video, half intensity, character, line or page transmission; TTY-compatible keyboard plus 14-key pad, local mode, erase, programmable function keys; cursor position and address controlling; RS-232 or 20/60-ma current loop; RS-223/20-ma printer port. Wired...

$874

SUPERTERM

132-column matrix impact printing terminal; 10-60 char/sec standards, 120 and 200 optional; Selectable-configured keyboard, alphanumeric key pad, dual-current loop serial interface, horizontal and vertical tabs; automatic top-of-form positioning. Optional: super- and subscripting, variable vertical pitch; direct Y/X addressing, adjustable L and R margins, automatic reverse printing, double-width characters, auto CR on line end, font-programmable char-set, 1200-baud communications package, APL/ASCII. Less options...

$1956

SuperCali. Built-in micro-cassette option...

$900

SUPERDEC THROUGHPUT OPTIMIZER

For installation in DECwriter II teletypewriter; increases speed up to 6 times; adds bidirectional printing, manual and auto top-of-form, addressable and absolute hor. & vert. tabs, adjustable R and L margins, RS-232C interface, doubles character set, up to 32 user-programmable characters. Direct, plug-in replacement for DEC writer electronics. Optional APL character set, selective addressing, answer-
back. Less options $495

**JHM MARKETING**

VOTRAX VOCIE SYNTHESIZER

Produces continuous speech analog input from instructions representing phonemes; RS-232 input. $1400

**LARKS ELECTRONICS & DATA**

ACCELEWRITER

Module to modify DECwriter LA36 from 110/150/300 baud to 110/300/600. Plug-in installation $95

**LEAR SIEGLER**

ADM-3a "DUMB TERMINAL"

CRT terminal; 80 characters × 24 lines on built-in, 12-inch-diagonal screen. Standard 64-character AS-

CII uppercase character set supplied; 90-character upper-case set optional. Switch-selectable cursor modes: Underline cursor homing to lower left of screen. With automatic scrolling, and page mode with reverse-character cursor homing to upper left. End-of-line tone. Full and half-duplex modes, 11 communication rates from 75 to 19,200 baud. Switch-selectable RS-232 and 20-mA interface to computer, extension RS-232C port for printer, re-

CII character set; extension, printer and internal system bus shiftable function keys; programmable function keys and cursor retention; 15" CRT display with dual-

ADM-3 SMART TERMINAL

Similar to ADM-3, but with two-page memory (can display either page). 90-key keyboard with integral numeric pad, tab, upper-case lock, character and line edit keys, line and page erase keys, field protection with dual-intensity, optional RS-232 extension or printer interfaces; keyboard-selectable transmission mode (page, line or message); visible control characters; polling-addressing option. Wired $795/$895 Lower-case option $50 Arithmetic keypad, with cable and connector $85

ADM-4 SMART TERMINAL

Two-piece terminal (keypad detachable from CRT). Two-page memory (expandable to 8 pages) with independent protection, write/protect, program mode and cursor retention, 15" CRT display with dual-intensity, blinking, blanking and protected fields, 24-line display with 25th line for status indicators; multiple tab modes; numeric keypad, cursor keys and 16-shiftable function keys, programmable function keys optional. Other options include alternate 128-

**LEWEN**

TVT-II SCROLLER

Adds scrolling to TVT-II type terminals. Adds up to 64 extra characters, programmable via EPROM. EPROMs available with lower-case and 32 weighted graphics characters, lower case and 32 special symbols, or 64 weighted graphics charac-

**EXPENDED CHARACTER GENERATOR KIT**

- Extends character set of TVT-II type terminals. Adds up to 64 extra characters, programmable via EPROM. EPROMs available with lower-case and 32 weighted graphics characters, lower case and 32 special symbols, or 64 weighted graphics charac-

**SM-2** $19

**LEWEN**

**EXTENDED CHARACTER GENERATOR KIT**

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**SM-2** $19

**M&R PENNYWHISTLE 103 MODEM**

May be used as acoustic couple (with telephone handset) or wired directly to the telephone via a di-

**SUPR’MOD II UHF INTERFACE**

- A/V modulator: Displays video output of all comput-

**SPINTERM**

- Printer interfaces; tractor feed.

**MAXI-SWITCH**

MAX Keyboard 60-key, with full 128-character ASCII set; includes two non-encoded function keys for user assign-

**MECA**

ALPHA-1 MASS STORAGE SYSTEM

Dual cassette system operating under computer control. Includes 30-track, 600 ft, 150,000 tracks, 3Vdc, 570 Kbyte/drive, 780 byte/sec; high-speed search at 100 in/sec.; will access any position on C-30 cas-

**M&B KEYBOARD**

Keyboard with upper and lower-case, numeric key-

**MKB-2 KEYBOARD**

Keyboard with upper and lower case, numeric key-

**MICROAGE**

SELECTRA-TERM

IBM Selectric II typewriter, adapted for use as print-

**MICROCOMPUTER DEVICES**

SELECTRA-TERM

IBM Selectric II typewriter, adapted for use as print-

**MICRO DIVERSIONS**

**MICRO-SLICE SINGLE-BORAD**

Z-80 single-board computer; power on jump to any 256K memory space; software-prioritized interrupt inputs; switch-selectable global wait-state option, 4K 2716 EPROM (upgradable to 2732) and 4K RAM; both switch-addressable to any 4K boundary; 1 serial interface (RS-232) and 1 parallel interface (20 mA); 4 software-selectable I/O channels, 3 video outputs and 3 video inputs. 4K EPROMs available for programs or data. With 1 keyboard, 1 expansion board, 1 power supply, and 1 software package: $495/$595

**ELECTRONIC EXPERIMENTER’S HANDBOOK**
MICRO PERIPHERALS INC.

**MPS PRINTER**
- 40-column, impact dot matrix printer, 75 lines/min., line-length 3.33 in. on adding-machine roll paper to 3½" W. Available with serial, parallel ASCII, and parallel programmable interfaces; 64-character upper-case ASCII; includes utility software, data control, and reverse-field printing on parity errors; option "B" provides the above, plus fast paper feed option (5 line/sec line-feed). Interface boards and printer mechanism with interface available separately; prices shown are for assembled and tested printers with power supply and case.
- **MP-40, parallel ASCII printer** $425
- **SSP-40 with Option A** $575
- **SSP-40 with Option B** $625

**MICRO SYSTEMS DEVELOPMENT**

**MSDS-100 FLOPPY DISK SYSTEM** ($1)
- Mini-floppy (5¼") system with Shugart SA-400 drive. Soft-sector format; requires six user-selectable port addresses (software supplied uses ports 60-65 octal); programmed I/O; controller may optionally interrupt main CPU when disk controller needs service; sector size user-selectable (MSD sectoring); requires on-line software; includes utility software and patches for Altair BASIC; system supports 3 drives. Drive requires 12 V (2 A and 5 V @ 1A); controller powered from S-100 bus.
- **Kit/wired** $499/$599

**ADDITONAL DRIVES**
- $50/MICRO-

**ACT-IA COMPUTER TERMINAL**
- Two-piece CRT terminal. Generates ASCII 128-character set, displays 96-char x 16 li; cursor control, space bar, relative and absolute cursor control; cursor -control, space and period keys auto-repeat; ninety keys, with tactile feedback, 100-million-operation guaranteed keyswitches. Upper- and lowercase, 12-function keys, numeric pad, four on/off keys, and auto-repeat. Wired, in enclosure. **$235**

**MICROTHERM**

**ACT-IA TERMINAL**
- With integral modem and acoustic-coupler; modular has separate serial I/O, allowing modem use independent of keyboard. **$550**

**ACT-IV TERMINALS**
- Available as single unit with numeric keypad (ACT-IV B) and two-piece unit (ACT-IV A). 80 char x 24 li display; descenders; 64 char x 16 li display; scroll, reverse video, and horizontal and vertical bars. **$80/MICRO-TERM**

**VTB VIDEO TERMINAL BOARD**
- All electronics of the ACT-IA on a 20 x 25-cm circuit board; requires parallel-data ASCII keyboard and cabinet. With ac power supply. Wired. **$200**

**ACT-8A TERMINAL**
- ACT-IA with integral modem and acoustic-coupler; modem has separate serial I/O, allowing modem use independent of keyboard. **$550**

**ACT-IV TERMINALS**
- Available as single unit with numeric keypad (ACT-IV B) and two-piece unit (ACT-IV A). 80 char x 24 li display; descenders; 64 char x 16 li display; scroll, reverse video, and horizontal and vertical bars. **$80/MICRO-TERM**

**MACROPOLIS**

**MACROFLOPPY** ($1)
- Double-density (5162 BPI) system for 5¼" hard-sectored diskettes. Records 43kB bytes per diskette. Requires 8K RAM controller power for up to 4 drives, cable, and diskettes with BASIC (requires 24K RAM) and DOS (19K required). Has built-in bootstrap and file project. 1024K RAM. Can be installed in S-100 chassis (with optional dc voltage-regulator kit). With one drive **$695**
- 1041-II two drives **$1045**
- 1041-II four drives **$1195**
- 1041-II eight drives **$1695**

**METAFLOPPY** ($1)
- "Quad density" 5¼" floppy systems, using double-density (5162 BPI) recording on 77 (not 35) tracks. Capacity 315KB per drive. Other features similar to MacroFloppy.
- 1041-II one disk-drive **$1145**
- 1041-II two disk-drives **$1695**
- 1041-II four disk-drives **$3200**
- 1023-II single add-on disk. Requires daisy chain cable. **$645**
- 1023-II dual add-on, requires cable **$1325**

**MIDWEST SCIENTIFIC INSTRUMENTS**

**FD-8 FLOPPY-DISK**
- 300kB/304kB (formatted), hard-sectored. Single-drive system interfaces to any parallel port (parallel interface card available for SS-50 I/O bus). Read after write for error-check. Complete disk operating system available for 6800-based systems; disk-drivers and Mini-DOS routines may be integrated with BASIC for 8800 systems. Includes controller for up to four drives. Kit/wired **$1150/$1395**
- **Dual-Drive System** Kit/wired **$1950/$2295**
- **Mini-DOS system on PROM (1702)** **$250**
- **FDOS/BASIC on diskette** **$65**
- **FDOS Bootstrap only, 1702 PROM** **$125**
- **Additional drives** **$900**

**MCRT-E TV ENCLOSURES**
- Holds terminal, keyboard, and CRT; as used in CRT-1 terminal. Removable keyboard mounting routed to accept SWTP KBD-5 keyboard. **$90**

**TYVE TVC ENCLOSURE**
- Designed for SWTP CT-1024 TV typewriter. Keyboard plate routed for SWTP KBD-5 keyboard, with space at right for additional control keys or number pad; space on top for setting CRT monitor. **$55**

**779 HIGH-SPEED PRINTER**
- Dot-matrix impact printer (five copies max.), 80 char/line, six lines/in, 60 char/sec. Sprocket-fed paper up to 9½-in. wide. Buffered input. Full alphanumeric uppercase, normal, and elongated characters. Less interface. **$1195**

**PR-1 PROM PROGRAMMER/VERIFIER**
- Programs 17-2 A PROMs directly from computer memory via parallel port. Reads and compares PROM after writing to verify contents; displays discrepancies and error message on terminal. Kit/wired **$325/475**

**PR-2 EPROM PROGRAMMER** ($3)
- Programs 2708 and 2716 EPROMs; plugs into SS-50 interface bus for read-access to S-100 interface by socket-mount outside computer chassis. Includes 2708 software. Kit/wired **$125/$190**

**MINITERM ASSOCIATES**

**WORD-PROCESSING KEYBOARD**
- Ninety keys, with tactile feedback, 100-million-operation guaranteed keyswitches. Upper- and lowercase, 12-function keys, numeric pad, four on/off keys, and auto-repeat. Wired, in enclosure. **$235**

**MOUNTAIN HARDWARE**

**INTROL REMOTE CONTROL SYSTEM** ($1)(AP)**
- Turns 110V ac devices on and off under computer control; transmits control signals over house wiring; adapters for S-100 or Apple computers. System consists of ac controller, ac interface adapter, and dual-channel ac remote, described below, plus software subroutines for most BASICS. Time control available with clock board.
- **AC Controller.** Controls up to 64 channels remotely, up to ½ mile to or local transformer, via 50-kHz PCM; bi-directional system, allows polling of remote channels, transmissions checked for parity, framing, and errors; requires 8080/Z-80, 12K RAM from 0000 (8K for AY interface board). Programs 2708 and 2716 EPROMs; plugs into SS-50 interface bus (S1); zero-insertion-force sockets. Specific 100 model (occupies 1 bus slot, 2 ports) or Apple II (occupies one I/O expansion slot). Includes ac interface Adapter, which connects controller to ac wiring, allows controller and computer from 115-V power, but allows control signals to pass. Kit/wired **$149/$189**
- **Dual-channel AC Remote Station.** Walnut case with two, independent 500-Watt channels, manual override switch and internal fuse for each channel; self-calibration circuit for alignment to controller; address selection via on-board jumpers. Kit/wired **$396/$419**
- **INTROL Basic.** Tiny BASIC with added commands for Introl Remote Control and Clock Board; requires 8080/Z-80, 12K RAM from 0000 (8K for Apple system). In 8734 EPROMs (8 PROMs, programmed). **$100**
- **CUTS cassette or paper tape** **$15**
- **CP/M or North Star diskette** **$25**

**MYKRO**

**K.C. I/O MODEM**
- Uses "Kansas City" standard (2400-Hz logic "1", 1200-Hz logic "0"). 300 baud). Connects between serial port (standard D825 connector) and cassette
recorder has hold circuit to enable unformatted record/ play without start-up error. Includes tape with IAPS International Academic Society Publication Standard) formatting for 8000/2000, can be cromem to Z80 monitor.

Wired, with assembled cables and connectors $129

With unassembled cables and connectors $109

NATIONAL MULTIPLEX

3M DIGITAL DATA RECORDER

Uses 3M Data Cartridge, Model DC-300, records nearly two megabytes per cartridge, on four tracks, phase encoded, at 9800 baud. Has internal gap light, full software or manual control of all functions including fast-forward and rewind; has high-speed search for inter-track record. Comes with software. Uses "Comcast carriage" drive construction. Requires serial I/O port with two parallel bit terminals for control. 2SIO(R) board (see below) recommended for S-100 or SS-50 bus systems. Wired $250

CC-8 DIGITAL COMPACT-CASSETTE READER

Direct digital recorder (no audio-cassette interface required) using standard Philips-type Compact Cassette. Handshake signals when motor is up to speed. RS-232-I/O standard, TTL optional (user selectable); speed adjustable. Uses Binary NRZ asynchronous single-track digital recording on half-track cartridges (flip cartridges over for second track). Adaptable for 12-V operation. Use of 2SIO(R) board recommended for S-100 bus computers. Motor start/stop by remote or local control. Fast forward and rewind. Manual only.

75-1200 baud version (1.6 ips) $185
1200-4800 baud version (3.0 ips) $185
2400-9600 baud version (6.0 ips) $195

CONTROLLER

(S1)(S3) I/O board with EPROM monitor and tape/file-handling routines: 2- or 4-channel, 2 cassette ports, usable for phase-encoded, K.C., MITS and IMSAI tapes; high-speed search and tape motion controls for 3M and other digital tape units, start/stop for CC-8 and audio cassette. 2SIO(R).

S-100 or SS-50 version. Wired $190

NEW

WHITEHANDER

Dome-shaped, one-hand, full-ASCII keyboard. Uses "knob" finger-activated key, plus key pair for thumb; key combinations yield full 128 ASCII characters, including control characters. Requires parallel port (7-bit) and 5V power. Single ribbon contains data, power, ground, reset, 8 data and 4 clock lines. Single port terminal for use with any ASCII computer. Wired $89

NORTH STAR

MDS-A MICRO-DISK SYSTEM

(S1) Uses MDS-A钞Micro-Disko钞 drive, 100 bytes per diskette. Controller on one Altair-boar bus, with bootstrap software in PROM. Supplied with DOS and disk BASIC software, all connectors and cables. Power required: 12-V, 2.0 A; can be supplied by computer or optional power supply. Drive assembled, controller available Kit/wired $699/$799

Power Supply Kit $39

Cabinet Kit $39

Additional drive Kit/wired $400/$450

MDS-A-400. System less drive, for use with previously purchased SA-400. Wired $449/$549

OLIVER

OP-80A PAPER TAPE READER

High-speed optical tape reader, no moving parts. Reads punched paper tape up to 5000 char/sec. Includes optical sensor array, high-speed data buffers, hand/keyboard logic for interfacing with parallel I/O. Kit/wired $285/$310

2708/15 PROGRAM PROMMER

Programs 2708 and new 2715 PROMs. Interfaces to parallel port; requires very little software—data is dumped via the output port to program the ROM. Requires 1-A, 8-V power supply. Takes less than 100 seconds to program 2708, less than 200 for 2716. Kit/wired $249/$295

Kit, less regulators $199

OPTIMAL TECHNOLOGY

EP-2A EPROM PROGRAMMERS

For 2704, TMS-2708, 2758, and 2716 EPROMs and others when specified. Requires 12-bit parallel I/O. Configured to match various MPU's (see below); replace "x" in model number with appropriate MPU code when ordering.

EP-2A SERIES

On 4.3 x 2.2" circuit card, with 44-pin edge connector. Requires +5 V (±15% 28 + 8 V) 50 mA (all PROMs); +12 V 100 mA and +5 V (±10 mA) (2704/08, TMS 2708/16 only).


EP-2A-78 SERIES

Similar to EP-2A, but also programs TMS2532, TMS2716, and 2732 PROMs; card size 4.3" x 2.4"; PROM type selected with jumpers at card edge connector.


EP-2A-79. Similar to EP-2A, but stand-alone type, with power supplies and enclosure; PROM type selected by plug-in personality module (one supplied, others $15 each).

EP-2A-79-x. Wired $145

MPU code. For letter "x" substitute: K for 6502; M for 6800; I for 8080, 8085, 280; R for 1802; F for F-8.

ANALOG I/O CARD

8-channel A/D and 2-channel D/A converter; ±5V full scale; requires 50 mA in ±12-15V; interfaces via 2 I/O ports; 8-bit accuracy, 10-meg input impedance; on a 4.25" x 3.75" card. Wired $99

I/O 820. Wired $59

I/O 902A. 8-channel A/D only. Wired $79

OTTO ELECTRONICS

OE 100 TERMINAL

Video terminal with composite-video output; requires monitor. Screen format 16 li x 64 char: upper/lower-case and TTY modes; display 96 ASCII characters and 2 special characters; full cursor control, automatic scroll, erase to end of line, erase to end of screen, and cursor-screen. Interfaces to 300-baud full-duplex serial port, 20 mA or RS-232. Has 57-key keyboard, plastic case; requires 115 V ac power. Kit/wired $275/$350

PACIFIC CYBER/METRIX

PC/M 660 CASIO EPROM PROGRAMMER

Programs its own front-panel controls, with a terminal, or as a computer peripheral; 20 mA and RS-232 interfaces, internal, 4k buffer; accepts all standard paper-tape formats; uses any desired number base from 2 to 16; punchy binary-format paper tape for permanent data storage; built-in buffer-editing capabilities.

PAIA

8702 DIGITALLY ENCODED KEYBOARD

Piano-type, 37-note keyboard for use with all systems, full-ASCII character set. Interfaces to any microprocessor, with or without additional hardware logic. Can be used with 8792 keyboard interface for limited sample-and-hold functions. Kit/wired $35

In addition to computer, above modules interface to complete series of synthesizer-module kits.

PERCOM DATA

CB-30 - CASSETTE INTERFACE

Self-closing audio cassette interface, functioning at 120, 60 or 30 bytes/s. Usable with any computer having a serial port, but designed for SWTPC 6800 systems. Use MKBUG for all ordinary functions except 120 byte/s loading, plays unmodified SWTPC cassette tapes, and is finished in matching colors. Includes RS-232 data terminal interface, allowing both tape and terminal to use one serial port; user-selectable 1200, 600 or 300 baud terminal interface. Separate 4-wire recorder interface permits dual cassette operation; use phase-locked (biphase/M) data and clock recovery; optional kit allows program control of recorders; local/line switch for off-line stopping of recorder programs to terminal only. Requires regulated +5V (±5% 28 + 12V ± 10%); both available from SWTPC 6800. Kit/wired $80/$100

IC Sockets $5

Remote-control kit $15

Test Cassette $5

CI-812 CASSETTE INTERFACE

(S1) Similar, but board for S-100 bus. Kit/wired $100/$130

LFD-400 MINIDISK SYSTEM

(S5) Mini-flipper system for S-50 bus (does not use I/O slots). Up to 3 drives. Consists of S-50 controller board with space for 3K PROM, Shugart SA-400 drive, power supply, cabinet, software and firmware. Controller turns drive motors off if system is inactive for more than 3 seconds; hands off without any use. Requires regulated +5V (±5% 28 + 12V ± 10%); all system components also available separately.

PERIPHICON

TYPE 511 IMAGE DIGITIZER

Video camera/digitizer; creates 32 x 32-element image; 14-mm f/1.9 lens focuses from 0.2m to infinity; in machined aluminum case with standard 1/4-20 tripod screw mount.

Diskette drives for full-size (8") diskettes; IBM-3740 compatible. Voice-coil head positioning, for fast access (76-tracks seek in 100 ms, 33 ms random average seek); diskette load/unload can be controlled by computer; double-density capability; single-density capacity 400K side unformatted, 240K formatted double density 800K side unformatted (6536 bpi). Dual-drive versions only 4.4" wide.

Single drive $605

277. Dual-drive $1295

295. Double-sided dual drive $1595

1670 SINGLE-DENSITY DISKETTE CONTROLLER

Stand-alone diskette drive controller with 8-bit parallel computer interface, optional RS-232 serial; includes 4K ROM file-management firmware, 1K RAM for I/O buffering. Supports up to 4 single or two dual drives.

$740

ELECTRONIC EXPERIMENTER'S HANDBOOK
1170 DOUBLE-DENSITY CONTROLLER (51)
Similar to 1070, but S-100 compatible; 2K RAM buffer; supports up to 4 single, 2 dual drives in drive-set order on both sides of diskette (16M bytes/multideck); includes S-100 controller, drives and 10M bytes of data storage capacity 16M bytes .......... $1050

PHONES
LOW-COST SPEECH INPUT
Self-contained, microprocessor-based speech recognition board; would identify up to 16 spoken words or short phrases of user's choice; parallel /0 port
PICKLES & TROUT
TYM-41 TV MOD KIT
King-size TV and other TV sets using Hitachi "SX" chassis for use as 9-in. or 12-in. video monitors; switch allows normal TV use. Up to 90 char/line; for EIA-format video signals with amplitudes of 0.6V, 1.1 V or higher. Has onboard regulator, draws about 12mA .................. $20
PET-488 CABLE ASSEMBLY (IEEE)
IEEE-488 plug-compatible cable for PET Adaptor; connects PET computer's IEEE-488 edge connector to standard IEEE-488 devices. Edge-connector key guaranteed to ensure correct insertion; cable length 16" (others on special order); available with male (PET-488M) and female (PET-488F) connectors .......... $550

POLY PAKS
ASCII KEYBOARD & ENCODER
64 key ASCII keyboard & 32 bit binary output display; requires +5, -12 V. Kit/wired .......... $65/$75
HEXDECIMAL KEYBOARD
4-bit binary/hex output, plus strobe; 2-key rollover; 20 keys 16-encoded and 4 user-definable; 4-LED binary output display. Requires +5, -12 V. Kit/wired .......... $35/$40

PROCESSOR TECHNOLOGY
HELIOS II DISK SYSTEM (51)
Includes dual PerSci 270, full-size floppy drive or drives, and Level-I BASIC; required for all peripherals below

RADIO SHACK
TRS-80 SCREEN PRINTER (RS)
Electrostatic printer for TRS-80; uses 4 paper; prints 220 char/sec; hard-copy of any CRT-screen contents, including graphic; required only 4K RAM and Level-I BASIC .......... $599

RS-80 EXPANSION INTERFACE (RS)
For TRS-80 system expansion. Contains sockets for added 16K or 32K RAM; disk controller for up to 4 Mini-Disk drives; microprocessor-selectable dual-drive, real-time clock; card-slot for future interface options; parallel port for Centronics printer. Usually requires Level-II BASIC; required for all peripherals below

TRS-80 LINE PRINTER (RS)
Impact printer, 60 char/sec; 5x7 dot matrix; character density 10-16 char/in.; for paper loaded at 9" 8.9 W; top-of-form software control, friction feed. Requires 4K RAM, Level-II BASIC and Expansion Interface .......... $1299

TRS-80 MINI-DISK SYSTEM (RS)
Holds 8K bytes/disk; includes TRS-80 DOS software; adds 14 drive-set attributes to Level-II BASIC; includes 16K RAM, Level-II BASIC and Expansion Interface .......... $499

Hand-held, machine-language terminal with hex keypad input with 8-digit LED displays; control keys for reset, run utility, run program, start program, increment, clear address, data/address entry select, continuous/step-single select; utility firmware. Designed for 1902 systems; direct plug-in to COSMAC Evaluation Kit, EK/Design Kit, and Development System II.

COSMAC FLOPPY-DISK SYSTEM II
Dual-drive system designed for direct plug-in to COSMAC Development System. Includes system diskette (IBM-compatible format) with editor, assembler, diagnostic, and utility programs.

COSMAC MICROMONITOR
In-circuit debugger for 1802 systems. Connects between MPU and socket. Has built-in keyboard, display and status indicators; interfaces to external terminals; allows real-time run with breaks, plus operation for specified number of machine instructions; in-system program symbols; programmable break conditions, with register preservation and trace; control of memory, I/O and all registers and flags; inhibits or allows system-generated DMA and interrupt requests.

COSMAC PORT CONTROL
Multi-cassette controller (51)
Controls up to four audio cassette recorders, including write, read, and start/stop, through one interface. Plugs directly into and is controlled through the Tarbell cassette interface. (See Module Boards) includes operating system software and basic I/O driver with cassette selection, multiple files with update and merge, split and duplicate; two-pass assembler, record compression, and other useful subroutines. Optional software: text file editor

MIB-48. With four cassette ports. Kit/wired .......... $140/$190

MIB-2B. With two ports .......... $110/$160

MIB-RA. Two-port add-on .......... $32

File maintenance system .......... $10

SANX
BLACK & WHITE MONITOR/RECEIVER
13-diagonal, black & white receiver with 75-ohm (switchable to high impedance) video input/output bridging connectors for computer or similar connection, 8-pin connector for VTR, front panel TV/monitor switch, audio input/output bridging connections. Horizontal resolution 250/450 lines

VM-4310 ............... $340

BLACK & WHITE MONITORS
600-line horizontal resolution, continuous DC restoration; video input and output connectors permit "loop-through" with other monitors; switch selectable front face; up-front control panel, locking options. Single and multiple rack-mounting frames available.

VM-4209. 9-diagonal screen .......... $220

VM-4215. 15" screen .......... $310

VM-419. 19" screen .......... $395

VM-405. Three, 5-inch monitors on single chassis; in-deck-mount cabinet, with rack mounting brackets included. .......... $775

COLOR TELEMONITORS
Similar to VM-4310, but color.

51C41. 12" screen .......... $310

51C60. 15" screen .......... $400

51C92. 19" screen .......... $450

SHUGART
SA400 MINIFLOPPY DISK DRIVE
Uses 5¼" diskettes, 110K storage capacity (unformatted). Includes Winograd, circuitry; DC servo-motor; stepping-motor actuator; positive media insertion keeps door from closing on media; 300 rpm. For hard or soft-sector formats. Wired .......... $395

SA450 MINISTREAKER CONTROLLER
Up to 4 SA400 drives; includes general-purpose host interface, has overtravel head seek, 128-byte buffer, IBM-3740 format with modified gap structure; responds to 8 macro control functions. Mounts on SA-400 drive. Wired .......... $90

SA4500 DOUBLE-SIDED, DOUBLE DENSITY MINIFLOPPY
Same size and features as SA400, but records single or double density on both sides of disk to 440 K (unformatted)

SA800/801 FLOPPY DISK DRIVES
Use 8" diskettes. Single or double density, unformatted capacity 400K single density, 800K double formatted capacity 256K IBM format, single-density. Available in IBM-compatible (SA800) and hard-sector (SA801) versions; also available in narrow-chassis versions (SA800R/801R) for side-by-side mounting in 19" racks

SA850/851 DOUBLE-SIDED DISKETTE DRIVES
Double-head versions of SA800/801. Same size as SA800/801, and plug compatible; media compatible with IBM single- and double-sided drives. Fastflex metal band actuator: heads may be loaded simultaneously on both sides of diskette, programmable drive lock and write protect; sensor differentiates single from two-sided diskettes; single or double density, unformatted capacities 800K single, 1600K double density, per disk; IBM extended format (max) 66/64 diskette single, 1212K double. Wired

Wired for single or double drives, capacity 14.5 megabytes/disk. Rack mountable, requires same power supplies and voltages similar interfaces as SA800/850 floppy drives, for easy use with Windows texts and environments. Wired

SA4004. single disk, 14.5 MB .......... $2550

SA4008. double disk, 29 MB .......... $3500

Head-per-track option (adds 144K capacity) .......... $350

SMOKE SIGNAL BROADCASTING
BFD-68 MINI-FLOPPY DISK SYSTEM (55)
SS-50 controller supporting up to 3 drives, 3-drive cabinet with space and power supply for 3 drives, DOS-88 and Disk File Basic DFB-8 software; other software available

BFD-68. Single-drive version .......... $795

BFD-68.2. Dual-drive system .......... $1139

BFD-68-3. Triple-drive system .......... $1479

SA-400. Additional Shugart drive for BFD-68 or BFD-68-2 .......... $355

ABFD-68. Single-drive system less cabinet and power supply .......... $649

POP-1 EPROM PROGRAMMER (55)
Self-contained 2708 programmer, designed to interface with Smoke Signal P-38-1 EPROM board. Wired with standard drives

P-38-1. 8K EPROM board with interface for POP-1. See Module Board section for details. Wired .......... $174

SOROC TECHNOLOGY
IQ-120 TERMINAL
CRT terminal, 160 char/line, on built-in 12-in.CRT. Includes keyboard with cursor control, numeric keypad, tab, auto-repeat; ASCII 96-character upper/lower-case set. RS-232C interface to computer and extension port (optional) for printer, etc. Has protect mode, displays protected data in reduced intensity. Can erase to end of line, end of field, end of memory, all unprotected data, or complete screen. Switch-selectable basic sets, 76, 102, 152. Wired .......... $995

IQ-125 TERMINAL
Similar to IQ-120, but with descendents on lowercase characters, block-mode transmit option, printer port with independently-selectable baud rates. Wired .......... $1095

IQ-140 TERMINAL
Similar to IQ-125, but with detachable, 117-key keyboard. Wired, including 16 function keys, separate numeric keypad; full screen edit capability and block mode transmit; reverse video, underline, blink, blank security fields; polling option. Wired .......... $1495

SOUTHWEST TECH. PRODUCTS
CT-64 TERMINAL
CRT terminal, 16 lines of 32 or 64 characters per line; scrolling or page mode operation; upper and lowercase characters, with switchable lowercase
dealt; reversed character printing; control character display, with defeat switch; cursor control; complete control character decoding. Usable with any eight-bit ASCII computer. Power-supply unit, key- board, serial interface, beeper, chassis, and cover. Kit. ...$325
CT-WM. Video monitor for above, in matching case. Receives CT-64's power supply. Wired. ...$175
CT-EA Screen Read Board. Allows block transmission of screen contents after editing. Kit. ...$18

CT-92 TERMINAL
CRT terminal with 9", green-phosphor screen; 82 char. x 16 or 20 lines, software-selectable; dual-intensity with upper/lower-case characters, graphics optional; protected fields; cursor addressing with 12-key cursor control pad, page or block transmit; driver for Centronics PR-40 parallel printer; decodes ready code and punch on/off control characters; socket for optional 2716-pinout custom character generator; optional light pen; 110-34, 800 baud. Control functions include scrolling by screen or quadrants, up and down, left and right slide; erase to end or beginning of line or frame, or erase quadrant; line and character insert/delete. Operates on 100, 120, 220, 240 Volts AC, 50-60 Hz. Wired. ...$795

AC-30 AUDIO CASSETTE INTERFACE
Interface between computer and terminal (requires accessibility, 16x clock and 300 baud rate, RS-232 serial). Provides independent control for two recorders, including automatic start/stop; either cassette may record while the other plays back data. LED indicates display record/read status and data flow. Local/remote switch permits using recorder with terminal alone. Kansas City-pinout. Kit. ...$80

GT-6144 GRAPHICS TERMINAL
Cell array is 64 wide by 96 high; each cell addressable by computer; programming allows fixed or moving images. Data can be loaded in less than 2 usec. Image reversal for white on black or reverse. Standard 525-line format; 6144-bit static RAM. Operates with any computer whose parallel interface outputs an 8-bit word and data-ready strobe; this includes any 8080 or 8080 machine. Does not include chassis or video monitor. Programming allows display of graphics, CT-1024 alphanumeric or characters, 16x16, 8x8. Kit. ...$99

CT-P Power supply. Kit. ...$16
Joystick potentiometer digitizer ....................................................$40
Slide-potentiometer digitizer .....................................................$36

PR-40 ALPHANUMERIC PRINTER
Alphanumeric printer with 64 upper case characters, 40 characters per line, 75 lines per minute.

Uses standard 3%-in. adding-machine paper. Has internal 40-character line-buffer memory; printing takes place at carriage return or when line-buffer memory is filled; 5 x 7 dot-matrix impact print mechanism. Accepts data up to one character per microsecond or slower; seven parallel data lines are TTL-compatible and enabled by data-ready signal. Used with any computer having eight-bit parallel interface, including 8080 and 6800 machines. Internal power supply.
Size 8 1/2" x 11 1/2" x 9 1/2". Kit. ...$250
Par. L4. Extra Ribbon. ...$5

MF-68 DISK SYSTEM
Dul minifloppy disk system for SWTPC 6800 and similar computers. Controller plugs into I/O slot 6, support up to 4 drives; includes SWTPC 8K BA-SIC ver. 2, modified for disk save/load, plus FIDOS, stores up to 85K bytes/disk; requires 16K memory in computer; with chassis, cover; power supply. Kit. With 2 assembled Shugart SA-400 drives. ...$995
MF-68 Expansion Kit. With power supply, enclosure, 2 drives. ...$850

DMAF FLOPPY
Full-size (8") floppy-disk system with DMA controller for up to 4 drives, 600K bytes/disk; with two Cal-Comp 143M double-density-rated disk drives; other features similar to MF-68 system. Kit/ wired. ...$2000/$2095

DMPA Drive Expansion ...$1850

SUMMAGRAPHICS
BIT PAD DIGITIZER
Converts graphic data into digital X-Y addresses. System consists of 15 x 15-in. digitizer board with 11-in. square live area, pen-size stylus, and small console cabinet with controls. Records single coordinate pairs, X and Y coordinates updated only when stylus touches graphic material. Specify 0.05" or 0.10" for 0.05" or 0.10" resolution. Requires +5V ±0.5A, +12V ±0.7A, -12V ±0.5A, all regulated.
BP-11. With 8-bit parallel output ...$555
C232 serial output option ...$125
CRT-1. Single-button cursor option ...$75
Power supply (in separate housing) ...$95
On-board regulator 3 ...$30
Spares ...$40

MULTIBUS BIT PAD
(MB) Similar, but with direct plug-in interface for Multibus (SBC) systems, all electronics located on one SBC card, controls and status indicators in small handheld console ...$625

SYLVANHILLS LAB
X-Y PLOTTER
Plotter and interface kit (mechanics assembled), for interface to any eight-bit TTL clock at port. Pen hoist- er accepts any writing instrument or stylus 7-11 mm diameter; encoded for 0.01-in/pulse, but 0.005-in optional. Pen travels at 2.5-in/sec max. with 24V supply, 4.25-in/sec with 36V. Includes control of pen lift, X and Y motion, and start and stop. Drawing surface and power supply not included.
DFT-1. Plotter kit, 11" x 17" drawing area ...$795
DFT-1M. Mechanical system only ...$669
DFT-2/2M. 17" x 22" ...$950/$825
UPS-2. Power supply; 24V, 1.5A, regulated ...$50
CON-1. Console for DFT-1 ...$110
CON-2. Console for DFT-2 ...$130

X-Y PLOTTER UNIT
Plotter, drawing surface and power supply, for interface to any 8-bit TTL parallel port. Pen holder ac- ccepts any writing instrument or stylus 7-11 mm dia. diameter; encoded for 0.01 pulse, 0.005" optional. Pen travel speed 2.5-in/sec max. with 24V supply, 4.25-in/sec max. with 36V. Includes control of pen lift, X and Y Hoist, and start and stop. Drawing surface, and power supply not included.
UNIT-1. 11" x 17" drawing area ...$1045
UNIT-2. 17" x 22" drawing area ...$1249

TED
REAL TIME CLOCK
Time-of-day clock, connects to TTL parallel I/O port of any computer system; requires 5V, +5V, +12V. Push- button timer setting; no run off powered supply or battery (crystal-controlled). Wired only. ...$50

TELE SPEED COMMUNICATIONS MODELS I PRINTER
Dot-matrix printer using pressure-sensitive paper. 64-character ASCII (upper-case); bidirectional printing at 80 char/sec; 80 columns, 10 char./in., 6 line/in.; totally visible print line. Jumper access to stepper motor drives and print drivers, for graphic and plot- ting applications, optional tractor mechanism, 80-column bidirectional buffer, RS-232 interface. In-desk-top cabinet, with parallel ASCII input. ...$615

TERMPAR
PS-4C Printer/Terminal
Printer with optional keyboard for use as full KSR terminal. Thermal print mechanism, dot matrix upper/lower-case ASCII 96-character set; 110 or 500 baud serial RS-232, 20 mA TTL parallel up to 960 char/sec; prints 48 columns, with automatic printing of excess on next line; recognizes negative vertical tab command from computer; uses 5V power. 

PS-4C Printer. Wired. ...$666
KB-5C Alphanumeric keyboard ...$222
Paper. 5 1/2" x 164" roll ...$3

PS-40 THERMAL PRINTER
Similar to PS-4C, but without power supply and case. Prints 24 char/sec with 110 or 300-baud transmission rates. Includes interface ...$40
PS-40. Wired ...$100
Power supply ...$100
Case ...$100

TERMIFLEX
HAND-HELD TERMINALS
Hand-held ASCII terminals with multi-function, calibrated-type keyboard, LED dot-matrix display, RS-232 interfaces. Keypad with 3 shift keys; accepts any 8080 ASCII characters, plus "back", has multi-key lockout; 120 char/sec, full duplex; display buffer, auto carriage return/line feed; automatic rollover; available with built-in acoustic coupler.
HT-3. One 12-char line, 12-char buffer ...$795
HT-4. Two 12-char lines, 24-char buffer ...$1195
HT-R. One 20-char line, 90-char buffer, full/half duplex, 10-120 char/sec ...$1795

TERMINAL DATA
CRT TERMINAL
High-speed TTY-replacement terminal with sepa- rate, 9" CRT monitor. IBM-compatible, 64 char x 16-line display, 110-9600 baud; half or full duplex, auto carriage return/line feed; automatic rollover; available with built-in acoustic coupler.

High-speed TTY-replacement terminal with sepa- rate, 9" CRT monitor. IBM-compatible, 64 char x 16-line display, 110-9600 baud; half or full duplex, auto carriage return/line feed; automatic rollover; available with built-in acoustic coupler.

DATA SPLITTER
Diode network providing dual-output interface from RS-232 port, allows printer and modem, printer and plotter, etc. to share a port, and isolates the two outputs from each other. Can be daisy chained.
1200K. Kit/wired ...$49/$99
1200R. Similar, but 4 in, 1 out ...$49/$150

TERRAPIN
TURTLE ROBOT
Computer-controlled robot, operating on 10" cable from standard parallel interface. Moves at 6 in/sec, turns at 120/sec, emits 2 tones from built-in speaker (more, with music generator in computer). Requires 12-18V unregulated, 1A; 8 bits in, 4 bits out. Kit/wired ...$300/$500
S-100 interface kit ...$40

THINKER TOYS
DISCUS II
Full-size, 8" floppy-disk system IBM-compatible, soft-sectored format, 256K bytes/disk. Software in- itialized to use on-board, memory-mapped serial I/O port, can be reinitialized to other ports. Printer can accommodate up to 8 drives, occupies 1X starting at 340;000 octal/E000 hex (other addresses on special order). Complete with Shugart 80PR drive, power supply, cabinet, BASIC-V, DISK/ATE DOS/ Assembler/Text Editor, and patches for CP/M.
Single-drive system, Wired. ...$995
Additional drive. With power supply, line cord cabinet. ...$795
Additional connector. For multiple drives. ...$25
Dual-drive system. Wired ...$1750
Software (with purchase) ...$800

ELECTRONIC EXPERIMENTER'S HANDBOOK
**Disk Jockey I Controller kit only**

**CP/M DOS**

$70

**Microsoft Extended Disk BASIC**

$199

**Microsoft FORTRAN**

$349

**Disk Jockey I Controller kit only**

$179

### U.S. ROBOTICS

**USR-310 ORIGIRATE ACOUSTIC COUPLER**

Asynchronous, half/full-duplex originate-only acoustic coupler for terminal communication to computer; data rates 0-300 baud; RS-232-computer interface; connects slave mode via standard telephones, with case and power supply

$139

**USR-330 AUTO-ANSWER MODEM**

Auto-answer modem, for computer to answer remote terminal; Requires Data Access Arrangement, available from U.S.R. or rentable from phone company (a $5/mo.oku installation). Other specifications same as USR-310.

With RS-232 or 20mA interface, no DAA

$190

With RS-232 or 20mA interface and DAA

$299

Dual interface option, RS-232 and 20 mA

$10

**USR-330 ORIGIRATE/AUTO-ANSWER MODEM**

Similar to USR-320, but for both original (terminal) and answer (computer) modes.

With RS-232 or 20mA, without/with DAA

$185/$324

Dual interface option

$10

### VAMP

**ACV1M-1 VIDEO ADAPTER**

Television modification kit for direct video input. For transformer-inserted or "hot-chassis" sets, allows displays up to 80 char/line, with bypass switch for normal TV reception; provides isolation to protect video source, provides positive or negative video directly to TV set's video amp

$25

### VECTOR GRAPHIC

**DUAL-STORE FLOPPY-DISK SYSTEM**

S1 Dual PerSci 277 drive (243 bytes/disk, IBM-compatible); uses programmed data transfer; will operate with any (both static and dynamic) memory of up to 25K bits/sec; includes controller, chassis, power supply, cabinet, CP/M and BASIC-E software. Wired

$2650

### VOLKER-CRAIG

**VC303A TERMINAL**

TTY remote display computer terminal; stand-alone unit with 1920-char screen, upper/lower-case, 12 CRT, RS-232 interface; 24 x 80 char; cursor control keys and direct X-Y cursor addressing; composite video output for slave monitor. Auxiliary serial and parallel interfaces optional

$1195

**VC404 STANDARD TERMINAL**

Similar to VC303A, but with detachable keyboard; clear end-of-line and end-of-screen; transparent/tape mode; switch-reversible video. Options listed below.

$1195

**VC404/R0**

Same, less detachable keyboard; receive only

$1050

**VC414 EDITOR**

Similar to VC404, but with block mode. Allows formatted data entry and complete local editing before transmitting all or variable data; multi-level display; block move mode permits inserting/deleting lines of text; line insert and delete; character highlighting, protected/unprotected data; line-drawing capability

$1395

**VC424 TERMINAL**

Similar to VC414. Complete editing terminal with polling and independent printer port

$1595

### OPTIONS FOR 400 SERIES

**SP**

Switches serial peripheral interface

$75

**KB1**

Numeric pad and function keys

$75

**APL**

Front-panel switch-selectable ASCII and APL character sets, type-pair/pair (no overstrikes)

$250

**PIP**

Auxiliary parallel input

$75

**CDS**

Colored anti-glare display screen (yellow and green) with option

$50

**MT1**

Multiple Terminal Interface. Switching box. Connects up to 5 VCS-series terminals to serial printer

$250

**BRI**

Bar code reader interface for Monarch 2243 scanner

$315

### COMPUTER MODULE BOARDS

Module boards for standard bus systems (including combinations of the above) are listed here.

#### ADVANCED COMPUTER PRODS.

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### AI CYBERNETIC SYSTEMS

**MODEL 1000 SPEECH SYNTHESIZER**

Forms words and sentences of standard American English from phonemes requested by ASCII characters. Speech rate and vocal pitch adjustable. Replaces less than 50 bytes of assembly or five lines of BASIC for programming, data rate typically 25 bytes/sec. Outputs to any amplifier or recorder

$380

### ALF PRODUCTS

**OCGP QUAD CHROMATIC PITCH GENERATOR**

16-tone, 12-tone generator, produces 4-16 tones simultaneously. Requires 2.2 MHz from bus pin 49, or option P01 crystal clock. Kits available with 14-channels, wired 4-channel only. 10-5-9 (A, K) Single-channel, kit

$111

Additional channels, each

$16

10-5-8 (A4) Wired, 4-channel

$185

PT, 2-MHz clock option

$16

(Also available in non-S100 form for parallel interface. See "Peripherals" section.)

**ADI MICRO-BUS ADAPTER**

Adapts ADB Micro-Bus Synthesizer System to S-100 bus (See "Peripherals" for section.)

$120

**OCGP QUAD CHROMATIC PITCH GENERATOR**

Produces 1-16 tones simultaneously. Produces 1-16, 96-tone, parallel interface; requires 8, 16, 168 unregulated (option P2) or 3, 12, +12V regulated (option P3). In kit form with 4-channel, wired 4-channels only; requires Option P1 clock if no 2-MHz available from computer. 10-5-10 (A, K) Single-channel, kit

$111

Additional channels, each

$16

10-5-9 (A4) Wired, 4-channel

$185

S-100 OCP

Similar to above, but for S-100 bus. Prices change model numbers from 10-5-10 to 10-5-9.

### ALPHA MICRO SYSTEMS

**AM-100 16-BIT CPU**

16-bit MPU board for S-100 bus. Includes software. See "Computers" section for details

$1495

**AM-200 FLOPPY-DISK CONTROLLER**

DMA floppy-disk controller for AM-100 16-bit and 8080 8-bit MPU's. Includes disk formatting, full and partial sector reading from drive, multi-disk control, multi-level interrupt capabilities. Supports PerSci 277 drive disk and Wango 80 disk drive subsystem

$595

CP/M operating system for 8080, with manuals

$85

CP/M Prom

$30

2766 PROM for IBM, AMS or CP/M formats

$30

### ANDROMEDIA SYSTEMS

**FDC-11 FLOPPY-DISK CONTROLLER**

LS Controls up to four drives, e.g. Pertec FDS11 or Shugart SA-600; personality cards available for other drives such as Pertec FDC-1100.

$150

**P4C00. Personality Card**

$80

**MDC1 MINIDISK CONTROLLER**

Similar to FDC-11, but for three up Shugart SA-400 minidisk drives; with sockets for up to 4K EPROM

$510

**PTRC11 PROGRAMMABLE REAL-TIME CLOCK**

Programmable timer/counter for LSI-11; timing rates from 1 MHz to 0.0002778 Hz (1 hour)

$600

**CB-11C, Rack-mounting controller box to interface devices to PRTC11**

$150

**DAC11 DIGITAL TO ANALOG CONVERTER**

Up to 4-D/A channels, 12-bit resolution

$700

**CB-11C, Rack-mounting controller box**

$150

**ADC11 ANALOG TO DIGITAL CONVERTER**

16 single-ended or differential input channels; 12-bit resolution

$850

**CB-11A, Rack-mounting controller box**

$150

**LP11 LINE PRINTER INTERFACE**

Q bus interface for a variety of popular printers; with 15-foot cable

$295

**LP11-A, For Centronics**

$340

**LP11-B, For Diablo 1300 (HyType II)**

$450

**MS1 MULTIPLE SERIAL INTERFACE**

Up to four serial interfaces per card; parallel printer interface may substitute for one serial channel. 50-19.2K baud, remotely selectable; RS-232/20 mA

$640

**MS11-1P, One serial interface**

$440

**MS111-3P, Three serial interface**

$640

**GENERAL PURPOSE PROTOTYPEING BOARD**

Provides space for up to thirty-one 16-pin and three 24-pin or two 40-pin DIP devices; holes drilled for wire-wrap sockets

$395

**BP-2K**

Kit/wired

$599/$799

**8080 MPU Board**

8080A microprocessor board with support chips

$190/$350

**DISK INTERFACE**

Non-DMA. Can drive up to four standard floppy disks or 3 minifloppies simultaneously; single or double density; program-controllable. Requires 2 slots.

**DBT Kit/wired**

$599/$799

**FLOPPY DISK INTERFACE**

DMA-type. For use with Calcomp 142M drives, must order DMA-A; requires two slots.

**FIF Kit/wired**

$599/$799

**LINE PRINTER INTERFACE**

Two-board set with DMA; permits high speed line printers to be interrupt-driven, allowing spooling

**LIF Kit/wired**

$599/$799

**MULTIPROCESSING/SHARED MEMORY FACILITY**

Uses up to 5 mainframes to access some memory. Consists of following boards (all configurations must be reviewed by factory)

**SMS**

Port Access Board Kit/wired

$325/$399

**SMC**

Port Timing Board

$225/$305

**SMB**

Buffer Board (order one per processor) similar to P1, 40-pin, wire-wrap sockets

$113/$175

**SMT**

Terminator Board

$98/$148

### ASSOCIATE COMPUTER CONSULTANTS

**UNIBUS ADAPTOR (UB/LI)**

Allows connection of multiple Unibus devices to LSI-11 or POP-11/03 system. Can support 20 Unibus loads; data transfer rates to 650,000 words/sec. Mounts anywhere in LSI-11 system backplane.
recessed Unibus connector equivalent to CPU end of PDP-11 Unibus $650

UMC-280 (UB) Z-80 microprocessor board for PDP-11 Unibus. Can load programs from PDP-11 or from PROM on the UMC board. Extends Z-80 capability for memory expansion and custom interfacing, plus on-board space for serial I/O modules. 1K diagnostic and program-load PROM, can be disabled by PDP-11. Suggested applications include communications, protocol processing, data acquisition, translation, formatting and processing, peripheral interfacing, etc. Memory expansion board available to 56K bytes $2495

AUM-IDEAS

HOBBYIST'S DUAL BUS BOARD (S1) (S5) Prototyping board with full S-100 bus compatibility, elevator compatible with SS-50 bus; board can be stacked in vertical or horizontal plane, eliminating dependency on particular motherboards; provision for up to 100 DIP ICs (14-pin, accepts 20-40-pin ICs, or other combinations of 28-, 24-, 16-pen ICs), also provides for four voltage regulators with independent power and ground lines, space for up to 38 additional discrete components, two card ejectors, filter capacitors, etc. Ground and power planes on both sides of board Kit, with heat sinks, plug sheets, and wire-guide wires $30

AUTOMATED INDUSTRIAL MEASUREMENTS

AIM-1005 8-BIT FREQUENCY METER (S1) Frequency-meter board for 8-bit computers; S-100 addressable. Measures frequencies from DC to 25 MHz, with 500 Hz and 1KHz measurements, 2% accuracy $789

AIM-1005 16-BIT CARD DIGITAL MULTIPLEXER (S1/DG) For use with AIM-1005. Allows 16 different inputs to be measured; has memory to store data output from AIM-1005; jumper-programmable for use with fewer channels, may be interfaced with microprocessors directly as standard or memory-mapped I/O. $143

AIM-1005 (S1) S-100 Mounting card with extra socket for AIM-1005 $35

BASE2

DIGITAL GROUP/S-100 ADAPTER (S1/DG) Allows use of up to four 100-adapters within S-100 8/16/32-bit bus. Group mainframe, in addition to existing D.G. boards. Includes “intelligent” motherboard, ribbon cables, and power wiring harnesses, fits S-3/4" x 12" empty space in standard D.G. cabinet. Kit only $295

Z-80 CPU BOARD (S1/DG) Z-80 MPU, 2708 EPROM socket addressable to any 4K boundary above 32K, power-on jump; can run without front panel in 8080 or Z-80 mode; wait state may be added to M1 cycle. $110/$135

BYTE

BYTE EFORT (S1) Extender board for S-100 bus $25

CANADA

CL2400 REAL-TIME CLOCK (S1) Keeps time in 24-hour format (hr/min/sec), direct output to processor; may be used as modified without using processor clock; generates periodic interrupts at programmable rates. Can be used as clock, event counter, computer use log, real-time control system. Usable with assembly language or BASIC. Requires 300 mA + 8, V, 50 mA ± 16 V Kit wired $96/$135

POWER CONTROL SYSTEM (S1) Interface board for power control of external devices, double insulated for safety. Low-voltage on-board switching controls external power switching unit. Controllable by BASIC or assembly statements. Consists of: PSCI1A - Control logic interface board; 16 independently addressable control channels accessed through a single, user-selectable peripheral address. Requires +8 V ± 270 mA, ± 16 V @ 170/250 mA board Kit wired $198/$340

PC3202 Power control unit. Single-ended remote power control unit, switches 120-V-a.c. loads up to 400 W, compatible with PC3216 control board. Kit wired $40/$52

PULSE OUTPUT INTERFACE (S1) For stepper motor control or any system requiring pulse output. Generates from 1 to 8 simultaneous pulses with single pulse output instruction; on-board timing logic for driving Calcomp, Houston and similar digital plotters; includes 16-bit, S-100 bus, addressable to 8K by 8-bit $19/$236

CGS MICROTECH

FRONT PANEL (S1/EX) Address, data, reset, memory protect, single-step and run switches; status LED’s and 7-segment hex displays. For CGS System 6000 (S-100), but also plug-compatible with Motorola EXORsor boards. Basic board/kit wired $40/$140/$200

6502 MPU Boards. See Computer section.

PETRIX S-100 ADAPTOR (S1/PT) Adapts S-100 computer with pitch computer with board provided, can be adapted to KIM, Motorola 6800, and other 6502 or 6800 computers with appropriate connector cables. Board fits S-100 card slot, generates all required S-100 control signals, such as psyc, i/o address, wait states. Cable fits PET memory expansion connector. Wired $135

COMMODORE/MOS

KIM-3B MEMORY EXTENSION (KM) 8K static memory for KIM-1, 450ns; write-protect and memory-monitoring, 7-segment hex displays. Requires 5 V ± 1800 mA. Plugs directly into KIM-1 mother-board (see Accessories) required for multiple extensions. $289

KIM-4 $39

KIM-5 ROM BOARD (KM) KM-compatible ROM board with 8 sockets, includes 3 MCS65640 ROMs with resident assembler/editor, addressed E000-F7FF. $198

KIM-6 $198

PROTOTYPING BOARD (KM) Wire-wrap board for user-defined extension of a KIM system $39

COMPUTALKER

CT-1 SPEECH SYNTHESIZER (CT) Voice generator board; produces speech output from acoustic-phonetic parameters transmitted at 3000 bytes/second. Two operating modes: predefined vocabulary for higher speech quality, optional CSR1 phoneme-conversion software for simpler operation. Data tapes and CTEIDET parameter editor included with CT-1. Requires 8V +/− 250 V ± 16V Kit wired $395

CSR1. Synthesis-by-rule software (8080) $835

COMPUTER KITS

P6-1 POWER-START Auto-load board; restarts computer at address of ROM monitor or bootstrap loader upon power-up or re-set. Can be switched out and on-board switches substituting for front-panel sense switches for terminal options. etc. Available with board, ROM, or without for use in systems with ROM. Can be located second. Two wire connection, ROM monitor or bootstrap loader upon power up, space. ROM Kit/wired $165/$265

PS-1. Without ROM. Kit wired $135/$236

COMPUTER MART SYSTEMS

PMC-1 RAM EXPANSION (PT) Dynamic RAM, 16K-32K (expandable at factory), 400-ns; no wait states, mounts inside PET computer, receives power from PET transformer, but does not use PET power supply. 16K $550

24K $650

32K $750

COMPUTERWARE, INC

REAL-TIME CLOCK (S1) Real-time clock board for S-100. Wired $186

Z-80 CPU (S1) Z-80 CPU, with provisions for on-board 2706 (unprogrammed), and power-on jump. Wired. 2-4 MHz $171/$186

CONTROLEX

CM324 CORE MEMORY (LS) Non-volatile core memory; 56K (32K and 48K versions available), for 11-10 "bus; 11 μs cycle. Requires +12 V in 27A, +5V in 2A. Wired. $2100

CM203 NO CORE MEMORY (LS) Non-volatile NDRG (non-destruct read-out) core memory, 4K. Exceptional noise immunity, no power-sequencing required; recommended for severe-environment industrial controls, etc. Has 350-ns ac- cess time in 1 cycle time, 3-16 different cycles per cycle. Kit $950

CONVENIENCE LIVING

EXPANDAPET (PT/KM/AI/S1) General-purpose expansion system for 6502 computer systems including KIM, VIM, APPEL AND PET. Includes motherboard with dynamic memory and invisible refresh, power supplies and daughter-board buffered sockets. Can mount inside PET. Standard system. 16K RAM, mounting slots for 4 daughter boards, cables, and power harness $345

Less daughter board $395

DAUGHTERBOARDS

EPROM/Parallel-port board, as above $50

S-100 I/O driver board. Maps PET memory locations into S100 I/O space $50

Serial I/O board. Software controllable $50

Experimentar's blank board $20

OTHER OPTIONS:

8K Additional RAM $110

16K Additional RAM $120

Memory board, KIM-4 adapter $25

CROMEMCO

CGI TV DAZZLER (KM) (S1) Interface: 128 × 128, 64 × 64, or 32 × 32 element resolution, software selectable output color (eight colors available) or black and white (16 gray-scale intensities). Analog output also available. Requires RP converter or direct video input. Uses two bus slots, draws 1.4 A ± 5V, 50 mA ± 18 V Kit wired $215/$350

Programs. Printed tape with documentation (14 available) each $15

Dazzler Programs. Dazzler games on 5" or 8" diskettes $95

Dazzle Graphics on 5" or 8" diskette $95

D ASSOCIATION INTERFACE (S1) I/O board with seven channels of eight-bit analog-to-digital conversion for input, seven channels D/A for output, plus channel extension for digital I/O port. For process control, digital filtering, games, oscilloscope graphics, speech and music uses. Analog signal range, −2.56 to +2.54 V. Takes 0.4 A + 8 V, 30 mA ± +18 V, 60 mA ± +18 V Kit wired $145/$245

EXPERTICAL ENGINEER'S HANDBOOK
DIGITAL MICROWAVE SYSTEMS

S-100 TERMINATOR BOARD
(51)
Terminates bus lines with 190-ohm impedance, to match bus output-drivers impedances, and reduce ringing, reflection, overshoot and noise.
DMTB
$25

S-100 EXTENDER BOARD KIT
(51)
Raises boards 5" for access by test instruments; jumpers in power supply lines for current measurements; provisions for pilot LED, can remain in machine with cover on.
DMKB
$16

DIGITAL PATHWAYS

TCU-50 TIMING CONTROL UNIT
(6.5)
Time/date board for LSI-11; battery supported during power-down for up to 3 months; on-board, independent crystal oscillator. Can be interrogated by computer to give day, month, hour, minute and second.
TCU-500
On quad-size board, with room for customer options such as milliseconds or year counters...
TCU-50D
On smaller, dual-size board...
RMA-032 RAM
(6.5)
2K-64K RAM for DEC "Q" bus. 450-ns dynamic addressable in independent 4K blocks; with BSC-256 bank switch controller module, can extend to 2048K bytes; standby power option. Requires +5V +12V
32K
$700
Factory upgrade to 64K
$600
64K
$1200

EDUCATIONAL DATA SYSTEMS OF VA.

S-100 WIRE-WRAP KITS
(51)
Component kits with software listings, designed to be used with any S-100 wire-wrap board. All kits listed below will fit together on one Vector 8800 board.
Bus Buffering-Input-Output Kit. Buffers S-100 bus to reduce noise, has board address selection logic, 8 individually-addressable 1-bit input and 8 1-bit output ports, required by all kits below except MIN and ADD.
BUF. Without/with sockets and wrap pins...$25/$32
MINIMUM INPUT BUFFERING KIT
Subset of BUF kit, provides 8, 1-bit TTL input ports plus board select logic and partial bus buffering; sufficient to interface a light pen (see Peripherals), or kits MUS and TI, using INTE line for output.
MIN. Without/with sockets...
$16/$19
ADD. Upgrades MIN kit to BUF...
$12/$16

ONE-BIT MUSIC KIT
Provides 0.1-W audio output into 8-ohm speaker or amplifier from single-bit output of BUF or interrupt-enable line of MIN; includes software for playing musical tones using software timing loops.
MUS. With/without sockets and pins...
$9/$10

REAL TIME CLOCK
Counts down the processor clock to obtain clock rates as low as 50 Hz; can directly drive RST7 interrupt, or connect to INT vectored interrupt kit; provides 400-KHz clock required by FPP floating-point processor kit; software provided for maintaining time-of-day clock from the interrupt, will accept 2-MHz or 4-MHz system clocks.
RTC
$10/$12

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109
H1-1 5 SERIAL INTERFACE (LS)
With optically-isolated 20-ma and RS-232 interfaces. 50-9600 baud. Kit/wired $95/$150

HUH ELECTRONICS
MEMORY & PERIPHERALS ADAPTER (S1/PT/AP)
Adapters PET 2001 or Apple II to S-100 bus for memory and I/O expansion. S-100 board, with cable for PET memory-expansion connector; allows full DMA (S-100 bus protocol); can be used with Cromemco Dazzler. Apple II cable extra. S-100 MPA Kit/wired $200/$280 Apple II Cable $35

6502 PROCESSOR BOARD (S1)
Contains MPA board plus 6502 Stand-alone option. Emulates complete S-100 bus signals. Kit/wired $250/$330 Stand-alone option for MPA board $50

VIDEO BUFFER
Allows video monitors or TV sets to be used with Commodore PET for color screen display or remote viewing. Plugs into PET user port, and provides standard 75-ohm composite-video output (PET has separate sync and video). For use with unmodified TV sets, space is provided for M&R SUP/R/MOD II RF modulator. Wired $30 With SUP/R/MOD II option and 60-8 antenna isolation switch. Wired $60

(Please note: Use of modulator may not meet FCC requirements.)

PETUNIA (S1)
8-bit digital-to-analog board for PET. Can be used as music generator (up to 4 notes at once), or for graphics, control and other applications. Plugs into PET user port. Requires external amplifier and speaker. Phono jack connection. Wired $30

COMBO (S1)
Combines Video Buffer and Petunia on one board, wired and tested $50 With SUP/R/MOD II modulator $80

BEEPER (S1)
Automatically beeps at file headers and program endings when reading or writing PET tapes; audible warning when computer is ready after save or load. Plugs into PET user port; can also beep under program control. Plugs into PET; has volume control. Wired $25

IMSAI
PRIORITY INTERRUPT BOARD (S1)
Includes programmable interval clock; provides up to eight levels of vectored priority interrupt. PIC-8 Kit/wired $125/$238

EXTENDER BOARD (S1)
Extends motherboard above card cage for service access. Ext. Kit/wired $39/$49

INDUSTRIAL MICRO SYSTEMS
DISK CONTROLLER BOARD (S1)
Single-board disk controller—syntax compatible with Altair BASIC and CP/M. C00300 $265

INNOVATIVE TECHNOLOGY
AD-62A ANALOG-TO-DIGITAL CONVERTER (S1)
Analogue-to-digital converter for SWRTC 6800 and similar computers; occupies one I/O slot. 8 analog input channels, input range 0-2.5 Vdc; 8-bit 50-10 μA max. 150 μs, 5 μs 26 mA max. Wired $40

INTERNATIONAL TECH. CORPORATION
PEM-8K RAM EXPANSION (PT)
Self-contained 8K RAM for PET. Static RAM; 475 ns; addressable in independent 4K blocks, with 115V/60 Hz power supply (220/50 Hz available). $297

ITHACA AUDIO
Z-80 CPU (S1)
Z-80 MPU with on-board 2708 EPROM, power-on jump to any K boundary above 32K. MWRITE for operation without front panel; selectable wait states on M1, memory request, on-board ROM, input and output cycles; selectable 8000 or Z-80 I/O addressing modes; clock-generator provides 8000-line signal for S-100 bus. Requires +8 V 6 mA; with optional 7208, requires +16 V 6 100 mA and -16 V 50 mA also. CP208, Bare board With 2-MHz/4-MHz Z-80 $25/$35 Wire-Wrap Programmer (S-100) $25

JADE
8000A MPU KIT (S1)
8000A-MPU. On-board interrupt circuitry need not be built up until system has real-time clock board, up to 8 levels of priority vector interrupt available. Bare board/kit/wired $30/$100/$150

Z80 KIT (S1)
Z-80 MPU with on-board 2708 EPROM, power-on jump. Selectable I/O address range 8000 mode, with peripheral address duplicated on high and low address bytes; Z-80 mode with peripheral byte on low byte. Accumulator contains on high byte, for multitasking.Input. MWRIWRITE generation allows operation without front panel, 8080 look-alike clock and status signals; wait states can be added to M1, memory request, on-board ROM, input or output cycles. on-board 2708 EPROM included; addressable to any 4K boundary above 32K; power-on jump to any 4K boundary above 32K. Bare board $35 2-MHz version Kit/wired $135/$185 4-MHz version. Kit/wired $150/$200 Z-80 monitor 2708 $15 2-MHz upgrade $50 Upgrade kit, with trade of your 2-MHz Z-80 chip and 9254 clock driver $18

8K 6800 ADAPTER
Adapts 6800 RAM (see RAM tables) to Motorola D-2 6800 evaluation kit. Kit $13

REAL TIME CLOCK
Real-time clock with 1 MHz crystal oscillator, 16-bit counter in 10-μsec steps, decade counter 100-μsec to 1 sec, both software programmable. Bare board/kit/wired $30/$125/$180

JHM MARKETING
VOTRAK VOICE SYNTHESIZER (S1)
Produces continuous speech analog output from phoneme instructions. On S-100 board $695

MARINCHIP SYSTEMS
M9000 16-BIT MPU BOARD (S1)
TMS9900 16-bit MPU on S-100 board. Processor features hardware multiply-divide, 16 general registers, ability to extend hardware language, 6800/6809 compatibles. Kit/wired $650/$950

MATROX
VIDEO RAMS
Video controller module addressed as RAM memory, each on-screen character equivalent to a one-byte memory location. Controllers available as plastic-packaged modules, or as complete module boards. ALT-2480 ALPHANUMERIC DISPLAY INTERFACE (S1)
4K video RAM providing 24 lines x 8 characters; strappable for two pages of 40 character line (recommended mode for use with ordinary TV, or other monitors with less than 10 kHz bandwidth); compatible with ALT-2510 for combined alphanumeric/graphic display; built-in refresh, available as 128- or higher lower-case ASCII 7 x 9 matrix, or uppercase only in 5 x 7 matrix, inverse and blinking under software control. Programmable in American or European character sets. Displays 40 lines x 80 columns, 11,520 addressable dots. Color or grey-scale available. Light pen, cursor selection, point plot, alphaneumers, and ROM screen patterns may be implemented. On PC board, with 4-pin edge connector $630 Character fonts. 1632 and 2480 may be supplied with upper- or lower-case ASCII, upper-case Aluminum, Greek, European characters, and other character fonts at no extra charge. Japanese, Chinese, Arabic, German, math symbols, etc., available for $150 per character. Custom-designed character fonts available.

MEMTECH
ARITHMETIC PROCESSING UNIT (S1)
Hardware arithmetic processing unit, designed for use with BASIC-E, but usable without if user writes own software. Performs floating-point, multiply in 42 μs vs. 3000 μs in software, performs parallel processing of arithmetic instructions. When CPU executes arithmetic program, includes trig and exponential functions; jumppable to any pair of I/O ports. Kits (add $15 for assembly). Without APU chip $155 With 2-MHz APU chip $375 With 4-MHz APU chip $475 BASIC-M (modified BASIC-E, using APUS, on CP/M disk) $25

MICRO DATA SYSTEMS
MDS-689A SINGLE BOARD COMPUTER (S1)
6802-MPU board with I/O, RAM, ROM, 6809-compatible. See Computers section. Kit/wired $198/$258

MICRO DIVERSIONS
SCREENSPLITTER (S1)
Video display board software-divisible into up to 50 logically-independent "windows." Displays 40 lines x 8 char; full 128x128 graphics, 256 gray scale or color capability; may be used with ALT-2480 for combined alpha/graphic display. Other specifications similar to ALT-2480. Wired $395

MTX-416. Video RAM for eight lines, 16 characters, upper-case ASCII (128 bytes) $179

MTX-1632. 512-byte VRAM, 16 lines x 32 characters, upper/lower-case ASCII. Drives up to 25 TV monitors $225

MTX-1632S. Externally synchronized version, allows output to be mixed with or superimposed on other images $395

MTX-2480. 24 lines x 80 characters, upper- and lower-case, half-intensity, blink, inverse video (lower-case requires long-persistence CRT phosphor) $395

MTX-562. Graphics board. 256 x 256, individually addressable dots. Color or grey-scale available. Light pen, cursor selection, point plot, alphaneumers, and ROM screen patterns may be implemented. On PC board, with 4-pin edge connector $830

Character fonts. 1632 and 2480 may be supplied with upper- or lower-case ASCII, upper-case Aluminum, Greek, European characters, and other character fonts at no extra charge. Japanese, Chinese, Arabic, German, math symbols, etc., available for $150 per character. Custom-designed character fonts available.

MICRO TECHNOLOGY UNLIMITED
MUSIC SYSTEM (S1)
8-bit, digital/analog-converter-based music system for KIM-1. Plays 4-part harmony with harmonics derived from Fourier series, separate carrier waves or pulses. 8-bit DAC, 6-pole low-pass filter, audio amp. K1002 $35

K-1001. Software, on cassette with source listing $313

K-1012 PROM & I/O BOARD (S1)
Combination EPROM and I/O board for KIM-1, VIC, AIM and similar computers. Programs and holds up to 12K of 2708 EPROMS; I/O includes 4

1979 Edition
MIDWEST SCIENTIFIC

WIRE WRAP CABLE (S5)
For S-53/0 (S53) bus. With MISBUG monitor, permits programs to be saved and loaded on Port 1 without altering Port 0 interface-terminal baud rate.

A1-1. Kit/wired $75/$105

MISBUG Monitor. For ACIA interfaces addressed $500 and $508. Mand RAM $1000.

MT-1. 2708 ROM

MT-2. Similar, built for use in SWTPC 6800 system.

RAM at $4000, I/O at $8000

MINIMUM ASSOCIATES

MERLIN VIDEO INTERFACE +I/O (S0)
Combination alphanumeric/graphics interface with I/O and ROM facilities. Alphanumeric: 40-character

MUSEK. Serial I/O expansion kits, expands MERLIN to three parallel inputs, three parallel outputs

$45/$75

MIC/IO Combines MACS and MUSEK on one pc board, designed to be housed in keyboard enclosure. Kit/wired $76/$99

MBI. Merlin Basic Intellgence, 2K ROM monitor/editor for Merlin, plus 256-byte RAM. Provides turnkey monitor, cursor control, wraparound scrolling, editingfacilities. Easily interfaced to BASIC or other monitors $45/$70

MEI. Merlin Expanded Intelligenced, ROM with MACS protocols, extended edit and monitor commands, graphic subroutines $35

ROM/EROM

8K, 2708 board (also for up to 2K ROM), with power-on start to any 1K address boundary. Kit/wired $80/$129

FDB. Minifloppy Interface kit for up to three drives, with bootstrap ROM. Kit/wired $200/$329

BKPL. Eight-slot, Altair-bus motherboard $35

BKPLE. Same, with edge connectors, wired $109

VDRK. Card rack and BKPL-E. Designed for card ejector $160

MEK ENTERPRISES

DTMF TRANSCIVER (S1)
Interfaces S-100 computer to Touch-Tone phone system, via DAA. Converts Bell System Dual-Tone Multi-frequency (DTMF) signaling to binary and vice versa; when used with interrupt controller (such as MS81 PIC 8), can perform ring detection and DTMF signaling without CPU looping, allows remote data entry from touch-tone phones; 4-bit input port allows additional data transfer on DTMF detection or servicing up to 8 incoming lines, 4-bit output port for supervision of DAA or other equipment; DAA not provided. Wired $425

MOUNTAIN HILL

100,000 DAY CLOCK (S1)
S-100 clock board, times in 100 u-s increments for periods up to 100,000 days (273 years); allows recall of time and programming of time-dependent functions, on-board battery backup. Uses 15/0 for time, plus one I/O port to set interrupt function, user-addressable to any 16 consecutive 8080/80-ports; time set by entering BCD digits through ports; write protect switch prevents accidental clock stop or reset; can interrupt computer at pre-programmed intervals; crystal control, 0.001% accuracy. Can be used with most BASICs. Introl Basic available with time set, compare, check, display and print commands. Kit/wired $179/$219

INTROL BASIC
Tiny BASIC with added commands for clocks and Introl Remote Control System.

EPROM
Cuts cassette or paper tape

CUTS cassette or paper tape $10

CP/M or North Star diskette

$25

AC CONTROLLER
For remote switching of Introl remote control system. Available in S-100 and Apple II versions.

Kit/wired $149/$189

PROR (S0)

7/8K EPROM board with programmer.

MULLEN

EXTERIOR BOARD ($1)
Raises S-100 boards above others in chassis, for easier in-circuit testing. Includes TTL logic probe indicating low- and high-level logic and pulses on 7-segment, I/O LED display; push-button switch has brightness corresponds to pulse-stream cycle; jumper links in power lines for current measurement and fusing of board under test; edge-connector with all lines labeled; “edge board” section with holes on .01” grid for user circuits. Kit only $35

OPTO-ISOLATOR/RELAY CONTROL BOARD (S5)

APLLE II/PRI-40 PRINTER INTERFACE (AP)
Interfacing Apple II computer to SWTP-PR-40 printer.

APPLE II EPROM BURNER (AP)

APPLE II/I/EPROM programmer for 2716 EPROM. Plug into Apple II; zero-insertion-force EPROM socket; onboard, 25V power supply

$90

APPLE II/MFE TAPE INTERFACE (AP)

Interfaces MFE digital tape drive to Apple II; with tape-operating-system software

$198

BPMEM

8080 SUPER CPU

Bare board. For details, see Computers section

$36

WIRE WRAP CABLE (S5)
For S-53/0 (S53) bus. With MISBUG monitor, permits programs to be saved and loaded on Port 1 without altering Port 0 interface-terminal baud rate.

A1-1. Kit/wired $75/$105

MISBUG Monitor. For ACIA interfaces addressed $500 and $508. Mand RAM $1000.

MT-1. 2708 ROM

MT-2. Similar, built for use in SWTPC 6800 system.

RAM at $4000, I/O at $8000

MINIMUM ASSOCIATES

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MEI. Merlin Expanded Intelligenced, ROM with MACS protocols, extended edit and monitor commands, graphic subroutines $35

ROM/EROM

8K, 2708 board (also for up to 2K ROM), with power-on start to any 1K address boundary. Kit/wired $80/$129

FDB. Minifloppy Interface kit for up to three drives, with bootstrap ROM. Kit/wired $200/$329

BKPL. Eight-slot, Altair-bus motherboard $35

BKPLE. Same, with edge connectors, wired $109

VDRK. Card rack and BKPL-E. Designed for card ejector $160

MEK ENTERPRISES

DTMF TRANSCIVER (S1)
Interfaces S-100 computer to Touch-Tone phone system, via DAA. Converts Bell System Dual-Tone Multi-frequency (DTMF) signaling to binary and vice versa; when used with interrupt controller (such as MS81 PIC 8), can perform ring detection and DTMF signaling without CPU looping, allows remote data entry from touch-tone phones; 4-bit input port allows additional data transfer on DTMF detection or servicing up to 8 incoming lines, 4-bit output port for supervision of DAA or other equipment; DAA not provided. Wired $425

MOUNTAIN HILL

100,000 DAY CLOCK (S1)
S-100 clock board, times in 100 u-s increments for periods up to 100,000 days (273 years); allows recall of time and programming of time-dependent functions, on-board battery backup. Uses 15/0 for time, plus one I/O port to set interrupt function, user-addressable to any 16 consecutive 8080/80-ports; time set by entering BCD digits through ports; write protect switch prevents accidental clock stop or reset; can interrupt computer at pre-programmed intervals; crystal control, 0.001% accuracy. Can be used with most BASICs. Introl Basic available with time set, compare, check, display and print commands. Kit/wired $179/$219

INTROL BASIC
Tiny BASIC with added commands for clocks and Introl Remote Control System.

EPROM
Cuts cassette or paper tape

CUTS cassette or paper tape $10

C/P/M or North Star diskette

$25

AC CONTROLLER
For remote switching of Introl remote control system. Available in S-100 and Apple II versions.

Kit/wired $149/$189

PROR (S0)

7/8K EPROM board with programmer.

MULLEN

EXTERIOR BOARD ($1)
Raises S-100 boards above others in chassis, for easier in-circuit testing. Includes TTL logic probe indicating low- and high-level logic and pulses on 7-segment, I/O LED display; push-button switch has brightness corresponds to pulse-stream cycle; jumper links in power lines for current measurement and fusing of board under test; edge-connector with all lines labeled; “edge board” section with holes on .01” grid for user circuits. Kit only $35

OPTO-ISOLATOR/RELAY CONTROL BOARD (S5)

APLLE II/PRI-40 PRINTER INTERFACE (AP)
Interfacing Apple II computer to SWTP-PR-40 printer.
Interface board for device control. Has eight Reed relays (rated 10VA, 20-200 V) controllable by eight-bit computer command, eight opto-isolators for feedback handshake. I/O port address switch selectable.

CB-1 Kit only $88

MULTI-TEK

BEFORE BOARDS

(S1) (59)
Prototyping boards for S-100 and all 8600 computers. Supplied with ('X') versions and with regulated power supply circuit; can be hand-wired or wire-wrapped, will accept flexible cable connectors for picketboard applications. S-100 version supplied without ('X') and with gold-plated connector.

S-100/5-10X $320/28.50
6800/6000X $24/22.50

NATIONAL INSTRUMENTS

LXI-I/IEEE-488 INTERFACE

(LS/EE)
Interfaces LXI-11 bus to IEEE-488 bus. Includes 4-meter cable with connector, allows user to connect as many as 14 instruments on a single interface; with software...

$695

NATIONAL MULTIPLEX

2160R "BOOTSTRAP ELIMINATOR" (S1) (53)
Combines dynamic RAM and serial I/O board. Connects terminal (20 mA, RS-232, or TTL), one or two digital or audio cassette units; all necessary routines in high-speed, EPROMs, including tape start/stop for audio cassette. Requires 2716 or 2708 PROM. $225

280 MU (S1) (55)
Z-80 processor board, available in S-100 and SS-50 versions. Includes 1K RAM, with monitor, tape read/write, field search, tape recorder start/stop control.

S-100 version only $160
8080 MU

S-100 version only $160

NATIONAL SEMICONDUCTOR

BLC-104 (MB)
Combination RAM/PROM and I/O board for SBC Multibus. Combines 8K, 576-nanosecond dynamic RAM addressable in 4K blocks), 8K PROM sockets, 48 parallel I/O lines, 1 serial port, 1 timer; battery back-up optional; 1-2 watt states. Requires +5 V in 3.3A, -5 V in 2.0A, +12 V in 340 mA, -12 V in 50 mA.

Wired $679
BLC-116. Similar, but with 16K, addressable in one 16K block $936

NEUTRONICS

HEXADIGIT BUS MONITOR (51)
Hexadecimal readout for S-100 address and data in-buses. Hex readouts in sequential form, with five-foot cable; requires +8 V or 625 mA. Kit/wired

$135/149

NEWTECH

MODEL 6 MUSIC BOARD (51)
Audio digital-to-analog converter with on-board amplifier, speaker and volume control, plus RCA jack for connection to external audio system. For music, sound effects, mouse code, touch-tone synthesis, etc. With BASIC and 8080 assembly-language software.

Requires +8 V in 100-200 mA. Wired $60

MODEL 6 MUSIC BOARD (51)
Similar to Model 6, but for SWTP-6800 type systems; uses one I/O slot. Supplied with software list and SWTPC AC-30 compatible cassette...

$60

NORTH STAR

HARDWARE FLOATING-POINT BOARD

(S1) (MB) Hardware arithmetic board performing floating-point add, subtract, multiply and divide with up to 14 digits of precision; approximately 50 times faster than 8800 software or firmware; uses BCD number representation; precision under software control. In versions for: SS-50 and SBC (Multibus) buses. Includes North Star BASIC modified for hardware calculations; specifies whether disk or paper-tape version desired.

FPB-A. S-100 version; requires +8 V in 1 A. Kit/wired $259/$359
FPB-B. SBC version; requires +5 V, regulated, @ 1.5 A $299/$399

Z-80A PROCESSOR BOARD

(S1) Z-80 processor board for S-100 computers with or without front panels. Compatible with Altair and IMS front panels; auto-jumps to any 16-bit address at power-on and reset; with 1K EPROM (2708 space); 8-level vectored interrupt capability; jumper option to add wait state to RAM in computer; available with/without EPROM and supporting parts and sockets.

ZPB-A. Without EPROM option. Kit/wired $199/$259
With EPROM option. Kit/wired $249/$328
ZPB-PROM. Kit to add EPROM option $49

NUCLEAR PRODUCTS

CRT-100 VIDEO INTERFACE

16- or 64-char; accepts TTL parallel ASCII data; has composite video output with selectable pos/neg video and sync; on 3.5" or 5" circuit board, with 20-pin flat ribbon cable. Complete; unit includes: erasing, erase-line and erase-to-end-of-line; automatic scrolling; blinking underscore cursor; character adjustable for different CRT screen widths and scan rates. Requires 3V or 5V, 20 mA, 3.3A...

CRTC-1000. Similar and plug-compatible, but with user-definable character set; foreground and background video, protected video fields...

$45
CRTC-1000. Similar to CRTC-2000, but with Screen Read... $190

OBJECTIVE DESIGN

PROGRAMMABLE CHARACTER GENERATOR (51)
Primary software option for any video display cards such as VDM-1, Polymorphic VTI, etc. Works with video boards using Motorola 9-7 matrix character generator ROMS. Board includes parallel keyboard interface, 2-dimensional joystick interface provisions, and 2K onboard memory; can produce graphic images up to 512 x 256 (not bit-mapping—suggested where basic images are not the external system memory or DMA, requires +8 for board, 16 if interfaced to keyboard requiring 12V list of bus-controlled memory). Software is available, specific video display in use when ordering. Kit/wired $150/$200

High-speed option for (4-MHz systems) $16

DATABASE

(P1) PROM programming and storage card on board RAM. Holds up to eight 2716 or 2708 PROMs (16K or 8K bytes), plus separate socket for programming; computer can read programmed PROM in place of any other on board, under software control, for testing and verification; on-board static RAM (1K on 2708 boards, 2K on 2716) can be software-substituted for any PROM, to test program patches, or can be independently addressed; 2nd programming socket may be connected to external socket on computer front panel or housed separately; size of address space occupied is switch-selectable; any external interrupt latch, patchable to any interrupt line. Instruction set is programmable, 4-consecutive I/O ports or memory locations. Software on K.C. tape included. May be addressed as 4 consecutive I/O ports or memory locations...

$45

256 bytes RAM; real-time clock with selectable interrupts from 100 usec to 100 ms; power-on jump option, optional board key is when device is powered. Available in several configurations, with firmware including interrupt service routines, time-of-year and general timer alarms, console functions, etc... $200

PARASITIC

CLOCK FIX KIT

Temperature-compensated, non-overlapping clock for Altair 8800 and B8800...

$15

PARATRONICS

MODEL 150 "BUS GRABBER" LOGIC ANALYZER (51)
One-board logic analyzer for S-100 bus. Automatically monitors address and data channels; measures data bus, interrupts and controls signals, performs automatic clock qualification and clock polarity selection, also offers 8 user-defined signals interfacing via optional plug-in, flat ribbon probe assembly, providing independent 8-channel logic-analyzer functions, triggering, display formatting and operational; one's complement circuitry from hand-held pod connected to main pc board by cable; trigger word can be up to 24 bits; analyzer reads data at 16,000 times faster than it can capture over 8 million 16-bit words/sec, for use with faster, faster S-100 systems. Data words displayed as ones and zeros on oscilloscope; counting above 1000 increases signals as selection of 8-bit, 16-word truth tables, selectable from control pod. Pod also formats data in hex or octal groupings, stores or updates individual truth table interface provisions, and 2K onboard character memories...

$549/$629

8-bit data probe set...

$10

PERCOM DATA

CI-812 CASSETTE/Terminal INTERFACE (51)
Dual-function interface board for S-100 bus. Cassette interface is K.C.-standard, with independent record and playback circuits, optional relay kit for programmed control of two recorder/players. Also includes RS-232 terminal interface. Tape data transfer at 30, 60, 120 or 240 bytes/sec, RS-232 in 300-9600 baud. Kit/wired $100/$130

Remote-Control Kit...

$15

C-1200 INTERFACE BOARD

$15
Test cassette with operating software...

Operating system firmware (2708)...

$45

LFDO-400 MINI-DISK CONTROLLER (SS-50)
SS-50 controller board for up to 3 Mini-Floppy drives. (See "Peripherals" section for system details). Wired...

$325

PICKLES & TROUT

BDPIO PARALLEL I/O BOARD (51)
Allows interfacing of up to 6 parallel devices with only 1 cable from computer, free use of devices requiring more than one I/O port. Board has 6 bi-directional 8-bit I/O plus 2 static bidirectional buses. Bi-directional buses consists of 8 bi-directional data lines, 3 control lines, 3 port number lines, 6 filtered interrupt lines, +V ground, and one user-definable line. All interrupts to any location in memory; up to 6K PROM; 256 bytes RAM; real-time clock with selectable interrupt intervals from 100 usec to 100 ms; power-on jump option. Optional board key is when device is powered. Available in several configurations, with firmware including interrupt service routines, time-of-year and general timed alarms, console functions, etc... $200

$325

PAT-488 INTERFACE BOARD

(S1) (EE)
For bi-directional communications between S-100 computer bus and other devices such as on-board... Can function as controller, talker or listener; includes Bitwiggler tape interface, K.C. compatible; software on K.C. tape included. May be addressed as 4 consecutive I/O ports or memory locations...

With 488-compatible cable, Kit/wired...

$250/$325

1979 Edition
POLYMORPHIC

I/O IDEAS (51)
Prototyping board for I/O in blocks of four addresses. Requires +5 or +6 V at 370 mA, excluding user-added components. Kit $55

CPU
8080 processor with 1kV RAM, vectored interrupt, real-time clock, space for up to 3K ROM (1K ROM monitor available). Accepts inexpensive printer (serial) and cassette interfaces. Kit $215

Interface
Fits above MPU only. RS-232 or 20 mA. Kit/wired $65/$80

Cassette Interface
For above MPU only. Kansas City Printer Interface. Fits above MPU only. RS-232 or 20 mA. Kit/wired $65/$85

SOUTHWEST TECH PRODUC TS

MP-A 6800 PROCESSOR BOARD (55)
Includes 6800 MPU with Mini-Operating System, 128-byte scratch-pad memory, clock, baud rate generator (110-1200 baud), power-up/manual reset circuit. Requires +5 V (0.8 A. Bare board/kit $15/$110

MP-A2, Similar, but with sockets for up to 52716 EPROM, on-board DIP switch for easier address assignment. Bare board/kit $15/$145

MP-N CALCULATOR INTERFACE (53)
Hardware arithmetic calculations, to simplify machine-language programs and conserve memory; features Reversc Polish Notation, floating-point or scientific operation (to 8-digit mantissa, 2-digit exponent); four-register stack, memory register, trig functions; base-10 and natural logs; overflow indicator. Bare board/kit $10/$47

MP-T INTERRUPT TIMER (53)
Provides software-selectable interrupts of 1 usec, 10 usec, 100 usec, 1 sec, 10 msec, 20 msec, 100 msec, 1 sec, 10 sec, 100 sec, 1 min, 1 hour, also includes fully-buffered 8-bit input port with handshaking. Requires +5 V (0.3 A. 12 V @ 15 mA. Bare board/kit $10/$40

TIME SPACE PRODUCTIONS

MASTER I/O-ROM- RAM BOARD (51)
Combines serial and parallel I/O plus RAM and ROM, allowing minimal two-board system in conjunction with a CPU (kboard). 1K ROM, 3K ROM, 16-bit counter/timers, programmable as binary or BCD counters; programmable one-shots, digital delay, pulse or square-wave rate generator; software or hardware triggered strobe. Syncronous serial I/O (TTL levels) to 56K baud, software programmable; parallel interface with total of 24 possible I/O lines, programmable as input, output, bidirectional data or handshake: 2 I/O lines have bit/reset. Bare board/wired $48/$369

SPEECH TECHNOLOGY

M 188 VOICE GENERATOR (51)(MB)
Formant speech synthesizer and interface, for generation of speech from vocabulary stored in on-board EPROM, computer memory, or both. On-board socket for EPROM. Features 27024, 2716 EPROMs, holding up to 60 words or 35 seconds of speech; supplied with cassette tape of 95 common words; other vocabularies available; 500-ohm audio output designed for 3-meter transmission; BAUD rates from 520 to 41,000 baud. Kit $395

SERLIP

PROM SETTER

EPROM programmer board with external programming socket and 3 parallel ports (2 out, 1 in). Programs and reads all 24-pin EPROMS, including 1727A, 2704, 2716, 2711 Ti, 25024, 6384, supplied for programming. Can be expanded for any combination. Single-read/write EPROM socket can be externally mounted for easy accessibility, has write-enable/disable switch. Requires four 5V power supplies, and 4 I/O lines: +8 V (0.7 A. ±16 V (a 0.2A. Kit/wired $210/$375

RAWROM

Includes 64K of any 24-pin EPROM (16 sockets), can accept two different EPROM types, in two groups of 8. Has power-on/PM & run for computers with front panel, jump-on-reset and Mentor logic for computers without. Kit/wired $117/$168

TARBELL

1001 CASSETTE INTERFACE (51)
Savers and复 readers and data on audio cassette machines. Data transfer rates up to 450 bytes per second with high-quality cassette recorder, 187 bytes/sec. suggested for medium-quality recorders (both Tarbell formats); modifiable for Kansas-City format 4 27 bytes/SEC With Triple-1 Phi-Deck, 1000 bytes/sec./ 10 in/sec. Extra status and control lines available

for use with computer-controlled drives such as Phi-Deck, or multiple tape recorders with Ro-Chet controller (see Peripherals). Includes soft ware, room for user-developed circuits. Kit/wired $120/$175

TELESENSORY SYSTEMS

SPEECH SYNTHESIZER MODULE
Converts digital speech data on on-board ROM to analog voice output (external filtering and amplification required). Requires 6-bit parallel address and start signal-16V and 5V power on 3.3V square board with 22-pin connector: can be made TTL compatible. Available with choice of one 24-word, two 64-word vocabularies; custom vocabularies available on special order. $99. With 24-word Calculatory vocabulary ...... $95

SBC. With 64-word “Standard” vocabulary $179

SBC. With 64-word “ASCII” vocabulary $179

CALCULATOR SPEECH SYNTHESIS MODULE
With 24-word Calculator vocabulary only; specify English, German or Arabic. On 4” X 7” circuit board with 15-pin DIP connector, audio filter circuit, 200mA amplifier, power, 2 speaker $150

DAJEN UCR

Universal cassette recorder interface. Switch-selectable baud rates from 520 to 41,000 baud (maximum usable typically 5000 baud on cassette, 12,000 baud on 7/16” tape), switch-selectable Tarbell, Kansas-City or other format. Independent switch selection of transmit and receive data input for use with different recorders. Level indicator light. Relay option for independent control of two recorders; independent latch input port for key-board or other use. Kit/wired $185/$210

DAJEN SYSTEM CENTRAL INTERFACE
Combines ROM reader/programmer, RAM, serial, parallel and cassette interface on one circuit board. CPU program 2708 EPROM, read up to 3K, software included in 2K firmware monitor. Has 3 parallel ports, RS-232/20mA/60mA serial port. Cassette I/O compatible. (S1) label: bi-phase recording at programmable speeds from 800 to 100K baud; 2 on-board relays control 2 recorders; status lines can control automatic decks; sync and level indicator LEDs. Word information monitor. For use with CP/M, EPROM programming, video-board drivers, hex arithmetic memory examine/move/verify/search/clear, tape verify. With all output connectors. Wired $385

THINKER TOYS

DISK JOCKEY CONTROLLER
Controller board for full-size, 8 floppy disks. IBM compatible soft-sectored format. 256K bytes/disk. Can accommodate up to 8 drives, on-board ROM with bootstrap and other functions. 256-byte RAM buffer; board operates 1K starting at 340000 or 4000 hex (other 1K-bank addresses on special order). Software is initialized to use on-board memory-mapped I/O port, allowing easy use or access to minimal address space desired. Supplied with DISK/ATE (DOS/Assembler/Text Editor) and BASIC-V. CP/M compatible; patches supplied for those with CP/M, disk available. $179

Cable for disk drive $20

Additional connectors for multiple drives $15

Software options: see under Peripherals.

ELECTRONIC EXPERIMENTER'S HANDBOOK
KEYED-UP 8080... (S1)
Combination 8080 MPU/front-panel board, with oc-
tal keypad and display, two on-board I/O ports (for
keyboard), 256K RAM and 256-byte ROM. Fa-
tivities to start, stop, or step any program; processor
remains active after HALT command. Kit...$250

VAMP
EXTERNOMETER... (S1)
Combination extender/terminator board. Fused
power-buses, low profile fits inside S-100 cabinets;
active termination to reduce noise, crossstalk, over-
shoot, etc. on bus.

VTE-100-K/A. Kit wired...$50/$75

VTE-100-B. Extender only, with edge connector and fuse clips...$23

POLYGRAPHIX
Add-on graphics board for Poly video card (specify
whether Rev 1.2, F or H). Stores up to 128
generated characters, 512(H) x 128(V) graphics;
reverse field and video; piggybacks onto Poly video
card. For version 1.2/versions F, H...$125/$245
Assembled on Poly video card...$255

ACVM-1 VIDEO ADAPTER
For direct video input into TV set. See Peripherals.

RFWM-1 VIDEO MODULATOR. See Peripherals.

VECTOR ELECTRONIC
Microcomputer prototyping boards with bus
lines, DIP-spaced holes, and appropriate edge con-
nectors for the following microcomputer systems.

S-100 Boards... (S1)

8800V. Power & ground planes for wire-wrap, for
52 16-pin DIPs or equivalent...$20

8800V-B. 8800V with sockets and wrap-ports in
place and ready to wire, for 240-pin, 8 24-pin, 36
16-pin DIPs...$90

8801-1. Bare board with edge contacts, for 88 16-
pin DIPs, or equivalent in any size DIPs and com-
ponents...$15

8802-1. With 2-hole pads, power & ground burs;
for 42 16-pin DIPs or equivalents...$22

8804. With power and ground planes for wire-wrap;
for 70 16-pins or equivalent...$22

8801. With 1 pad per hole, plus power & ground
buses, for 16-pin DIPs or equivalent...$20

SBC MULTIBUS BOARDS... (MB)

4608. With 3-hole pads, power & ground buses, for
54 16-pin DIPs or equivalents...$45

4608-1. Bare board with edge contacts, for 144 16-
pin DIPs or equivalent...$34

H11 BOARD... (LS)

4637. For Heathkit H11, DEC LSI-11, PDP-8,
PDP-11. Bare board with edge contacts, for 89 16-
pin DIPs or equivalent...$16

VECTOR GRAPHIC

PRECISION ANALOG BOARD... (S1)
Contains two analog outputs, eight analog inputs,
one control port; 12-bit D/A and A/D conversion for
measurement and control of up to eight analog input
channels, dipolar and monopolar operation, user
breadboard area. PA. Wired...$390

ANALOG INTERFACE BOARD... (S1)
For interfacing with potentiometers, joysticks or vol-
age sources; 8-bit digital port with latch strobe can
be used as keyboard input port. Ton pulse genera-
tors can be used to produce sounds (450 and
800 Hz) for games or keyboard audio feedback. Four A-
D inputs. MWRITE logic and power-on jump for
computers without front panel; A/D resolution under
software control; 16-64 counts for cursor motion,
1024 or more for graph plotting or feedback con-
trols; typical conversion 480 usec for 16-count
resolution. All. Kit/wired...$75/$155

HIGH-RESOLUTION GRAPHICS BOARD... (S1)
Switch-selectable high-resolution (156H x 240V)
and grayscale (128H x 120V) display modes; 16-
level programmable gray scale; uses Vector Graph-
ic 8K static RAM board (not included) as refresh
memory, interfaces standard scan-convert monitors;
memory available for general use when graphics
not in use, with software alpha-numeric character
generator and x-y plotter. Requires +8 Vdc 750 ma
THP. GR. Kit/wired...$195/$235

2-80 BOARD... (S1)
Z-80 MPU, 4-MHz clock rate jumper-selectable;
jump-selectable automatic wait state allows 4-
MHZ operation with slower memory while maintain-
ing 8080 better throughput speed. Jump-select-
able MWRITE for systems without front panel; all
three Z-80 interrupt modes. Requires +8 V dc 750
ma. Wired...$215

8080 CPU BOARD... (S1)
8080-MPU board with real-time clock generator and
8-level priority interrupts. Requires +8 V dc 900 ma,
+16 V dc 40 ma, -16 V dc 10 ma. Wired...$190

WAMECO

WMC-8080A CPU WITH R-L LEVEL INTERRUPT... (S1)
WMC-8080A MPU board for S-100 bus, with R-L
level interrupt. Circuitry need not be built up until
system has real-time clock board.

CPU-1. Bare board/kit/wired...$30/$185/$220

WMC REAL-TIME CLOCK BOARD... (S1)
Includes 8-page source listing and 3-page flowchart
for Time-of-Day and Day-of-Week display;
whether Rev 1.2, F or H). Stores up to 128 user -
programmable words. Kit/wired...$95/$169/$229

WWW ENTERPRISES

DYNAMIC RAM

4K-16K dynamic RAM board for homebrew inter-
face. Connects via 4, 14-pin DIP sockets, has bank
select; 270-nas access time, 470-nas cycles. Requires
+12 V dc 33 ma, +5 V dc 40 ma, -5 V dc 5 ma.

WWW-16KA. Kit/wired...$449/$549

4K RAM expansions...$60

STATIC RAM

Similar to WWW-16KA, but static. 200-ns access,
300-nas cycle; requires 48 ma at +12 V, other re-
quirements same.

WWW-16KS. Kit/wired...$550/$650

4K RAM expansion...$90

XECON MICRO

SMART CASSETTE/I/O CONTROLLER... (S1)
Audio cassette interface with on-board RS-232/20-
ma serial port. Tape system has control, filing-for-
mating and search functions in ROM. Switch-
addressable to any of 512-byte memory segment;
records modified-KC standard tapes at 1200, 2400,
4800 bits/sec transfer. Requires +12 V dc 0.4 A, +5 V
dc 2.5 A, -5 V dc 0.2 A...$140

ACCESSORIES

ADVANCED ELECTRONICS DESIGN

101 TRIple-OUTPUT POWER SUPPLY... (S1)
Primarily for floppy-disk subsystems with up to 4
drives. +5 V dc 12 A, -12 V dc 0.7 A, +24 V dc 3.5
A (5.0 peak, max 2 minutes); other regulated out-
put configurations optional...$250

201 TRIPLE OUTPUT POWER SUPPLY... (S1)
Similar, but for up to 2 drives. +5 V dc 5 A, -5 V
dc 0.7 A, -24 V dc 2.6 A (3.5 peak)...$140

BYTE

BYT-8... (S1)
10-slot S-200 chassis with start switch (front panel
optional; see Module Boards section), real-time
clock, MWRITE logic; power supply delivers +8 V
dc 10 A, ±18 V dc 1.5 A each...$229

CGS MICROTECH

AUDIO INTERFACE

Adds audio-cassette mass storage to RS-232 port
or terminal extension port. Reads and records Kan-
sas City or Tarbell Bi-Sync tapes. Bare board/kit/
wired...$10/$30/$50

FREE CATALOG

115

CIRCLE NO. 23 ON FREE INFORMATION CARD

A bright stars of the Little Dipper®

FASTEST manual DIP inserter in the market.
Guaranteed never to wear out.

• Rugged
• Self-aligning
• Static control — Safe

SPECIAL!

10% Discount/12 or more

SEND FOR
FREE CATALOG

TECHNI-TOOL inc.
Apollo Rd., Plymouth Mkt., Pa. 19462 (215)825-4990 Tix 83-4763

1979 Edition
For rack-mount or table-top use, has room for motherboard and power supply, with end plates, side rails, card guides and mounting hardware. Kit/Assembled $50/$60

COMMODORE/MOS

KIM-4 MOTHERBOARD (KM)
Interfaces KIM-1 with up to six system expansion modules, with all required buffering (motherboard not required to interface KIM-1 with a single expansion board). Includes +5 V, +12 V regulators (external power supply required).
KIM-4 $119

COMPUTERWARE

QM MOTHERBOARD (SI)
14-slot motherboard, including slot for front panel (passively terminated). Wired $120

CROMECO

CARD CAGES
Assembled S-100 card cages, complete with Blitz Bus shielded motherboard, full set of wave-soldered edge-connectors, card guides and card-retaining bar.
CC-8 slots $195
CC-21 21 slots $395

CURTIS ELECTRONIC DEVICES

HAM S-100 (SI)
Computerized Morse and Baudot code operating system for ham radio. Receives, decodes, and displays (on user's CRT) Morse or 5-level Baudot TTY at 10-100 or 60-100 wpm. Also serves as keyboard or paddle with CRT display of transmitted text. Contains 7K EPROM with SOL firmware (patchable for other 8080 systems), 1K RAM $700

DIGITAL MICRO SYSTEMS

CRT LOWER-CASE KITS
Add lower-case letters to terminals specified below. Assembled. Takes 15 minutes to install.
A to O $18
A to Z $25

DYMA ENGINEERING

LINE SURGE PROTECTORS
Protect 120-V electronic equipment against power-line surges. 20-A capacity. Available with barrier strip connections (#1AC) 2-pin AC connector and plug (#2AC), 3-wire U-ground connector and plug (#3AC) $17

ELECTRO-DATA POWER

E.D.P.-188 POWER SUPPLY
Tripolar output: +5V dc @ 2.5 A; -5V dc @ 0.3A, +12V dc @ 0.3A, all regulated ± 1%. Output ripple 50 mV rms maximum. Current limited ±5V output; circuit breaker on ac line. In cabinet, 3½" x 10" W x 7 D $70

E.D.P.-190 Dual-output: +5V dc @ 1.2A, +12V dc @ 100 mA. ±1% regulation, 50 mV ripple max. In cabinet, 3½" x 5¼" x 9½" $39

ELECTRONIC CONTROL TECHNOLOGY

ECT-100 CARD CAGE (SI)
Card cage for S-100 boards, mounts in 19" rack.
ECT-100 With 20-slot motherboard, connecters and guides. Kit/wired $200/$250
ECT-100 With motherboard only. Kit $100

GODBOUT

16-SLOT MOTHERBOARD (SI)
Includes all edge connectors, active termination circuits (see Module Boards); connectors on 0.75" centers, 1.5" spacing on 18th connector for front panel, etc. $124

10-11-SLOT MOTHERBOARD (SI)
Same features as 18-slot, but shorter (8.5" x 11"), with 0.75" connector spacing throughout. Can be used as 10-slot extension to existing system, or as 11-slot stand-alone system $90

Bare board, with instructions $30

CPU POWER SUPPLY
Regulated supply, 5V (±4A with crowbar overvoltage protection; ±12V ±1A, adjustable (±5V to 10V) negative bias supply ±10 mA $50

12V 8A SUPPLY
Handles 12A peaks with 50% duty cycle; crowbar overvoltage protection; short protection, current limiting; RF suppression; output adjustable 11-14V $44.50

INDUSTRIAL MICRO SYSTEMS

DUAL-DRIVE FLOPPY COMPUTER CASE (SI)
12-slot S-100 motherboard and power supply in enclosure with openings for two 800-series Shugart or PerSys 277 floppy drives; 19" rack mount or desk top with wood sides; all plugs and connectors. 61-0070. With wood sides $705

Rack $655
Less motherboard $565
Less motherboard and power supply $499

MOTHERBOARD (SI)
12-slot motherboard, with AMP 100-pin edge connectors; reset lines terminated; cross grounds between pins; slot and screw connectors for power supply.
C00301 Wired $90

MICRO DATA SYSTEMS

MD-601 MAINFRAME (SI)
Six-slot motherboard, power supply, in aluminum case with redwood and panels, space for two miniflop drives.
Kit/wired $139/$179
M-61 Six-slot motherboard. Kit only $20

MICRO TECHNOLOGY UNLIMITED

K-1000 POWER SUPPLY (KM)
Basic KIM-1 power supply; enclosed, terminal-strip output. +5V ±0.2A, ±12V ±0.1A regulated; ±7.5V ±0.75A, ±16V ±0.25A, unregulated. $40

K-1000-2 ADVANCED POWER SUPPLY
For KIM-1 and most other one-board systems. Similar to above, but +5V ±2A, ±12V ±1A, regulated; ±7.5V ±2.5A, ±16V ±2.5A, unregulated. $74

K-1005 CARD FRAME AND MOTHERBOARD
Hold KIM-1 and up to 4 other Kimbus compatible boards under it; requires no extra table space. $68

MIDWEST SCIENTIFIC

HARDHOLES
Protect diskettes from center-hold damage due to improper insertion, clamping-hub slippage, or improper alignment. Mylar; require mounting tool.
HDH-1 Box of 50 hardholes $12
HDT-1. Hardhole mounting tool $9

COMPUTER SYSTEM CABINET
Walnut veneer cabinet with slide-out work surface and front doors. Available with two interior partition settings; A and B (recommended for systems with large CRT, A for systems with small; consult maker for dimensions); overall dimensions 46" H x 24" W x 18" D $650

MOTHERBOARD (SI)
SS-50, 16-slot motherboard, with connectors; connections for front-panel power, reset, IRQ and NMI; requires MSI Interface Adapter board if decoded-address interface slots desired.
MB-1 Kit/wired $85/$135

INTERFACE ADAPTER BOARD (SI)
SS-50 (SI) interface-card board; eight I/O slots, strappable for 4 or 8 decoded addresses per slot, allowing use of cards with more than one PIA chip; adapter strappable to any desired high-order interface address. 1A-1 Kit/wired $54/$81

MSI CHASSIS & HARDWARE KIT
For MSI motherboard and interface adapter board power supply.
CH-1 Kit $45

POWER SUPPLY
+5V ±20A, ±15V ±2A each; can support 800 system with 56K RAM and/or PROM. All dc circuits individually fused. Power supply tapped for line voltages from 105-125V and 210-250V ac.
PS-1 Kit/wired $724/$105

NO NAME

MAINFRAME
To accommodate S-100 and other motherboards. With S-100 power supply; fused, switched-accessory power receptacle; fan; line cord; rear panel punched for 6 DB-25 I/O connectors, 3 BNC-video/ audio connectors; front panel has lighted reset button, keyed power switch; power +8V ±10A, ±16V ±1.5A 3A, dimensions 17½" W x 17" D x 7" H. Assembled $310

CARD CAGE
For S-100 cards, fits all S-100 motherboards. With 12 sets guides, assembled. $39

OBJECTIVE DESIGN

CARDFRAME CONSTRUCTION KIT (SI)
Builds 22-slot S-100 mainframe. Includes pre-punched front and rear panels, support and structural bars, motherboard supports, 10 card guides, chassis plate, optional power supply. Panels include cutouts for switches, power cords, connectors, and motherboard extensions. No motherboard or fan provided, but will accept most popular S-100 motherboards; frame allows addition of front panel, cover and bottom plate (not supplied) $50

With power supply ±16V ±2A, 110/120/130V in $155

PARASITIC

CONSTANT-VOLTAGE KIT
Constant-voltage transformer, high-current rectifiers and improved filtering to maintain Altair performance with line voltage swings up to 90-140V. $100

24A POWER SUPPLY KIT
General-purpose power supply with constant-voltage transformer. +9V ±2A, ±16V ±6A at 6A total. $210

PENTEC

MS-4 CARD RACK (EX)
Card rack for Motorola EXORiser, Micromodules, and MEK68002 microprocessor, and other compatible boards. Rack can accommodate up to 4 boards; power supplied via barrier terminal block on motherboard; four 8-pin edge connectors; cards guided. Kit/wired $85/$90

E&L PFEIFFER

HEXADASIY CALCULATOR
Circular slide rule for hexadecimal calculations. Calculations relative addresses, two's complements, hexadecimal addition and subtraction; converts decimal to hex and back. $4

SMOKE SIGNAL BROADCASTING

PS-1 POWER SUPPLY MODIFICATION KIT (SI)
For SWTPC 6800. Provides ±16V up to 2A, to power up to 5 fully-loaded Smoke Signal P-38 EPROM boards; also allows SWTPC 6800 8V supply to be increased by 1V, for more adequate regulation with line voltage fluctuations of less than 16K of memory. $25

SOUTHWEST TECH. PRODUCTS

MP-B MOTHERBOARD (SI)
Provides 7 SS-50 slots (for processor, memory, etc.). 8 SS-30 I/O-board slots. Bus may be paralleled onto another MP-B with power supply. Bare
Converts numbers in base 8, 10, or 16 to either of the other bases, performs arithmetic in all 3 bases; mode indicator shows base in use; eight-digit capacity. Hex and octal use two's-complement arithmetic, one's-complement key-selectable; logical AND, OR, XOR and Shift. Decimal base features signed floating-point arithmetic. Three-key memory stores, recalls or sums to memory contents, parentheses allow operation order to be specified, up to four pending operations. Can handle mixed bases, combined logical and arithmetic operations; constant mode for arithmetic and logical operations. With case, fast-charge batteries & charger $50

**SQUARE 1**

**FLIPPY-DISK-KIT**

Pc board with 1 male, 1 female RS-232 interface; enables user to check all lines to see which ones are active; probe posts and an LED included. $25

**LINE TESTER KIT**

Converts most 5 1/4" mini-floppy diskettes for dual-sided use. Punch and template for holes allowing both sides of disk to be used; only for diskettes whose reverse side is coated or burnished. $10

**TERMINAL DATA**

**PROGRAMMABLE LINE AND TERMINAL SIMULATOR**

ASCII code generator, for checking terminals, ports and modems; also usable for burned in digital devices after construction. Kit wired. $199/$249

**TEXAS INSTRUMENTS**

**TI PROGRAMMER**

Hexadecimal/octal/decimal calculator/ converter. Converts numbers in base 8, 10, or 16 to either of the other bases, performs arithmetic in all 3 bases; mode indicator shows base in use; eight-digit capacity. Hex and octal use two's-complement arithmetic, one's-complement key-selectable; logical AND, OR, XOR and Shift. Decimal base features signed floating-point arithmetic. Three-key memory stores, recalls or sums to memory contents, parentheses allow operation order to be specified, up to four pending operations. Can handle mixed bases, combined logical and arithmetic operations; constant mode for arithmetic and logical operations. With case, fast-charge batteries & charger $50

**ULTRA-VIOLET PRODUCTS**

**UVS-116 EPROM ERASING LAMP**

Erases up to 4 UV-erasable EPROMs at a time, in as little as 20 minutes, has safety interlock to protect eyes. EPROM holding tray holds up to 4 chips at constant 1" exposure distance, has conduction foam liner to prevent electrostatic buildup, transmits visible while blocking UV light. Lamp shuts off when lifted from tray. Provides 1 watt/sec/cm2 in 200 secs. (Larger systems available.) $65/$70

**VECTOR ELECTRONIC**

8807 MOTHERBOARD (S1)

11 slot, S-100 motherboard, with etched circuit for active or passive termination $30

**VECTOR GRAPHIC**

8-SLOT MOTHERBOARD (S1)

18-slot shielded motherboard, connectors, card guides and card-locking buttons. With all connectors, no cards. Wired $295

**HEAVY-DUTY POWER SUPPLY**

- 8 V $18
- 16 V $2.5 A
- 110/120/130 V primary: with mounting bracket, fuse, all hardware.

MPS, Wired $125

**MAIN FRAME**

(S1) Eight-slot mainframe with front-panel reset switch, rear-mounted power switch; motherboard with eight connectors, power supply $356

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