Electronics Today

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April 1986

Canada's Magazine for Electronics & Computing Enthusiasts

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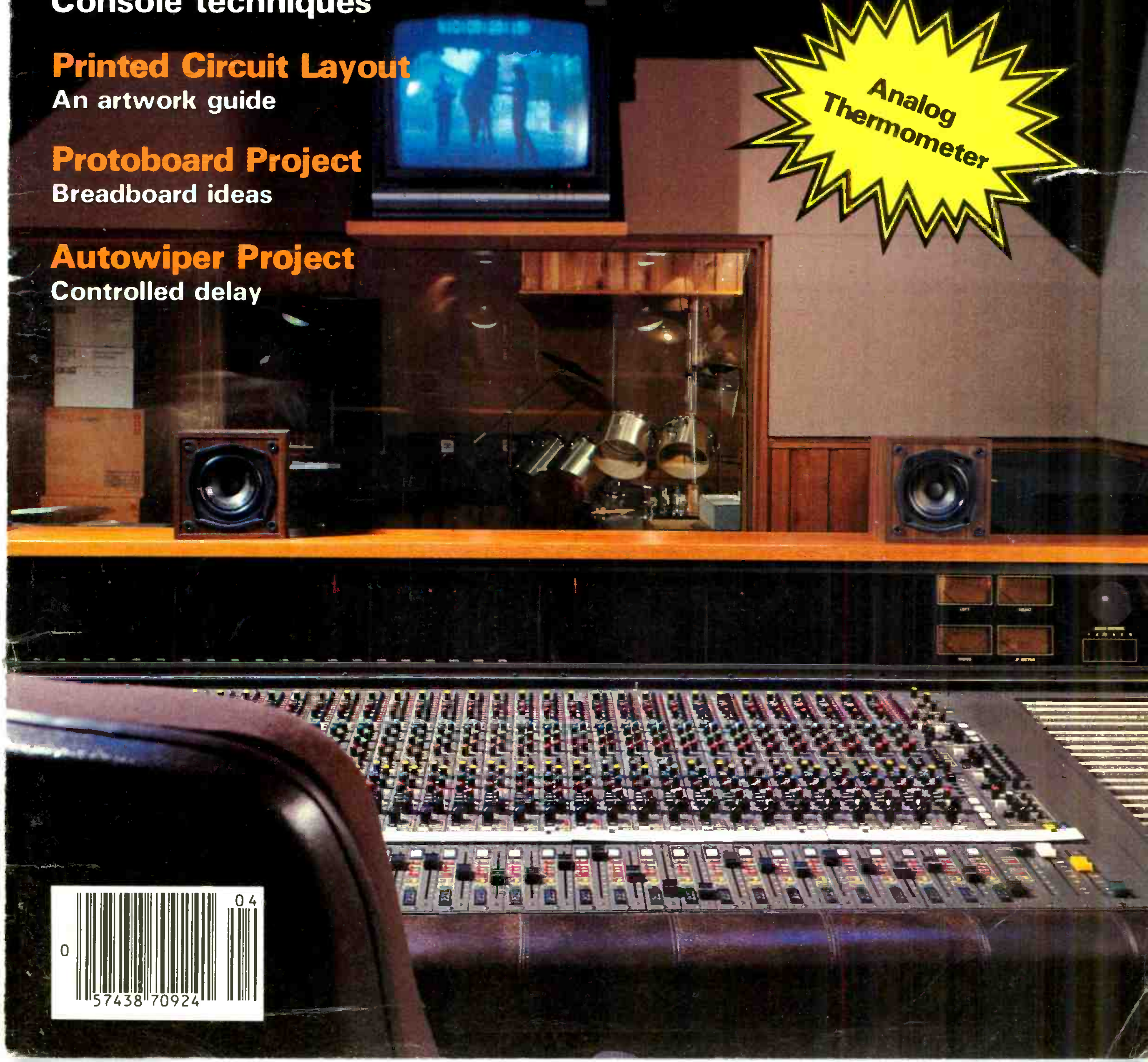

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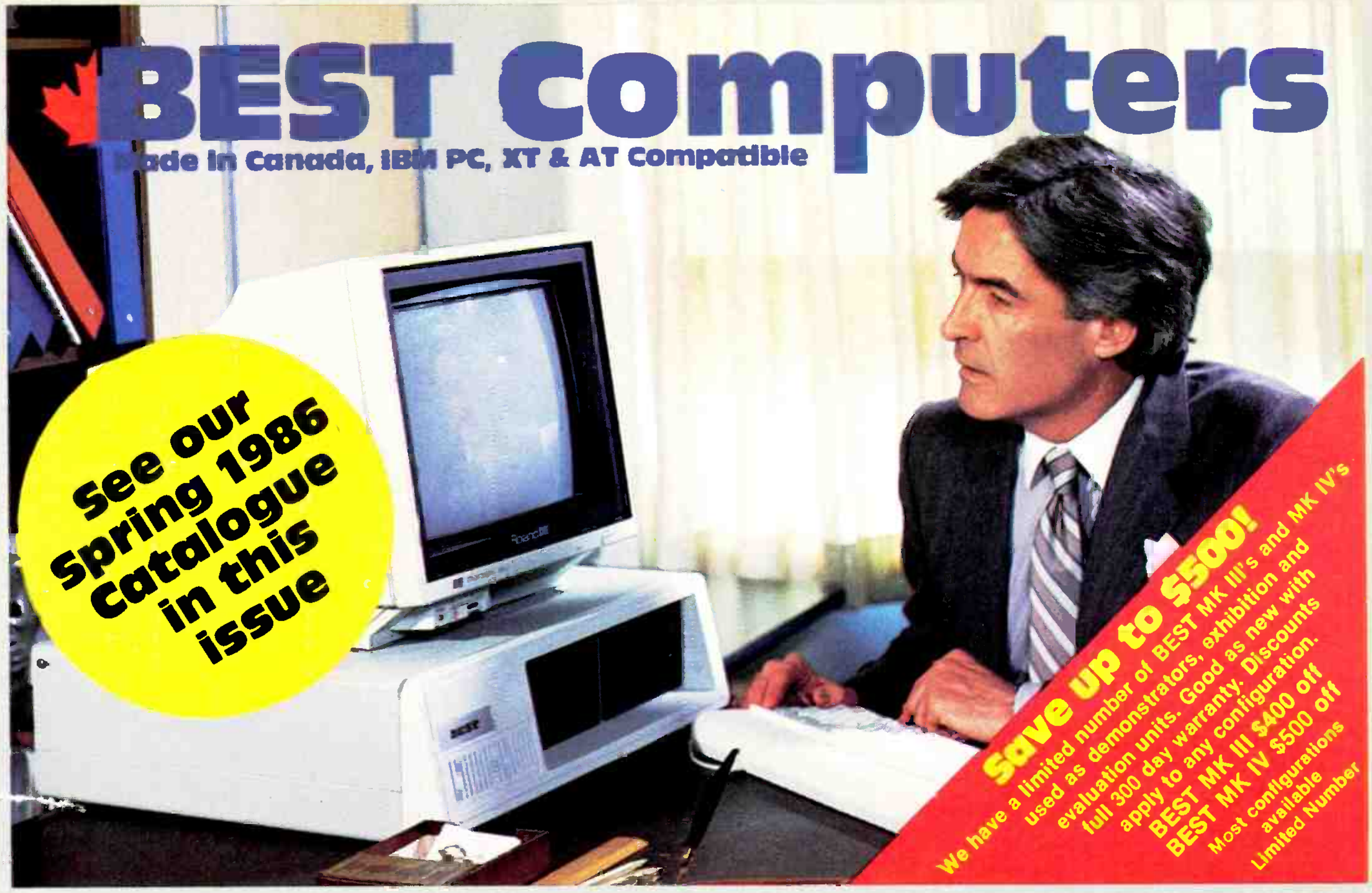

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TOMORROW'S TECHNOLOGY TODAY

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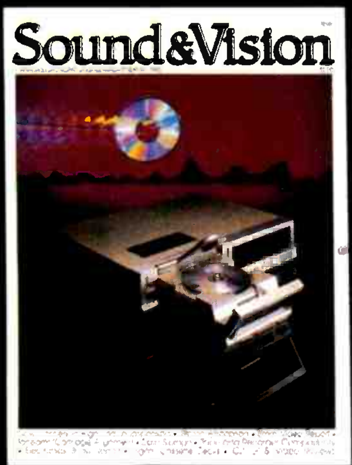

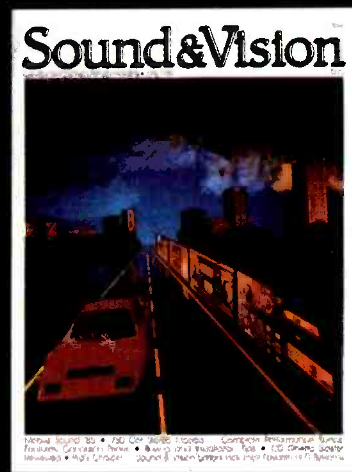

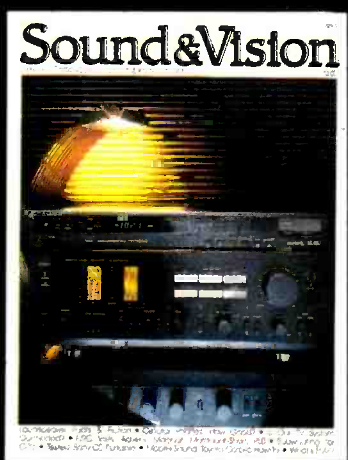

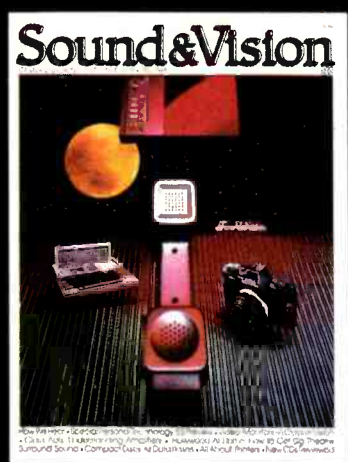

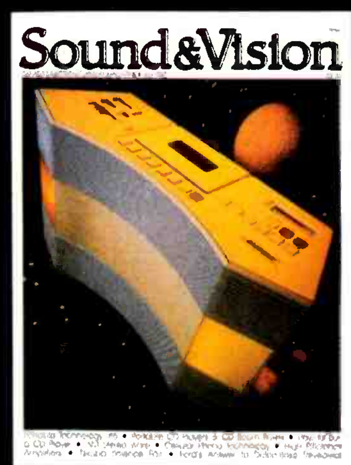

With it, you can check loudspeaker and tape deck frequency response, channel balance and speaker phasing; evaluate turntable rumble, cartridge tracking and stereo separation; and optimize speaker positioning and low-frequency performance. No special equipment is required; step-by-step instructions allow you to make the most of your hi-fi system's performance.

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Our Cover

Special thanks to the staff at The Master's Workshop, Rexdale Blvd., Toronto, for letting us invade; shown is the MCI console doing soundtracks. Photo by Bill Markwick.

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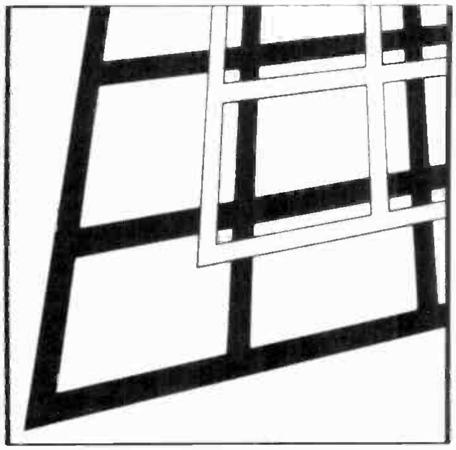

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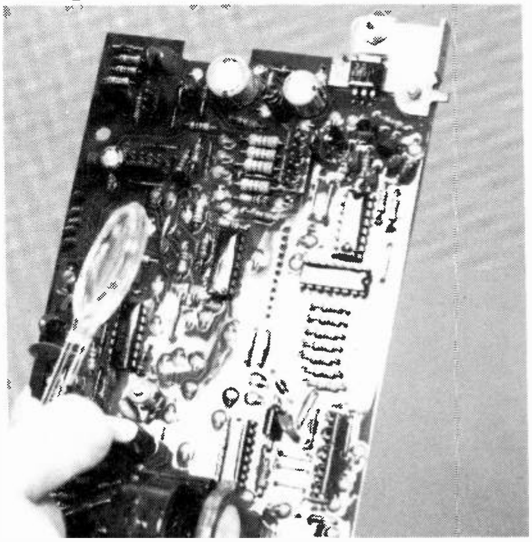

Loctite's new Shadowcure 361 is a PCB coating which can protect boards from environmental exposure. It's sprayable and cures in seconds under ultraviolet light. The thin protective film resists solvents and moisture. Loctite Canada Ltd., 5115 Timberlea Blvd., Mississauga, Ontario L4W 2S3, (416)625-6511.

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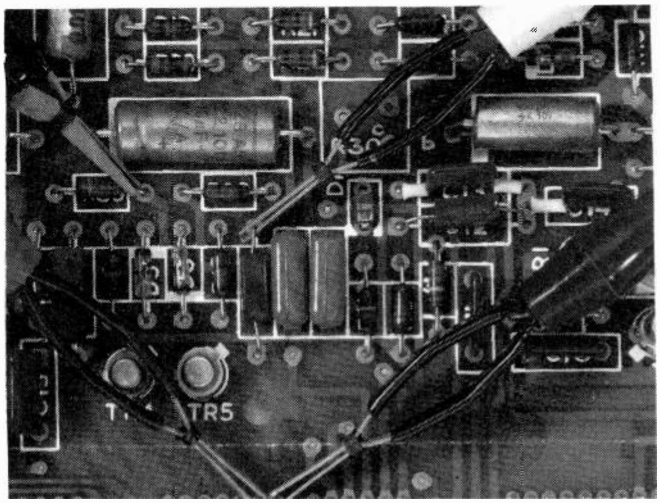

Miniclips from Maag Technic of Switzerland are called 'eagle' clips because of the beak-like tip. The metal spring tips open easily and close securely in the smallest of spaces; the spring clips are coated with epoxy insulation right up to the tip. From I.J. Safety Distributors Inc., 3356 Henry St., Port Moody, BC V3H 3K4, (604) 461-3191.

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Digital Thermometer

The model 901C hand-held digital thermometer from Brunelle Instruments operates with a Type K thermocouple with a five-foot length. The 3 1/2 digit display has a hold switch; temperature range is -50 to 750 degrees C with an accuracy of plus or minus 0.5 percent. For further information, request bulletin 901C from Brunelle Instruments, 73 6th Range S., St. Elie d'Orford, Quebec J0B 2S0,, (819) 569-1408.

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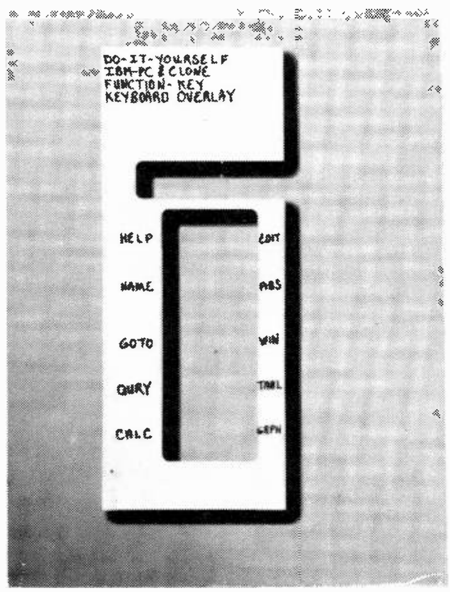
Low-Cost Overlay



If you can never remember how you've set up the function keys on your IBM or compatible, these mini-templates are the simplest answer. They're six for $9.95 (US) plus $1 (US) for shipping. Made of plastic and stackable for use with different software, they have a surface that accepts pencil or pen. Micro Logic Corp., PO Box 174, 100 2nd St., Hackensack, New Jersey 07602, (201) 342-6518.

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Component Notation and Units
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. Electronics Today has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1 uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.
Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

PCB Suppliers
ETI magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies when ordering boards.
Please note we do not keep track of what is available from who so please don't contact us for information PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

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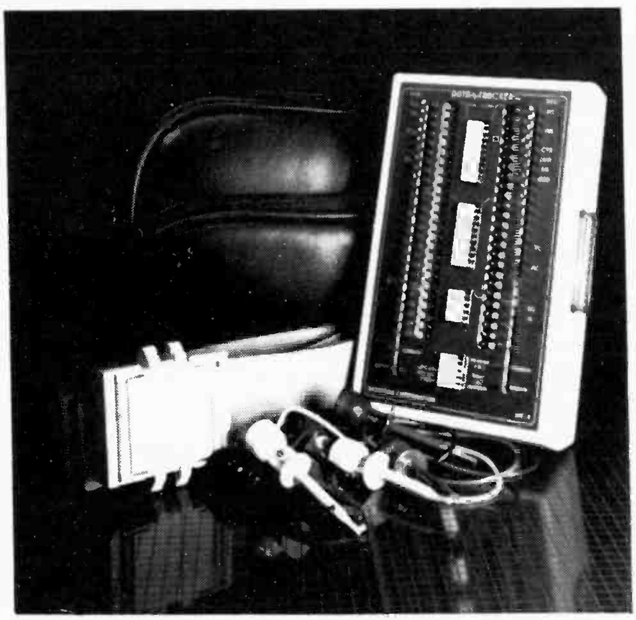
For Your Information

RS232 Breakout Box



The Datatracker has turret-topped test points that permit easy multiple clip lead connections or accessibility to other test equipment. The indicator LEDs draw only 2mA each, a typical RS232 receiver load. Contact Home Base Inc., 60 Nably Court, Scarborough, Ontario M1B 2K9, (416) 293-4488.

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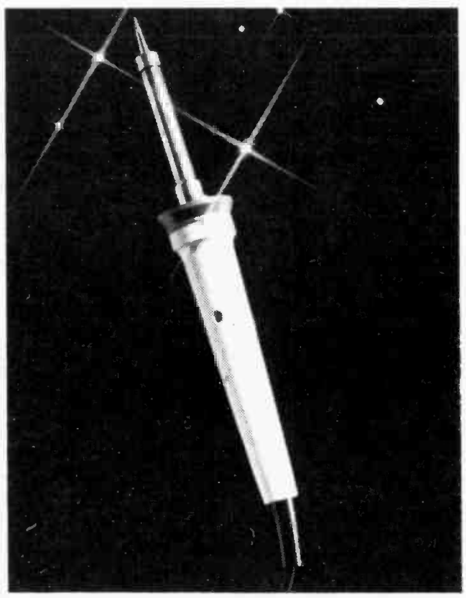
Controlled Iron



The Oryx Platinum 45 has a thick film cermet element and a platinum temperature sensor. The iron runs directly from 115VAC and is rated at 45 watts. The temperature is adjustable by the user over the range 490 to 750 degrees F. The control circuit features zero-point switching to eliminate RFI. Oryx, 4 Columbus Avenue, Mt. Kisco, NY 10549, (914) 241-0237.

Circle No. 35 on Reader Service Card.

Continued on page 28

Automatic Test Equipment

Analog electronics is considered by many electronic engineers to be a black art, and the testing of analog circuits even darker.

By W.P. Bond

BECAUSE OF the specialized nature of most analog circuits, the main limitation on their design is the ingenuity of the designer. It is difficult to lay down any single technique which would work for all possible analog circuits. The automatic test equipment used to test analog circuits must allow for a variety of different techniques and has to be capable of being modified to provide a range of input stimuli and response measurement configurations. Such ATE is usually described as modular.

Modular ATE will incorporate a standard instrument bus (most commonly, the IEEE 48 or General Purpose Interface Bus, GPIB) and all the test instruments required can be hung on the bus. The instruments are controlled by the ATE program and are routed to the unit under test (UUT) by a set of scanners, for example, a relay matrix. Each instrument can be considered a module of any given testing configuration. Each testing configuration would employ a particular set of modules, typically including programmable power supplies, programmable DC sources, an AAC source, a digital voltmeter, general purpose or reed relays, a phase angle voltmeter and logic units to perform drive and sense functions. Specialist modules would include spectrum analysers, synchro sources and pulse generators. For obvious reasons, such a modular system is often referred to as 'rack and stack', and a typical configuration is shown in **Fig. 1**..

Having a Breakdown

The circuit to be tested is broken-down into functional blocks for which we have defined test procedures. **Fig. 2** shows a basic block layout for a data acquisition subsystem, consisting of input buffering, input multiplexing, sample and hold, analog-to-digital conversion, output buffering and control/decode logic.

This last block should be tested first in any circuit in which it features. Signature analysis or static truth-table testing could be used. Input buffering and multiplexing come next and are tested for insertion loss and crosstalk errors. All MUX inputs are grounded and the addresses are stepped through in sequence until all channels have been selected.

Insertion loss results from the inclusion of networks and functional blocks in a signal path. It can readily be measured by comparing output with input (voltage, current or power) and if the result is outside acceptable limits, the measurement can be interpreted as indicating a fault within the network or functional block. Similar comments apply where insertion gain might be expected from the inclusion of amplifying stages in a circuit.

In our example, the output of the multiplexer would be monitored assuming a fixed input. If the analog-to-digital converter in the circuit operates at a full-scale (FS) of 10V, insertion loss might be tested at + FS, -FS and 0V. The limit for acceptable loss in this sort of circuit would usually be set at the voltage equivalent of one least-significant bit (1 LSB) - with a 12-bit bipolar ADC operating over a 20V range this would be 20V/4096 or 4.88mV.

As each channel is tested for insertion loss, the other inputs are grounded. Tests for input shorts and multiplexer selectivity (channel isolation or crosstalk) can be carried out at the same time since, if any channel is not isolated when another is selected, the output of the multiplexer will be loaded. Pin faults can also be detected during this procedure.

The sample and hold (S-H) circuitry is tested next. Its function is to hold the instantaneous (sampled) input voltage constant while the ADC is converting it. All tests after the MUX will usually be made with a signal routed through one particular channel so that known channel losses can be accounted for and kept constant. In testing the S-H block, it is desirable to have low offset in sample

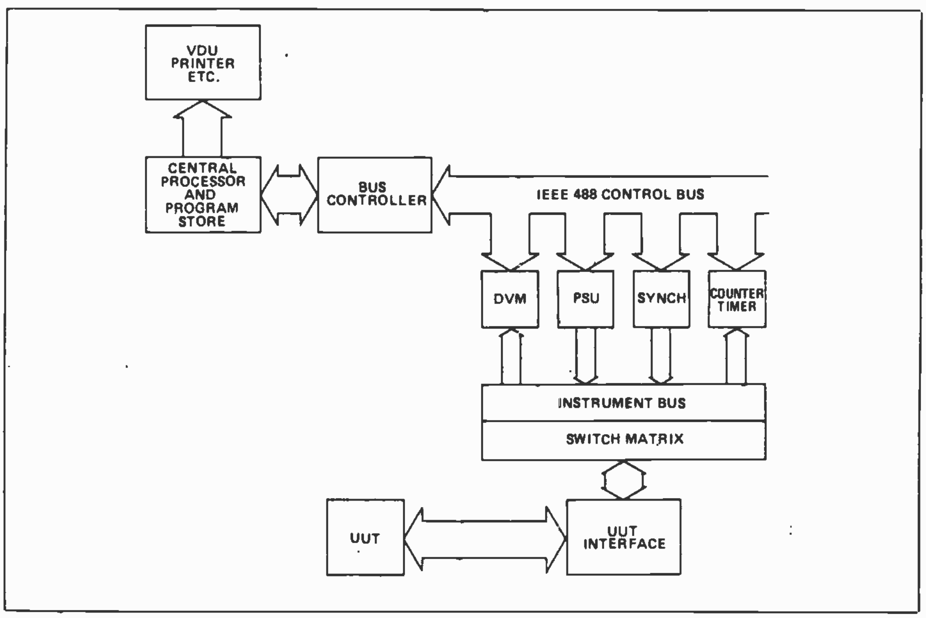


Fig. 1 Analog test-bed.

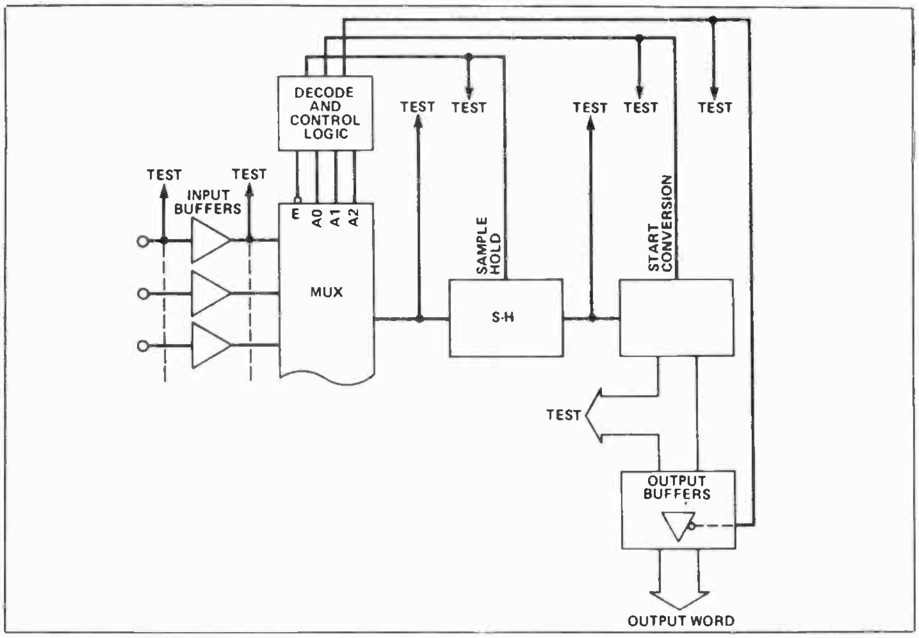


Fig. 2 Data-acquisition system.

mode with 0V and +/-FS as suitable input voltages. Acceptable errors are specified in manufacturers' data sheets. It is easier to check S-H hold performance by performing a conversion than by dynamically measuring the drift.

Testing the Converter

A comprehensive test on an ADC block can be very complex. First, offset and gain adjustment should be set according to manufacturers' directions. After adjustment, the 0V offset should be tested to check that it is within 1 LSB. Offset (or zero scale) error is a measure of the difference between theoretical and actual behaviour of an ADC at zero input voltage. As **Fig. 3b** shows, the effect is to shift the transfer characteristic of the ADC to the right or left. Offset is determined as the difference between the theoretical and actual input voltage at which the output of the ADC switches from zero to one bit and can be expressed as a percentage of the full-scale voltage. it is usually adjusted to 1/2 LSB, at which value quantization error is minimized.

Gain (or full scale) error is a measure of the difference between the theoretical and actual behaviour of an ADC at an input equal to full-scale (**Fig. 3c**). The effect is to rotate the ideal transfer characteristic about the origin. The error is determined as the difference between the theoretical and actual input voltage at which the output switches to full-scale and is expressed as a percentage of FS. Gain error is sometimes adjustable to zero in the circuit, but where it is greater than 1 LSB and is not adjustable, it will have to feature in later calculations.

The single most important error when it comes to determining the performance of an ADC is linearity error. It is a measure of the maximum deviation of actual performance from the theoretical straight-line (**Fig. 3c**). It is an intrinsic feature of the ADC and cannot be adjusted, and it should be measured after offset and gain have been calibrated. it is expressed as a fraction of LSB or as percentage of FS and it is tested for by checking actual ADC output against expected output for a range of definite input voltages. The number and value of the test voltages are fixed only by the degree of accuracy desired.

The final test for ADCs is for differential non-linearity (DNL) which will reveal missing codes. Differential non-linearity implies that the ADC will display non-monotonic behaviour and it is, if it exists, an intrinsic feature of the particular ADC. The ideal step size for any ADC is 1 LSB. A deviation from this ideal may result in some codes not appearing at the output at all (**Fig. 3d**). The important parameter is code-width, that is, the voltage range over which a given code will be output. It should be clear that a code width of 1 LSB gives a differential linearity error of zero, in other words, there will be missing codes.

Testing for code-width usually demands a programmable DC voltage source with a high resolution (at least 1mV). By gradually incrementing the voltage applied to an input in, say, 1 mV steps it is possible to count the number of steps between actual transition points and compare the count with the theoretical code-width representing 1 LSB in mVs. An error can then be used to generate a fault message. The accuracy is dependent on the precision with which the transition voltages can be determined. Differential non-linearity only relates to adjacent codes. In order to obtain a comprehensive idea of the DNL of an ADC it is, of course, necessary to test at every transition point.

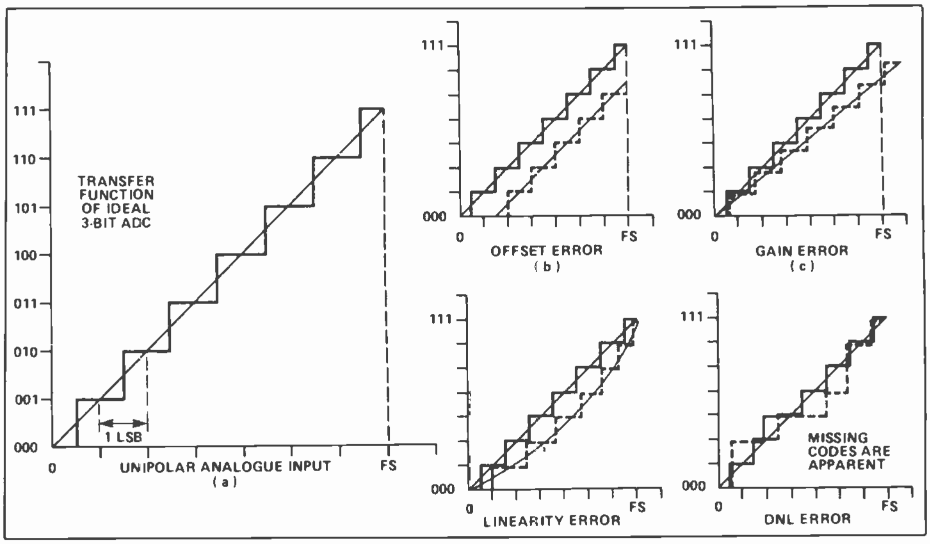


Fig. 3 ADC errors.

The final test in our example circuit would be on the output buffer. The required procedures have all been dealt with before, so I won't repeat them. The principles outlined above for testing analog units can be readily modified for the testing of practically any such module.■

Almost Free PC Software

Volume VII

Total sensory overload on a single floppy disk

There seems to be no end to the ingenuity one finds in public domain software for the IBM PC. Far from being simply programs and video games, there seems to be stuff for every application, ranging from end user applications to business packages. We've assembled another selection of some of its finest works.

This disk includes a host of remarkable code. Some, like PCBW, are tiny files that solve large problems. Others, like QUIKGRAF, a business graphics generator, are complete applications in many ways comparable to commercial software.

BLACKJACK is a BASIC implementation of this popular card game. It's both interesting to play and enlightening to dismantle. It can, of course, be easily listed so you can see how it works.

EDSCR is a screen editor which can be used with pretty well any programming language from assembler to dBASE III. It generates PC screens replete with block graphics and text, creating universally applicable source files for them. An example screen is included.

FK allows you to make the function keys of your PC do more useful things under DOS. You can program them for macros, store your most used commands in them and generally make them less mysterious.

FXMASTER is a printer program for the popular Epson FX series printers and all work alikes. It uses a full screen menu to give you easy access to the features of these powerful boxes.

INDEX allows you to generate indexes from WordStar documents... or text files from any other text editor, for that matter. It's an invaluable writer's tool.

KEYCLICK is a resident program which will make your keys click. It's very small, easily included in an AUTOEXEC file and solves a multitude of problems associated with clone keyboards.

PCBW is another tiny program... run it and it will convert colour screen displays from one's software to black and white video for a green screen monitor.

PINBALL is a pinball simulation that's easily worth the cost of the disk all by itself. It will waste more of your time for you than you knew you had.

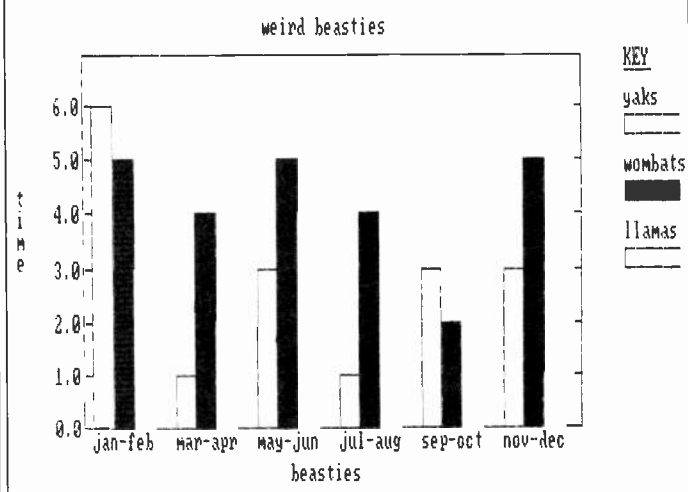
QUIKGRAF is powerful business graphics package which renders complex bar, line and scatter charts in medium and high resolution. An Epson compatible printer with GrafTrax is required to produce hard copy with this package.

SERPENT is a variation on the classic snake game in BASIC. It's remarkably fast and moderately weird.

SHOWCLK is yet another clock program... it's the smallest one yet, and it beeps to chime the hour.

VTREE is a graphic TREE program that shows you how the subdirectories are set up on your disk... in a much more easily understood way than does the MS-DOS TREE utility.

WORLD is a remarkable program which incorporates a world map. It allows you to zoom in on bits of the globe, locate major cities and perform a number of useful calculations about the map. It also has a feature for tracking hurricanes... tracked any good hurricanes recently?



Sample plot from QuikGraf

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Almost Free PC Software

Volume VIII

This is another collection of fairly large applications. We've had to spread them over two disks. However, the extra three bucks is nothing compared to the power of some of this software. Whether you're interested in games, business applications or code hacking, you'll find something of interest in this larger than usual collection of programs. In addition to the programs themselves, the set includes all the support files needed to use them.

Load-Us allows users of the popular Lotus 1-2-3 and Symphony programs to run them on a hard drive. It isn't a cracking program, but, rather, a preboot to avoid the inconvenience of this copy protected software for legitimate users.

DDCal is a very clever perpetual calendar and desk diary. It keeps track of your appointments and performs several other functions that you probably thought could only be done on the backs of match books.

PC Key Draw is the remarkable public domain paintbox program which blows away so many commercial applications. It'll handle multiple screen images, business graphics and superb computer art...all in full colour. It's worth the cost of this package all by itself.

CPU is a tiny program to tell you the effective speed of your system.

Xray is a remarkable co-resident utility to monitor what a program is doing while it's busy doing it. It allows you to interrupt the execution of your code and have a look inside.

Game...well, there are no words for this program, or, at least, none that are printable. This game is a bit rude... depending on just how weird your mind is, it can get pretty bizarre. This program does use some suggestive language, and we recommend that young or sensitive users not boot it.

Tune is a very small music generator to make noises from within batch files. It's useful to see where things are in a complex process.

Chasm, or cheap assembler, is just the thing if you want to get into assembly language programming but don't want to spring for the Microsoft macro assembler package. It's reasonably fast, not too huge... it'll run in as little as sixty-four kilobytes... and, above all, cheap.

Getdir is a resident directory utility. It allows you to see what's happening on your disks even if you're in the middle of doing something else.

CopyPC, not to be confused with the commercial Copy II PC, is a quick disk backup utility for the IBM.

Lookit is a full screen browsing program to let you scroll forward and backwards through text files... a sort of a tiny word processor that can't edit anything.

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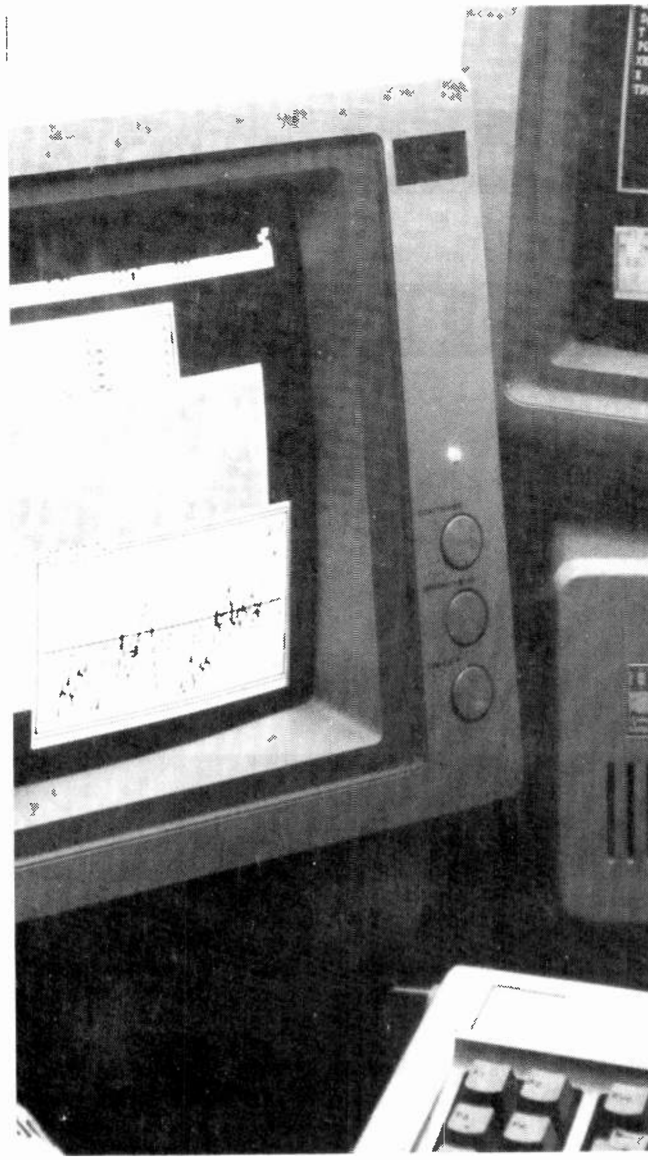

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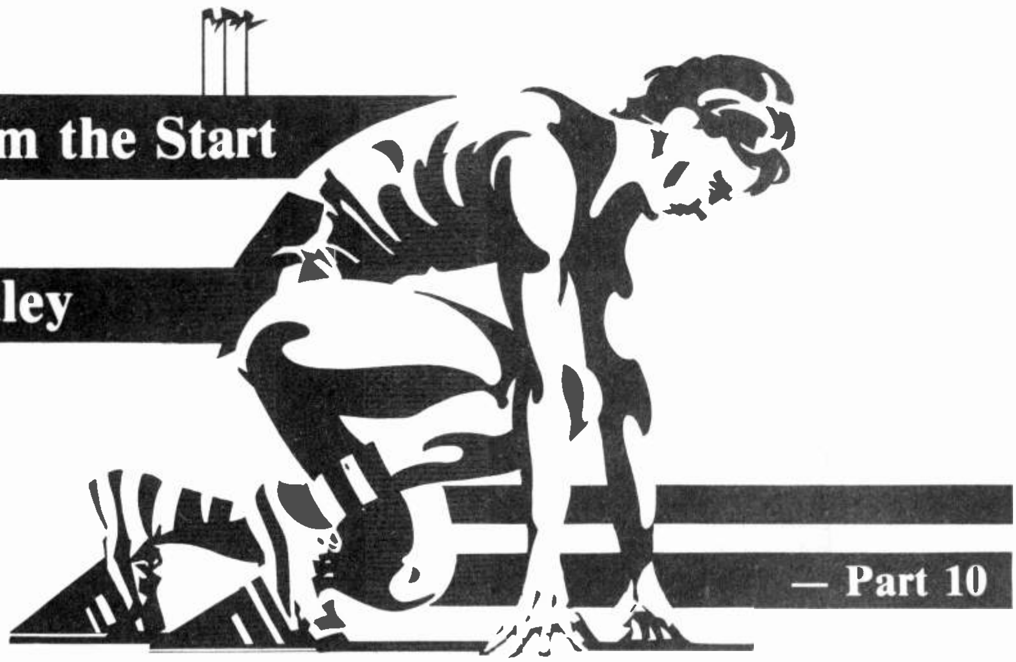
Electronics from the Start

by Keith Brindley



— Part 10

Transistors: how they work and how to use them correctly.

YOU DON'T need many components this month, just the following resistors:

1 x 100k
1 x 220k
1 x 47k miniature horizontal preset,
and one 2N3053 transistor.

You'll see that the transistor has three terminals labelled, base, emitter, and collector (commonly shortened to B,C and E). When using transistors in electronic circuits it's essential that these three terminals are correctly oriented. The 2N3053 transistor terminals are identified by holding the transistor with its terminals pointing towards you from the body and comparing the transistor's underside with the diagram in **Fig. 1**. The terminal closest to the tab on the body is the emitter, then in a clockwise direction are the base and the collector.

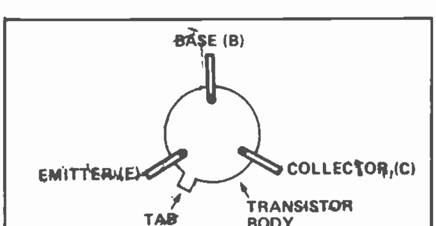


Fig. 1 How to recognize the location of the base, emitter and collector connections on a common transistor body.

Other transistor varieties may have different body types so it's important to check with reference books or manufacturer's data regarding the transistor terminals before use. All 2N3053 transistors, however, are in the same body type, known as a TO-5 body, and follow the diagram in **Fig. 1**.

Recently we have looked closely at diodes, the simplest of the group of components known as semiconductors. The many different types of diodes are all formed by combining doped layers of semiconductor material at a junction. The PN junction (as one layer is N-type semiconductor material and the other layer is P-type) forms the basis of all other semiconductor-based electronic components. The transistor, the component we're going to look at now, is made of two PN junctions back to back. **Fig. 2** shows how we may simply consider a transistor as being two back-to-back diodes, and we can verify this using our meter to check resistances between the three terminals of the transistor.

To do the experiment, put a transistor into your breadboard, as shown in **Fig. 3**, then use the meter to test the resistance between transistor terminals. We know that if there are three terminals there must be six different ways the meter leads can be connected to the terminals. Table 1 lists all the combinations but the results column is left blank for you to fill in as you perform the experiment. It's not necessary for you to measure the exact resistance obtained between terminals, it's sufficient just to find out if the resistance is high or low.

Fig. 2 A symbol for a transistor considered as two diodes, back-to-back.

One final point before you start, the casing of the transistor body (sometimes called the 'can') is metal and therefore conducts. When connecting test leads to the transistor terminals, make sure that they don't contact the can; short circuits give an incorrect result! The can of a TO-5 bodied transistor such as the 2N3053 is also electrically connected to the transistor's collector, so take extra care.

Your results should show that low resistances occur in only two cases, indicating forward current flow between base and emitter, and base and collector. This corresponds as we should expect to the diagram of **Fig. 2**.

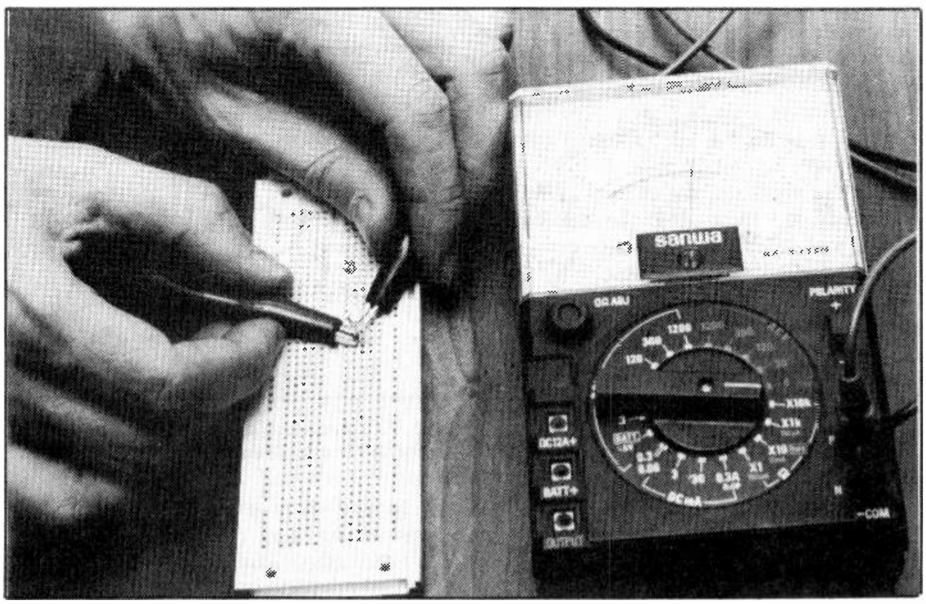


Fig. 3 An experiment to check resistances between the transistor terminals.

Very Close

Unfortunately things aren't quite as simple as that in electronic circuits, where individual resistances are rarely considered alone. The real life transistor deals with currents in more than one direction and this confuses the issue. What is happening is that the two PN junctions are very close together. So close that, in fact, they affect one another.

Fig. 4 illustrates how a transistor can be built up, from two PN junctions situated very close together. It's really only a thin layer of P-type semiconductor material (only a few hundred or so atoms thick) between two thicker layers of N-type semiconductor material. Now let's connect this transistor arrangement between a voltage supply, so that collector is positive and emitter is zero, as in **Fig. 5**.

From what we know so far, nothing can happen and no current can flow from collector to emitter because two back-to-back PN junctions lie between these two terminals. One of these junctions is reverse biased and so, like a reverse biased diode, cannot conduct. So, what's the point of it all?

Well, as mentioned earlier, what happens in one of the two PN junctions of the transistor affects the other. Let's say for example that we start the lower PN junction (between base and emitter) conducting by raising the base voltage so that the base-to-emitter voltage is above the transition voltage of the junction (say, 0V6 if the transistor is a silicon variety). **Fig. 6** shows this situation. Now, the lower junction is flooded with charge carriers and because both junctions are very close together, these charge carriers allow current flow frqm collector to emitter also **(Fig. 7)**.

To summarize, a current will flow from collector to emitter of the transistor when the lower junction is forward biased by a small base-to-emitter voltage. When the base-to-emitter voltage is removed the collector-to-emitter current will stop.

We can build a circuit to see if this is true, as shown in **Fig. 8**. Note the transistor circuit symbol. **Fig. 9** shows the breadboard layout. From the circuit you'll see that we're first measuring the transistor's collector-to-emitter current (collector current) when the base-to-emitter junction is first connected to zero volts (reverse biased), then when the base is connected to positive and the base-emitter junction is forward biased.

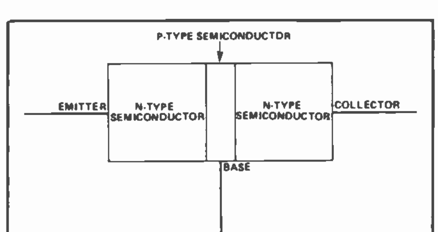


Fig. 4 A narrow P-area gives two PN junctions very close together.

Now do the experiment and see what happens. You should find that when the base is connected to zero via the 100k resistor nothing is measured by the meter. But when the base resistor is connected to positive, the meter shows a collector current flows. In our experiment a collector current of about 12mA was measured, yours may be a little different. Finally, when the base resistor is returned to zero volts (or simply when it's disconnected!) the collector current again does not flow.

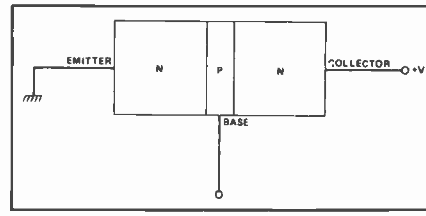


Fig. 5 Connected up, the emitter is at 0V and the collector is positive.

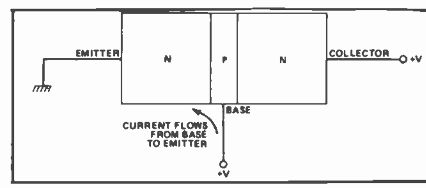


Fig. 6 If the voltage at the base is raised, current flows from base to emitter.

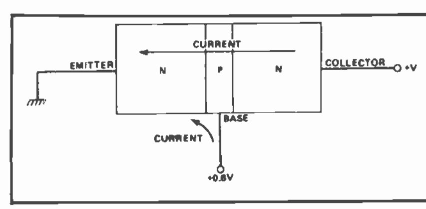


Fig. 7 Charge carriers accumulating around the lower junction allow current to flow from the collector to the emitter.

What use is this? Not a lot as it stands, but it becomes very important when we calculate the currents involved. We already know the collector current (about 12mA in our case) but what about the base-to-emitter current (base current)? The best way to find this is not by measurement (the meter itself would affect the transistor's operation) but by calculation. We know the transistor's base-to-emitter voltage (base voltage) and we know the supply voltage. From these we can calculate the voltage across the resistor, and from Ohm's law we can therefore calculate the current through the resistor. And the current through the resistor must be the base current.

So, the resistor voltage is:

$9 - 0.7 = 8.3V$

And from Ohm's law the current is:

I = V/R = 8.3/100,000 = 83uA

Now we can begin to see the importance of the transistor. A tiny base current can turn a large collector current on or off. This is illustrated in **Fig. 10** and is of vital importance.

In effect, the transistor is a current amplifier. No matter how small the base

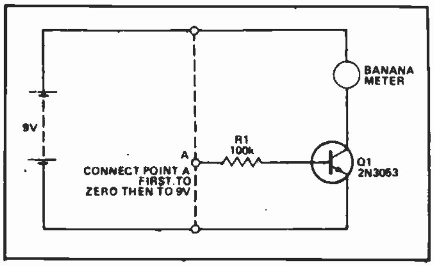


Fig. 8 An experimental circuit to test what we have described so far.

current is, the collector current will be much larger. The collector current is, in fact, directly proportional to the base current. Double the base current and you double the collector current. Halve the base current and the collector current is likewise halved. It's this fact that allows the transistor to be used as a controlling element (the base current controlling the collector current) which makes it the most important component in electronics.

The ratio:

collector current/base current

gives a constant of proportionality for the transistor, which can have many names depending on which way you butter your bread. Officially it's called the forward current transfer ratio, common emitter, but as that's quite a mouthful it's often just called the transistor's current gain (seems sensible!). You can sometimes shorten this even further if you wish, to the symbols: hfe, or B. In manufacturer's data sheets for transistors the current gain is normally just given the symbol hfe (which if you're interested stands for Hybrid parameter, Forward, common Emitter. Are you any wiser?). However, we'll just stick to the term current gain, generally.

We can work out the current gain of a transistor by measuring the collector current, and calculating the base current as we did earlier, and dividing one by the other. For example the current gain of the transistor we used is:

(12 x 10E-3)/(83 x 10E-6) = 145

Yours may be a bit different. Manufacturers will quote typical values of current gain in their data sheets; individual transistors' current gains will be somewhere around this value, and may not be exact at all. It really doesn't matter, too much. The transistor we use here, the 2N3053, is a fairly common general purpose transistor. High power transistors may have current gains more in the region of about 10, while some modern transistors for use in high frequency circuits such as radio may have current gains around 1000 or so.

NPN

The 2N3053 transistor is known as an NPN transistor because of the fact that a thin layer of P-type semiconductor material is sandwiched between two layers

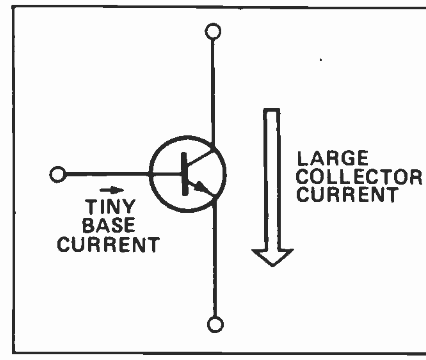


Fig. 10 Important: a very small base current can control a large collector current.

of N-type semiconductor material. The construction and circuit symbol of an NPN transistor are shown in **Fig. 11a.** You may have worked out that there is another way to sandwich one type of semiconductor material between two others, and if so you would also have worked out that such a transistor would be called a PNP transistor. **Fig. 11b** shows a PNP transistor construction and its circuit symbol. The only difference in the circuit symbols of both types is that the arrow on NPN transistor's emitter points out and the arrow on the PNP transistor's emitter points in.

The emitter arrow of either symbol indicates direction of base current and collector current flow. So from the circuit symbols we can work out that base current in the NPN transistor flows from base to emitter, while in the PNP transistor it flows from emitter to base. Likewise collector current flow in the NPN transistor is from collector to emitter and from emitter to collector in the PNP transistor.

Knowing this and comparing the PNP construction to that of the NPN transistor we can further work out that a tiny emitter-to-base current (still called the base current, incidentally) will cause a much larger emitter-to-collector current (collector current). This is illustrated in **Fig. 12.** The ratio of collector current to

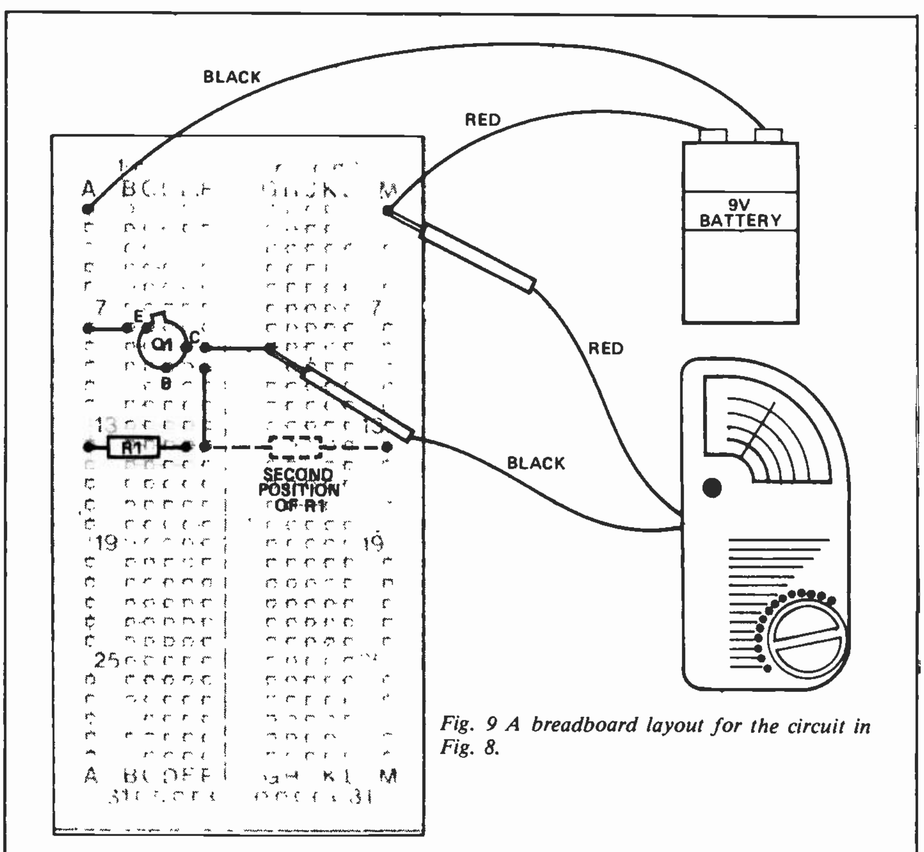


Fig. 9 A breadboard layout for the circuit in Fig. 8.

base current of a PNP transistor is still the current gain. In fact, apart from the different directions of currents, a PNP transistor functions identically to an NPN transistor. As we've started our look at transistors with the use of an NPN transistor, however, we'll finish it the same way.

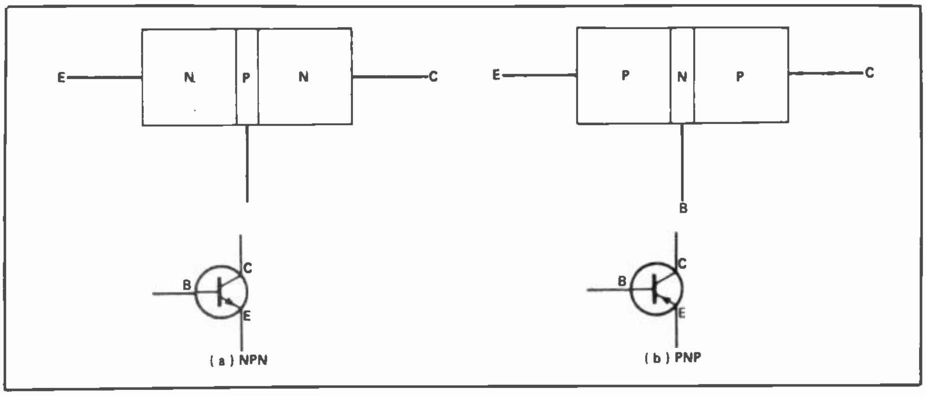


Fig. 11 The internal construction and circuit symbols for NPN and PNP transistors.

Using Transistors

We've seen how transistors work but we don't yet know how they can be used. Only two basic uses of a transistor exist, and every transistorized circuit, every piece of electronic equipment, every television, every radio, every computer, etc, contains transistors in one form or another which do only one of two things. We've already seen the first of these two uses, an electronic switch, where a tiny base current turns on a comparatively large collector

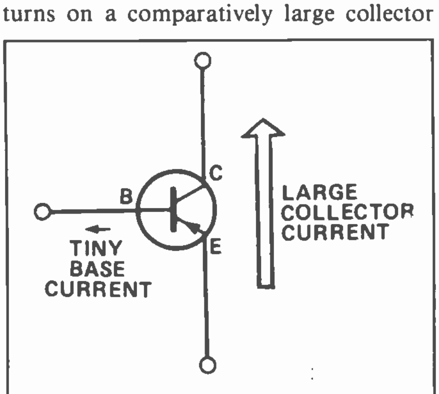


Fig. 12 An NPN has the same effect as a PNP transistor, but in the opposite direction.

current. This may appear insignificant in itself, but if you consider that the collector current of one transistor may be used as the base current of a following transistor or transistors, then you should be able to imagine an enormous number of transistors inside one appliance, all switching and hence controlling the appliance's operation.

We can see the second use of a transistor in the circuit of **Fig. 13**. From this you should be able to see that we're going to use a variable resistor to provide a variable base current for the transistor in the circuit. The breadboard layout of the circuit is in **Fig. 14.** Before you connect the battery, make sure the preset variable resistor is turned fully anticlockwise.

Now, connect the battery and slowly (with a small screwdriver) turn the preset clockwise. Gradually, as you turn the preset, the LED should light up: dim at first, theen brighter, then fully bright. What you've built is a very simple lamp dimmer.

So, the other use of a transistor is as a

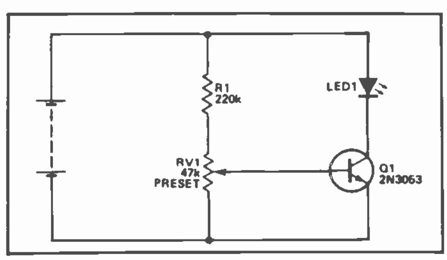


Fig. 13. The preset should be turned slowly with a small screwdriver.

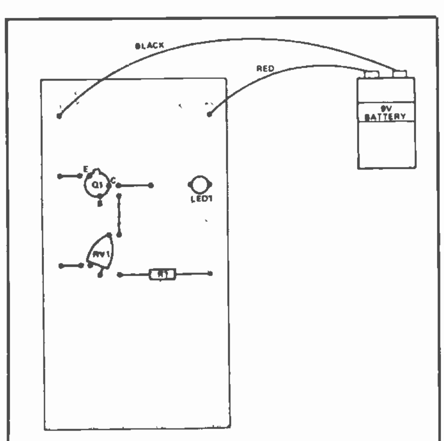


Fig. 14 A breadboard layout for the circuit in Fig. 13.

variable control element. By controlling the transistor's tiny base current we can control the much larger collector current, which can be the driving the current of an LED, an ordinary lamp, a motor, a loudspeaker, in fact just about anything which is variable.

These two operational modes of transistors have been given names. The first, as it switches between two states, one where the collector current is on or high, the other where it is off or low, is called digital. Any circuit which uses transistors operating in digital mode is therefore called a digital circuit.

The other mode, where transistors control, is known as the analogue mode, because the collector current of the transistor is simply an analogue of the base current. Any circuit which uses transistors operating in the analogue mode is known as an analogue circuit. Sometimes analogue circuits are mistakenly called linear circuits. However, this is wrong, because although it might appear that a linear law is followed, this is not so. If transistors were linear they would follow Ohm's law, but (like diodes) they do not follow Ohm's law and are non-linear devices. ■

Designing Transistor Stages

Concluding the investigation of simple transistor stages with a roundup of some useful two-transistor configurations.

By Les Sage

SO FAR all the circuits we've looked at have used only one transistor. A second transistor, however, can bring about a dramatic improvement in one aspect of circuit performance, if used judiciously.

Fig. 1 shows a simple and economical method of achieving higher gain, just by running two stages together in series. Since neither stage has any emitter degeneration, the total gain (the product of each individual stage gain) can be very high indeed, around 5000 in this case. With such a high gain, it is important to keep the power supply smooth. In most applications, the power rail should be decoupled with a small series resistor and a parallel capacitor. It should also be noted that the DC operating point of each transistor is dependent on its hFE figure, so that R1 and R3 may need to be changed for individual transistors. General purpose NPNs are suitable, but each transistor will demand attention to these resistor values, so no recommendation has been made.

In fact, the circuit can also suffer from high distortion and demands low level signals in and out. Its only virtue is simplicity, and that is not outstanding.

A few extra components can make all the difference, as in **Fig. 2**. This is a universal gain block which finds many applications in audio equipment, particularly as an input stage in high quality amplifiers and is the basis of equalization stages. It utilizes the very high gain of a two-transistor stage to provide negative feedback (via R6). The eventual gain is considerably reduced, but the circuit is much less prone to noise, distortion and the idiosyncrasies of transistors than that of Fig. 1.

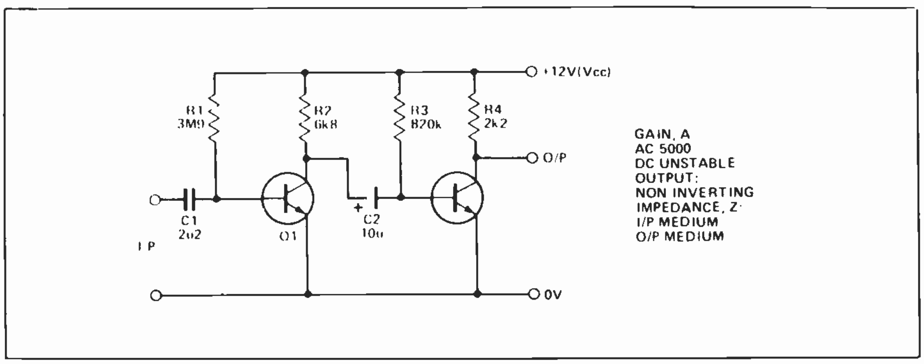


Fig. 1 Economic high gain amplifier. (Note: all circuits use general purpose silicon transistors operating at lower power AF or RF frequencies).

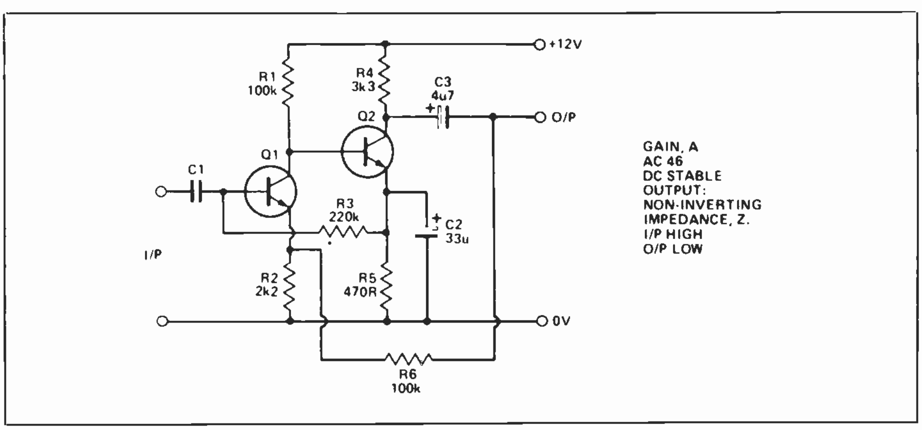


Fig. 2 Low noise, low distortion.

The operating point of Q2 is set by the emitter resistor, R5, while R4 determines the open-loop output impedance (that is, assuming no feedback). DC feedback is run separately from AC feedback via R3. This biases Q1 and gives the circuit very good DC stability. R1 has a relatively high value to give the circuit low noise performance which is better than that of most op-amps. The feedback resistors, R6 and R2, set the overall gain at (R6 + R2)/R2 (in theory, 46.45). The negative feedback through R6 also controls the input and output impedances. The lower R6 is, the more feedback there will be and the lower will be the output impedance.

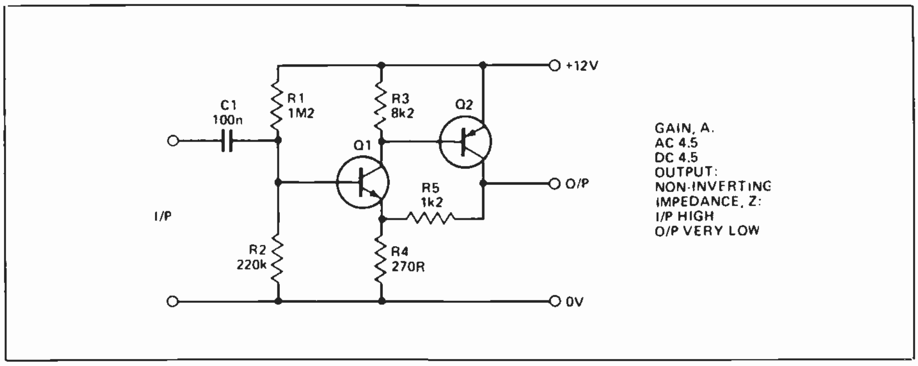


Fig. 3 Low gain, very low distortion.

Lowering the value of R6 also increases the circuit's input impedance and a high input impedance using one component is very desirable in audio circuits. It can also be exploited to design equalizing stages by replacing R6 with a suitable RC network, and such circuits are frequently found in RIAA equalizers.

Really Negative

Negative feedback is further exploited in the next two configurations. In the circuit shown in **Fig. 3**, the feedback is enormous, with the result that gain is very low and distortion is even lower. The circuit is popular in high quality pre-amps. With DC coupling as featured gain must be kept low in order to prevent DC operating point drift. The gain is actually determined by R5 and R4 and is given, approximately, by (R5 + R4)/R4. If gain is altered by changing these values, then R1 and R2 will also need to be altered to bring the output DC point to around half the supply voltage. Like the previous circuit, this one features high input impedance (thanks largely to the negative feedback in the Q1 circuit) and low output impedance. In this case, the output impedance is very low at a few tens of ohms. Once again general purpose transistors can be used, remembering that Q2 is PNP and both transistors should be low noise varieties for audio work.

The next circuit (**Fig. 4**) features significantly higher gain at the cost of worse performance from the noise and distortion point-of-view. The circuit is very similar to that of Fig. 3, but has separate DC and AC feedback paths. the DC gain is unity and the AC gain (determined by feedback resistors, R4 and R5) is around 20. AC gain is given by (R4 + R5)/R5 and can be adjusted over a wide range without significantly affecting the DC operating point.

Distortion tends to increase with gain, but can be kept down by the use of complementary transistors. As with the Fig. 2 circuit above,frequency response can be tailored to the user's requirements by including reactive networks in the feedback loop. If the gain is lowered too much at HF, circuit stability might suffer with spurious oscillations as the result.

Both of the last two circuits depend heavily on feedback and may tend to oscillate if they are required to drive a large capacitive load. It is a wise precaution to include a small series resistor of around 100R at the output, especially if driving a shielded cable.

More Frequency

Amplifying frequencies above, say, 100kHz demands different techniques, as touched upon in discussing the common base amplifier. Video frequencies go from DC to around 10MHz, and we need to consider how to prevent deterioration of performance over such a considerable bandwidth.

The circuit shown in **Fig. 5** has been designed with the main considerations for any bandwidth amplifier in mind. Firstly, it features optimum collector current for maximum current gain/bandwidth product. An increase in emitter current (and therefore collector current) produces a decrease in the dynamic resistance of the base-emitter junction of a transistor as viewed from the base. This parameter is known as hIE and is related to the dynamic resistance of the base-emitter junction as viewed from the emitter (or, rE) by the following equation:

$$h_{ie} = (h_{fe}+1)\,r_e.$$

The decrease in hIE with increasing emitter current follows from the approximate equation:

$$h_{ie} = (h_{fe}.25)/I_E$$

which itself follows from the relationship between rE and iE:

$r_e = 25/I_E$, where I_E is in milliamps.

Unfortunately, as collector current increases the effective base-emitter capacitance also increases due to a phenomenon known as base-stretching. It is the base-emitter capacitance, Cbe, which determines the high-frequency current-gain of a transistor and the cut-off frequency (the point at which transistor current gain falls by 3dB). The cut-off frequency, in fact, is defined as the frequency at which Cbe and hIE are equal, while the transition frequency, fT, is defined as the frequency at which current gain, hIE, falls to unity. The transition frequency is roughly equal to the product of current gain and cut-off frequency.

Clearly, there will be an optimum collector current at which Cbe going up meets hIE coming down. In practice, this current is between 5mA and 50mA and is the value at which the transition frequency of the transistor is at its maximum.

Another consideration involved in the design of the Fig. 5 circuit is the inclusion of a low-level load resistor, R3. As well as helping to achieve optimum collector current in Q2, this serves to minimize the time constant of the output of the stage.

The circuit shown in Fig. 5 achieves a bandwidth of more than 40MHz although, like most video circuits, it is a heavy consumer of current. It also has a low input impedance. Transistor Q2 is configured as a common base amplifier giving a good voltage gain up to the transition frequency. It is fed by Q1 providing current gain alone and therefore not

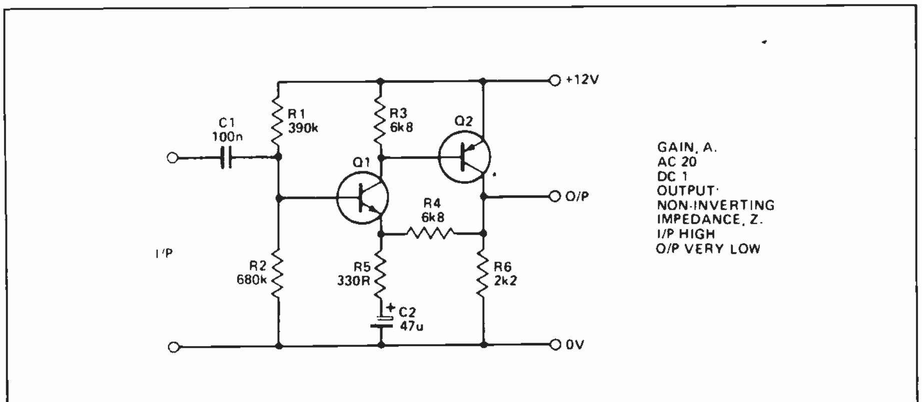


Fig. 4 DC stable, low distortion (Note: Q2 is PNP).

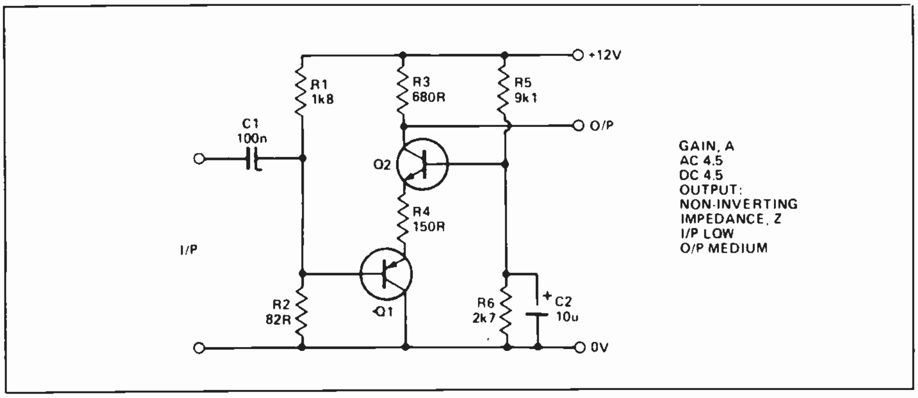


Fig. 5 Video amplifier (Note: both RF, Q1 is PNP).

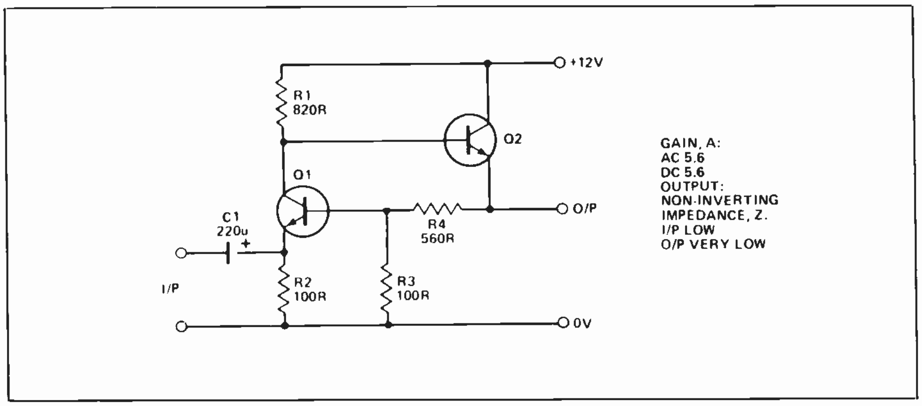


Fig. 6 Video amplifier.

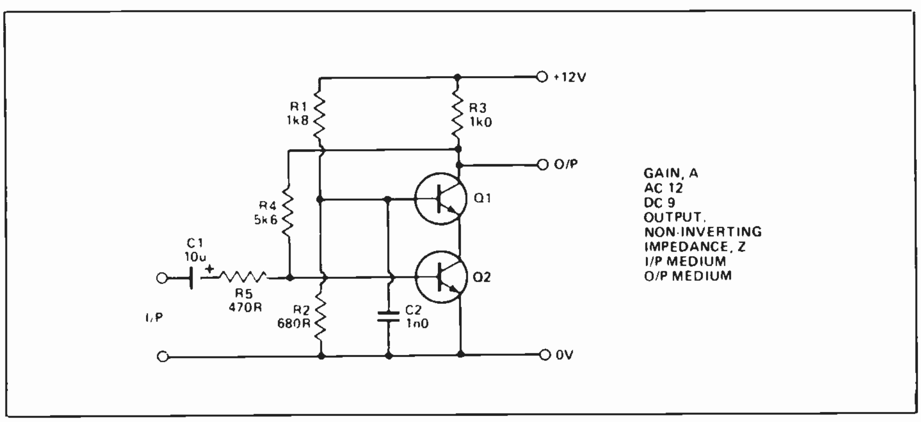


Fig. 7 Very linear cascode stage.

susceptible to bandwidth limitation. In fact, Q1 is configured as an emitter follower, giving a suitable low output impedance to match the subsequent stage. Resistor R3 provides a low load for Q2. The circuit resembles a standard cascode amplifier, but gives superior performance. It should be remembered that layout and supply decoupling are very important with any HF amplifier.

The main drawback with this cut at the cost of increasing output impedance. Fig. 6 shows a circuit using two NPN transistors configured as common base and emitter follower stages and employing parallel feedback. Here, the feedback path is provided by R4 and R3. The circuit has a very low output impedance, although its high frequency response is weaker than that of the Fig. 5 circuit. The open loop gain of this circuit is given by R1/(R2//Rs), where Rs is the source resistance. Closed loop gain is effectively (R4 + R3)/R3.

The next circuit (**Fig. 7**) is a more-or-less conventional cascode amplifier with Q1 in common base mode and Q2 connected as a common emitter. The common emitter provides current gain and feeds the common base which provides voltage gain. The arrangement produces a high power gain. With the base of Q1 held at a constant voltage, Vce for Q2 is also constant. This avoids the effects of Miller capacitance and so the normal deterioration of frequency response of a common emitter stage does not occur.

The configuration is widely accepted as a very high frequency amplifier displaying extremely good linearity. This feature is useful for quality audio, and the circuit can often be found in amplifier systems.

In this circuit, gain is controlled by parallel feedback via resistor R4, lowering the open-loop output impedance and successfully stabilizing the circuit. Improved frequency response can be obtained by omitting R4, short-circuiting R5 and placing resistor in the emitter of Q2 to provide series feedback. This will increase both the input and output impedance.

Vive La Difference

The circuit shown in **Fig. 8** is commonly called a differential (or operational) amplifier, although it was once universally referred to as a long-tailed pair in deference to the joint emitter resistor. In this configuration, the input signal is applied across the two input terminals and the output is taken from across the two output terminals. If there is no potential difference across the two inputs (both being positive for conduction to take place) and assuming the transistors and collector resistors are identical, then both halves of the circuit will conduct equally and a there will be no difference across the output terminals. The input here is described as common mode. Referred to ground, each output terminal produces an inverted version of the input at a gain given by the ratio of one collector resistor to twice the tail resistor (in the example, about unity).

Now, imagine that input 1 is made slightly more positive than input 2, either by increasing the applied DC voltage or through the application of an instantaneous AC voltage. More current will flow in the collector-emitter circuit of Q1 and the voltage across R1 will increase. Referred to ground, the voltage on output 1 will fall and a potential difference will appear between outputs 1 and 2. This potential will be proportional to the potential across the inputs and will be inverted (output 1 voltage decreasing as input 1 voltage increases). The same reasoning applies if input 2 voltage is changed, with the net result that the output of the circuit will be proportional to the potential difference across the input terminals.

Assuming that the tail resistor is large enough (much greater than the dynamic emitter resistance of the transistors, rE), then the potential drop across the inputs can be expressed in terms of emitter current and 2rE. In this way, it becomes clear that the output can be taken from only one collector with reference to ground and

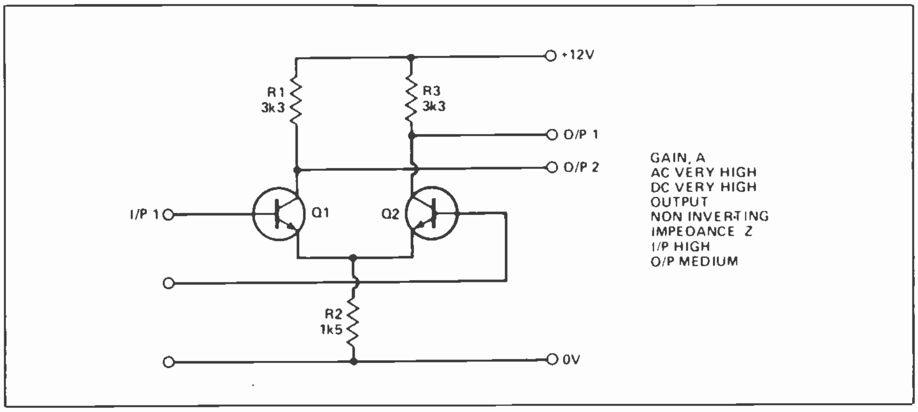


Fig. 8 Basic differential amplifier.

still be proportional to the potential difference across the two inputs.

In fact, this depends on the tail resistor acting as a constant current source, which it will do if it is large enough. Looked at in this way, the voltage drop across the resistor remains constant and the current flowing through it remains constant - which actually applies only when small voltage changes take place. As long as R3 can be considered a constant current source, any change in collector and emitter current in one transistor will be exactly matched by an opposite change in the other. Current is diverted to whichever transistor is more heavily biased into conduction and, using a single-ended output,
one input becomes an inverting input and the other non-inverting. In effect, R3 is decoupled to difference signals across the input terminals while common mode signals produce a voltage across it thereby providing negative, gain-reducing, feedback.

For difference signals, the differential amplifier has a very high gain, given approximately by the formula 10ItR1, where It is tail current and R1 is one of the collector resistance values. The compromise involved here is due to the fact that, in our circuit, a high tail current is incompatible with a high tail resistance value. In practice, differential amplifiers tend to be designed with genuine current sources in the tail (usually a fully stabilized transistor circuit producing a quiescent collector current).

The most important feature of differential amplifiers is their common mode rejection, which ensures that thermal noise, drift and any similar voltage disturbances common to both transistors are ignored during amplification. The measure of a differential amplifier's quality is its common mode rejection ratio (CMRR), given by the ratio of difference signal gain to common mode gain and usually expressed in dB. In the Fig. 8 circuit, the CMRR would be between about 20 and 40 dB, an unimpressive figure, given contemporary op amp CMRRs in excess of 100dB. The simplest way to improve the CMRR would be to increase the value of R3, but this would require higher supply voltages (or even a split rail supply) to maintain tail current.

Conclusion

The few circuit blocks described in this series should show the wealth of design opportunities for those willing to work with discrete components. The important thing to remember is that a circuit can be readily designed for practically any given purpose, if first you are clear as to the requirements that will be made of it. Once the general outlines have been understood and a configuration decided on, the calculation of component values can proceed with recourse to little more than Ohm's Law. Rather than tie yourself up with complex mathematics (unless, of course, that is what you enjoy) a circuit sense, a few rules of thumb, a few sums and a clear idea of what you want. The final stage in the process, of course, is to build your design and test it. You will, undoubtedly, find that minor adjustments need to be made to your component values, but if you pay heed to the advice that a little observation and measurement is worth a ton of theory you will almost certainly produce circuits which work and work well. The theory may produce working circuits, but only the practice will make them perfect. ■

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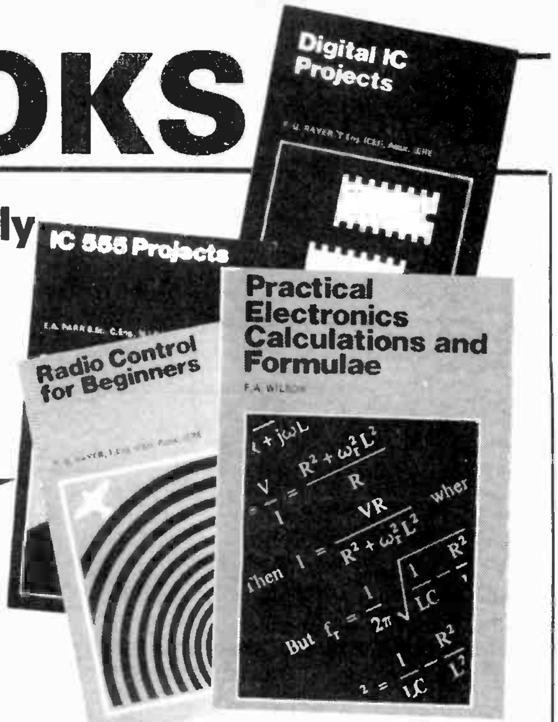

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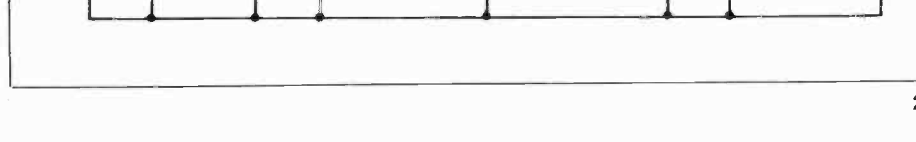
trolled by a discrete resistor (R2). Output currents of 1 microamp to 10 milliamps can be accommodated, and the output current is approximately equal to 0.0677 divided by the value of R2 in ohms. Using the specified value of R2 gives a nominal



For Your Information

Continued from page 8

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Owners of Texas Instruments 99/4A computers may be interested in the TI 99/4A National Users Group with chapters all across Canada. Software, hardware and full assistance can be yours for $10 per year. Call or write the headquarters for further information: 759 – 6th St., Brandon, Manitoba R7A 3P3, (204) 727-7715.

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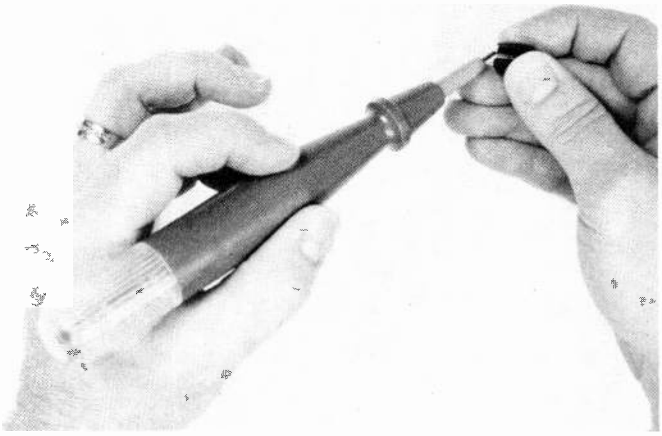

The UTM tester checks circuits not under power for continuity, and also checks live circuits from 5 to 380 volts, AC or DC. When DC is checked, the tester reacts only to positive voltages. It's said to be ideal for cable testing, checking wring and computer circuits, checking car circuits and various components. $29.95 including postage and handling. From Rolek Enterprises, PO Box 22186, Barrie, Ontario L4M 5R3, (705) 737-3334.

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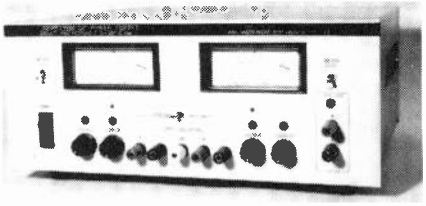

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Continued on page 60

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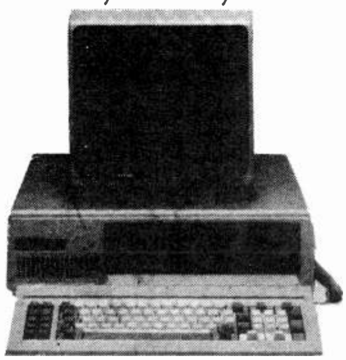

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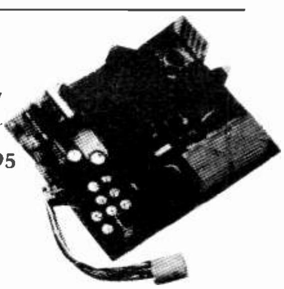

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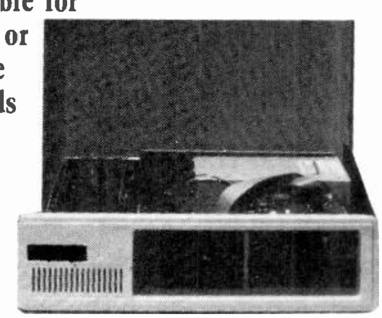

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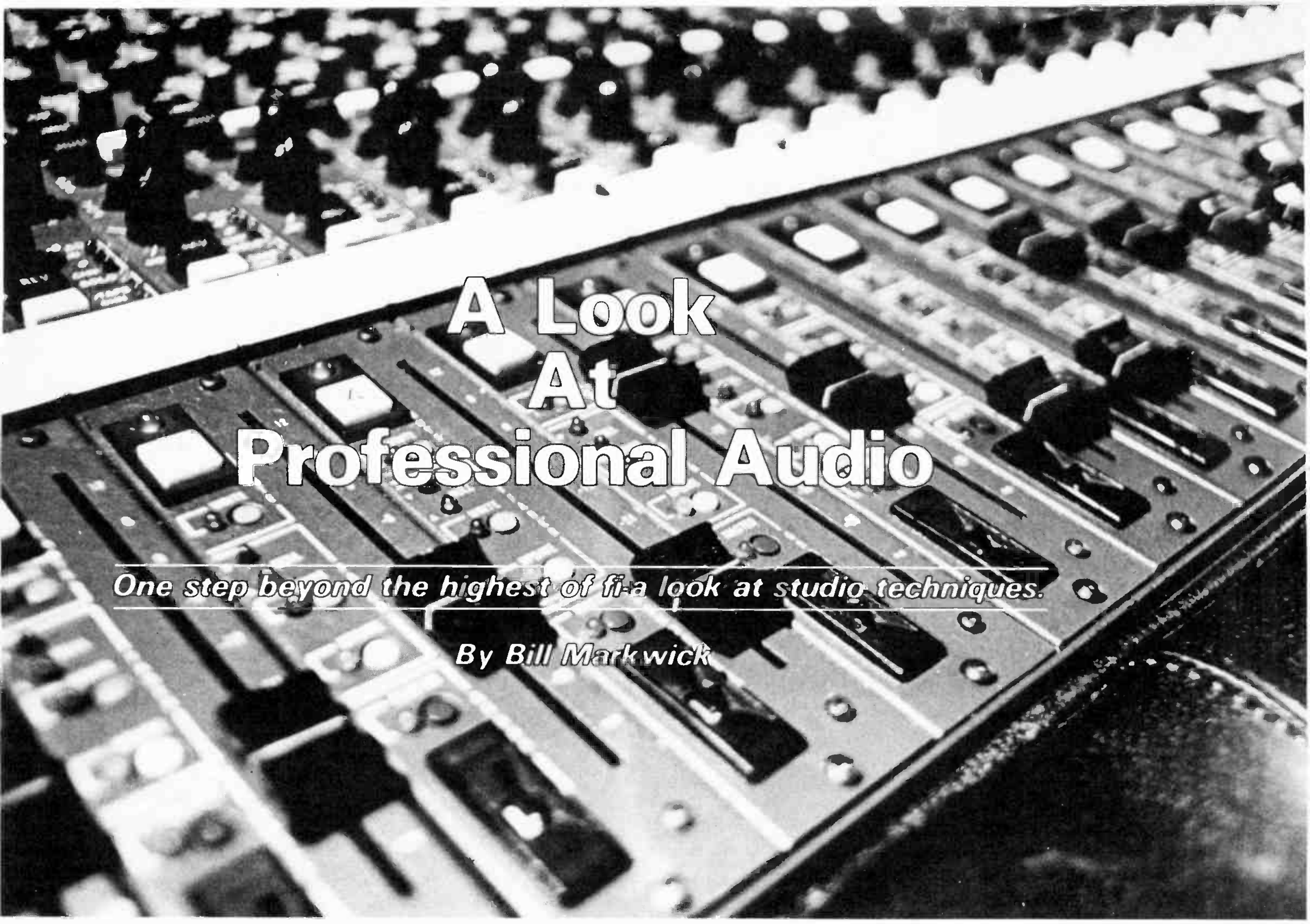

A Look At Professional Audio

One step beyond the highest of fi-a look at studio techniques.

By Bill Markwick

WHEN you play a compact disk or a quality regular disk and you revel in the clarity and power of really good sound, you might assume that studios have some sort of other-worldly high-tech electronics available to them, something that isn't accessible to the regular herd.

Your suspicions will be confirmed if you try to make a recording in your living room, even under the best of conditions with really good equipment. 'Well, that clinches it,' you think, after you hear your efforts. 'They're onto something cosmic, I guess.'

Yet it isn't true, at least not in the sense of the existence of some sort of special high-performance circuitry that's light-years above home hifi. Most of the electronics in recording studios or professional sound reinforcement is pretty much a cousin to the circuit cards in your home system. In fact, there are studios whose technical performance is the same or falls behind the quality audio gear available at reasonable prices today. A lot of professionals in sound or photography or similar crafts envy the amateurs with the time and money to tinker with really good gear.

Mind you, I'm oversimplifying a bit here, but in general, the splendid results obtained by the pros result more from techniques of design and application than from dark secrets of the inner sanctum. Of course, when you see the dazzling array of controls in a large studio, or get your ears flapped by a huge tower of speakers at a concert, it's hard to keep in mind that it's all related to the stereo on your bookcase.

Overview

The basic idea is straightforward; each of up to 32 or more microphones has its own amplifier and equalizer (tone controls); the output of these amplifiers can be switched into any of the tracks on the tape machine. Each microphone can then be recorded onto any number of the tape tracks.

There may be only one track, for mono recordings, or up to 24 or more. Some gigantic setups use two 24-track machines synchronized together with digital techniques, giving a total of 44 tracks after you subtract the four control tracks for sync and level controls. What they do with 44 tracks remains a mystery to those of us who think of stereo as two mikes, but it's sort of like computer memory space: the more you have, the more uses you find for it, and you soon fill up 640K, or what used to be a staggering amount of RAM.

On multi-track recordings, the input channels on the console are switched from mike to line; the channels now get their input from the tape machine's playback. The console's mixing facility is now used to mix the recorded tracks down to stereo. Or quad, back in the days when they wanted to sell more speakers and amps.

That's really all there is to the basic layout; everything else is icing on the cake, providing a myriad of functions to manipulate the sounds into their final form.

An Input Strip

The input channel, or strip, is responsible for setting up the initial corrections to the tone, and routing its output to the final mixing stage, which is usually just a fader (volume control) which accepts any number of input channels and sends them to one tape track.

The first control that you usually meet will be the gain control. This is a control missing from most microphone inputs on home or amateur equipment; it's usually just a feedback resistor in an op amp circuit that can vary the gain up or down. On some mixing boards a switch is included to insert a resistive attenuator ahead of the first stage of amplification for handling really large outputs from microphones.

It's interesting to consider the output of microphones. The best way to do it is to watch the microphone's output using an oscilloscope, because what we're interested in is the peak voltage that the microphone can achieve under operating conditions. Studio mikes are always low impedance, usually 50 to 600 ohms, and will usually be either dynamic (moving coil) or electronic types (condenser, electret, etc.). A 250-ohm dynamic mike may only produce 50 to 100mVAC if you sing directly into it, but on certain sounds, particularly sustained ones, it's not unusual to see peaks of up to 2V. High-impedance mikes were once very popular for home use because the internal transformer gave a voltage gain of about 20dB (ten times), and this allowed manufacturers to scrimp on expensive gain stages. These can hit a remarkable 20V of output.

The input stage, then, must be designed to handle high input voltages as well as supplying up to 80dB of gain for very soft signals, and this can only be done by using a variable gain control. The maximum input can be found by dividing the amplifier's output by the gain. For instance, an op amp running from plus-and-minus 15VDC can usually swing about 9 volts RMS. If the gain is 40dB (a good general-purpose gain figure), then the maximum output is 9/100, or 90mV (we'll get further into the decibel as we go). This is 90 x 1.414 = 127mV peak.

At one time, most consoles ran with plus-and-minus 15V supplies to accommodate the limitations on the op amps of the time, but now that higher-voltage amplifiers are available, bipolar supplies of 20V or higher are becoming popular.

While the professional input preamp is fitted with gadgetry for optimizing the signal, it probably isn't a great deal different in noise or distortion than a good home stereo. For instance, a zillion radio stations and studios use Shure mike mixers for auxiliary mixing, and the older models of these had signal-to-noise about 10dB worse than an average stereo system. I recall them being plagued with hum and hiss, but everybody went on using them anyway.

The next function in the strip is the equalization, or EQ. The EQ on even a basic board should consist of bass and treble control similar to a home stereo and a midrange control which can boost or cut (by 15 or 20dB) a band of frequencies tunable from about 500Hz to 5kHz. The mid control is essential; because it affects the frequencies to which the ear is most sensitive, it's the best control for brightening or diminishing the tone of almost any sound. In fact, it's such a useful control that the more expensive boards have up to four of them, tunable to overlapping bands covering the audio range. In effect, each input strip then has a graphic equalizer, except that rotary controls are used.

Next comes the auxiliary outputs. These vary tremendously in number with the make and price of the console, but in general, the two most-often used outputs are the effects send and the cue (or foldback) send. Both of these are generally switchable from pre- to post-fader; that is, they can work independently of the main fader (pre) or they can fade along with it (post). The effects send is used to send the mike output to a reverberation unit, or an echo unit, or similar. Generally, the master tapes are made without an special effects added; it's easy to add them later, but very difficult to take them out afterwards. The separate output allows the effects (if used) to be stored on a separate tape track or just sent back to performers.

The cue or foldback outputs are used to send the mike output to one or more headphone amplifiers so the performers can hear each other via headsets. On most boards the cue feeds can be 'wet or dry'; that is, the sound heard by the performer can be straight from the mike without effects added, or it can be jazzed up with reverb or echo. It's a bit easier to hear your own voice in a headset if there's some reverb added.

The fader comes in now. Most are conductive-plastic for low operating noise, and the taper is logarithmic. The usual operating level is marked near the top as OdB, and there's another 10dB or more remaining in the travel. Large consoles have insertion points before and after the fader; this lets the operator add in (patch) special effects boxes in the pre- or post-fader mode.

Lastly comes the assignment buss (or bus) strip. It consists of two banks of pushbuttons, one for each track, usually with the odd numbers on one side and the evens on the other. A pan pot is used to adjust the level between any two opposite buttons, allowing positioning of a track or mike in a stereo mix.

It's like the balance pot on a stereo, but with only one input.

Outputs and Monitoring

The various inputs are mixed; each mixing buss will consist of a resistor from each input strip wired to a common rail that runs the length of the mixer. Most consoles use feedback mixing; the common rail is fed into an inverting output and a resistor wired from the output to the input. This resistor is usually the same as the mixing resistors (typically 10k); the feedback method has the advantage of lowering the buss impedance to a few ohms, and this means that you can add or subtract input channels without disturbing the buss level through impedance changes. The voltage level out of the mixing amp is usually 30 or 35dB below maximum, giving lots of headroom when multiple signals are added together.

Each mixing amplifier goes to a fader and then to the final line amplifier which feeds a track of the tape machine. A typical line amplifier is an op amp with a current booster on the output, capable of swinging about 12 volts RMS into 600 ohms. This is about 20dB higher than line level, allowing lots of room for transient peaks.

Monitoring is an exceptionally important part of any mixer. It's the gadgetry that lets the operator hear what's going on in the studio and what's been put on tape. Several pairs of speakers are switch-selected so the operator can hear the sound through super speakers, through car-radio types, and so forth. The top-of-the-line studio monitor speakers are extremely impressive. Not that you can't get them for home use, but most people just can't afford them.

The monitor controls and patchbay of an MCI console. The patching jacks allow direct outputs and equipment insertions.

The monitor speakers are fed in one of two ways, at least in general. The first way is the separate monitor panel. This consists of a separate mixer all on its own, but mounted on one side of the console. This little mixer has two main sets of inputs: the first one listens to the outputs of the console (the audio going to the tape) and lets the operator doodle with levels and effects and panning without actually affecting the tape. The second set of inputs is connected to the playback outputs of the tape machine; this set can be switched in place of the console outputs all at once, either by a massive mechanical switch or by electronic switching (FETs, 4066 ICs, etc.). If the operator wants to hear a single microphone or tape channel, there's a switch called the Solo; it activates a relay to change the monitor feeds from multi-track to the output of the desired channel. Most operators spend a lot of time punching the solo buttons frantically, yelling 'where's that buzz coming from???'

The second method of monitoring is to have a volume control and pan pot on each input channel. This greatly simplifies the console monitor panel, but lots of switching is still needed to go from console output to tape machine output. The choice is a matter of operator preference.

Patching

Consoles have inputs and outputs routed to 1/4' telephone-type jacks in a large panel; how many you have depends on how much money you have. Operators would like thousands of patch point for inserting special effects wherever they want, but the high cost of the hardware usually limits the choice to pre- and post-fader. In addition to insertion points (in which the connection is normally made by spring contacts in the jacks and broken by the plug for adding other equipment in series), there are also channel outputs and tape machine inputs. This is a great moneysaver, because it minimizes the number of mixing busses required. The operator only needs so many mixes, and some input channels can bypass the mixing process completely and go straight to the tape machine via the patching jacks (the monitoring facilities still listen to these direct channels). This is how a console with only eight output faders can be called a 16-track board. The other eight tracks are fed directly through the patchbay; the line returns (playbacks) from the tape machine are listened to via a 16-input monitoring system.

Balancing

Studios consist of enough wire to lash up a trawler net if you needed one. This incredible tangle of mike, console and tape lines makes an ideal setting for interference, crosstalk, RFI and what have you. To minimize the problems, all lines are balanced in professional studios, though on smaller setups you often see unbalanced lines which do the job using very low impedances and lots of filters. The subject of balance/unbalance or transformer versus electronic balancing will provoke a hot debate among operators any time. The choice of monitor speakers, for instance, is seen as a personal thing, like your choice of religion, but wiring fans see unbalanced studios as some sort of ignorant recklessness, or balancing as intolerably old-fashioned. In fact, it doesn't matter an awful lot. Both systems work excellently if properly installed.

The balanced line consists of two wires plus a shield; the output amplifiers are either transformers or two amps in antiphase. The inputs are either transformers or differential amplifiers. Since only the potential difference across the line pair is amplified, interference signals common to both sides of the line are subtracted by an amount dependent on the quality of the unit.

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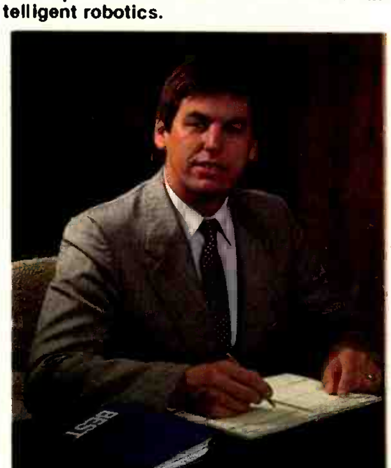


Eugen F. Hutka, the founder and President of Exceltronix, Multiflex and all the associated companies.

All our own products are manufactured in Canada to the highest quality, including being flow-soldered and ultrasonically cleaned.

All prices and specifications in this catalogue are subject to change without notice.

Our cover shows our AVT-286, IBM AT compatible computer with a graph showing our rapid and sustained growth.

The History and Development

of our successful and rapidly expanding All-Canadian company committed to high technolgoy.

Now in its seventh year, **Exceltronix** and its associated companies, has grown from a single store, to three retail outlets, a large mail order division, and an ever expanding engineering and manufacturing facility with revenues for 1986 expected to exceed **$15** million.

Many of the products sold at our own retail outlets are manufactured by our associated company, **Multiflex Inventions and Technology** in Toronto. This direct link between manufacturing and retailing benefits our customers in several ways. Our competitive prices result from not having to deal with middlemen (with their markups) and enables us to respond rapidly to the changing needs of customers. We are proud of both the high quality of our products and their excellent reliability and consequently we are able to offer warranties far better than the industry standard. **Exceltronix** is probably most widely known for its highly successful line of IBM compatible **BEST** personal computers and peripherals, but when an off-the-shelf product will not satisfy your needs, the engineering division at **Multiflex** is able to analyze your problem and develop a cost effective solution. Proof of this is the Advanced Message Display System in the Toronto Subway System and the Vancouver LRT, manufactured by **Versa-Digital**, another associated company. These examples are just some of the many solutions that we have provided for Canadian industry and commerce and we will be happy to discuss your particular requirements.

Even though we have grown enormously, we have not lost the personal touch that contributed to that growth. Although we are now one of the largest manufacturers of computers in Canada, our dedicated and knowledgeable staff are happy to discuss your needs, be it for a computer to solve a problem or a single electronic component.

In the recent past, the microcomputer business has seen huge booms and some massive recessions. Despite this, **Exceltronix** and its associated companies have grown consistently and we continue to increase our market share. Being diversified, we have the resources to research and develop our products properly. Not being dependent on a single line, we have avoided the mistake of many computer companies of bringing out products before they are properly developed.

Our company is proud of the fast and excellent service in our stores and we now have available a team of specialists who can provide on-site analysis of your hardware, software and interfacing needs.

We have yet to see what tomorrow has to offer, but you can be assured that the **Exceltronix** group of companies will be acceptingthe challenge.

Associated Companies:
Exceltronix Inc.
Multiflex Inventions and Technologies Inc.
BEST Computers Inc.
Toronto Computing Centre Inc.
Versa-Digital TechnologyInc.
Digi-Media Inc.
XL Electronix Computer Music Centre Inc.

BEST AVT-286: the IBM AT Compatible

Designed and made in Canada with pride.

Proving once again that Multiflex is an industry leader, by producing more than just affordable alternatives in personal computer design, we are pleased to announce the **BEST AVT-286** *Microcomputer, our new, fast IBM AT compatible.* The **AVT-286** is based on the *80286* microprocessor. **The AVT-286** is supported by the *Phoenix AT compatible Bios*, the same software house that supplies the Bios for all other **BEST** computers as well as many of the well known IBM compatibles currently manufactured.

Check the long list of standard features that are included on the new **BEST AVT-286**:

- The **AVT-286 runs faster than the (12MHz) IBM AT** but retains superb software compatibility.
- The main board features a **standard 640K RAM** using state-of-the-art memory chips for fast, reliable data processing.
- **Seven expansion slots** of which five support IBM AT signals. The two remaining slots are compatible with IBM PC or XT peripheral boards.
- **Presocketed** for the optional 80287 math co-processor
- **Two floppy diskette drives,** one formatted for a capacity of **1.2 Megabytes,** the other for 360K to read and write normal diskettes.
- The **BEST** Colour Video board which offers the user four modes of operation, composite and RGB output.
- An **AT compatible keyboard.**
- On board **Real Time Clock/Calendar** with battery backup.
- **Parallel Port** (for printers etc.)
- **Serial Port** (for communications).
- **Heavy duty Power Supply** as standard allows for adding extra cards as well as a Hard Disk without requiring an upgrade.
- Attractive **flip-top case.**
- A **keyboard lock** with unique security key which prevents any unauthorised use of the system.
- A **front control status panel** provides information on the keyboard lock status, reset, power-on, disk activity and parity errors.
- A **hardware reset button** so the system can restart without having to power down.

The BEST AVT-286

Canadian designed and made, Super IBM AT compatibility, 640K RAM, Two 5.25in. Disk Drives (one high density 1.2Mb, one 360K), Serial and Parallel Ports, High quality keyboard, Keyboard lock and Status Panel. See detailed description above.

Simpler or more complex configurations available at most competitive prices.

$3495.00

As standard configuration with fast-stepping Hard Drives:

20 Meg Hard Drives **$4950**
30 Meg Hard Drives **$5475**
40 Meg Hard Drives **$5795**

Warranty

We have such confidence in the time tested reliability of the BEST that we offer a 300 day warranty which is way above the industry standard. On-site service plan available at extra cost Nation-wide through 3M of Canada Ltd.

The BEST IBM AT Compatible 4 Meg Memory Card

In order to take advantage of the memory addressing capabilities of the IBM AT or the BEST AVT-286 business computer, we developed a memory card to give the user up to 4 Megabytes of dynamic RAM. The memory card will run at speeds up to 16MHz, which is fast enough to meet the needs of any 80286 microprocessor on the market today. The design uses state-of-the-art (256K x 9) memory arrays, to allow for maximum memory in the smallest physical space. The ninth bit is used as a parity bit to insure the validity of the data. The card is available in memory sizes from 512K to 4 Megabytes in steps of 512K. Boundaries are switch selectable above 1 Meg in blocks of 512K.

With 512K .... **$ 695**
With 1 Meg .... **$ 895**
With 4 Meg **$1995**

Attention IBM Owners!

BEST AT Compatible Enhancement Card

This card includes the following featues: Two Serial Communications Ports, One Parallel Printer Port and Memory starting from 128K to 512K in selectable boundaries. This card will allow IBM AT user with 256K or 512K of on-board memory to expand that AT machine to full 640K capability as well as provide them with two serial ports and one parallel port.
.... **$299.00**

Exceltronix

319 College Street, Toronto, Ont. M5T 1S2
(416) 921-8941. Order line only 1-800-268-3798
Ottawa 217 Bank Street (613) 230-9000
Visa, Mastercard and American Express accepted.

SUPER-FAST BEST Mark IV

In today's Industry, more than ever, time is money. It is for that reason we developed the **Mark IV** personal computer.

Still retaining IBM PC and XT software and hardware compatibility, the **Mark IV** uses the **true 16-bit 8086-2** microprocessor. Although the system runs at the same clock speed as the Mark III, the 8086-2 has a 16-bit external data bus compared to the 8088 and 8088-2's 8-bit data bus. This allows memory access to occur **much faster** than with most other IBM PC/XT and compatible computers.

The bus structure of the **Mk IV** remains compatible with the standard IBM 8-bit I/O channel but still has the benefits of the 16-bit architecture.

Couple the 8086-2 microprocessor with the 8087 math co-processor and you have **one of the fastest, most reliable business or engineering aids available** in this price range.

Since the **BEST Mark IV** is geared towards the serious microcomputer user, a **standard complement of 640K RAM** is installed on the main board, along with a long list of standard features.

Made in Canada with pride. Superb IBM PC/XT Compatibility

Standard Features of the BEST Mk IV

- Superb **IBM Compatibility.**
- Canadian made
- **Phoenix BIOS,** as used in many major brand IBM compatible systems.
- **640K of RAM** Memory.
- **Seven Expansion slots,** so that you have lots of room to tailor the system to your needs, with the wide range of peripheral cards available.
- **Real Time Clock/Calendar,** with software and battery backup.
- **Parallel Printer port,** to interface dot matrix, letter quality printers and digital plotters.
- **Serial Communications Port** that supports all RS232-C signals (a second serial port can be added.
- **Two double sided, double density 360k 5.25 inch floppy disk drives,** with the option of adding an additional two drives.
- **Colour graphics video board,** with both RGB and composite video outputs. Four modes of operation are available with this board.
- **Pre-socketed** for the optional Intel 8087 math co-processor.
- A **reset** switch, which can be a life saver, in the event of a program hanging your system.
- A **150 watt** power supply, with more than enough power to supply expansion boards, disk drives, and hard disk drives.
- IBM compatible, **high quality** keyboard.

Warranty

We have such confidence in the time tested reliability of the BEST that we offer a 300 day warranty which is way above the industry standard. Nation-wide on-site service plan available at extra cost through 3M of Canada Ltd.

SUPER-FAST BEST MK IV

As BEST MK III plus TRUE 16-Bit machine, 8086-2 processor, IBM compatible 8-Bit I/O channel bus, even faster than MK III due to 16-Bit architecture. With 640K RAM.

$2500.00

Other Configurations:

With 10 Meg Hard Drive/1 Floppy/640K **$3395**
With 20 Meg Hard Drive/1 Floppy/640K **$3495**

Options:

Tape Drive .... from **$1295**
Second Floppy on H.D. systems **$180**
300/1200 Baud Modem Board **$379**
BEST Monochrome Card **$179**

The BEST line

ALL of the **BEST** personal computers come with standard features that other manufacturers consider expensive options. The excellent reliability proved since we started manufacturing this range enables us to offer warranties far, far better the industry standard.

A complete description of the personal computers manufactured is included in this catalogue. Before you buy your system our computer fluent sales staff can provide you with advice on the hardware and software required to solve your problem. And remember that after you purchase the **BEST** computer that suits your needs, **Exceltronix** and its sister companies will be around long after some other retailers have come and gone, to offer you unparalleled service and selection, as we have been for the last six years.

Special Requirements? We have the in-house experts in both hardware and software to interface a lot of complex equipment to IBM, **BEST** or compatible computers. We can recommend or customise existing software packages for your business or industrial needs. We have excellent in-store and on-the-road sales staff with computer expertise and a superb team of in-house hardware and software engineers.

We can probably help you with every aspect of your computer needs at reasonable, honest prices. Call us.

APPROXIMATED SPEED COMAPRISONS

For the speed comparison test a PL1 programmer was compiled on a 360K RAM disk, namely VDisk supplied on Dos 3.0. The reasons for this instead of a diskette are twofold: 1. The drive characteristics between an AT and a PC are radically different. We wouldn't know if we were comparing speed of the drives or speed of the machines. 2. The 16-bit machines such as the Mark IV and AT cannot utilize their full power while talking to 8-bit devices.

The base was an IBM PC/XT with 640K running at 4.77MHz. The compile was of moderate length: 170 seconds. The table here gives the results of the speed test:

Machine Type	IBM PC/XT 4.77 MHz	Mark III 8.00 MHz	Mark IV 8.00 MHz	IBM PC/AT (12 MHz) (6 MHz CPU)	AVT-286 (16 MHz) (8 MHz CPU)
Seconds	170	105	80	67	53
Relative Speed	1.00	1.62	2.13	2.53	3.2

Looking at the table we see a number of remarkable things. The first is the speed of the AVT-286 over the IBM PC/AT. The AVT-286 is about 25% faster than the IBM AT. The other remarkable thing is that the Mark IV is only 16% slower than the IBM AT! (This is even more remarkable considering the price differential). We also see, as expected, that the 16 bit data path of the 8086 in the Mark IV gives 31% improvement over the Mark III at equivalent processor clock speeds.

If you want the Best, buy the BEST

We are proud to introduce the
New FAST BEST Mark III

Made in Canada with pride.

To meet the demanding needs of industry for faster information processing, Exceltronix is pleased and proud to introduce the Mark III personal computer. Based on the success of the BEST Mark II, the Mark III goes a step beyond. The system is based on the **8088-2** microprocessor, which is capable of running almost twice as fast as any 8088 based system.

- **Superb IBM PC/XT software and hardware** compatibility has been retained.
- A hardware switch allows you to go **from 4.77MHz to 8MHz** operation. Any software that implements a lot of memory manipulation will run visibly faster. Compilers work much faster, spreadsheets will speed through calculations, and even video intensive games run quicker.
- All the same cost effective package that made the Mark II a success, has been continued in the Mark III. We consider features such as a **Real Time Clock, Parallel Printer Port, Serial Communications Port and a minimum of 256K RAM memory**, necessities in today's personal computer. These have been included in the base price along with a colour video board, so even if you don't need the options today, tomorrow you will not have to pay to have them installed.

Superb IBM PC/XT Compatibility

Monitor and printer not included. IBM is a registered trade mark of IBM Canada Limited.

The FAST BEST MK III

As BEST MK II plus speed selectable: 4.77 and 8MHz (most software will run on the higher speed), uses 8088-2 processor.

$1895.00

Other Configurations:

With 640K RAM	$1995
With 10 Meg Hard Drive/1 Floppy/256K	$2795
With 10 Meg Hard Drive/1 Floppy/640K	$2895
With 20 Meg Hard Drive/1 Floppy/256K	$2895
With 20 Meg Hard Drive/1 Floppy/640K	$2995

Standard Features Common to the BEST MK II and MK III

- Superb IBM Compatibility.
- **Phoenix BIOS**, as used in many major brand IBM compatible systems.
- **Minimum of 256K RAM** (Random Access Memory) using 41256K RAM chips, expandable to 640K or higher on the main board.
- **Seven Expansion slots**
- **Real Time Clock/Calendar**, with software with battery backup.
- **Parallel Printer port**
- **Serial Communications Port** that supports all RS232-C signals (a second serial port can be added for only $39.00 extra).
- Two double sided, double density 360k **5.25 inch floppy disk drives**
- **Colour graphics video board**, with both RGB and composite video outputs.
- **Pre-socketed** for the optional Intel 8087 math co-processor
- **A reset switch**
- A **150 watt power supply**, with more than enough power to supply expansion boards, disk drives, and hard disk drives.
- IBM compatible, **high quality keyboard.**

Warranty

We have such confidence in the time tested reliability of the BEST that we offer a 300 day warranty which is way above the industry standard. Nation-wide on-site service plan available at extra cost through 3M of Canada Ltd.

Options:

Tape Drive	from $1295
Second Floppy on H.D. systems	$180
Second Serial Port	$39

The BEST Mark II
Made in Canada
Superb IBM PC/XT Compatibility

In the past two years, thousands of BEST personal computers have been working their way into the Canadian business, educational and home environment. Based on the 8088 microprocessor, the BEST Mark II is an inexpensive entry into the personal computer field.

As with all the BEST product range, it is made in Canada to the highest standard of quality.

It is the success of the original BEST and the Mk II that prompted us to develop the newer and faster Mk III and Mk IV.

Monitor and printer not included. IBM is a registered trade mark of IBM Canada Limited.

BEST MARK II

Standard Mark II with 256K RAM and two 360K DD/DS diskette drives, Serial and Parallel Ports, Real Time Clock, Phoenix BIOS. Uses 8088 processor.

$1695

Other Configurations:

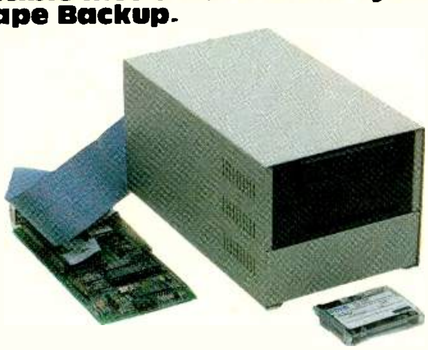
With 640K RAM	$1795
With 10 Meg Hard Drive/1 Floppy/256K	$2595
With 10 Meg Hard Drive/1 Floppy/640K	$2695
With 20 Meg Hard Drive/1 Floppy/256K	$2695
With 20 Meg Hard Drive/1 Floppy/640K	$2795

If you want the Best, buy the BEST

Upgrade your IBM

BEST External Hard Disk Drive and Tape Back-up Unit

Easily Convert your IBM PC or Compatible into a Hard Drive System with Tape Backup.



As more people become educated in the use of personal computers, the office computer becomes victim to late night hackers and curiosity seekers. The data upon which your business decisions are made every day is in danger of being wiped away by a wrong sequence of key presses or the data may be seen by those without proper authorization. Protect your data and yourself by removing the hard disk drive from the system.

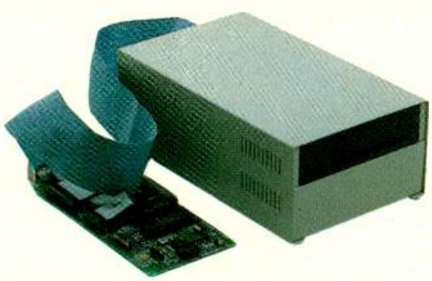
Multiflex has designed a unit which allows you to physically remove the mass data storage device and lock it in another room without disassembling your entire system. The external hard disk drive and tape backup unit is self contained with its own power supply and connects to back of your system through a ribbon cable. Simply follow normal shut down procedures then unplug the unit and carry it to a safe location.

With Seagate 20 Megabyte Hard drive and Scorpion Tape Backup unit
$2795.00

With 10 Megabyte Hard Drive and Irwin Tape Backup unit
$2395.00

Convert your IBM PC or XT into a Hard Drive System within Minutes

Do It yourself with no mechanical alterations.



This unit rapidly converts your system into a Hard Drive unit, and it is compact enough to fit in a brief case. The unit contains it own power supply, fan, a reliable Seagate 20 Megabyte hard drive and a controller card which plugs into your existing system.

With Seagate 20 Megabyte Hard Drive
$1295.00

With 10 Megabyte Hard Drive
$1195.00

BEST EXPANSION System for your IBM PC

If you are one of the many who invested thousands of dollars in an IBM PC, you may be realizing the limitations of the hardware you own. The power supply may not be able to handle the addition of a hard disk drive or the five expansion slots may already be filled with necessities, leaving no room for the luxuries of more memory or communications hardware.

The BEST Expansion System was designed to function in a transparent fashion to the IBM operating system. The host system (IBM PC or XT) will look at a peripheral card in any of the eight slots of the expansion system as if it were installed in the slots on its own main board.

The Expansion System is packaged in an attractive flip-top case with its own power supply and ventilation fan. Two 3 foot long ribbon cables connect the host computer to the expansion system, which allows the expansion system to be placed on top, beside or underneath of your existing IBM PC or XT system.

The expansion chassis is powered by a 150 watt power supply with power connectors for two disk drives included as a standard feature. This power supply has enough power to run four diskette drives, expansion cards, or hard disk drives.

Although the system provides you with more slots and the capacity for a hard drive, your existing system will run with less load and therefore cooler.

Complete BEST Expansion System including the peripheral adapter to plug into your existing IBM PC or XT system, 8-slot expansion bus, with flip-top case and 150W power supply and cooling fan.

Price $795.00

Add a Tape Drive to your Existing System

Those who have used computers for any length of time can explain the absolute necessity for an external backup of the data held in a Hard Disk. Our self-contained unit, including power supply, (which looks similar to the Hard Drive Unit illustrated left) has a cable and peripheral card which simply plugs into your IBM or compatible system.

Tapes for these systems are readily available.

With Irwin Tape Drive and BEST Controller
$1195

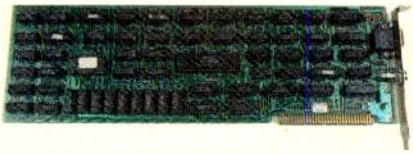
With Scorpion Tape Drive and Controller
$1395

Add Extra 360K Disk Drives to your System

If you need more than the two existing drives for your system, our self-contained external unit with two 5.25in. 360K disk drives with its own power supply, fan and controller will be of interest.

Price $595.00

The BEST Colour Graphics Video Board



The BEST Colour Graphics Video Board was designed for those personal computer users who require an inexpensive, but versatile video display. The user has a choice of three types of monitors that can be connected to the card, a composite monochrome monitor, composite colour monitor or direct drive RGB colour monitor. Software utilizing a light pen can be run since the BEST Colour Video board supports the necessary hardware.

The video board is capable of operating in four modes, two text and two modes of graphics display

Text display

The BEST Video Card can display either 80 or 40 characters on one line. The character generator contains all the standard ASCII characters plus block graphic characters and a set of international characters such as the English pound and Japanese Yen. Depending on your choice of monitor, the application text can be displayed with a variety of foreground and background colours. In addition, black and white mode allows for the following attributes: reverse video, blinking and highlighting.

The operator can switch between 40 and 80 column display by using the DOS MODE command. The 80 column mode gives crisp characters on either colour or monochrome monitors. The 40 column text mode is suitable to use if you were to use a common television set in conjunction with a RF modulator that can be directly attached to the video board.

Graphics Display

The BEST video board is capable of displaying three styles of graphics.

Low resolution — Monochrome or Colour

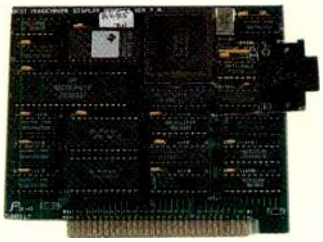
In the low resolution mode either colour or monochrome graphics can be displayed. The screen is capable of displaying 200 rows of 320 pixels (a pixel is one dot on the screen). In the colour graphics mode each pixel can be one of four colours, and the background can be one of 16 colours. Many software packages are written with colour graphics capabilities. LOTUS 123, and Symphony for example become more powerful and easier to use with the addition of crisp and vivid colour graphics.

High resolution — monochrome

For applications such as computerized drafting or intricate business charts, colour may not be desired, but high resolution is required. The BEST card is able to double the resolution of the display to 200 rows of 640 pixels, by selecting the monochrome instead of colour graphics. In the high resolution mode an inexpensive composite monitor can still be used.

$179.00 with Warranty

The BEST Monochrome Card



In the office environment where a great deal of word processing, or data entry takes place, eye fatigue may be a problem. A solution to this problem is an upgraded text display card for your BEST, IBM PC or compatible. The monochrome card displays a character that is made up of 7 x 9 matrix of dots in comparison to the 5 x 7 matrix used on the standard colour graphics video board. The finer dot pattern makes text appear much cleaner and easier to read. The monochrome card will display characters in four modes; normal, intensified, reverse video and blinking. The display is 80 x 25 characters. Note: This is a half size board which will fit even those computers with restricted space.

$179.00 with Warranty

Phoenix Video Board

The choice of a video display card can be a difficult one. There are many different capabilities for each style of video card available. If your display needs are as diverse as the number of cards available, you may have to install two or three video cards in your system. Not only is this expensive, but it also steals precious expansion slots from your system. Phoenix Computer corp. has a designed an expansion card to satisfy all of your display needs. The Phoenix video card can emulate the following styles of display cards.

IBM colour graphics card — 40 or 80 column character display
320 x 200 colour graphics
640 x 200 monochrome graphics
IBM monochrome text display — 80 column high resolution text display
Tecmar
Hercules high resolution monochrome graphics display 120 x132 column colour text display mode

Depending on which display mode you choose any monitor up to 25kHz colour monitors can be interfaced to the Phoenix video card. The setup software is menu driven, and allows the user to program its own character set, as well as selecting from a 64 colour pallet.

$395.00 with Warranty

Hercules

Colour Graphics Board **$312.00**

4 colour graphics and printer board that fits into standard PC/XT or compatible slot. Also included is a parallel interface.

Monochrome Board **$600.00**

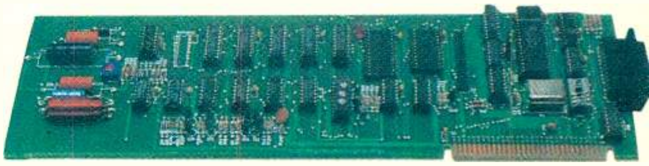
A high resolution monochrome display of graphics. Supports word processor, and business graphics software.

Tecmar

Graphics Master Board/Paint **$799.00**

Displays alphanumeric text and graphics on any monochrome display or other standard composite or RGB monitors. Comes complete with a light pen and PC paint brush.

EPROM PROGRAMMER



External Card.

This card can program any one of the following EPROMs: 2716, 2732, 2732A, 2764 and 27128s. Two sockets are available on the adaptor board, one for the 28-pin EPROMs, the other for 24-pin types. These sockets are standard sockets, however as an option ZIF sockets can be used (we recommend ZIF sockets if large numbers of EPROMs will be programmed). Also as an option an extension board is available. This board attaches to the adaptor via a ribbon cable and extends out the back panel. This is to allow EPROMs to be programmed without removing the cabinet cover every time programming is to be performed. Also as a standard feature, the source software is supplied to allow users to modify the program to suit their needs.

As an option a serial port can be included on the card; this serial port has the same features as the port described with the floppy disk controller (see the floppy disk description for documentation of the serial port).

MAIN EPROM PROGRAMMER CARD (WITH SOFTWARE)

With 2 standard EPROM sockets **$99.00**

EPROM PROGRAMMER WITH ZIF SOCKETS (WITH SOFTWARE)

With one 24-pin. ZIF socket and one 28-pin ZIF socket with provision for serial port **$139.00**

EXTERNAL CARD

Ready to plug into the main EPROM Card (includes one 24-pin and 28-pin ZIF socket and cable). Saves you from opening the computer each time you want to program your EPROMS **$69.00**

SERIAL OPTION

For your main EPROM programmer. Provides you with a second RS232 serial port **$49.00**

BEST MODEM

The BEST modem is a smart 1200/300 direct connect modem. It can either be a stand-alone unit in which case it requires a small wall adaptor, or it plugs in one of the IBM slots. When used as a stand-alone unit, the modem looks like a Hayes 1200 Smart Modem, that is, it emulates the same instruction set. When it is used in the IBM, it looks like an intelligent serial communications port which also supports a super-set of the Hayes instruction set.

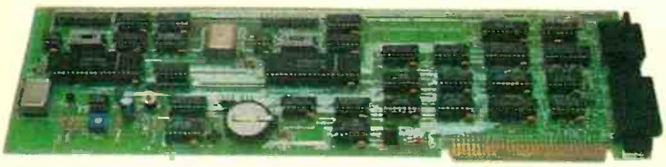
The modem supports auto-dial, auto-answer, and auto-speed select directly from software control. The modem also has a speaker so that aural monitoring of the call is possible. There are also LED monitors so that the state of the modem can always be known. These LEDs are: Modem Ready, Auto-Answer enabled, Carrier Detected, Transmitting, Receiving, Data Set ready.

Software packages such as Crosstalk, PC-talk, and Hayes' Smartcom II also will run with this modem.

300 Baud **$179.00** 300/1200 Baud **$249.00**

300/1200 Baud, Stand-Alone Unit, Attractively Packaged **$299.00**

The BEST Quanta Board



Do you find that your PC is not able to communicate with the outside world and you are constantly having to tell it the correct time and date? A simple solution for a system's short coming would be the BEST Quanta Board. Another of the multi-function boards designed with the personal computer user in mind, its features include the following:

Serial Ports

- Two serial communication ports that are configured under PC or MS-DOS as COM1 or COM2. Both communications ports support RS232-C signals (TxD, RxD, DTR, DSR, RTS, CTS, CD, and RI) at communication rates of up to 9600 Baud. One or both the serial ports can be disabled, to alleviate contention between any other serial port your system may already contain. The serial ports can also be configured to support the IBM PC mA current loop. The current loop allows the system to communicate with some types of teletype printers.

Parallel Printer Port

- A parallel printer port which supports many of the popular dot matrix and letter quality printers, as well as digital plotters that are commercially available. The parallel port can be selected as the primary or secondary printer port (LPT2 or LPT3 using DIP switches).

Games Port

- A game port which allows up to four game paddles, or two joy sticks to be connected to the system. The port is not limited to entertainment software. The port actually gives a value proportional to the resistance on the input, which allows your system to control industrial applications and CAD (computer aided design) software.

Real Time Clock/Calendar

- A real time clock/calendar with software to interface the clock hardware with the TIME and DATE functions of MS-DOS and PC-DOS. The clock continues to keep the correct time when the system is powered down by utilizing a replaceable lithium battery. The clock is based on the MM58274 CMOS chip and it is accurate to within seconds every year.

$159.00 Cables Extra.

BEST Multi-Function Disk Drive Controller

The BEST Multi-Function disk drive controller is much more than its name implies. This card makes the most use of an expansion slot in your system by including many needed options on one card. This board may be the last you will have to install in your IBM PC or compatible system because of the extra features we have included.

Floppy Controller

- Floppy disk drive controller, which can handle up to four double sided, double density 5.25in. 360K disk drives.

The controller circuitry will also control some Tape Back Up units such as those manufactured by Irwin Magnetics in place of one of the four disk drives.

Serial Ports

- Two serial communications ports that support RS232-C standard signals (TxD, RxD, CTS, RTS, DSR, DTR, and RI).

Parallel Printer Port

- Parallel Printer Port that can be configured as either your primary or secondary printer port.

Real Time Clock/Calendar

- Real Time Clock with software, to integrate the clock with your version of PC-DOS or MS-DOS. The clock is designed around an ICL clock chip and is accurate to within seconds a year. A battery back up continues to keep the time during power down.

This is the same floppy controller used in all versions of the BEST personal computer, with excellent reliability and compatibility. Using PC-DOS 2.0 or later, each diskette has a formatted capacity of 360 Kilobytes.

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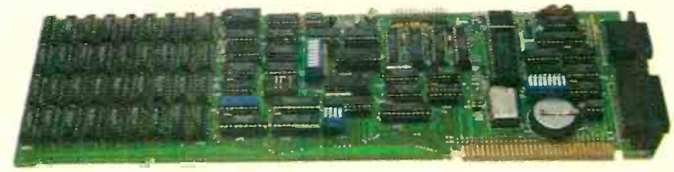
The BEST 256K/512K PentaRAM Board



Almost every option your system is lacking can be supplied by the BEST PentaRAM board. This combination of options is one of the most economical ways (from the point of view of both your pocketbook and the expansion slots on your system) to expand your system. All communication ports follow the Industry standards. The additional memory continues on from where your main board's memory stopped, in a completely transparent fashion. In detail the features of the BEST PentaRAM board are as follows:

Memory

- Up to 256K RAM using 4164's or 512K RAM using state-of-the-art 41256's can be added to your system. The starting memory boundary can be set to 256K, 384K, 512K, or 640K by configuring a bank of dip switches. The added memory is necessary for anyone wishing to operate a RAMdisk, and much of today's software requires a minimum of 384K RAM (Symphony, Framework, etc.) which many of the older PC's are not capable of holding on the main board. Each bank of memory contains an extra chip to support a parity bit for reliable data handling. (If the above boundaries do not match your system's configuration, they can be modified at the factory).

Serial Port

- A serial communication port that is configured under PC-DOS or MS-DOS as COM1 or COM2. The communications port supports RS232-C signals (TxD, RxD, DTR, DSR, RTS, CTS, CD, and RI) at communication rates of up to 9600 Baud. The serial port can be disabled, to alleviate contention between any other serial port your system may already contain. The serial port can also be configured to support the IBM PC mA current loop. The current loop allows the system to communicate with some types of teletype printers.

Parallel Printer Port

- A parallel printer port which supports many of the popular dot matrix and letter quality printers, as well as digital plotters that are commercially available. The parallel port can be selected as the primary or secondary printer port (LPT2 or LPT3 using DIP switches).

Games Port

- A game port which allows up to four game paddles, or two joy sticks to be connected to the system. The port is not limited to entertainment software. The port actually gives a value proportional to the resistance on the input, which allows your system to control industrial applications and CAD (computer aided design) software.

Real Time Clock/Calendar

- A real time clock/calendar with software to interface the clock hardware with the TIME and DATE functions of MS-DOS and PC-DOS. The clock continues to keep the correct time when the system is powered down by utilizing a replaceable lithium battery. The clock is based on the MM58274 CMOS chip and it is accurate to within seconds every year.

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PentaRAM Board with 512K and all options
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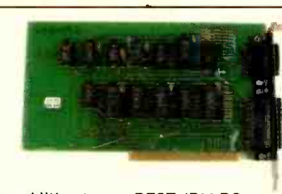
The BEST Parallel/ Game Card



$69.00 (Cables Extra)

The BEST parallel/game card is an inexpensive addition to any BEST, IBM PC or compatible, which gives you the ability to connect almost any parallel printer or plotter to you system. The Parallel port is accessible through a DB25 connector located on the back of the card, which eliminates the need to disassemble the system case to connect the interface cable to the card. Printers such as the Epson family and Star Micronics, Toshiba and others work with the BEST printer card with no special hardware except the connecting cable.

The game port is compatible with game paddles. Up to four game paddles or two joysticks can be connected via a 15-pin connector on the back of the card.

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4086	Expandable 4 by 2 AND/OR invert gate	.52
4093	Quad 2 input NAND Schmitt trigger	.59
4094	8 stage shift/store register	.99
4097	Diff 8 channel analog mux/demux	1.90
4099	8 bit addressable latch	.99
4501	Industrial control unit	2.99
4502	Strobex Hex inverter/buffer	1.25
4503	Hex tri state buffer	.89
4504	Hex level shifter	1.49
4506	Dual Expandable AOI gate	2.50
4508	Dual 4 bit latch tri-state	1.75
4510	BCD up/down counter	.95
4511	BCD to 7 segment latch/decoder/driver	.95
4512	8 channel data separator	.89
4514	1 of 16 decoder/demultiplexer	1.85
4515	1 of 16 decoder/demultiplexer	1.85
4516	Binary up/down counter	.95
4518	Dual BCD up counter	.89
4519	4 bit AND/OR select gate	.65
4520	Dual binary up counter	.79
4521	24 stale frequency divider	1.99
4522	BCD divide by N counter	1.25
4526	4 bit binary divide by N counter	1.10
4527	BCD rate multiplier	1.10
4528	Dual retriggerable/resettable monostable	1.10
4529	Dual 4 channel mux	1.30
4530	Dual 5 input majority logic gate	1.05
4531	12 bit parity generator/checker	1.35
4532	8 bit priority encoder	1.35
4534	Real time 5 decade counter	7.50
4536	Programmable timer	2.37
4538	Dual precision monostable multivibrator	1.30
4539	Dual 4 channel digital multiplexer	1.25
4541	Quad 2 input analog mux	1.15
4543	BCD to 7 segment latch/decoder/driver	1.05
4553	3 digit BCD counter	2.89
4555	Dual binary 1 of 4 decoder	.63
4556	Dual binary 1 of 4 decoder	.75
4557	1-6 bit shift register	4.87
4558	BCD to 7 segment decoder	1.55
4560	NBCD adder	5.69
4561	9's complimenter	1.05
4562	128 bit static shift register	7.95
4566	Industrial time base generator	1.89
4568	Phase comparator/programmable counter	2.50
4572	Hex gate	.65
4573	Quad programmable op amp	3.43
4575	Quad programmable comparator	3.25
4580	4 x 4 multiport register	6.49
4581	4 bit A/U	2.25
4582	Carry look ahead generator	1.75
4583	Dual Schmitt trigger	.95
4584	Hex Schmitt trigger	.60
4585	4 bit magnitude comparator	.99
4702	Programmable bit rate generator	11.99

LINEAR

109	1A + 5V regulator	8.38
124	Quad op amp	3.95
139	Quad comparator	3.95
148	Quad op amp	5.50
300	General purpose op amp	4.10
301A	General purpose op amp	.50
305	Voltage regulator	1.15
306	Improved voltage comparator	1.50
307	Op amp	.60
308	Super beta op amp	.75
309	+ 5V regulator	1.89
310	Voltage follower	3.38
311	Voltage comparator	1.50
317	3 terminal adjustable regulator	1.29
318	Precision high speed op amp	1.45
319	High speed dual comparator	1.89
323	3A + 5V regulator	5.19
324	Quad op amp	.58
337	3 terminal negative regulator	1.75
339	Quad comparator	.55
348	Quad low-power 741	.88
350	3A 3 term. positive adjust. regulator	7.25
355	FET input op amp	.89
356	Monolithic J-FET input op amp	1.95
357	Monolithic J-FET input op amp (uncompensated)	1.95
358	Dual version of 324	.55
380	2W audio amp	1.10
393	Dual version of 339	.60
398	Sample and hold amplifier	5.94
555	Timer	.45
556	Dual timer	.82
558	Quad timer	1.90
567	Tone decoder	.95
709	Op amp	.78
710	Differential comparator	1.32
711	Dual channel differential comparator	.99
714	Precision op amp	4.45
715	High speed op amp	5.25
723	Voltage regulator	.59
725	Instrumentation op amp	2.99
733	Differential video amp	1.15
739	Dual high performance op amp	2.05
741	Operational amplifier	.59
747	Dual op amp	.75
748	Op amp	.65
749	Dual audio preamplifier	2.99
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1372	RF modulator	4.30
1436	High voltage op amp	4.49
1458	Dual op amp	.54
1488	Quad line driver	.59
1489	Quad RS232 line receiver	.59
1495	Multiplier	5.25
1496	Modulator/demodulator	1.35
1558	Dual op amp	1.99
1595	Four quad multiplier	7.78
1596	Modulator/demodulator	5.49
1800	Demodulator	6.25
1889	Video modulator	6.25
3900	Quad op amp	0.95
26LS29	Quad RS423 line driver	5.49
26LS30	Quad RS422/432 line driver	3.95
26LS31	Quad differential line driver RS422	2.30
26LS32	Quad differential line driver RS422	2.70
26LS33	Quad differential line driver RS422	2.45
3470	Floppy disk read amplifier	5.99
3486	Quad RS422/423 line receiver	2.25
3487	Quad line driver RS422	2.35
76477	Analog complex sound generator	5.00
76478	Analog complex sound generator c/w amp	6.90
76489	Microprocessor cont. complex sound generator	8.30
8T26	Quad tri-state bus transceiver	1.75
8T28	Quad tri-state bus transceiver	1.50
TL070	Low noise bifet op amp	.86
TL071	Low noise bifet op amp	.78
TL072	Low noise bifet op amp	1.10
TL074	Low noise bifet op amp	1.95
TL075	Low noise bifet op amp	2.99
TL080	General purpose bifet op amp	.69
TL081	General purpose bifet op amp	.75
TL082	General purpose bifet op amp	.99
TL083	General purpose bifet op amp	2.50
TL084	General purpose bifet op amp	1.85
TL497	Switching voltage regulator	2.35
ULN2002	7 segment transistor array	1.00
ULN2003	7 segment transistor array	1.00
ULN2004	7 segment transistor array	1.00
XR200	Multifunction I C	67.95
XR205	Monolithic waveform generator	8.10
XR210	FSK modulator/demodulator	4.99
XR215	Phase lock loop	4.99
XR240	PCM repeater	11.95
XR320	Monolithic timing circuit	1.64
XR1310	Stereo demodulator	1.25
XR2206	Monolithic function generator	4.95
XR2207	Voltage controlled oscillator	2.75
XR2208	Operation multiplier	2.99
XR2209	Precision oscillator	3.25
XR2211	FSK demodulator/tone decoder	6.99
XR2212	Precision phase locked loop	8.99
XR2242	Long range timer	2.25
XR2567	Dual monolithic tone decoder	2.40
XR4739	Dual low noise op amp	1.55
XR14412	FSK modem system	8.75

7400 SERIES TTL

7400	Quad 2 input NAND gate	.49
7402	Quad 2 input NOR gate	.49
7403	Quad 2 input NAND gate O/C	.49
7404	Hex inverter	.55
7405	Hex inverter gate O/C	.54
7406	Hex inverter buffer/driver	.65
7407	Hex buffer/driver	.65
7408	Quad 2 input AND gate	.49
7409	Quad 2 input AND gate with O/C	.49
7410	Triple 3 input NAND gate	.49
7411	Triple 3 input AND gate	.39
7414	Hex Schmitt trigger	.65
7416	Hex inverter buffer/driver	.65
7417	Hex buffer/driver	.65
7420	Dual 4 input NAND gate	.50
7422	Dual 2 input NAND gate	.59
7423	Dual 2 input positive NOR gate	.59
7425	Dual 4 input NOR gate	.56
7426	Quad 2 input NAND gate	.56
7427	Triple 3 input NOR	.49
7430	8 input NAND gate	.65
7432	Quad 2 input gate	.53
7437	Quad 2 NAND buffer	.52
7438	Quad 2 input NAND buffer	.65
7439	Quad 2 input NAND buffer	.65
7440	Dual 4 input buffer	.69
7442	8 bit shift register	.79
7445	BCD-decimal to decoder-driver	1.29
7446	BCD-to 7 segment driver	1.58
7447	BCD-to 7 segment driver	1.58
7448	BCD-to 7 segment decoder/driver	1.56
7450	2-1 input and/or invert gate	.49
7451	And/or invert gate	.49
7454	4 wide and/or invert gate	.49
7474	Dual D flip flop	.76
7475	4 bit bistable latch	.76
7476	Dual JK master/slave flip flop	.69
7485	4 bit magnitude comparator	1.19
7486	Quad 2 input exclusive or gate	.75
7489	64 bit read/write memories	3.54
7490	Decade counter	.77
7491	8 bit shift register	.77
7492	Divide by 12 counter	.63
7493	4 bit binary counter	.63
7495	4 bit right shift/left shift register	.79
7496	5 bit shift register	.95
7497	Synchronous rate multiplier	2.75
74104	Gated JK master/slave flip/flop	1.45
74105	Gated JK master/slave flip/flop	1.45
74107	Dual JK flip flops with clear	.75
74109	Dual JK edge triggered F/F	.75
74120	Dual pulse Sync	2.19
74121	Monostable multivibrator	.75
74122	Retriggerable one shot multivibrator	.95
74123	Dual retriggerable one shot	.67
74125	Tri-state quad bus buller	.95
74126	Tri-state quad bus buller	.95
74128	50-ohm line driver	.95
74132	Quad 2 input Schmitt	.95
74136	Exclusive or NAND gate	.92
74141	BCD to decimal decoder driver	1.79
74142	Counter/latch/decoder/driver	5.59
74143	Center decoder	6.95
74144	Center decoder	5.99
74145	BCD to decimal decoder driver	1.29
74147	10-4 priority encoder	2.45
74148	Priority encoder	1.59
74150	16 line to 1 line multiplexer	2.35
74151	8 channel digital multiplexer	.89
74153	dual 4-1 multiplexer	.89
74154	4 line to -16 decoder	1.99
74155	Decoder/demultiplexer	.79
74156	Decoder/demultiplexer	.99
74157	Quad 2 input multiplexer	.82
74159	4-16 decoder	2.10
74160	BCD decade counter, async. reset	.89
74161	Synchronous 4 bit counter	1.09
74162	Sync. 4 bit counter	1.19
74163	Sync. 4 bit counter	1.09
74164	8 bit serial shift register	1.09
74165	Parallel load 8-bit shift register	1.25
74166	8 bit shift register	1.79
74167	Sync. rate multiplexer	4.65
74170	4 by 4 register file	2.99
74172	16 bit register file	6.75
74173	4 bit tri-state register	1.59
74174	Hex D flip flop with clear	1.19
74175	Quad D flip flop with clear	.89
74176	Presettable counter/latch decade	1.45
74177	Presettable counter/latch binary	1.45
74178	4 bit shift register	1.69
74179	4 bit parallel access shift register	1.75
74181	Arithmetic logic unit	3.55
74182	Look ahead carry generator	1.45
74184	Code convertor BCD to binary	3.55
74185	Binary to BCD convertor	3.50
74190	Synchronous up/down decade counter	1.29
74191	Up/down bi cntr.	1.29
74192	Binary up/down counter	1.09
74193	Binary up/down counter	1.09
74194	4 bit bi-directional shift register	1.25
74195	4 bit parallel access shift register	1.09
74196	Presettable decade counter	1.45
74197	Presettable binary counter	1.45
74198	8 bit shift register	2.19
74199	8 bit shift register	2.19
74221	Dual Monostable multivibrator	1.29
74251	Tri-state 8 input multiplexer	1.45
74259	8 bit addr latch	3.19
74273	Octal D-type flip flop	3.19
74276	Quad JK flip flop	3.75
74279	Quad shift register/latches	2.10
74283	4 bit binary full adder	1.78
74284	Tri-state 4 bit multiplexer	4.65
74365	Hex bus drivers 3 state output	.89
74366	4 bit binary full addr.	.89
74367	Hex bus drivers/non inverted	.89
74368	Hex bus drivers inverted data	.89
74390	Dual decade counter	2.19
74393	Dual 4 bit binary counter	2.19

74ALS00 Advanced Low Power Schottky TTL

74ALS00	Quadruple 2 input POS NAND gate	.57
74ALS02	Quadruple 2 input POS NOR gate	.57
74ALS03	Quadruple 2 input POS NAND gate OC	.57
74ALS04	Hex inverter	.57
74ALS05	Hex inverter OC	.57
74ALS08	Quadruple 2 input POS AND gate	.57
74ALS09	Quadruple 2 input POS AND gate OC	.57
74ALS10	Triple 3 input POS NAND gate	.57
74ALS11	Triple 3 input POS AND gate	.57
74ALS12	Triple 3 input POS NAND gate OC	.57
74ALS15	Triple 3 input POS AND gate OC	.57
74ALS20	Dual 4 input POS NAND gate	.57
74ALS21	Dual 4 input pos AND gate	.57
74ALS22	Dual 4 input POS NAND gate OC	.57
74ALS27	Triple 3 input POS NOR gate	.57
74ALS28	Quadruple 2 input POS NOR buffer	.57
74ALS30	8 input POS NAND gate	.57
74ALS32	Quadruple 2 input POS NOR gate	.57
74ALS33	Quadruple 2 input POS NOR buffer OC	.65
74ALS35	Hex non inverter with O/C output	.58
74ALS37	Quadruple 2 input NAND buffer	.67
74ALS38	Quadruple 2 input POS NAND buffer OC	.67
74ALS51	Dual AND/invert gate	.76
74ALS74	Dual D type POS edge triggered F/F	.77
74ALS86	Quadruple 2 input exclusive OR gate	.77
74ALS109	Dual JK positive edge triggered F/F	.77
74ALS112	Dual JK NEG edge triggered Flip flop with preset and clear	.76
74ALS113	Dual JK NEG edge triggered flip flop with preset	.77
74ALS114	Dual JK NEG edge triggered FF/with preset, common, clear/clock	.77
74ALS133	13 input POS NAND gate	.67
74ALS136	Quad exclusive OR gate OC	.77
74ALS138	3 to 8 line decoder/demultiplexer	1.19
74ALS139	Dual 1 of 4 decoder	1.85
74ALS151	Dual 4 line to 1 line data Selector/multiplexer	1.19
74ALS157	Quad 2 input multiplexer non inverting	1.55
74ALS160	Sync 4 bit counter	1.65
74ALS161	Sync 4 bit counter	1.65
74ALS162	Sync 4 bit counter	1.65
74ALS163	Sync 4 bit counter	1.65
74ALS169	4 bit up/down sync. counter	1.65
74ALS174	Hex D type flip flop	1.19
74ALS175	Quad D type flip flop	1.19
74ALS190	Sync up/down counter (BCD)	1.55
74ALS191	Sync up/down counter (binary)	1.55
74ALS192	Sync up/down dual clock counter	1.55
74ALS193	Sync. up/down dual clock counter	1.55
74ALS240	Octal buffer line driver/rec	2.19
74ALS241	Octal buffer line driver/rec	2.19
74ALS242	Quadruple bus transceiver	2.15
74ALS243	Quadruple bus transceiver	2.15
74ALS244	Octal buffer line drive/rec	2.19
74ALS245	Octal bus transceiver	2.45
74ALS251	Data selector/multiplexer	2.37
74ALS253	Dual data selector/multiplexer	2.37
74ALS257	Quad data selector/multiplexer	2.37
74ALS258	Quad data selector/multiplexer	2.37
74ALS273	Octal D type flip flop	2.35
74ALS299	8 bit bidirectional universal shift/storage register	5.45
74ALS352	Dual 4 line to line data selector/multiplexer	1.19
74ALS353	Dual 4 line to 1 line data selector/multiplexer	1.19
74ALS373	Octal D type latche	2.45
74ALS374	Octal D type flip flop	2.45
74ALS465	Octal buffer with 3 state output	2.45
74ALS466	Octal buffer with 3 state inverted output	2.45
74ALS467	Octal buffer with 3 state ouptut	2.45
74ALS468	Octal buffer with 3 state inverted output	2.45
74ALS518	8 bit magnitude comparator	3.75
74ALS519	8 bit Magnitude comparator	3.75
74ALS522	8 bit Magnitude comparator	7.57
74ALS533	Octal D type transparent latche	2.45
74ALS534	Octal D type edge triggered F/F	2.45
74ALS540	Octal buffer and line driver	2.19
74ALS541	Octal buffer and line driver	2.19

74SXX Series TTL

74S00	Quad 2 input NAND gate	.62
74S02	Quad 2 input NOR gate	.62
74S03	Quad 2 input NOR gate O/C	.75
74S04	Hex inverter	.62
74S05	Hex inverter O/C	.75
74S08	Quad 2 input AND gate	.62
74S09	Quad 2 input AND gate O/C	.79
74S10	Triple 3 input NAND gate	.79
74S11	Triple 3 input AND gate O/C	.79
74S15	Triple 3 input AND gate O/C	.79
74S20	Dual 4 input NAND gate	.62
74S22	Dual 4 input NAND gate O/C	.79
74S30	8 input NAND gate	.72
74S32	Quad 2 input NOR buffer	.62
74S37	Quad 2 input NAND buffer	2.49
74S38	Quad 2 input NAND buffer O/C	2.49
74S40	Dual 4 input NAND buffer	.99
74S74	Dual D flip flop	.79
74S85	4 bit magnitude comparator	2.50
74S86	Quad 2 input XOR gate	1.00
74S109	Dual JK positive edge triggered flip flop	2.50
74S112	Dual JK flip flop	1.69
74S113	Dual JK negative edge triggered flip flop	1.25
74S114	Dual JK negative edge triggered flip flop	1.45
74S124	Dual VCO	3.95
74S132	Quad 2 input Schmitt trigger NAND	2.20
74S138	3-8 decoder/multiplexer	1.99
74S139	Dual 2-4 decoder/multiplexer	1.99
74S140	Quad line driver	1.05
74S151	8 channel digital multiplexer	1.99
74S153	Dual 4-1 multiplexer	1.50
74S157	Quad 2 input multiplexer	1.59
74S158	Quad 2 input multiplexer	1.59
74S160	Decade counter with async clear	4.95
74S161	Sync 4 bit counter	4.95
74S162	Sync 4 bit counter	3.69
74S163	Sync. 4 bit counter	2.75
74S168	4 bit up/down sync counter	7.44
74S169	4 bit sync. counter	6.95
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74S175	Quad D flip flop with clear	1.80
74S182	Look ahead carry generator	3.75
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74S244	Octal line driver	3.75
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74S280		3.19
74S299	8 bit universal shift storage register	8.50
74S373	Octal D latch	2.90
74S374	Octal D latch	3.50

74F00 Series

74F00	Quad 2 input NAND gate	.73
74F02	Quad 2 input NOR gate	.73
74F04	Hex inverter	.73
74F08	Quad 2 input AND gate	.73
74F10	Triple 3 input NAND gate	.73
74F11	Triple 3 input AND gate	.73
74F20	Dual 4 input NAND gate	.73
74F32	Quad 2 input NOR gate	.88
74F74	Dual D type flip flop	.85
74F86	Quad exclusive OR gate	.99
74F109	Dual JK POS edge triggered flip flop	1.99
74F112	Dual JK NEG edge triggered flip flop	1.79
74F113	Dual JK edge triggered flip flop	1.79
74F114	Dual JK NEG edge triggered flip flop	1.75
74F138	3 to 8 line decoder/multiplexer	1.79
74F139	Dual 1-4 decoder demultiplexer	1.79
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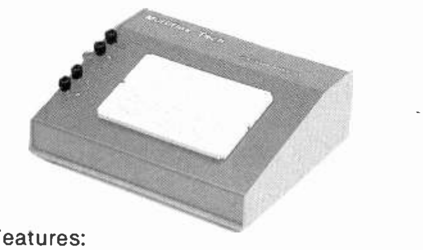
74F158	Quad 2 input multiplexer	1.75
74F160	Synch. presettable BCD decade counter	4.35
74F164	Serial in, parallel out shift register	2.95
74F174	Hex D flip flop	2.95
74F175	Quad D flip flop	3.79
74F181	4 bit ALU	6.75
74F182	Carry, look ahead generator	2.99
74F190	Up/down decade counter	4.35
74F191	Up/down binary counter	4.35
74F192	Up/down decade counter	5.25
74F193	Up/down binary counter	5.45
74F240	Octal buffer/line driver	3.19
74F241	Octal buffer/line driver	3.19
74F243	Quad bus transceiver 3S	6.49
74F244	Octal buffer/line driver/line receiver	3.19
74F245	Octal bidirectional transceiver	6.95
74F251	8 input multiplexer	1.75
74F253	Dual 4 input multiplexer	1.75
74F257	Quad 2 input multiplexer	1.75
74F258	Quad 2 input multiplexer	1.75
74F280	9 bit parity generator/checker	2.19
74F283	4 bit binary full adder	3.75
74F299	Shift/store reg. 3/S	13.99
74F350	4 bit shifter	3.99
74F352	Dual 4 input multiplexer	1.75
74F353	Dual 4 input multiplexer	1.75
74F373	Octal transparent latch	4.35
74F374	Octal dual flip flop	4.35
74F378	Parallel D register	2.65
74F379	Quad parallel register	2.39
74F381	4 bit ALU	5.99
74F382	4 bit ALU	6.19

Prices and Specifications subject to change without notice.

Designers Dreambox



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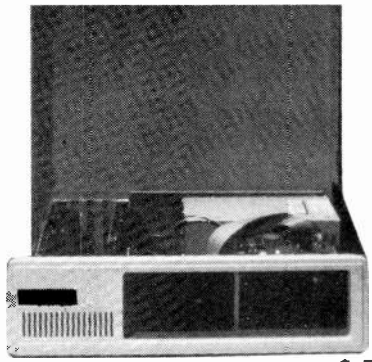

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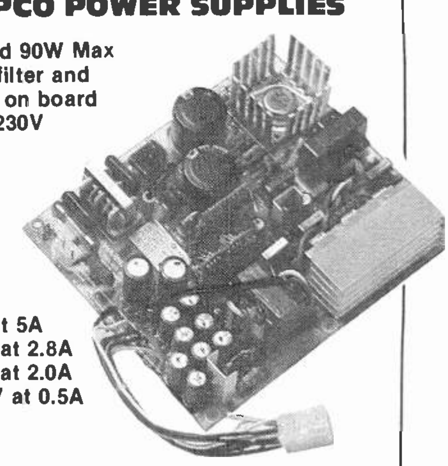

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DP15S Rght Angle PCB Mount Female	$2.95
DB15P Flat Ribbon IDC Crimp Type Male	$7.95
DB15S Flat Ribbon IDC Crimp Type Female	$8.50
DB15 Shell (Economy Type)	$0.95
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DB37S Solder Tail Female	$4.25
DP37P Rght Angle PCB Mount Male	$7.75
DP37S Rght Angle PCB Mount Female	$8.95
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DB37S Flat Ribbon IDC Crimp Type Female	$14.95
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Female Screen Lock Assemblies for DB Connectors $2.49/Set

TRANSISTORS

DEVICE													
2N697	$ .50	2N3391A	$ .45	2N3773	$2.99	2N4339	$ .45	2N5771	$ .75	MPSA20	$ .30	TIP49	$1.20
2N2219A	$ .80	2N3394	$ .80	2N3819	$ .65	2N4400	$ .25	2N5772	$ .37	MPSA55	$ .48	TIP115	$ .98
2N2221A	$ .40	2N3415	$ .28	2N3820	$ .85	2N4401	$ .25	2N6028	$ .45	MPSU51	$.78	TIP122	$1.80
2N2222A	$ .50	2N3440	$1.10	2N3904	$ .19	2N4402	$ .25	MJ802	$4.50	MPSU56	$ .99	TIP125	$1.00
2N2270	$ .50	2N3442	$2.25	2N3905	$ .25	2N4403	$ .25	MJ2955	$1.63	PN2222A	$ .39	TIP142	$2.95
2N2369A	$ .50	2N3566	$ .78	2N3906	$ .28	2N4416	$1.40	MJ4502	$5.50	TIP29C	$ .70	TIP146	$2.98
2N2646	$1.42	2N3568	$ .78	2N4062	$ .86	2N4353	$4.22	MJE340	$2.50	TIP30C	$ .70	TIP2955	$1.85
2N2906	$ .49	2N3638A	$ .78	2N4112	$ .28	2N4856	$1.39	MJE802	$4.95	TIP31C	$ .70	TIP3055	$1.50
2N2907A	$ .52	2N3642	$ .78	2N4123	$ .20	2N4891	$ .65	MPF102	$ .65	TIP32C	$1.10		
2N3053	$ .70	2N3643	$ .78	2N4124	$ .50	2N5245	$ .75	MPS6515	$ .42	TIP33C	$1.80		
2N3055	$1.89	2N3645	$ .78	2N4208	$ .87	2N5400	$ .27	MPSA05	$ .35	TIP34C	$1.85		
2N3117	$1.50	2N3703	$ .28	2N4222	$1.89	2N5457	$ .57	MPSA13	$ .35	TIP35C	$3.10		
2N3227	$4.18	2N3704	$ .31	2N4248	$ .85	2N5485	$ .57	MPSA14	$ .35	TIP41C	$1.15		
2N3250	$ .70	2N3705	$ .29	2N4250	$ .78	2N5770	$ .48	MPSA18	$ .36	TIP42C	$1.90		

Heat Sinks

TO220	$0.38
TO3	$2.99

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Large LEDs
T-1 3/4 (Normal Size)

Red (General purpose)	$ 0.25
Green (General pupose)	$ 0.39
Yellow (General Purpose)	$ 0.39
Red (Extra Bright)	$ 0.59
Green (Extra Bright)	$ 0.65
Yellow (Extra Bright)	$ 0.65

Small LEDs (T-3/4)

Red	$ 0.30
Green	$ 0.35
Yellow	$ 0.35

Rectangular LEDs 75 cents each

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8-Segment, (Red, Green or Yellow)	$4.95
35 LED Matrix 2' or 3'	$9.95

(Great for Digital Signs)

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1N4004 400V 1A	$ .09
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1N5403 300V 3A	$ 40
1N5404 400V 3A	$ 40
1N5406 600V 3A	$ 60

Switching and Signal Diodes

1N34A	$ .19
1N914	$ .5
1N4148	$ .5
1N4448	$ .5

Zener Diodes

1 Watt. All Values 25 cents each.

Voltages Available
3 9, 4 3, 4 7, 5 1, 5 6, 6.2, 7 5, 8 2, 9 1, 10, 12, 13, 15 16, 18, 20, 22, 24, 27, 30, 33, 36

SCR's

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2N6337	$ .55
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TIC116D	$1.99
TIC126D	$1.99

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7805 + 5V 1A	.99
78L05 + 5V 1A	.75
78H05 + 5V 5A	9.44
78P05 + 5V 10A	14.97
7806 + 6V 1A	.99
78L06 + 6V .1A	.75
7812 + 12V 1A	.99
78L12 + 12V .1A	.75
78H12 + 12V 5A	10.95
7815 + 15V 1A	.99
7824 + 24V 1A	.99
78GUIC Adjust. 1A	1.80
78HGASC Adjust 5A	11.47
78S40 Switching regulator	3.84

NEGATIVE:

7905 .5V 1A	.99
79L05V. 1A	.75
7906 -6V 1A	.85
7912 -12V 1A	.85
79L 12-12V. 1A	99
7915-15V 1A	99
79GUIC Adjust. 1A	1 65
79HGASC Adjust 5A	17 99

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1.00MHZ	$6.95	12.00MHZ	$2.25
1.8432MHZ	$3.99	14.00MHZ	$2.99
2.00MHZ	$2.50	14.318MHZ	$2.19
2.457MHZ	$3.75	16.00MHZ	$1.99
3.57MHZ	$1.55	18.00MHZ	$2.29
4.00MHZ	$1.99	18.432MHZ	$1.99
5.00MHZ	$1.95	20.00MHZ	$2.15
5.017MHZ	$3.50	17.43MHZ	$2.99
5.068MHZ	$1.95	22.118MHZ	$2.99
8.00MHZ	$1.95	48.00MHZ	$3.99
10.00MHZ	$1.95		

Delta Ribbon Connectors

Quantity Discounts Available

(Centronics Parallel Printer Connector)

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36 Contacts Chassis Mount female	$6.95
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36 Metal Shell (for solder male)	$2.95

Flat Cable Card Edge Connectors

(Disk Drive Connectors)

50 Pin Edge Connector (8" Drive)	$5.95
40 Pin Edge connector	$4.95
34 Pin Edge Connector (5¼")	$5.85
20 Pin Edge Connector (Hard Drive)	$4.79

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.1uF 50V Bypass ....10¢
Monolithic
100 of the above $8.95

TANTALUM CAPACITORS

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0 15uF 35V	$ .26	6 8uF 35V	$ .58
0 22uF 35V	$ .26	10uF 25V	$ .58
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0 47uF 35V	$.26	15uF 25V	$ .95
0 68uF 35V	$ .26	15uF 35V	$1.79
1 0uF 35V	$.27	22uF 25V	$1.30
1 5uF 35V	$.27	22uF 35V	$2.25
2.2uF 25V	$.25	33uF 25V	$1.95
2 2uF 35V	$ .30	33uF 35V	$2.49
3 3uF 25V	$ .35	47uF 10V	$1.25
3 3uF 35V	$ .40	47uF 25V	$2.70
4 7uF 25V	$ .40	47uF 35V	$3.99
4 7uF 35V	$ .50	68uF 10V	$1.90
6 8uF 16V	$ .40	68uF 25V	$2.79

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All 10 Cents each.

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Special Quantity Discounts Available.

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(Flat Ribbon Crimp Type Socket Connector)

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34 Pin Female Header 17x2	$3.20
26 Pin Female Header 13x2	$2.95
20 Pin Female Header 10x2	$1.89
16 Pin Female Header 8x2	$1.95

Two Position Female Jumpers (Shunts) 20 cents each

Switches

Momentary push-button switches	$0.99
Momentary push-button switches SPDT	.395
On-Off Switch SPDT	.395

Parts for your Modem

Small Speakers $1.84
600 ohm to 600 ohm (1.1) isolation transformers..........................$9.95
Relay for your modem (HE721A0500) 5V ...$4 99
DAA 1812 for Modem (Contains Built-in Transformer, relay and surge protector ...$39 00

Wire Wrap Wire. All Colours (30 gauge)

25 ft	$2.80
50 ft	$5.00
100 ft.	$8.95
Wire Wrap /Unwrap Tool/ Strip Tool	$16.25
Wire Wrap Gun and Bit	$83.00

IC Extractor	$3.99
IC Insertion Tool	$18.95
High Quality 24-40 Pin Extractor	$23.50

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P C MOUNT MULTITURN TRIMPOTS
RESISTANCE

10	500	10K	200K
20	1K	20K	500K
50	2K	50K	1M
100	5K	100K	2M
200			

$1.65 ea.

TRIMPOTS
RESISTANCE

100	1000	10K	100K	1M
250	2500	25K	250K	2 5M
500	5000	50K	500K	5M

OPEN CASE 35¢ ENCLOSED CASE 85¢

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We carry a full range of 1/4 Watt, 5% resistors...5 cents each.

SIP Resistor Networks

Part #	Pins	Common Pin #	
6-1-XXX	6	1	0.39
8-1-XXX	8	1	0.44
10-1-XXX	10	1	0.59

XXX = Value

Europe's best selling oscilloscopes, made in West Germany

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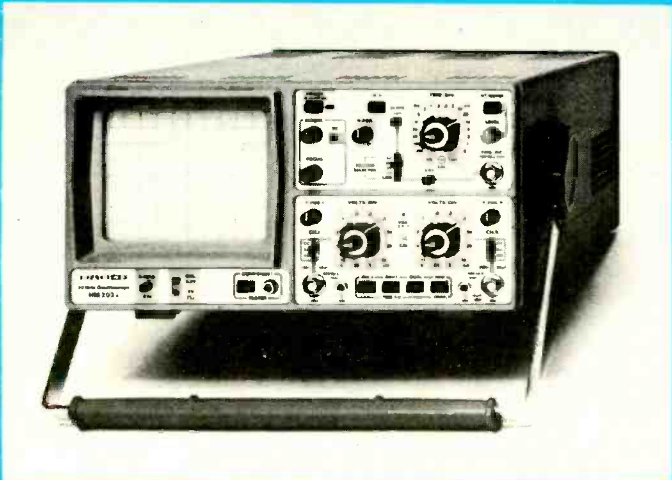
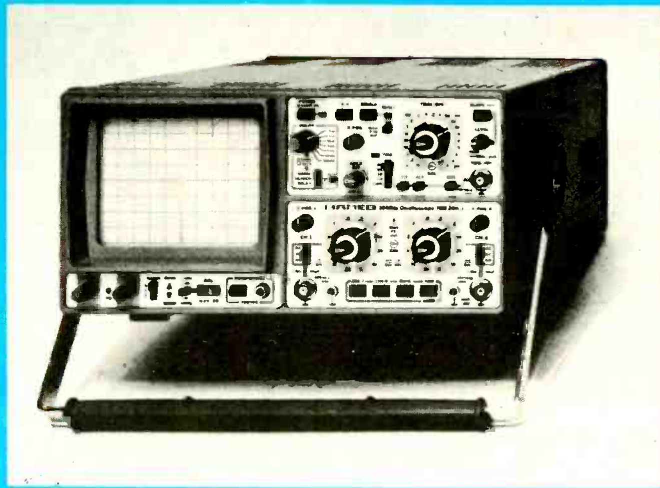


OSCILLOSCOPE HM 203-5

20 MHz Standard Oscilloscope

Y:2 channels, DC-20 MHz, max. sensitivity 2mV/cm;
X: 0.2s/cm-20ns/cm incl. x 10 magnification;
triggering up to 40 MHz; Component Tester

$695.00

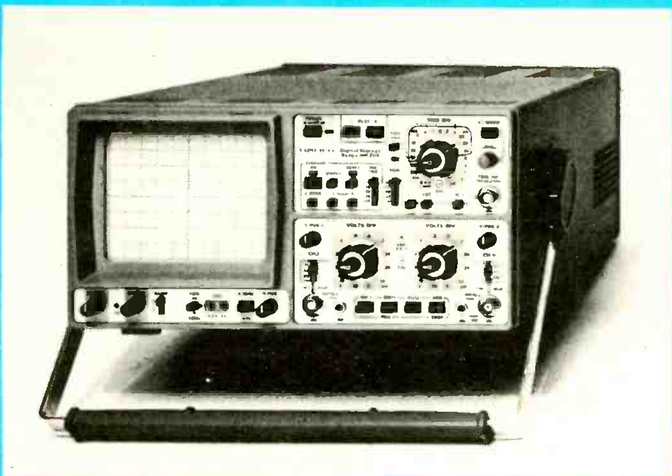


OSCILLOSCOPE HM 204-2

20 MHz Multifunction Oscilloscope

Y: 2 channels, DC-20 MHz, max. 1mV/cm, delay line;
X: 1.25s/cm-10 ns/cm incl. x 10 magnification, delayed sweep;
triggering up to 50 MHz; var. hold-off time; Component Tester.

$1140.00

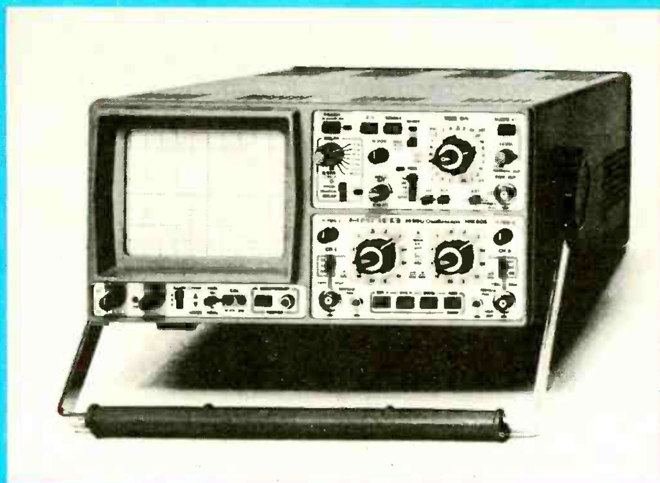


OSCILLOSCOPE HM208

20 MHz Digital Storage Oscilloscope

Y: 2 channels, DC-20 MHz, max. sensitivity 1mV/cm;
X: 0.25 s/cm-20ns/cm incl. x 10 magnification, trig. to 40 MHz.
Storage: max. clock rate 20 MHz; Single and X-Y operation.

$2885.00



OSCILLOSCOPE HM 605

60 MHz Multifunction Oscilloscope

Y: 2 channels, DC-60 MHz, max. 1mV/cm, delay line;
X: 2.5s/cm-5ns/cm incl. x 10 magnification, delayed sweep;
triggering up to 80 MHz; var. hold-off time; Component Tester.

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The 8088 Controller and Trainer System

Based on the success of our Multiflex starter systems, we are proud to announce the arrival of the 8088 Controller and educational Trainer System. With the option to upgrade to a full IBM PC compatible, the starter system is the perfect education tool to learn 8088 based hardware and assembler code. It is also ideal for use as a complex, high speed industrial controller at an affordable price. This 8088 System consists of two boards. The first board (as seen in the picture) is the motherboard which can be used as a general purpose controller and contains the following:

- Socketed for 64K static RAM
- Socketed for 64K of EPROM
- RS232-C serial communications port
- Controller Port
- 300 baud modem
- 3 IBM PC compatible expansion slots (when the multifunction board is used)
- Wire Wrap area

The motherboard is a very versatile controller for which it is very easy to write software on the IBM PC/XT.

The second component is a console which connects to the motherboard via a ribbon cable. The console contains a display, hex keypad and another keypad containing function keys to perform memory block moves, register examination, the examination of I/O ports and a myriad of other functions. This board also contains an EPROM programmer.

A further multi-function board which has been designed specifically for the system to make it IBM PC compatible is available. This multi-function card contains a floppy diskette controller, DMA controller and up to 512K dynamic RAM.

Controller Board with 16K RAM (optionally expandable to 64K) $250.00

Keyboard and Display Board with EPROM programmer and monitor software $159.00

Multi-function Board with 64K RAM (expandable to 512K) $250.00

S100 Starter System

Complete, Assembled and Tested

$299

Options:

64K Dynamic RAM and Multiplexers **$19.95**

Big Piggyback Board with RS232 and Real Time Clock **$179**

RS232 Option for Motherboard **$38.00**

DC to DC Converter Option . . **$29**

Extra S100 Connectors . . . **$5.95**

S100 Video Board **$149**

S100 Floppy Disk Controller **$199**

S100 256K RAM Card (with 256K) **$250**

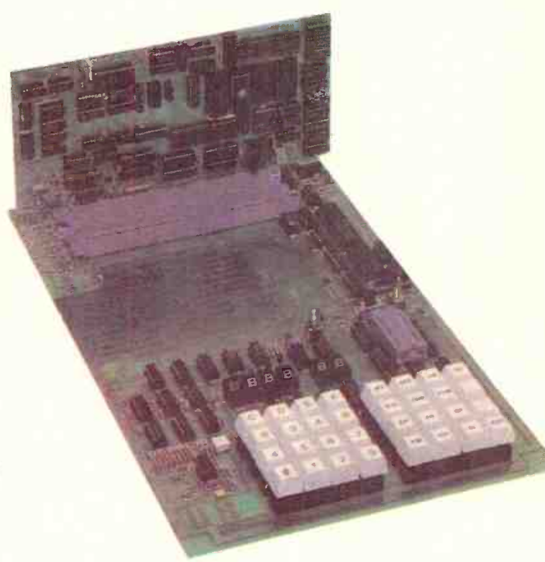
S100 CPU Board with 64K . . . **$149**

MULTIFLEX's Z80 computer is a versatile and expandable stand-alone computer system designed and built right here in Canada. It uses the newest technology to provide the user with the most capabilities for the smallest price-tag. Its adaptability to any situation and extremely low cost allow it to be used in many applications ranging from a trainer to a complete CP/M-based computer comparable to the best on the market, at a fraction of the price.

The actual layout of the system is a two board design. One board (the "motherboard") contains a 24-line parallel I/O chip for interfacing to the external world, an RS232C serial port with baud rates selectable from 110 to 9600 baud, a hex address and data display, a hex keypad, 14 monitor function keys, 2 user definable keys, a 40-chip wire wrap area with full access to all the bus signals, on-board provision for regulators so that the board can be supplied with standard S-100 voltages, an EPROM programmer which will handle 2708 (1Kx8), 2716 (2Kx8), 2732 (4Kx8) 2532 (4Kx8), 2764 (8Kx8) and the brand new 27128 (16Kx8) EPROMs, a DC-to-DC converter to supply the programming voltage to the EPROM programmer and four (4) slots for IEEE S-100 compatible boards for further expansion. This is an extremely useful and important feature as it allows expansion of the system with all boards using this industry-standard bus structure, which are available from MULTIFLEX, as well as from hundreds of manufacturers worldwide.

The other board is the CPU card. This card plugs into one of the S-100 slots on the motherboard and is IEEE 696/S-100 compatible with the full 24-bit address path to allow up to 16 megabytes of memory to be addressed. The processor used is the Z80 (running up to 6 MHz) and there is provision on-board for 64K of dynamic memory (using 4164 chips) which will operate without wait states. Provided for as well is a 2K to 32K (selectable in 2K blocks) common resident area in memory for use with multiple memory banks. There are also 4 sockets on board which will handle 2732 (4Kx8) or 2764 (8Kx8) EPROMs or the new 6116/2016 (2Kx8) static RAMs (all of which can be software deselected if desired) to allow the user complete versatility in setting up the board to meet his own specifications. Also on board is 1 parallel port with 24 lines of I/O and 3 16-bit counter/timers for applications which require the unit to keep track of real time. Another feature of the CPU board is that it was designed by our engineers to run the CP/M 2.2 disk operating system so that if a floppy disk controller board is added to the system a fully configured CP/M machine can be set up for a very low cost

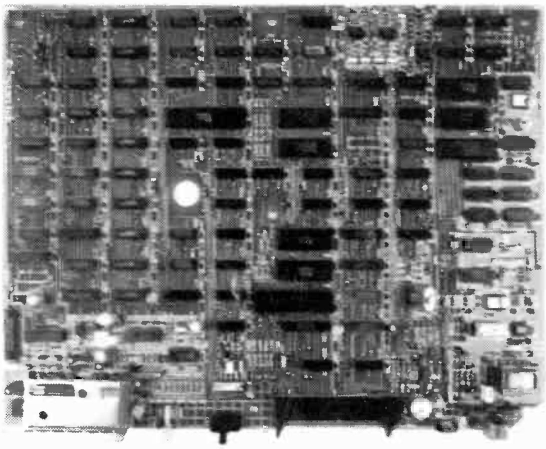
The monitor software that comes with the kit is a well-written extensive package which allows the user to have complete versatility in machine language programming and execution as well as control of all the features on the board. The monitor functions include: examine/modify memory locations, memory block moves, compare 2 blocks of memory, examine CPU register, ex-

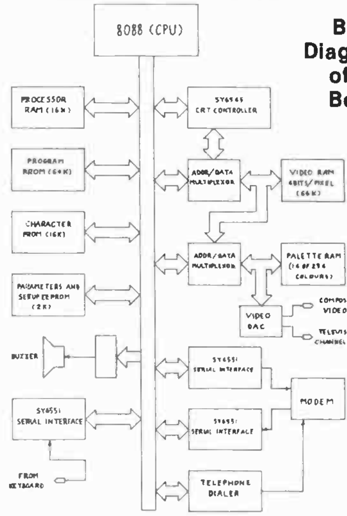


amine I/O ports, load and save from cassette calculate relative branch offsets, set breakpoints single step programs, execute programs, and program EPROMs. Each of these process is invoked by a single keypress. Also available to the use are 2 spare keys definable for special functions a required by specific applications and applicator programs.

The standard kit includes the CPU board with a Z80A (4HMz) processor, 2K of RAM (a 6116), and 4K of EMPROM (a 2732) as well as the motherboard with all the features mentioned above except the RS232C port and the DC-toDC converter. Also supplied are sockets for all IC's and 1 S-100 connector.

8088 Board with Built-in Modem: $49.95!





Block Diagram of the Board

This could be the biggest bargain of all times.

The main board shown can be used in many different ways. Made recently by one of Canada's leading electronics companies, this board utilizes some of the most current technology and parts.

Use your imagination, software and hardware to make this board into many interesting projects. The board is capable of colour graphics and was originally designed as a terminal for home-ordering system many of the facilities similar to the Telidon terminals in use in shopping malls, hotels etc.

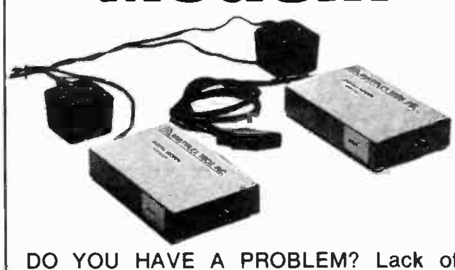
This magnificent board features an 8088 CPU, 6545 CRT Controller, 150/1200 Baud auto-dial, direct-connect modem, serial ports, RF Modulator (Ch.3) for 40 characters, EEPROMs, 64K Video RAM, 16K RAM and 64K of EPROM for the processor.

All you need is a power supply with 5V at 2A, plus/minus 12V at 0.05A

The current value of the parts alone on this board is in excess of $300!

A. The Board itself with the original software, schematics, memory map and block diagram: **$49.95**
B.Membrane Keyboard Kit **$19.95**
C. Plastic Case to house the main board .... **$ 9.95**
Items A, B and C as a package **$74.95**

Digital Modem



DO YOU HAVE A PROBLEM? Lack of wires for two-way communications? Do you have a single coax cable between four floors of a building?

If the above holds true for you, as it may well do, if you wish to put equipment in some older Government buildings which were wired years ago, using a single coax to communicate between main frames and which may now be obsolete, you need our solution. If you want to communicate using RS232 between your computers and all you have is a single coax between rooms or floors or buildings, now you can do it without rewiring using our economical solution.

About a year ago we were approached by a Government agency asking if we could solve the problem described above. Well, we solved their problem economically, in fact it worked so well that they bought hundreds of units from us.

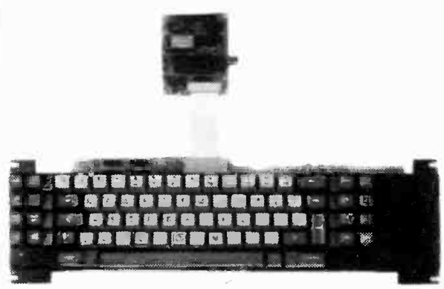
The Digital Modem consists of two boxes (approx. 6" x 4") and two wall adaptors. Now you can simply have the RS232 of your computer terminal or other devices plugged directly into one of our Digital Modem boxes (which has a wall plug adaptor to get its power) and you can run up to 800 feet over a single wire to another of our Digital Modem boxes (which again has its own CSA approved power supply) and you again plug in the RS232 DB25 connector to your equipment. Now you can communicate at 9600 Baud or faster (or slower) simultaneously in both directions using your existing single coax cable wiring.

Digital Modem Pair $350.00

(Two Boxes and two adaptors) Quantity Discounts.

Keyboard $19.95

Suitable Serial Adapter $19.95



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Almost Free PC Software Now Available

These collections are comprised of 'Public Domain', 'Freeware' and other software represent one of the last remaining bargains. The software itself is free charge, the charge is for the patching, debugging, selecting and the cost of disks, copying and distribution. All disks are 5¼", DS, DD for the BEST, IBM a compatible computers. Two of the collections are Double Disk sets.

Volume 1

PC-Write While not quite WordStar for nothing, this package comes extremely close to equalling the power of commercial word processors costing several hundred dollars. With full screen editing, sophisticated cursor movement, PC-Write also boasts features such as user-definable help screens and a 'printer ruler file' which can be customized to work with virtually any printer.

SOLFE is a small BASIC program that plays baroque music. While it has little practical use, it's a lot of fun. It's also a fabulous tutorial on how to use BASICA's sound statements.

PC-TALK Telecommunications packages for the IBM PC are typically intricate, powerful and huge. This one is no exception It has menus for everything and allows full control of all parameters, evan the really silly ones. It does file transfers in both ASCII dump and MODEM7/X-MODEM protocols. And, it comes with a comprehensive documentation file which uses 119424 bytes of disk space.

SD This sorted directory produces displays which are a lot more readable that those spewed out by typing DIR.

FORTH This is a small FORTH, written in Microsoft BASIC. It's good if you want to get used to the ideas and concepts of FORTH. You can build on the primitives integral with the language.

LIFE This is an implementation of the classic ecology game written in 8088 assembler code. While you may grow tired of watching the cells chewing on each other, the source code provides a good example of how to write assembler applications.

MAGDALEN This is another BASIC music program. We couldn't decide which of the two we liked better, so we wound up putting both of them on the disk.

CASHACC is a fairly sophisticated cash acquisition and limited accounting package written in BASIC. It isn't exactly BPI, but its a lot less expensive and suitable for use in many small business applications.

DATAFILE is a simple data base manager, written in Microsoft BASIC

UNWS WordStar has an unusual propensity for setting the high order bits on some of the characters in the files it creates. Here's a utility to strip the bits and 'unWordStar' the text. The assembler source code is also provided.

HOST2 This program includes BASIC source and documentation files to allow users with SmartModems to access their PC's remotely

$19.95

Volume 2

SWEEP is a disk utility which virtually replaces the DOS COPY command. It allows one to do mass copying, deletions, renaming and other disk operations in menu-driven comfort

Worldmap is a sophisticated graphics program which draws a very detailed map of the world. It can display its wares on the tube, or send them out to a dot-matrix printer.

ANITRA plays Anitra's Dance by Edvard Grieg. A beautiful addition to your computer music collection

RAMDISK is one of the most useful utilities you'll ever plug into your PC. Once installed, it creates a virtual drive in memory on your PC. Files can be copied to the RAM-disk and accessed in less time than real drives take to turn on their LEDs.

Allen plays a bizarre adventure game and will lead you into some of the most exotic spots in the universe. It comes with a massive data file for an adventure that you won't get tired of 'til the dragons come home for the evening.

FOS is a well designed personal finance manager which will do much to help you tame your cheque books.

Jukebox represents yet another PC music system. This one comes with a host of songs to play and some really electric graphics

ASMGEN is one of the best text disassemblers we've come across. It takes any executable COM or EXE file and produces an assembler listing it's surprisingly good at distinguishing between code and embedded data or text.

STRUCT will appeal to the rabid programmer in everyone. It enables MASM to be used to assemble a higher level language. Included also is a test file to illustrate the syntax

PRTSC replaces the internal PC screen dump code with something more suited to reality It allows one to hit the PrtSc* key and then select the print quality from a menu It supports a number of popular printers.

BREAKOUT plays a PC version of the popular game It will accept input from either a joystick or the keyboard The graphics are good and the action is adjustable from a beginner's level right up to 'fast and nasty'.

UTIL is a collection system utilities which can be accessed from a single menu Among its many talents are a sorted directory, keyboard redefinition and the facility for scrolling up and down through a text file.

$19.95

Volume 3

FIXWS is a simple utility which modifies WordStar files so that they can be used by programs which work with ordinary ASCII files.

WRT DOS 2.0 allows for each file to have a 'read only' flag, but it lacks a way of manipulating them. This pair of utilities allows you to set and unset this flag, protecting important files from accidental erasure.

BROWSE is a timesaving program which provides a useful alternative to the DOS 'TYPE' command. BROWSE allows you to easily scroll up and down through text files, saving you the effort of running your word processor just to get a quick look at a text file.

CAT if the DIR display is too dull for your tastes, CAT may be just what you need. It will tell you everything you could possibly want to know about the files on your disks

CGCLOCK is a simple little program which displays the running time in the upper right hand corner of your screen. In addition, the program has lots of display options and works with the colour graphics card

CURSOR A tiny twenty-four byte program which displays a large cursor on your monitor

CMP This program does a very elaborate comparison of two files and reports their differences It can for example, spot corrupted files and may prove useful when dealing with files created by redirection

JUMPJOE A bit like "Miner 2049'er", this game is certain to damage your mind You get to be the janitor of a space station and must deal with berserk robots and other weirdness. It's a hoot!

CASTLE Wander through a deserted castle collecting treasures... but mind you don't get killed by the nasties A solution is included should frustration set in.

78INT This is a small BASIC program to calculate interest using the rule of seventy-eight.

MOON is one of the nicest lunar lander games we've come across. This version uses high resolution graphics and startling sound effects to hurl you to your doom in style.

PERTCHT is a BASIC program which prints PERT charts. It should interest anyone involved in project management and scheduling.

DATNOIDS is one of the strangest games ever put on a disk In fact, mere words don't serve to describe it you'll have to try it for yourself

NUK-NY This is one of the nastiest bits of software we've ever seen. It produces a full color high resolution simulation of a nuclear attack on New York City.

$19.95

Volume 4

BACKSCROLL Perhaps one of the cleverest DOS utilities, BACKSCROLL hooks itself into the PC and buffers whatever scrolls by. Using a well thought out command structure, it allows one to scroll back and forth through text which would normally have scrolled off the screen into oblivion.

BIGCAL is a BASIC program which performs calculations on extremely large numbers Using floating point form instead of scientific notation, very accurate calculations can be made

BUGS is an off the wall ASCII game in which a player uses the cursor pad keys to move a 'nuclear fly swatter' around the screen blowing up a long crawling bug.

CLOCK is a useful tutorial in writing character oriented device drivers for the PC In addition, the program is an improved replacement CLOCK.SYS file which works with many real time clocks The ASM file is included

CRYPTO is a BASIC program which unscrambles cryptograms. It's an interesting study for puzzle enthusiasts.

DEFRAG is a utility that lets you "de-fragment" your disks to make your applications run faster The utility reorganizes a disk, connecting up the fragments of files created by DOS

DOSEDIT is one of the most useful DOS utilities available. It enhances the command line facility of MS-DOS by creating a command stack Instead of merely being able to recall a command with the F3 key, DOSEDIT lets you use the cursor arrow keys to scroll through a whole stack of previously entered commands, re-executing the ones you need.

DUmp is a utility program designed to produce Hex dumps of object files Useful in its own right, the program also serves as a good example of how to use DOS disk service calls The ASM file is also included

FREE is a tiny file which tells you how much space is left on a disk.. without having to view an entire directory listing Its especially handy for hard disk systems

KBFIX displays the status of the keyboard lock keys on the screen and expands the size of the keyboard character buffer to avoid losing bytes.

LABEL changes the labels on disk drive volumes It's a simple utility, but useful if you use volume labels to keep track of your disks

LIST is an improved version of the DOS TYPE command which shows you the contents of a file page by page

MEMBRAIN is the most sophisticated RAM disk program we've seen yet It lets users install variable sided disks and provides control over several other parameters.

MONOCLOK is a screen clock display program, designed specifically to work with monochrome displays

MOVE is a disk utility which moves and optionally erases disk files. Using wild cards, the user can ensure that specific types of files are not MOVED by the program.

NEWBELL is a tiny program which performs the lowly task of changing the sound of the PC's control G beep.

NUSQ is a file un-squeezer Its a useful utility for people who download compressed files form bulletin board systems

PARCHK is a trap which prevents the system from 'freezing' when a "parity error" is encountered It gives you a option of finding out what caused the error and recovering from it.

PURGEDUP is an intelligent little program which cleans up obsolete backup files Very useful on a hard drive.

PX is a cross reference generator for assembler programs It helps you keep track of where you put procedures in large files.

QS is a DOS patch which eliminates some of the wait encountered when DOS is booted while it performs a number of system checks The program is not compatible with all software, but is still handy to have

SDIR is an improved sorted directory program

SP is a clever print spooler which lets you 'print' files into a RAM buffer The PC then sends the file to the printer at its leisure, leaving the user free to move on to other tasks using the computer

SPACE INVADERS A fast variation of this popular arcade game the graphics are superb

SPEED is a simple program which changes some of the PC's floppy disk parameters and effectively speeds up disk accesses for some applications

VDEL is a multiple deletion program that queries the user prior to erasing each entry Similar to MOVE, but much smaller

WHEREIS will locate a file on a disk even if it lurks in a subdirectory Most useful on hard disk systems.

WIZARDS is an adventure game in the classic style, except that it ranks as one of the most sarcastic programs in creation The program is vast you can wander about its darkened corridors for hours

$19.95

Volume 5

AREACODE is a useful tool if you use the telephone a lot Give it an area code and it will match it with the city in which the code is used

D in another sorted directory program This one emulates the CP/M style D, which arguably more useful for most applications.

FRACTALS An amazing implementation of the Mandlebrot Microscope, which generates unearthly images on your screen.

HIDE is a set of utilities which let you create, enter and remove invisible DOS directories This allows you to set up a hard drive system with secure areas which can only be used by people who know about them

LAR is a library utility that allows you to concatenate several small files into a library to save on disk overhead Individual files can be extracted as they are needed

MAIL1 is a mailing label utility written in BASIC

MORERAM This is an assembler program. You need MASM and LINK to make it work It lets you alter the memory setting on the PC's motherboard to enable it to use more than 640K RAM It will even let you set the switch settings to 64K to speed up disk boots and then change the RAM setting after bootup

MORTGAGE generates amortization charts

MXSET lets you control the parameters of Epson printers form the DOS command line It's a lot easier than LPRINTing characters from BASIC every time you want to change print modes

NUSQ unsqueezes files that have been previously compressed to save space. Should be of primary interest to bulletin board users

PARCHK is an assembler program which requires MASM and LINK to work It installs a trap for parity errors in your computer A vital aid to help locate suspect RAM chips

PCBOSS is a handy "DOS shell" program which creates a user-friendly working environment It lets you access DOS file handling commands such as COPY, DEL and DIR from the comfort of a menu

VDEL is a Delete with Verify program. You could type VDEL * BAK and it would show them name of every .BAK file in the current directory and ask you if you want it deleted.

WHEREIS finds files in a complex hard disk system

ZAXXONPC This is an incredible implementation of one of the most popular micro games ever created

$19.95

Volume 6

3-DEMON is one of the most interesting variations on Pac-Man in the known universe Instead of simply looking at a map of a maze, this program shows you a three dimensional view of it You wander through endless corridors, munching food pellets or granola bars... your choice . and avoiding the deadly ghosts.

DU was one of the most powerful CP/M-based disk utilities ever created This version for the PC captures much of its power and flexibility It allows you to see what the tracks and sectors on your disks look like, recover erased or damaged files, and meddle with the system tracks.

General Ledger This is a complete general ledger accounting program Written in BASIC, the program possesses most of the feature found in commercial packages. An enormous documentation file is also included.

PC-CHESS is a slick chess program which makes good use of the PC's colour graphics abilities and boasts a running chess clock

RAMDISK is the assembler source code for a memory disk program If you've always wanted to know how these things work, or have a secret desire to write your own variation of this useful utility, here's your chance

VFILER is a file management utility which lets you view files in a directory and allows you to COPY, TYPE and even run programs... in short, it does almost everything DOS does but it's user-friendly.

QMODEM is unquestionably the best telecommunications package in existence. The most recent version of it is replete with windowing, multiple protocols, definable function keys. And the code is unspeakably well debugged.

ARC is a sophisticated file archiving program which stores several files in single library files As an added bonus, ARC applies one of four data compression techniques to each file in order to optimize disk space

ZAPLOAD is a utility for programers to handle Intel standard HEX files. Very fast and well documented.

SOPWITH Using superb graphics, SOPWITH lets you pilot a World War I biplane on dangerous bombing missions.

JSB Another BASIC music program for your collection This one plays a soothing sonata

STAR is one of a growing breed of small somewhat silly novelty programs. This one, as you might guess, draws stars.

SURFACE demonstrates the complexity of the hat" function by graphing it on a monitor screen

OP is the operator program from the November '85 issue of Computing Now!

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(Two Disk Set)

Volume 7

BLACKJACK is a BASIC implementation of this popular card game. It's both interesting to play and enlightening to dismantle. It can, of course, be easily listed so you can see how it works.

EDSCR is a screen editor which can be used with virtually any programming language from assembler to dBase III. The program lets you 'paint' PC screens with block graphics and saves them as DAT files which can be easily adapted to work in most languages An example screen is included

FK allows you to make the function keys of your PC do more useful things under DOS They can be redefined to execute commonly used commands and command sequences.

FXMASTER is a printer program for the popular Epson FX Series and compatible printers. It uses a full screen menu to enable you to easily change printer settings and modes.

INDEX allows you to generate indexes from WordStar documents . or text files from any other text editor Its an invaluable writer's tool

KEYCLICK is a memory co-resident program which will make your keys click Small and easily included in an AUTOEXEC file, KEYCLICK solves many problems associated with clone keyboards.

PCBW is a small utility which makes colour screen displays show up in monochrome video. Great for users with colour graphics cards and monochrome monitors.

PINBALL is a pinball simulation that is easily worth the cost of this disk all by itself. The games plays much like a real pinball machine. . but Its hard to tilt.

QUICKGRAF is a powerful business graphics package which generates complex bar, line and scatter charts in medium and high resolution An Epson with GrafTrax or compatible printer is necessary to produce hardcopy

SERPENT is a variation on the classic snake game Written in BASIC, this one is weird, but very fast

SHOWCLK is yet another clock program Its the smallest one yet, and it beeps to chime the hour

VTREE is a graphic TREE program that shows you how the subdirectories are set up on your disk.. in a fashion more easily understood than the MS-DOS TREE utility

WORLD is a remarkable program which incorporates a world map. It allows you to zoom in on specific areas of the globe, locate major cities and perform a number of useful calculation. It also has a feature for tracking hurricanes... tracked any good hurricanes lately?

$19.95

Volume 8

This is another collection of fairly large applications We've had to spread them over two disks. However, the extra three bucks is nothing compared to the power of some of this software. Whether you're interested in games, business applications or code hacking, you'll find something of interest in this larger than usual collection of programs. In addition to the programs themselves, the set includes all the support files needed to use them.

Load-Us allows users of the popular Lotus 1-2-3 and Symphony programs to run them on a hard drive It isn't a cracking program, but, rather, a preboot to avoid the inconvenience of this copy protected software for legitimate users.

DDCal is a very clever perpetual calendar and desk diary It keeps track of your appointments and performs several other functions that you probably thought could only be done on the backs of match books.

PC Key Draw is the remarkable public domain paintbox program which blows away so many commercial applications. It'll handle multiple screen images, business graphics and superb computer art...all in full colour. It's worth the cost of this package all by itself

CPU is a tiny program to tell you the effective speed of your system.

Xray is a remarkable co-resident utility to monitor what a program is doing while it's busy doing it. It allows you to interrupt the execution of your code and have a look inside.

Game...well, there are no words for this program, or, at least, none that are printable This game is a bit ruda.. depending on just how weird your mind is, it can get pretty bizarre. This program does use some suggestive language and we recommend that young or sensitive users not boot it

Tune is a very small music generator to make noises from within batch files. It's useful to see where things are in a complex process

Chasm, or cheap assembler, is just the thing if you want to get into assembly language programming but don't want to spring for the Microsoft macro assembler package. It's reasonably fast not too huge. . it'll run in as little as sixty four kilobytes. and, above all cheap

Getdir is a resident directory utility. It allows you to see what's happening on your disks even if you're in the middle of doing something else

CopyPC, not to be confused with the commercial Copy II PC, is a quick disk backup utility for the IBM

Lookit is a full screen browsing program to let you scroll forward and backwards through text files. a sort of a tiny word processor that can't edit anything.

Syslock is a security device for hard disk users. By implementing this package on your XT or compatible no one without a secret password will be able to get access to your computer

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Business Software

MA.BAS The Micro Accountant is a complete, working accounting and check register program, with a 25K documentation file.

PCWNDW22 A "Sidekick"-like co-resident window utility. Pop-up window functions include ASCII table, stopwatch, alarm, printer setup utility and notepad. The entire program takes up less than 30K of space on your disk

PSHIFT A time saving and convenient memory partition' utility. Lets you define up to nine memory areas. Load programs such as dBase II and WordStar into separate partitions and 'flip' between them instantly with simple keystrokes.

PC-TOUCH.BAS Increase typing speed and accuracy with this easy-to-use typing tutor Also provides accuracy and speed statistics

PCYEARBK.EXE Appointments and reminder program to help you keep track of your time.

TASKPLAN.BAS Project management software which lets you track up to 50 tasks during 50 time periods (days, weeks or months).

NOCOLOR A handy little utility for users with monochrome monitors and colour software

MAXIT A simple but subtle game for two human opponents, or one player and the computer Hours of fun!

PERTCHT A sophisticated project management tool using the Program Evaluation Review Technique

PLUS More utilities to help organize maintain and copy your files, including a "monitor saving" program which blanks out your screen when it is not in use

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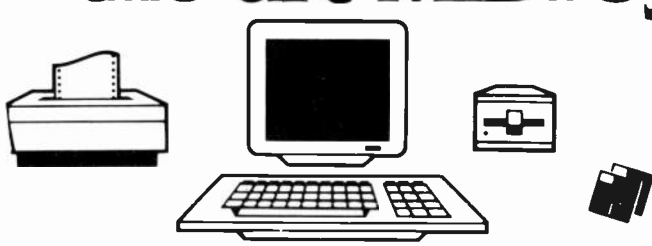

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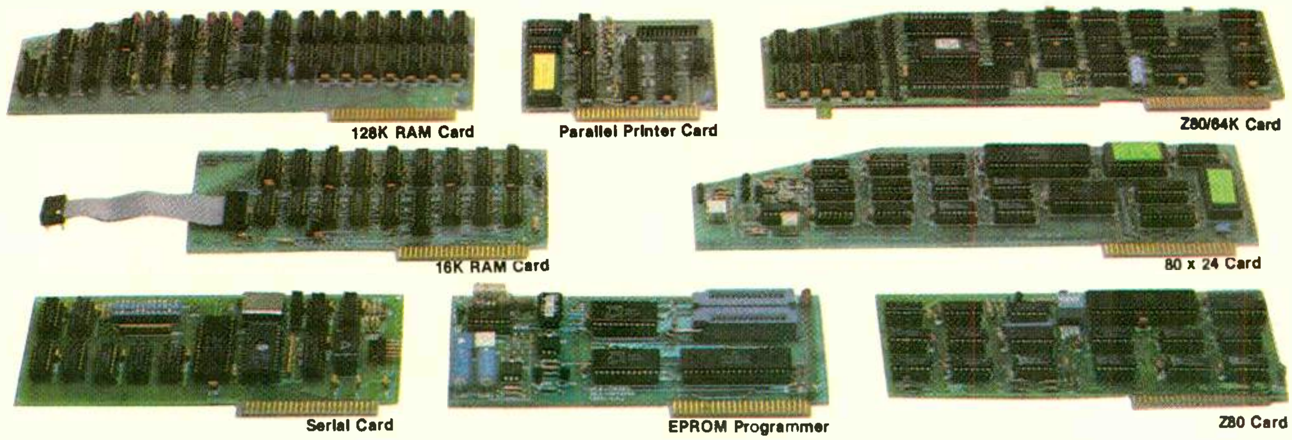

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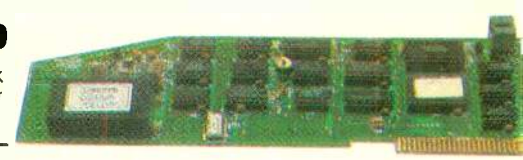

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Understanding XENIX ... $27.95
Understanding UNIX ... $27.95
CP/M Programmers Encyclopedia ... $25.95
Using Microsoft Word ... $55.00
IBM PC AT User Ref. Manual ... $42.00

Data Books

Motorola
DL128 Linear Data Book ... $14.95
DL129 High Speed CMOS ... $ 9.95
DL118 Opto Device Data ... $ 8.75
DL130 Cmos Integrated CCTS ... $ 9.95
DL110 RF Data Manual ... $14.95
DL111 Power Data Book ... $14.95
DL113 Memory Data Book ... $ 9.95
DL121 TTL Data Book ... $12.95
DL122 Mecl Data Book ... $ 9.95
DL126 Small Signal Trans. ... $15.00
DL105 Cmos Data ... $14.95
HB206 Voltage Regulator Handbook ... $ 9.95
SG73 Master Selection Guide ... $ 5.55
TB301 Basic Micro. & The 6800 ... $35.00
TB303 The 6800 Family using Micropro & Microcom. ... $34.00
MC68000um AD4 68000 Users Guide ... $12.50

Single Chip Microcomputer Data (includes 6800 Series and Support Chips) ... $19.95

Other Data Books

Intel Micro System Components Handbook Vol. 1 and 2 (includes 8088 and support chips) **$26.00**

National Linear ... $19.95
National TTL ... $14.95
National CMOS ... $14.95

Keyboards

Keytronics 5151 (PC/XT compatible) ... $195.00
Keytronics 5150 (PC/XT compatible) ... $135.00
Keytronics 5151A (AT compatible) ... $279.00
Maxiswitch ... $135.00

Printer Ribbon's

Star Micronics
SG10 ... $ 4.50
SG15 ... $ 4.50
SR10 ... $ 4.50
SR15 ... $4.50
Power Type ... CALL
Radix 10 ... $16.00
Radix 15 ... $19.00

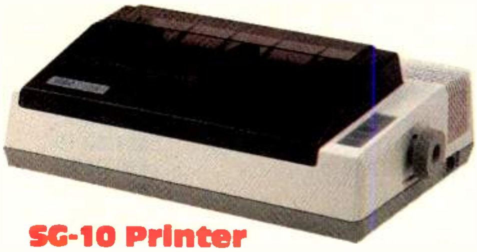
Toshiba
P-1351 ... $15.50
P-1340 ... $15.50
P-351 ... $15.50

Epson
FX80 ... $10.95
FX100 ... $15.95
LQ1500 ... $24.00

Copal
SC-1200 ... CALL
SC-55001 ... CALL

Oki Data
ML80, 82A, 83, 92, 93 ... $ 3.50
ML182 ... CALL
ML183 ... CALL
ML184 ... CALL

New from Star Micronics



SG-10 Printer

Ideal for Text & Graphics

• Dual Mode – NLQ/draft standard (NLQ = near letter quality) • 120 CPS and 20% faster throughput • Bidirectional, logic/seeking • 2K buffer (expandable to 6K with optional buffer interface) • 100% IBM PC or Star standard control codes-switch selected • Friction and tractor standard • full 1 year warranty • 10" wide carriage • Standard parallel interface (serial optional) **$379.00**

SG-10C for Commodore **$399.00**
(No interface required)

SG-10 C for Commodore Computers

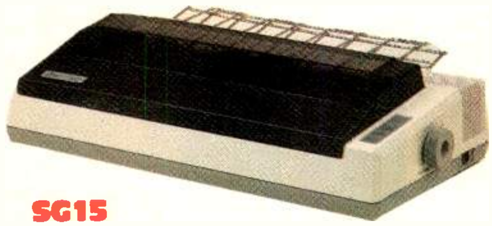
All the same features as the SG-10 but includes built-in interface which plugs directly into Commodore computers.

$389.00

SR-15

• 200 cps and 20% faster throughput • IBM PC or Star standard control codes switch selected • Dual Mode – NLQ/draft standard • Friction/tractor and automatic single sheet feed – standard • 15" carriage • 16K buffer • Bidirectional, logic seeking • Price/performance leader • Parallel port standard, serial optional • Full 1 year warranty. **$995.00**

Star Micronics



SG15

Same as SG10 except with 15" carriage and standard 16K buffer **$599.00**

Radix

15" 200 cps, 100% duty cycle • 16k buffer • serial & parallel standard • proportional & downloadable characters • 240 x 144 Ultra High Res. • tractor & friction...
Radix 15 PC (for IBM PC)............ **$995.00**

Star Printer Accessories

Printhead	$80.00
Printwheel	$18.00
Ribbons	$4.50
Paper (500 sheets) (8½x11)	$9.95
Paper (2,000 sheets) (8½x11)	$32.00
Dust covers	$8.50
Printer Stand (plastic) 10"	$34.00
Printer Stand (plastic) 15"	$38.00

Star Micronics — Power Type daisywheel printer

Letter Quality **$535.00**

Print Speed: 18 c.p.s. bi-directional, logic seeking
Interface standard parallel (Centronics compatible) and serial RS232C-20mA current loop
Paper Slew Speed: 12 l.p.s. @ 1/6" spacing
Print Buffer: One line
Print Size: 10,12, 15 c.p.i and proportional spacing
Number of Columns: 110,132, 165
Character Sets: over 100 Type fonts available.
Special Features: proportional spacing; dual interface; standard printer mode and word processing mode; 32 easy access format switches reverse paper feed; short form tear-off;
Line Spacing: 3,4,6,8 lines/inch; switch and software selectable
Paper Handling: single sheet: 5.5" to 8.5" wide; sprocket 4" to 13" wide; copies 3 carbonless sheets
Ribbon standard cassette

NEW NB-15 ..... $CALL

Impeccable letter quality at 100 c.p.s!
• 24 pin Dot Matrix • Letter Quality 100 c.p.s. (12 c.p.i) • Draft quality 300 c.p.s. • Optional Character Font cartridges • Optional sheet feeder • 4"–15" paper widths • IBM compatible.

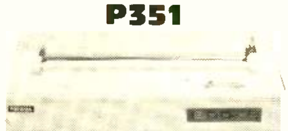
Toshiba Printers

P321

Impact Wire Dot Matrix, 24-pin overlapping. Letter quality 72 c.p.s; Draft quality 216 c.p.s. (12 cpi), 180 c.p.s. (10 cpi). Accepts Font Cartridges and downloadable font disks, Qume Sprint 11 emulation, 4" to 11" paper widths, PC compatible and more.

$1079.00

P351



Impact wire dot matrix, 24-pin overlapping. 4" to 15" paper width.
Accepts font cartridges and downloadable font disks, Qume Sprint 11 emulation, IBM PC compatibility, and more.

- Letter quality at 100 cps
- High-speed drafts at 288 cps
- Superb graphics at 360 x 180 and 180 x 180 dots per inch.

$1995.00

Copal

SC5500I 180cps, 132 column **$699.00**

Copal SC1500T.......... $499.00
180 cps, 80 column

Copal SC1200L.......... $329.00
120 cps, 80 column

Okidata ML192 .... $699.00
(Apple Imagewriter or compatible, IIe, IIc, Mac)
• 120 cps • 2K Buffer, Serial int., upgradeable to 10K • Tractor and friction • 10" • 19.2K Baud max. • Cable extra.

Okidata ML192 (IBM) $679.00
• 160 cps • Parallel (optional Serial) • Correspondance quality • 10".

Okidata ML193 .... $1089.00
(Apple imagewriter compatible IIe, IIc, Mac)
• 120 cps • 2K Buffer, Serial int., upgradeable to 10K • Tractor and friction • 15" • 19.2K Baud max. • Cable extra.

Okidata ML193 (IBM) $1069.00
• 160 cps • Parallel (optional Serial) • Correspondance quality • 15".

Epson

FX 85	$649.00
FX 286	$1129.00
LQ1000	$1495.00
CR 420	$5499.00
SQ 2000	$3099.00

Cable Assemblies

DB25 Male to DB25 Female $35.00

RS232 Cable (6ft of round conductor) $39.00
RS232 other lengths and connector configurations available on request.

Parallel cable 36 pin Centronics type connectors, male joined by 6ft of ribbon cable to female $35.00

Parallel Cable for IBM interface DB25 through 6ft of ribbon to 36 pin centronics with appropriate connections $35.00

Cable Assemblies for two 5-1/4in drives and controller (e.g. IBM) using three 34 pin connectors and appropriate length of 34 conductor cable $35.00

20 pin Female header 24in. to 20 pin for Apple drives $6.95

Serial Switch Box . . $59.00

Contains 3 RS232 connectors and a switch which switches all lines between input and one of two outputs.

Monitors and Disk Drives

Zenith Data Systems

NEW

ZVM1220A

12in. diagonal screen • non-glare amber display • composite input • 25 lines x 40/80 characters

$135.00

NEW

ZVM1230A

12in. diagonal screen • non-glare green display • composite input • 25 lines x 40/80 characters

$135.00

NEW ZVM 1240 ● 12" diagnoal screen ● glare amber display ● PC monochrome input (TTL) ● 25 lines x 80 characters ● 720 x 350 pixels ● IBM PC & compatibles

$229.00

NEW ZENITH COLOUR MONITORS

NEW ZVM 1330 ● 13" diagonal screen ● input ● 25 lines x 80 characters ● 640 x 240 pixels • green screen only switch ● 16 colours including PC brown ●

$799.00

NEW ZVM 1350 ● 13" diagonal screen ● RGB/composite inputs ● 25 lines x 80 characters ● 640 x 240 pixels ● sound capability ● green screen only switch ● video "loop thru" feature ●

$839.00

CV-2560 ● 25" diagonal screen ● RGB/composite input ● 25 lines x 80 characters ● sound capability ● green screen only switch ● video "loop thru" feature **$1049.00**

ZVM 136 ● 13" diagonal screen ● RGB input ● 25 lines x 80 characters ● 640 x 480 pixels ● long persistence phosphors for interlaced applications ●

$1195.00

Amdek Monitors

300A • 12in amber composite • 40-132 character display **$218.00**

310A • 12in amber TTL • 40-132 character display **$229.00**

700 Ultra high resolution .... **$Call**

Princeton Graphics Monitors

HX-12 12in 15MHz RGB high resolution, horizontal resolution 690 dots, vertical 240 lines (non-interlaced) 480 lines (interlaced) **$1199.00**

SR-12 12in, 30MHz RGB ultra high resolution, horizontal resolution 690 dots, vertical 400-480 lines (non-interlaced) **$1249.00**

NEC Monitors now available — Call for price

Irwin 10 Meg Tape Drive Backup

$1199.00

Hooks up to your existing floppy controller.

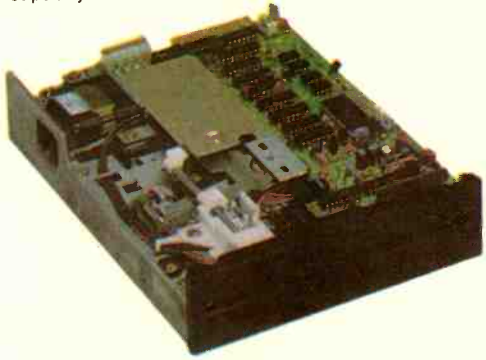
Scorpion 20 Meg Tape Drive Backup and Controller.

$1495.00

5.25in. Disk Drives

SA455 .... **$169.00**

• Shugart/Panasonic 5.25in. slimline, double sided, double density disk drive with 360K storage capacity. IDEAL FOR IBM COMPUTERS.



Diskettes

Prices per box of 10

10% discount on 3 or more boxes.

Dysan DS/DD	$35.95/10
Dysan SS/DD	$27.50/10
Maxell DS/DD	$35.95/10
Maxell SS/DD	$28.95/10
Exeltronix DS/DD	$24.95/10
BASF DS/DD	$29.95/10
BASF SS/DD	$22.95/10
Pinnacle DS/DD	$21.95/10
Pinnacle SS/DD	$16.50/10
Elephant DS/DD	$24.95/10

Modems

Anchor Automation

Singleman 1200	
300/1200 baud smart modem	$469.00
Volks Modem (300-1200)	$399.00

Hayes

1200B Modem (stand alone)	$605.00
1200 Modem	$620.00
300 Modem	$365.00
Smartcom II	$188.00

Joysticks & Input Pads

CH Products

Mach II	$ 67.00
Mach III	$ 67.50

Koala Technologies

Koala Pad W/PC Design	$199.00
The Speed Key System	$259.95

Kraft

Kraft Joysticks	$ 65.00

Mice

Microsoft

Microsoft Mouse	$227.50

Mouse Systems

PC Mouse	$239.20
PC Mouse/PC Paint	$277.20

Bill Boards

Compuserves Starter Kit	$ 59.00

Toshiba Disk Drives

ND-04D 360K DS/DD (black or grey) **$169.00**

ND-08DE-G 1.2Mbyte AT Compatible, Grey **$269.00**

Prices and specifications subject to change without notice.

Toshiba Hard Drives

MK 53FA, 43.5 Meg	**$2579**
MK 54FA, 60.5 Meg	**$2725**
MK 56FA, 86.5 Meg	**$2898**

Controllers available.

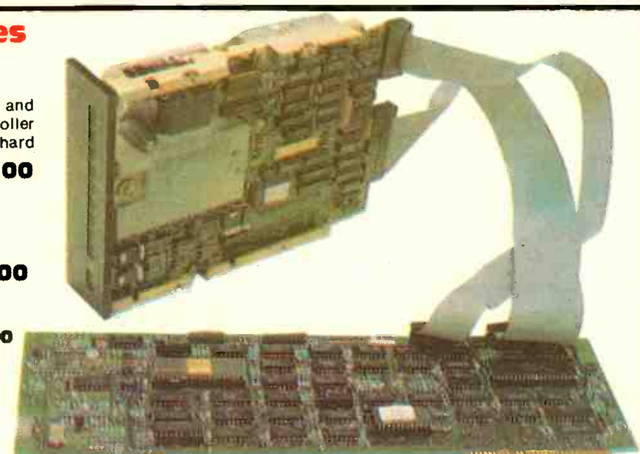
Hard Disk Drives

10 MEG Seagate, slimline drive and hard disk controller. This controller can handle up to two 10 MEG hard drives. **$895.00**

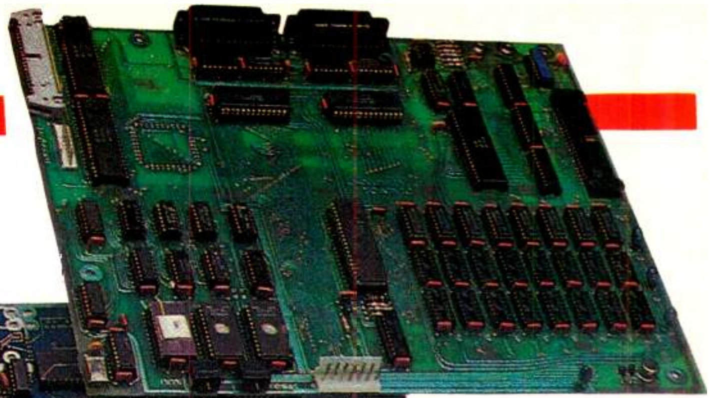
Seagate 20 MEG. with controller **$995.00**

Cables (for 10 or 20 MEG) **$18.00**

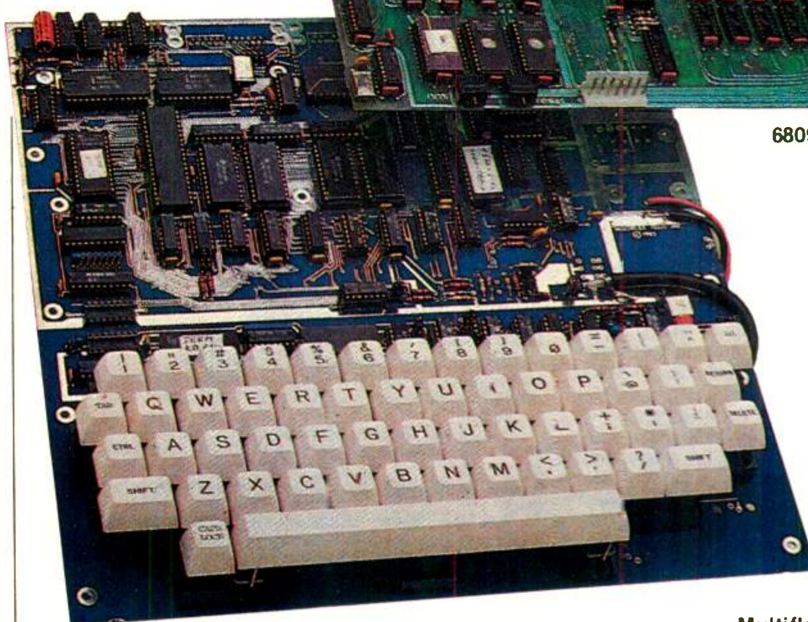
Quantity discounts available on two or more



Multiflex Products



6809 Board

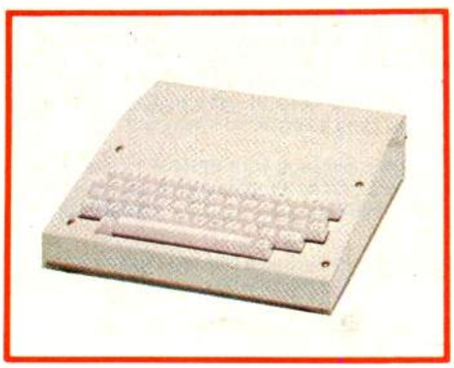


Multiflex Terminal

Multiflex Economy Video Display Terminal

Now available from MULTIFLEX is an economy video display terminal. Originally designed as a low cost access unit for our mail-ordering and bulletin board system, this terminal is a semi-intelligent system which is controlled by a Z80A microprocessor and a 6845 CRT controller chip. The keyboard is fully ASCII encoded and the character generator contains the full 128-character set as well as a 128-character alternate set both of which are in the 5x7 dot matrix format. The screen display is 80 characters by 24 lines if the unit is hooked to an external monitor. (Monitor not included). There are 3 software selectable attributes (dim, reverse video, and alternate character set) which can be chosen one at a time for the whole screen. The attribute can then be switched on and off for each individual character. A 2K buffer is provided for normal operation. However when the optional 6K memory upgrade is purchased, 4 screen pages can be loaded from the host machine, edited, locally, and then downloaded back to the host again saving on connect time and phone line bills. Also included are 2 RS232 ports: one for a modem and one so that a printer can be attached to the terminal. The baud rates on these ports are software programmable and can range from 110 to 9600 baud. With all these features, you would expect to pay a lot for this system, but all this is available to you, complete with an attractive case, for an extremely low price.

A&T board with keyboard (as picture top right) with one RS232 and 2K buffer
$169.00



Terminal Complete: Tested and 90 days warranty with 2 RS232 ports, 2K buffer case and power supply (Hydro approved)

$299.00

U of T 6809 Single Board Computer

The 6809 Single Board Computer, designed at the University of Toronto and distributed exclusively by EXCELTRONIX, is a compact hardware unit which was designed originally as a lab board for teaching students about microprocessor systems. Its many features, however, make it an ideal unit for stand-alone control applications or software development systems as well.

The system is designed around the Motorola MC6809 microprocessor. This is an 8-bit processor with full 16-bit internal architecture, 2 index registers, 2 stack pointers, 2 8-bit or 1 16-bit accumulators, a direct page register and a wide range of addressing modes, including a program-counter-relative mode. This mode allows the user to write completely position independent software, important in systems software development.

There is provision for up to 48K bytes of dynamic RAM on-board. The refreshing of this RAM is controlled by an 8202 Dynamic RAM Controller. This chip allows for completely transparant refreshing of the RAM (ie. no wait states to slow the system down). There is also provision for up to 12K of EPROM using 2532 chips.

There are 4 complete I/O circuits built onto the board. 2 of them are serial (RS232); one is used for a terminal (which is required for use of the board with the supplied monitor software), and the other one is user defineable, but it is set up to communicate with either a modem or a printer. Also on-board are 2 6522 VIA chips. These provide 2 parallel ports per chip along with 2 16-bit timer/counters. One of the parallel ports and one of the timers are use by the monitor software to provide a cassette interface (which operates at 300 baud). The second parallel port on that chip is wired into a connector which is ideal for interfacing a parallel printer or keyboard. The 2nd VIA is not used at all and is completely free for the user. For further expansion of the system, a fully buffered version of the CPU signals (data, address, control lines and a signal indicating whether or not the current address is located on the board) is available at a cable connector.

The software provided with the system is in a 2532 EPROM and allows the user to: test the memory; dump blocks of memory; examine and modify single memory locations; read or write from the cassette port; set and examine breakpoints; single step and/or execute machine language programs and set and examine the processor registers. All this is accomplished through a 9600-baud terminal interface (one of the serial ports) Included is a full screen editor/assembler which allows the user to work in 6809 assembly language rather than machine language. All this makes this board an ideal trainer, control unit or software development unit for just about anyone.

Includes U of T course documentation

A&T with 48K
$299

Special Pricing is available when both items on this page are purchased together

Multiflex Low-Cost Logic State Analyzer

Ideal for educational institutions and hobbyists.

You've just completed a microprocessor system, and it doesn't work. What next? You can use an oscilloscope to check for clock signals and the like, but if everything appears to be in order you can't go much further without sophisticated equipment. In these situations, professionals turn to their logic state analyzers, each of which cost thousands of dollars. MULTIFLEX has the answer for all those people who don't want to take a mortgage on their house just to get a computer working. The MULTIFLEX Logic State Analyzer has all the essential features of those more expensive units at a fraction of the cost. This is a high-quality piece of test equipment, suitable for industrial or scientific use, but its price is well within the price range of a hobbyist.

Easy to understand and operate, the Logic State Analyzer allows you to monitor 16 points in a digital system (ie. data and/or address bus, or control lines) which carry continually changing signals. You can select a bit pattern you expect will appear at these points. Once the pattern appears the Analyzer will trigger and record ("freeze") the next 1023 bit patterns so that they can be examined step by step even though data is no longer available in the unit being examined. For software development the Analyzer is invaluable, especially in dedicated systems. If you design a microprocessor system for a specific function, and you have no monitor, assembler or other such software, the best and often only way to debug the system is to use a logic analyzer. It will let you look closely at the data flow as a program is executing, or monitor the address lines to make sure that the instructions are being executed in the proper sequence. The various control lines such as memory read and write, DMA, interrupts, or enable and disable signals can also be examined. You can, of course, monitor any combination of these signals, such as the data bus and half of the address bus, or half of each plus 4 control lines. The combinations are endless.

Complete, assembled and tested
$369

Note from Industry to Educational Institutions:

At Multiflex we interview many technicians each year, from a variety of Colleges. Only a few applicants know what a Logic State analyzer is and even fewer know how to use one.

Yet in our industry, it is almost as important to know how to operate logic analyzers as it is to use an oscilloscope since the technician will need to use a logic or timing analyzer to trouble-shoot complex equipment.

We have spoken to many other companies and found that they are experiencing the same problems with technicians coming fresh fromCollege. So, we asked educational institutions why they don't teach this aspect of electronic engineering. The teachers are fully aware of the problem but explained that they cannot afford the high cost of logic analyzers; even those institutions which have them can afford only one or two which gives the students little chance to learn them.

Our LSA is a time-proven product which is considerably less expensive than the alternatives.

Here is your chance to prepare technicians for the real world!

EPROM Emulator

If you are a computer designer who values your time, you can't afford to be without this!

Did you ever write a piece of code, burn it into an EPROM, plugged it in and it didn't work?

Did you then go through the code (using an analyzer or your brain power) and then discover you left out some crucial Byte which caused the processor go the point of no return?

If the above holds true, how many EPROMs have you reprogrammed, erased and damaged? More important how many hours have you wasted?

Put an end to all the above problems and save time, money and frustration: Buy an EPROM Emulator.

It allows you to download over RS232 (at 300 to 9600 Baud) a program from your computer into the Emulator's memory (16Kx8) and then simply plug a 24 or 28 Pin header connected via ribbon cable to the Emulator in place of your EPROM and you have successfully emulated an EPROM.

If you need to change your code, simply change it on your computer, download to the Emulator's memory and you are back in business in seconds.

This stand-alone product emulates the following EPROMs: 2716, 2732, 2764 and 27128. Can be used with any computer with an RS232 interface.

This product is a must for any hardware development since it allows the user to test and modify EPROM data roughly 20 times faster than conventional methods.

The Emulator normally comes attractively packaged and contains its own power supply. However, to make it more affordable for beginners, we have separated the price into several categories:

1. Complete Emulator with 16Kx8 memory, attractively packaged with power supply. Fully assembled and tested with warranty. **$189.00**

2. As above but with 8Kx8 of memory **$159.00**

3. Emulator with 4K RAM, no housing or power supply (requires +5V at 1.5A Max, +/- 12V at 0.03A. Fully assembled and tested. **$99.00**

SPECTACULAR GANG EPROM PROGRAMMER AND EMULATOR

Totally self-contained (has its own display, entry keypad and power supply).

Based on the Z-8 microprocessor.

Can program up to 8 EPROMs simultaneously (anywhere from one to 8 EPROMs at the same time with the information in its own memory or or master EPROM).

Each of the 8 EPROM programming sockets is individually buffered and isolated from one another providing protection in situations when there is a bad EPROM among the eight being programmed. Clearly indicates and singles out any defective or marginal EPROMs prior to or after programming.

After programming the unit does a full VERIFY routine of the EPROM (at a Max Vcc of 5.4V and at a Min Vcc of 4.5V) to ensure high reliability of your EPROMs. Very simple to use.

A standard unit contains 8x16K of on-board memory which is sufficient in most cases, but can easily optionally be upgraded to 8x64K of on-board memory.

The Gang Programmer can handle a wide selection of EPROMs: 2716. 2732, 2732A, P2732A, 2532, 2564, 2764, 27128,27128A and optionally upgradeable to handle 27256, 27512, 2758 and 2724.

Gives you option of entering the data which you want to be programmed on the EPROM through a built-in keypad and display into the EPROM programmer's built-in RAM or by downloading the data to be programmed by RS232 interface (110 to 9600 Baud). The RS232 is standard — not optional!

Data can be checked or modified, since you can examine any memory location of the programmers built-in RAM, this holds true even after you have down-loaded through the RS232 from your computer; you can check or modify the memory before finally programming it on your EPROMs.

Read Master EPROMs; you can plug in a programmed EPROM, dump it into the programmers RAM, check the contents on display by stepping through the memory and, if you wish, you can alter any location before copying to other EPROMs.

EPROM Programmer can also be (optionally) used as an EPROM emulator, saving hours of frustration, reprogramming and waiting.

Using the Emulator option, you can enter via the keyboard or down-load through the RS232 from your computer or development system, the information which you think is right for whatever project you are building. This is the same information which you would normally burn into an EPROM, plug into your new undebugged processor and moments later you realise that you forgot to enter a code or that you must add or delete some codes. This normally would mean waiting 20 minutes for erasing of the EPROM and reprogramming and wasting time.

Using the Emulator option, you simply plug in a 24 or 28 Pin buffered pod into the socket on your board where you would normally fit the EPROM, the difference being now that you can have all the information in the programmers RAM, connected to the pod by a ribbon cable and you can start your testing. If you wish to change, add, delete any codes, you can modify the contents of the programmers RAM using the keypad and display and continue testing moments later. Keep in mind that the RAM is protected from being accidentally altered.

Complete package with EPROM Emulator, 8 ZIF sockets, Gang Programmer with 16Kx8 of RAM and RS232 . . . . **$995.00**

Gang EPROM Programmer with 8 ZIF sockets, 16Kx8 RAM and RS232. without Emulator **$695.00**

EPROM Programmer with only one ZIF socket, 16Kx8 RAM and RS232, without Emulator. Able to do all the functions describe but can handle only one EPROM at a time **$499.00**

UV EPROM Erasers

Industrial quality EPROM erasers. Erase time about 15-20 minutes

Starting at $129.00

Exceltronix Computers and Components Inc.

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We also accept phone orders: **(416) 921-8941** Check our advertisements monthly in Electronics Today and Computing Now! Magazines. Long distance (orders only) **1-800-268-3798.**

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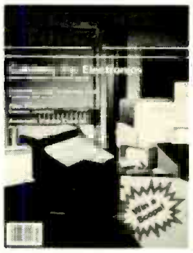

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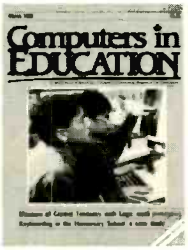
Regular 1 year (12 issues) **$22.95**



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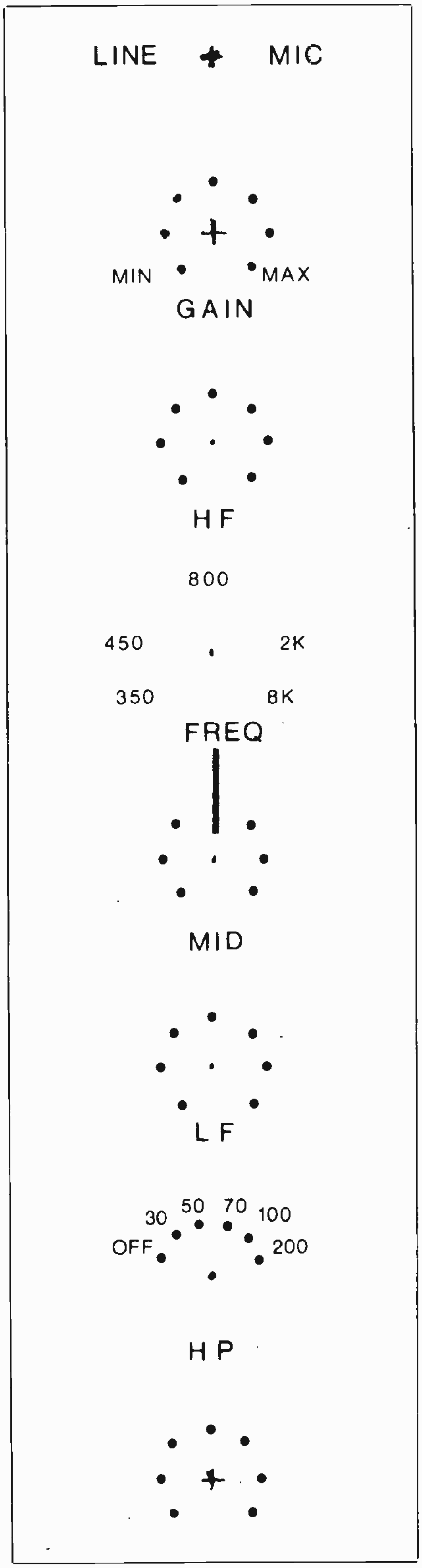


The artwork for a typical console, showing the gain and tone controls. The HP is a highpass filter.

nomical, but they do suffer from hum loops and hum pickup unless a lot of care is taken to ensure proper grounding (an article, nay, a book unto itself). Once it works, it's just fine. The drawback is that adding new equipment may upset the apple cart. This is one big advantage to balancing: it's very tolerant of changing or unusual circumstances, something that's important if you're pressed for time.

Standard Level

More arguments arise as people try to explain the decibel and the concept of 'operating level', which gets confused some more by the VU and the VU meter.

Here we go, but I guarantee that as you read this, you'll hear distant shouts of 'no, no! Here's what it really is!'

The unit of level in pro audio is the dBm. Properly speaking, this is a measure of power levels, with the 'm' meaning that 0dB is 1mW or 775mV across 600 ohms. This is borrowed from the engineering art of telephony.

However, solid-state has nixed the old 600-ohm concept, which was fussy about source and load impedances being exact. Now we have buffered op amp outputs with an output impedance close to zero, and input amps that bridge the line with impedances of 10k or more.

Still, the dBm hangs in, and is popularly used to mean plus-or-minus so many dB above or below .775V, regardless of the actual line impedance. There have been attempts to correct things, what with one-volt standards and 775mV standards and so forth, but the dBm as a voltage level refuses to go away, even if it makes engineering teachers grind their teeth.

And the VU? Many moons ago, someone in Bell Labs set the standard for the mechanical VU meter, and it just happened that if you put it across a 600-ohm line, it loaded it down by 4dB. The level had to be cranked up by 4dB to get the needle to register 0 VU, and line level was born. That's where the +4dBm standard audio line level comes from.

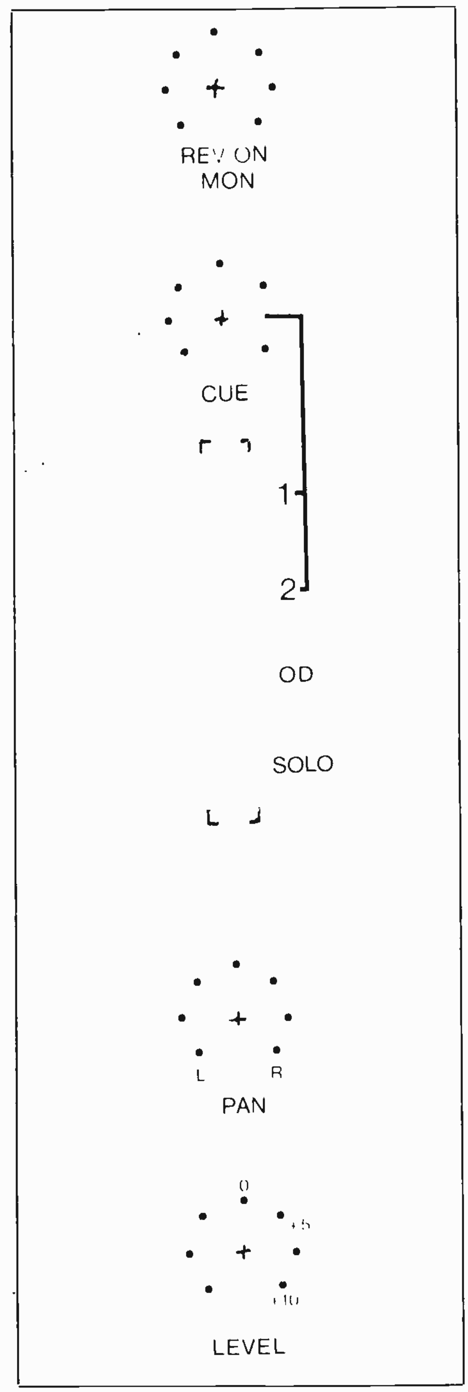
There's been some attempt to get home stereo levels standardized, with 0 VU indicating about .775 or .75V RMS. It isn't always followed, but having patch points such as tape-monitor jacks at a standard level simplifies changing equipment.

Fadeout

Now that we've covered the basics of routing the signals around the studio, there are the gadgets and widgets that are used to simulate natural acoustics or create a completely new sound, but there isn't room to even begin to cover them all (another article idea!).

Is it true that given enough toys, you can make a bad singer sound good? You bet. It happens all the time. Some studios turn out music like Campbell's makes soup. The performer is almost an irrelevant part of things, like an effects box.

On the other hand, there are lots of studios doing a great job of capturing the musician's sound. Aside from lots of money, the secret lies in lots of overload protection (headroom), standard levels at all input and output points, and properly installed audio lines. And, of course, the most important part: the skills of the people who operate the equipment. ■



One of eight monitor channels from a console designed by the author. It can listen to either the console or the tape with or without reverb, and features an overdub button for mixing live and taped sound.

THE PREDOMINANCE of VLSI chips in modern computer boards does not mean that small logic devices are becoming a thing of the past. A microprocessor chip does not usually 'bolt' directly into RAMs, EPROMs or PIAs but instead requires a considerable amount of interface logic, using ICs often referred to as 'glue chips' and most frequently being 74LSTTL devices. A look at the inside of many personal computers will confirm that the glue chips often account for a significant proportion of board space. Clearly it would be of considerable advantage if these TTL devices could be combined together into a single integrated circuit. Since each different application has slightly different interfacing requirements the computer manufacturer, rather than the semiconductor manufacturer, would have to specify the device and have it made.

Custom chips dedicated to one narrow function within one circuit design are prohibitively expensive to develop for all but highest volume production runs (in excess of 100,000). The one-chip, one-product notion is attractive, but for moderate volumes or circuit development a compromise is necessary.

The Semi-Customer is Always Right

The first alternative is the semi-custom chip. These chips fall into two categories: standard cell and gate arrays. The closest in concept to full custom is the standard cell integrated circuit. Various semiconductor manufacturers provide a service for customers to specify such a semi-customized device.

Rather than have to build up a custom circuit from scratch, in the standard cell approach the chip is built up from a library of standard elements. The building blocks include quite complex functions such as RAM, EPROM and CPUs as well as simpler ones such as gates, flip-flops, decoders and multiplexers. Using the semiconductor manufacturer's data on the available circuit elements and computer aided design (CAD) workstations, the customer generates data describing the requirements from which the supplier manufacturers the chip.

As in the case of the full custom design, a complete set of masks must be produced for the manufacture of a standard cell device and although design time is shorter, the initial cost is still very high. Accordingly, volume production would once again be required to justify the approach - although the point at which it becomes viable is not quite as high as for the full custom design.

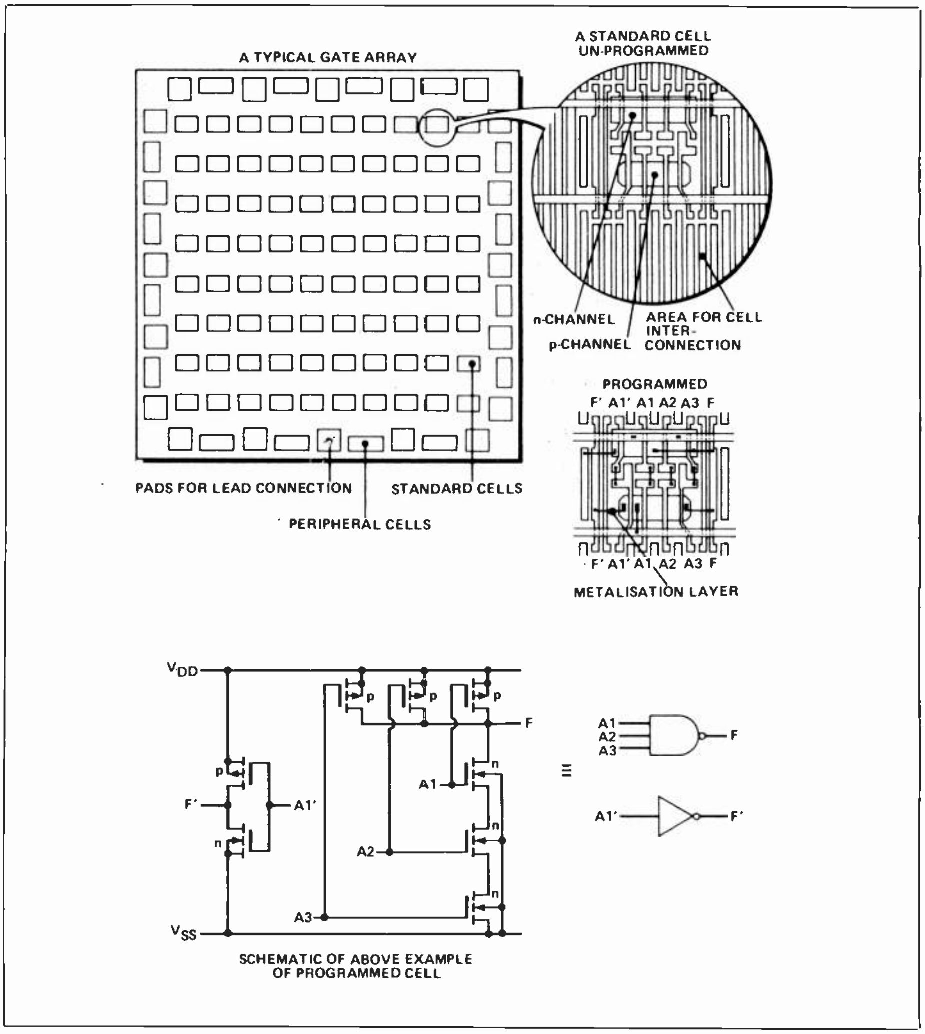


Fig. 1 A typical gate array.

The gate array, or uncommitted logic array (ULA), offers a quite different approach to semi-custom chip design. The basic building block here is nothing more complicated than cells of n-channel and p-channel transistors which can be configured as simple logic gates. Unlike the standard cell, the elements are already etched onto the chip and the customer need only provide interconnection data. Only the mask needs to be produced, for the final, metallization layer.

Fig. 1 shows a typical gate array. It will be noticed that there are two distinct areas on the chip. Around the edges are pads for lead connection and a number of special peripheral cells. These cells, being close to the outside world, are especially suited to providing I/O interfacing to a variety of other devices.

The centre of the chip, on the other hand, is composed of a matrix of standard cells, sometimes thousands in numbers. Figure 1b shows a typical standard cell. The cell has been masked to provide an inverter and a 3-input NAND gate. Conducting strips between the cells are used in conjunction with the mask programming

Designer's Note

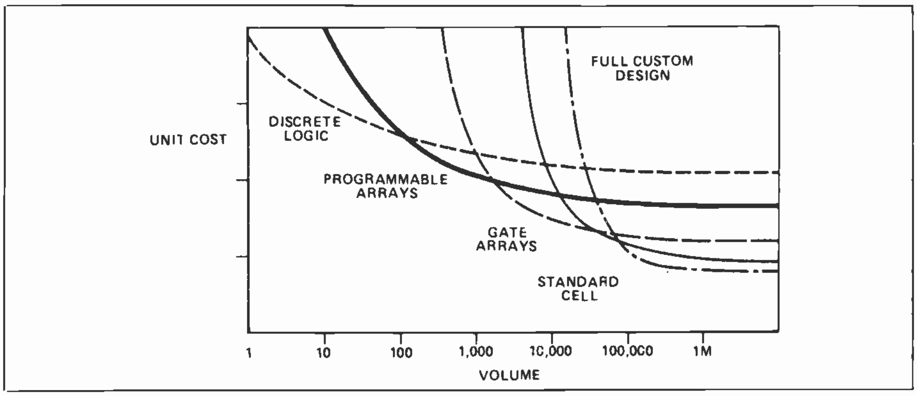


Fig. 2 Price comparison of logic technologies.

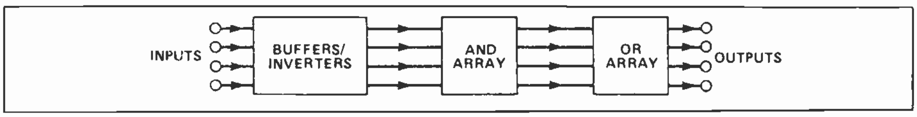


Fig. 3 Generalized AND/OR array.

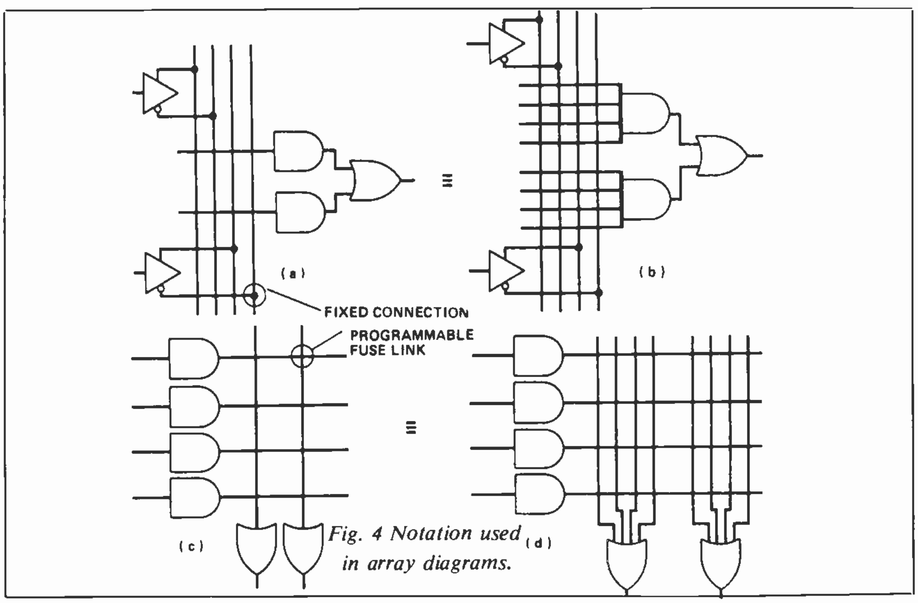


Fig. 4 Notation used in array diagrams.

within the cells to provide the required interconnections. Designing interconnections is more involved than in the case of standard cell chips but the initial manufacturing set-up cost of gate arrays is much less and they are, therefore, suited to smaller volumes. Even so, they would not be used for runs of less than a few thousand.

Array of Hope

Programmable arrays constitute a class of devices which are much less versatile than either custom or semi-custom chips but still provide a high degree of flexibility. Their major advantage is that the semiconductor manufacturer is not involved in the customization process. Instead, standard devices are obtained and programmed by the customer using equipment similar to a PROM programmer. Initial costs are nowhere near as high as with custom and semi-custom ICs and the devices can be used for relatively small volume production runs. In high volume, the lower initial cost would be more than offset by a higher unit cost. **Fig. 2** illustrates the varying costs of custom, standard cell, gate array, programmable devices and discrete logic against the volume used.

Programmable arrays are of three types: PROMs, PALs and FPLAs. The first will be well known to home computer enthusiasts as non-volatile data or program memory chips. The PROM is actually a special case of the programmable AND/OR array. **Fig. 3** illustrates such an array. The configuration can be used to implement any logic function expressed as a sum of products by selecting appropriate connections into the AND array and out of the OR array. In fact, any Boolean transfer function can be translated to this logic form, given the use of inverters, the only limitations being the number of inputs and outputs.

In order to understand the differences between the various programmable arrays, it is necessary to clarify the notation used in diagrammatic representations of these arrays. Since the gates in any array may well have tens of inputs, for convenience single input lines are used to represent actual multiple inputs (**Fig. 4**). This also shows that two lines crossing in a programmable section of an array represent a fuse programmable link. Fixed sections of an array use the convention of a solid dot to show a connection and crossing lines without a dot to indicate no connection.

PROMs

the characteristic feature of a programmable read-only memory is that the AND array is fixed while the OR array is programmable (**Fig. 5**). This will be a novel way of looking at a PROM to those who are used to its application as a microprocessor memory. The **Fig. 5** circuit should convince you that this truly is a 4-bit wide, 8-location PROM. In the general case, there will be one AND gate for each combination of inputs (that is, for each location or address) and one OR gate for each output bit.

PROMs have the advantage of low cost and are relatively easy to program. However, since the AND array is fixed, with one gate for each combination of inputs the chip size increases rapidly with the number of inputs. In fact, the total number of AND gates will be equal to 2

Continued on page 43

Digital Superglue -

The superchips of today are beginning to use programmable logic for all the small but vital tasks that hold a complex piece of equipment together.

By Mike Bedford

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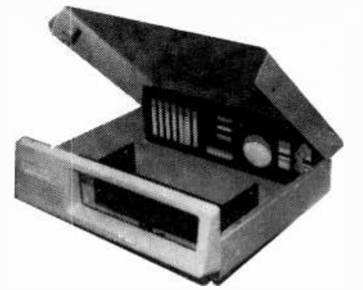

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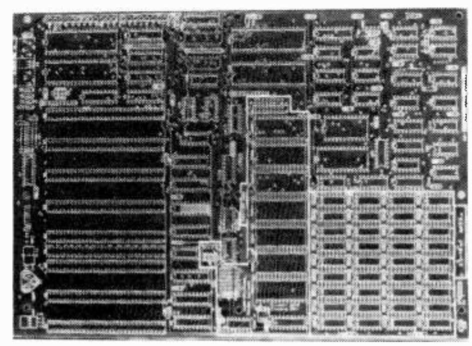

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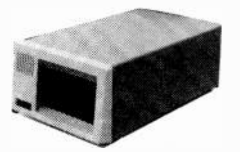

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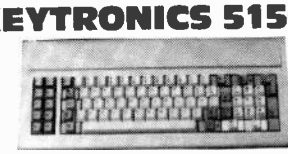

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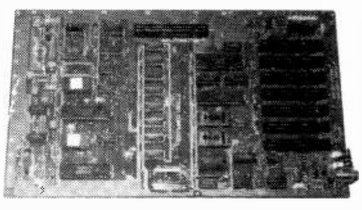

100% IIe* Compatible, for those of you who wish to build a clone of the very popular APPLE IIe*. This board is a reverse engineered copy of the IIe* and is 100% compatible. We have the motherboard and the custom ICs only. All other parts are widely sold. The custom ICs are workalike chips that do not infringe any copyrights. The software for operating the board must be obtained elsewhere as we do not have it for sale. When we say 100% we mean it.

A very good buy at	$49.95
Custom IC set(2)	$49.95
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48K 6502 Motherboard, same old 100% compatible 2 + clone	$29.95

IIe* ABS PLASTIC CASE
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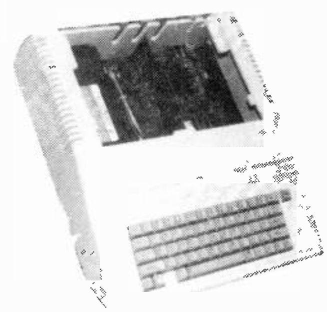

This case is made to fit the Mother Board listed here for making IIe* clones and it makes a very nice looking copy. There is just enough difference to avoid design infringement. The case also has no brand names or other marks on it.

A good buy at	$59.95
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Pin in stock at only

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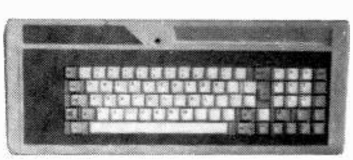
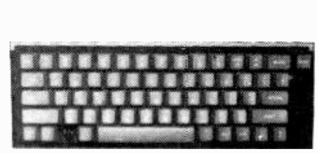


For those of you who would like to put your IIe in another case we have a high quality 100% plug in compatible Matrix keyboard with all IIe keys plus the highly desirable numeric keypad for quick entry of numeric data . . . .

IIe® MATRIX KEYBOARD



This keyboard fits the above case and has 100% clone compatibility, it will allow operation of all IIe* commands. Another bargain at . . . $79.95
2+ numeric keyboard for 48K mother boards. 100% comp 88 basic functions for only . . . $69.95
Standard same as above . . . $69.95

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You may have heard of the NEC V-20 chip. It is an upgraded 8088 that can run programs up to 50% faster (depending on code). It also can run Z-80 code, allowing it to be used for Z-80 development. Especially good for Video when using using it's features. A hot and hard to get CHIP at (5 Mhz) $24.95
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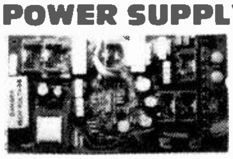

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(M) 512K card	$24.95
(N) 256K short card	$19.95
(O) IBM 6" extender for service	$19.95
(P) WW Proto, full sized with DB-9 & DB25 footprint	$24.95
(Q) WW Memory proto, full sized with 256K (1Meg) memory laid out on one end with DB-9, DB25 footprint	$29.95
(R) 512K Mapping PROM	$12.95
(S) Multifunction PROMS(2)	$24.95
(T) 2732 for color graphic	$10.00

All cards come with a detailed parts list and placement drawing, we also have all parts needed for them

The Protoboard

Make these simple, inexpensive accessories for your solderless, plug-in experimenter's breadboard.

By Harold Wright

THE accessories described here will save a lot of time and reduce the frustration index when a circuit is being set up on a plug-in board. Every time you set up a long string of LEDs, driven by a 74154 or similar IC, all 16 anodes, (or in some cases cathodes), must be tied together and run to V+ or ground through a common, current limiting resistor. Whether you jumper all the LEDs together with hairpin bend copper wire conductors, or use a common bus strip, it will still require the preparation and insertion of sixteen small jumpers, a tedious task. If you use the common bus strip, that strip will be tied up and cannot be used for voltage distribution purposes.

Extra Strips

Fig. 1 shows a cheap and simple solution. Made mostly from the junk box, it consists of a scrap of leftover 0.1 inch hole spacing perforated board, a length of self-adhering copper tape (Bishop Graphics), a small amount of five-minute epoxy cement, some 22 gauge solid, tinned, insulated hook-up wire and some solder. The cut-off ends from resistors and capacitors, after they have been installed in a circuit board are good because they are a bit stiffer than ordinary hook-up wire. Do not use wire larger than 22 gauge because the pins may damage your plug-in board sockets and the accessory will be very difficult to insert. The copper tape is applied along the center row of holes on the perf-board strip and is punctured at every other hole using a large darning needle. This spacing allows room for the body of the LED on the plug-in board. Short lengths of bare wire are given a right-angle bend, soldered to the copper tape and held rigidly to the perf-board with a long bead of epoxy cement. After the epoxy has cured, the protruding wires are trimmed evenly to a

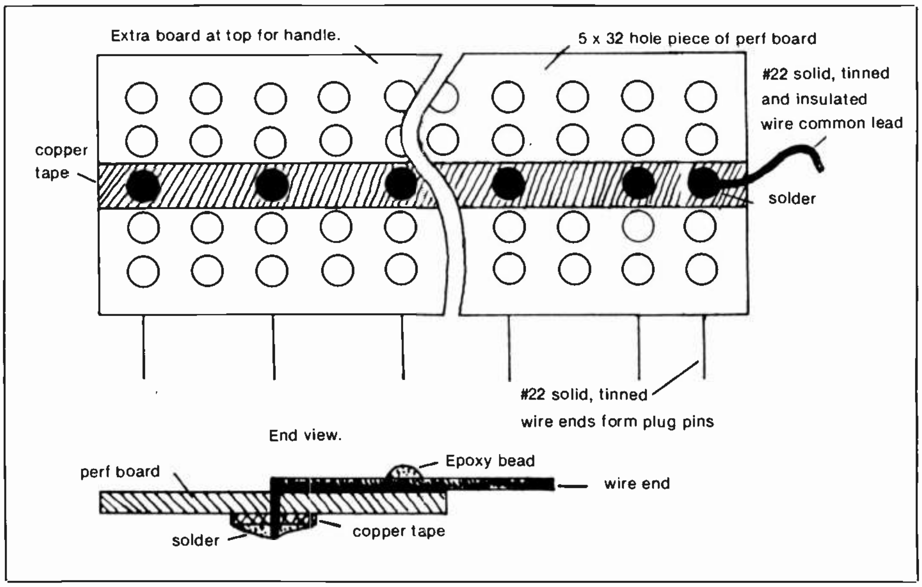

Fig. 1 Simple plug-in protoboard common bus for connecting the cathodes or anodes of a long string of LEDs.

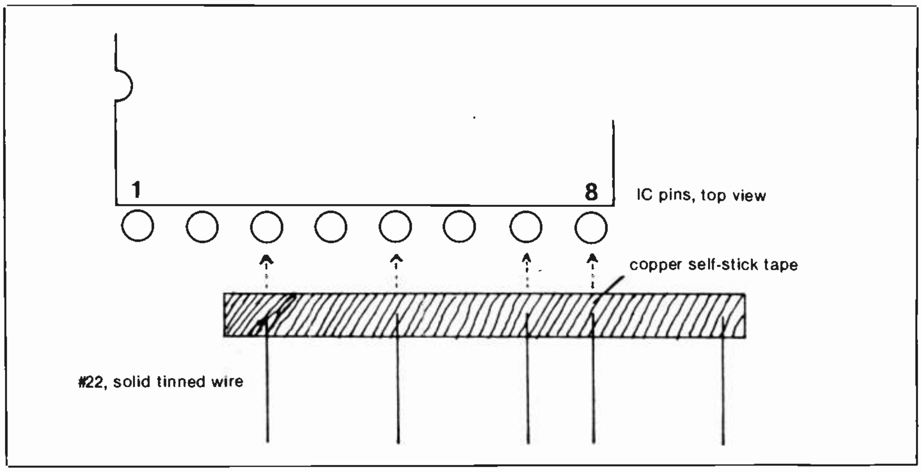

Fig.2 Pin pattern for 4049, 4010, 4050 ICs; the construction is the same as in Fig. 1. The extra pin at the right provides a connection to a separate row of holes on the protoboard via a simple loop to the ground strip.

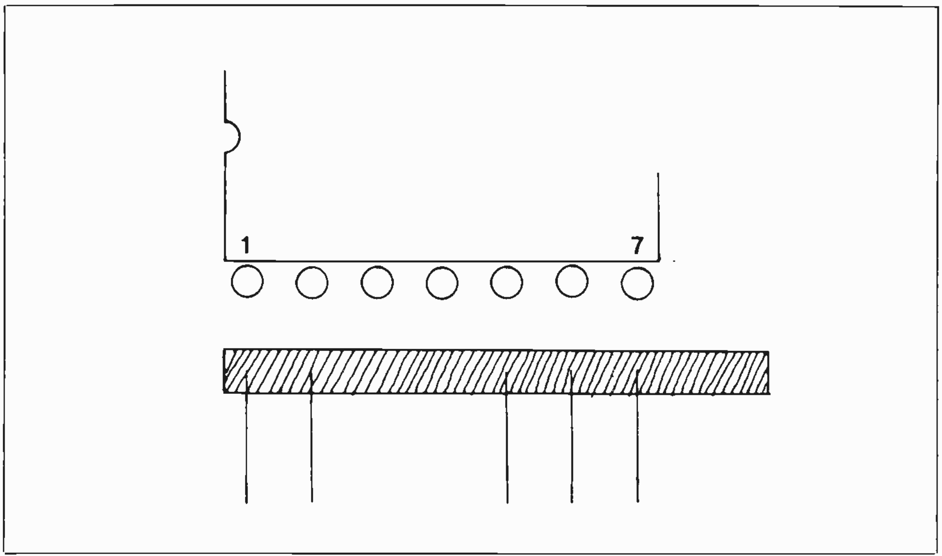

Fig. 3 Grounding strip for 4011, 4001, 4070, 4071, 4077, 4081, and 4093.

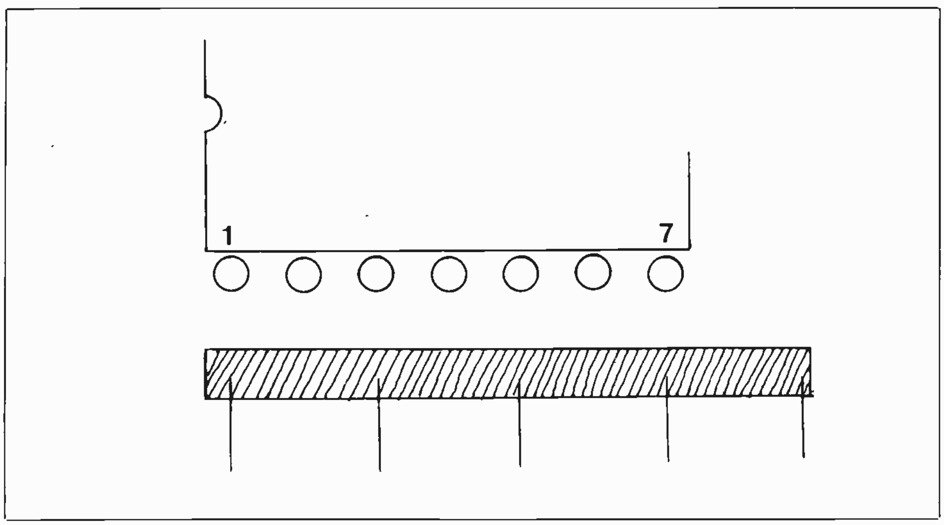

Fig. 4 Grounding strip for 4584 hex Schmitt trigger.

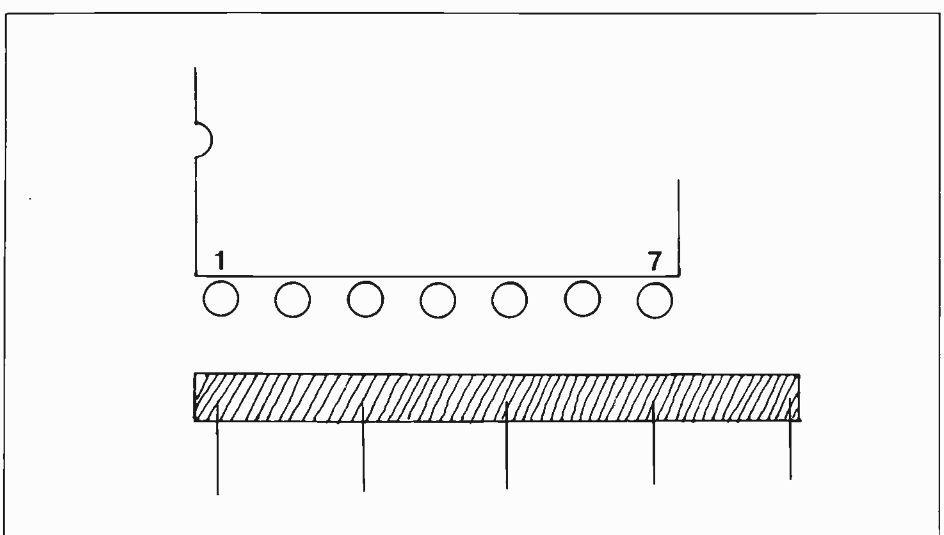

Fig. 5 Grounding strip for 7404 — 7407, 7414, 7416, and 7417.

length of about one-quarter inch. This accessory can be made in about half an hour and will save much time on future circuit development projects. A ten pin strip can be made for ICs such as the 4017.

IC Grounds

There are many times when a circuit is under development that only one inverter from a hex such as the 4049 or one gate from a 4001 is required. On these devices all unused inputs must be grounded or strange effects may occur. **Fig. 2** shows another, even simpler strip that will ground half the inputs on a 4049, 4010 or 4050 IC. This one has only five pins and can be made in ten or fifteen minutes. Once built as in the first one, it can be used over and over again. Construction is the same as Figure 1 except for the pin spacing.

These grounding strips will serve a large number of different IC types because there is a large degree of pin-out standardization between ICs with similar functions. **Figures 3,4,5 and 6** show the pin arrangements for shorting unused inputs to ground on a large number of CMOS-4000 series and TTL-7400 series devices. In these figures only the pins and tape are shown related to the IC socket. A top view of the socket is shown in each case because this is the way ICs are seen on a protoboard.

Interfacing

Have you ever tried to interconnect a completed circuit on a plug-in card with a developing circuit on the plug-in board? A tangle of 22 or more midget alligator clips with flex wires perhaps? What a great way to get lost in the resulting rat's nest, not to mention the damage the clips might do to the card contacts! It can be very simple if you build an adapter plug interface similar to the one shown in **Fig. 7**. A surplus double 22-position socket that had been chopped from a cable was used in the prototype. Enough flex wire had been left on the socket to allow spreading and permit connection to a 44 pin edge set of male pins made the same way as in Figure 1. Many of these surplus card edge sockets have gold plated contacts and are of very high quality. The interconnection between the socket flex wires and the solid wires required for the edge pins was made by using a 22 hole length of Bishop Graphics self-stick DIP pattern. If you can find a card socket with solder eyelets, the copper DIP pattern can be eliminated. One row of contacters was wired to alternate pins and the other row filled in the gaps. Different insulation colours were used to allow easy identification between front and back row contacts. If you are only involved in single sided boards, the construction would be simpler and the adapter length reduced.

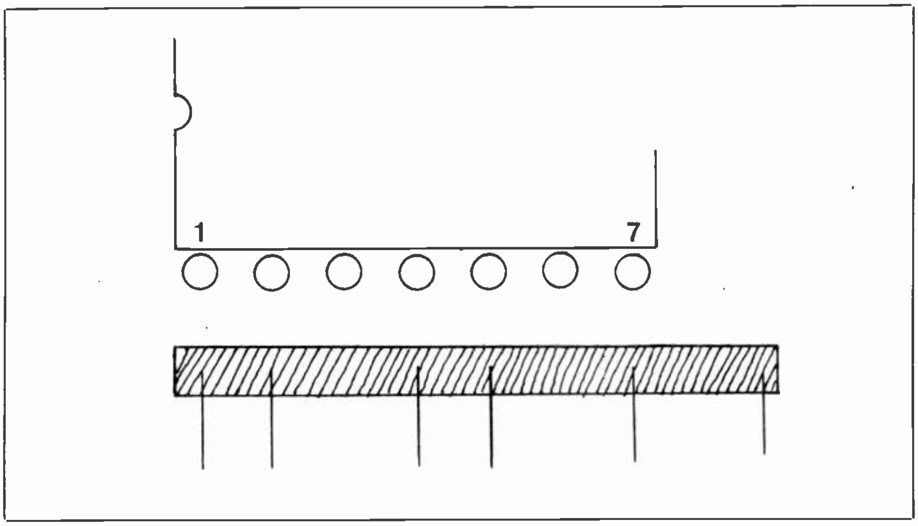

Fig. 6 Grounding strip for 7401, 7403, 7408, 7432, 7437, and 7486.

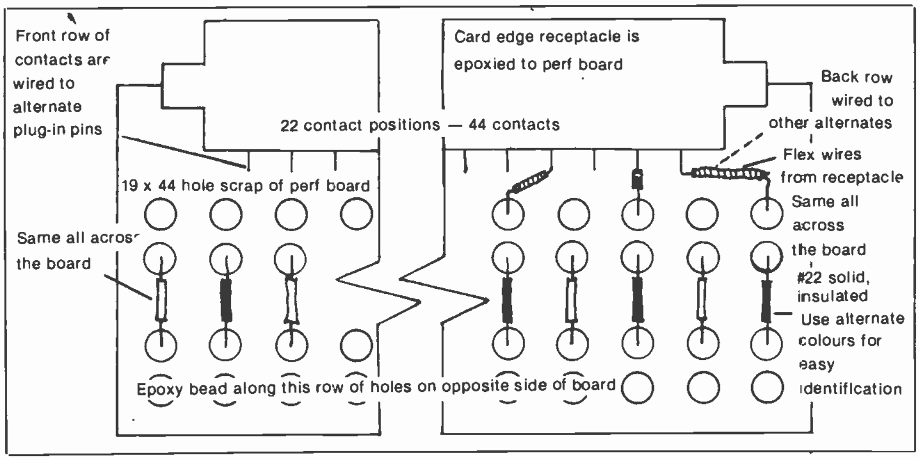

Fig. 7 Construction layout for 44 contact adapter for plug-in cards. Output pins match the spacing for protoboards.

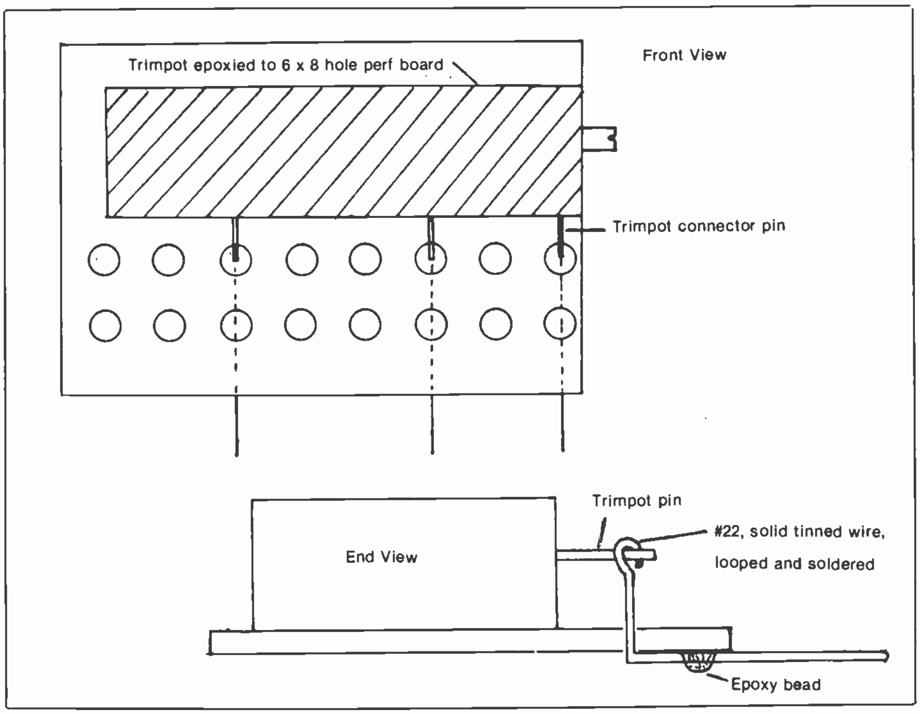

Fig. 8 Trimpot adapter for protoboard.

Another useful addition to these time savers is shown in **Fig. 8**. Here, similar techniques are used to mount multi-turn trimpots on scraps of perf board. The same technique can be used on one-turn rotary resistive trimmers or for screwdriver operated trimmer capacitors. Some trimmers have pins that will not enter the plug-in board sockets and when surplus trimmers are used it is usually impossible to insert them into the plug-in board. Figure 8 provides a solution for this and at the same time lifts the trimmer a bit higher than the DIP ICs and other components allowing easier access to the adjusting screws.

It is also possible to make an interface between decoders and distributors using similar techniques to those described above. A string of NPN or PNP transistors would be needed with base input limiting resistors and where necessary, output load resistors. Some devices cannot drive LEDs directly except at very low currents and low visibility. Such an interface could also be used to drive outside world devices such as relays or lamps.

Care should be used when inserting these devices. They enter the sockets more easily, for the long ones, if they are started at one end and worked along the strip using a tiny screwdriver to push a pin that may be slightly out of line. These pins will withstand straightening and if broken are easily replaced. If you build a few of them you will wonder why you didn't have them sooner! ■

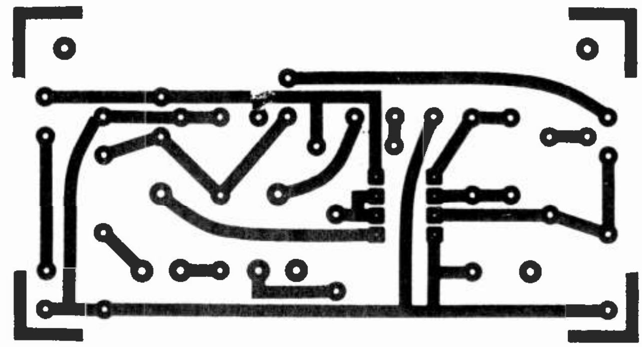

Fig. 4B The PCB

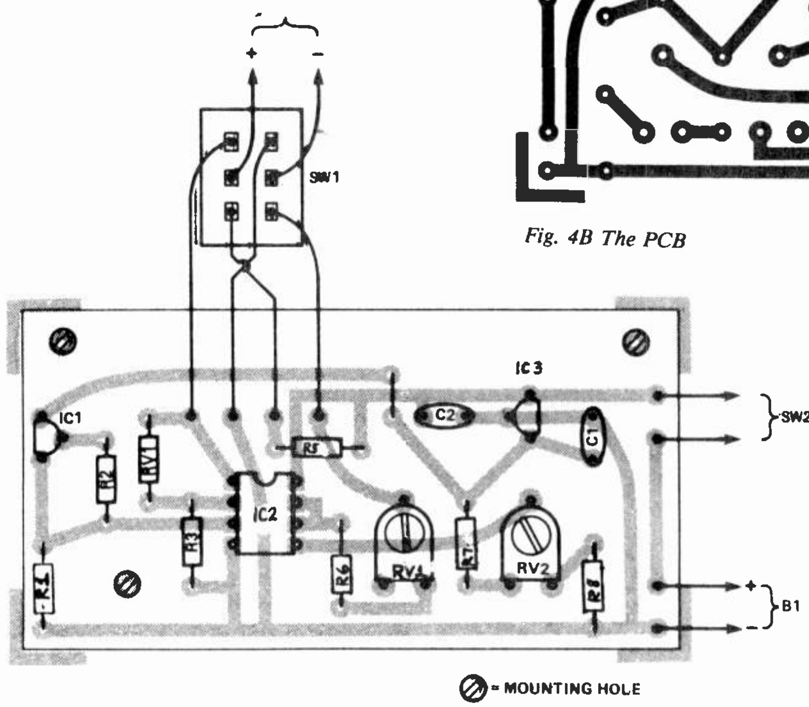

Fig. 4 The PCB layout.

way cable should be suitable.

Adjustment

Start with RV1 adjusted for maximum resistance (fully anticlockwise), and RV2 at roughly the midway setting. Set SW1 to the *normal* mode, switch the unit on, and immediately adjust RV2 to give a reading of about half full scale deflection from the meter.

In order to calibrate the unit it is necessary to have two glasses of water; one at or close to 0 degrees Centigrade (throw in some ice) and the other in the region of 30 to 50 degrees Centigrade. A thermometer placed in each glass will allow the monitoring of the temperature during the calibration process.

The basic procedure for calibration is to first place the temperature sensor in the cold water, and then to adjust RV2 to zero the meter. Next, the sensor is placed in the hot water and RV1 is adjusted to give the correct reading on the meter. This procedure is repeated a few times until no further adjustment is needed. RV2 is then adjusted to obtain the approximate temperature reading from the meter, rather than to zero the meter. However, calibration is likely to be much quicker and easier using water at 0 degrees Centigrade.

The meter has been designed to use a 50 microamp meter so that a 0 to 50 scale is obtained, and no re-marking of the scale is needed. ■

Parts List

Resistors (1/4W 5% except where noted)	
R1,3,4	10K
R2	680R
R5	200k 1%
R6	1k
R7	33k
R8	22k
Capacitors	
C1,2	100nF ceramic
Potentiometers	
RV1	4k7 0.1W horiz. preset
RV2	22k 0.1W horiz. preset sub-min.
IC1	LM334 current regulator
IC2	LM358 dual op amp
IC3	78L05 5V 100ma voltage reg.
Miscellaneous	
ME1	50uA moving coil panel meter
SW1	DPDT min. toggle switch
SW2	SPST min. toggle switch
B1	9V battery

Battery connector; plastic case approx. 150 x 80 x 50mm; PCB; 5-way DIN plug; 5-way DIN socket; three-way lead wire (screened); Veropins etc.

Continued from page 35

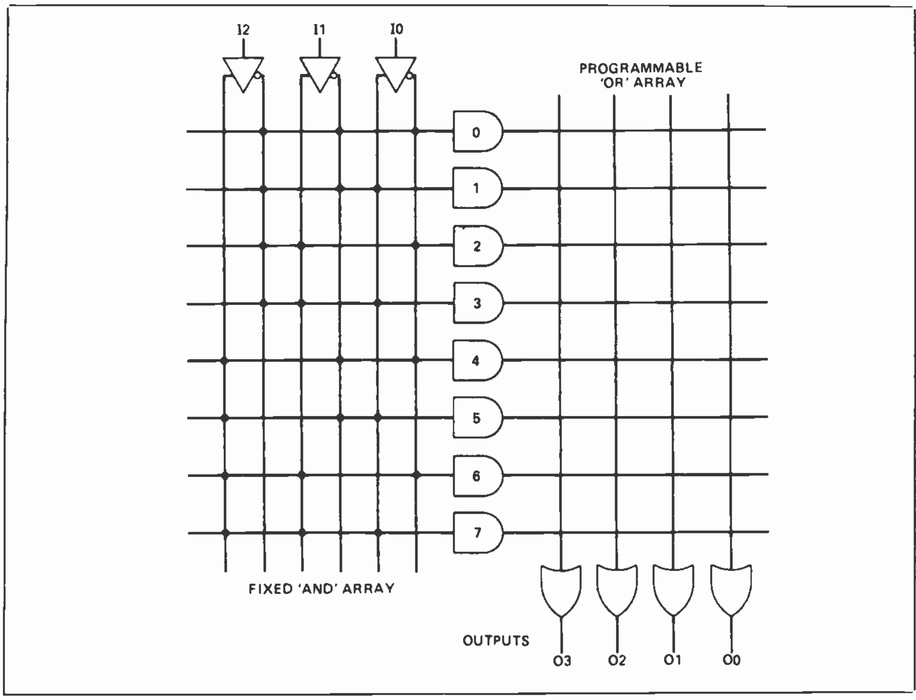

Fig. 5 Typical PROM arrangement (8 x 4 bits).

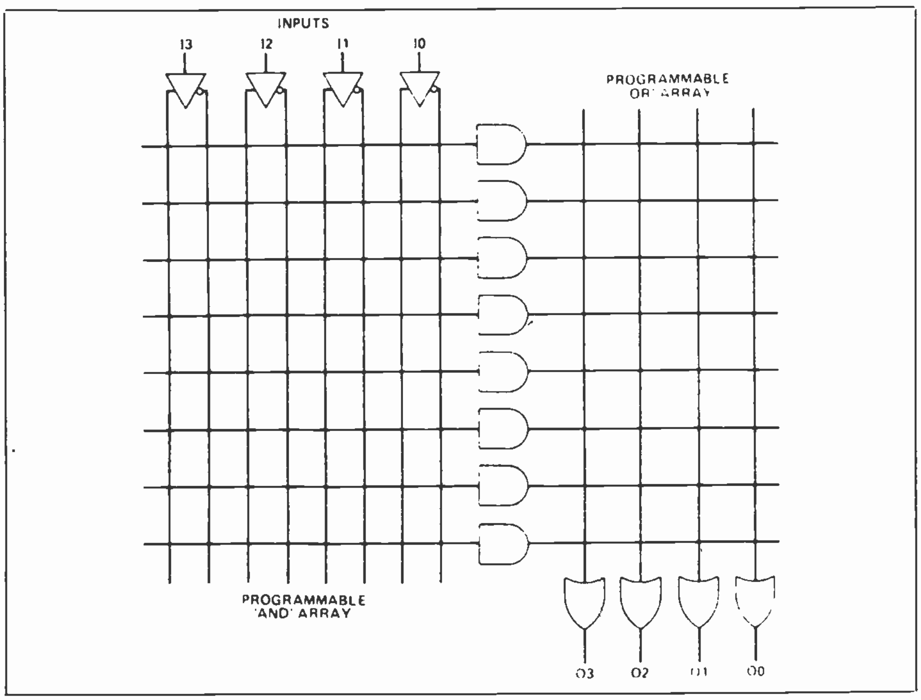

Fig. 6 Typical FPLA arrangement.

raised to the power of the number of inputs. For example, a 16-input PROM will have 64,000 locations. In the vast majority of applications such a PROM would be heavily under utilized.

A further limitation shows itself in the implementation of state machines. A feedback path is required for each state and, since there is no provision within the PROM for feedback, the loop has to be wired externally - using up valuable inputs and output. Despite these drawbacks, the PROM does find application as a programmable array.

FPLAs

The field-programmable logic array (sometimes known by the acronym PLA or IFL, for integrated fuse logic) is illustrated in **Fig. 6**. It differs from PROMs in that the AND array is programmable as well as the OR array, giving a much greater degree of flexibility. The FPLA does not need a very large array to accommodate a reasonable number of inputs. Further advantages in the form of registered outputs, internal feedback and output polarity are sometimes offered in FPLAs, but since these features are common to PALs, they will be fully covered under that heading.

Despite these advantages, FPLAs have attracted less interest than PALs, possibly because they are too flexible. The increased flexibility results in longer propagation delays, making FPLAs unsuitable for very high performance designs. All programmable arrays are costly in silicon area, so that if everything is programmable, as with FPLAs, the number of gates is more of a limiting factor. The pros and cons of FPLAs and PALs are hotly debated, the manufacturers of each pushing the advantages of those they supply.

PALs

The PAL configuration (**Fig. 7**) is the third option for a logic array: a programmable AND array with a fixed OR array. Like FPLAs, PALs provide a number of additional features beyond the basic AND/OR structure. The previously mentioned limitation of PROM architecture due to the fixed number of inputs is overcome in many PALs by use of bi-directional outputs (Fig. 8).

The output shown in **Fig. 8** is fed through a tri-state buffer controlled from the AND array, and so can be disabled. Since a line from this output is fed back to the AND array, the same pin could be used as a further input. It is also possible to provide feedback to the AND array even if the pin in question is being used as an output.

A further facility sometimes offered is the use of D-type latches on the outputs to provide a registered output (**Fig. 9**). Implementations of state machines use internal feedback from this registered output. An output enable may also be provided, controlled from a line common to all outputs on the device.

Programming PALs is not as straightforward as programming PROMs. The procedure is complicated by the fact that it is impossible to address the large number of fusible links inside a typical PAL without multiplexing the functions on the limited number of pins. It would not be outside the realms of possibility for an ambitious home constructor to design and build a PAL programmer. Commercial programmers usually have a reasonable degree of intelligence and only require Boolean equations to be entered in order for a fuse map to be worked out automatically. It is outside the scope of an introductory article to go into programming in great depth but the information is of course available from manufacturers' data books.

Applying Some Logic

The application of programmable logic using a PAL can be demonstrated in the simple microcomputer interfacing circuit of a typical low complexity 6809 board (**Fig. 10**). Discrete TTL logic is used to generate chip select signals for the EPROMs, RAMs, VIA, ACIA and CRTC. Also generated are the OE and WE signals for the memories and a signal to other boards in the system to indicate that on-board memory is being accessed, which is also used to enable or disable the address and data buffers.

The resultant memory map of this circuit has EPROM 1 at E000 - FFFF, EPROM 2 at C000 - DFFF, RAM 1 at A000 - BFFF, RAM 2 at 8000 - 9FFF and I/O at 6000 - 7FFF. The I/O area is partially decoded to provide addressing for the VIA, ACIA and CRTC. This implementation uses 5 TTL packages, the functions of which may be expressed by the following Boolean equations:

$$\begin{aligned}
\overline{\mathrm{EPROM1}} &= \mathrm{A15.A14.A13} \\
\overline{\mathrm{EPROM2}} &= \mathrm{A15.A14.}\overline{\mathrm{A13}} \\
\overline{\mathrm{RAM1}} &= \mathrm{A15.}\overline{\mathrm{A14}}\mathrm{.A13} \\
\overline{\mathrm{RAM2}} &= \mathrm{A15.}\overline{\mathrm{A14}}\mathrm{.}\overline{\mathrm{A13}} \\
\overline{\mathrm{VIA}} &= \overline{\mathrm{A15}}\mathrm{.A14.A13.A5.A4} \\
\overline{\mathrm{ACIA}} &= \overline{\mathrm{A15}}\mathrm{.A14.A13.A5.}\overline{\mathrm{A4}} \\
\overline{\mathrm{CRTC}} &= \mathrm{A15.A14.A13.}\overline{\mathrm{A5}}\mathrm{.A4} \\
\overline{\mathrm{OE}} &= \mathrm{E.RW} \\
\overline{\mathrm{WE}} &= \mathrm{E.}\overline{\mathrm{RW}} \\
\overline{\mathrm{MEMACC}} &= \overline{\mathrm{EPROM1}}\mathrm{.}\overline{\mathrm{EPROM2}}\mathrm{.} \\
&\quad \overline{\mathrm{RAM1}}\mathrm{.}\overline{\mathrm{RAM2.VIA}}\mathrm{.} \\
&\quad \overline{\mathrm{ACIA}}\mathrm{.}\ \overline{\mathrm{CRTC}}
\end{aligned}$$

These functions may be implemented by a PAL device, reducing the chip count from 5 to 1.

Ten active low non-registered outputs and at least seven inputs are necessary and are available on the 20L10 PAL. **Fig. 11** is a schematic diagram of this device programmed for the example application. The program was worked out by hand but it should be quite clear that it will implement the above equations and replace the discrete TTL of the original circuit. This is a simple case, the equations only consisting of ANDed terms so that only one of the inputs of each OR gate is used, the tri-state buffers are always enabled and five of the chip inputs are not used at all.

Programming would not usually be done manually. Instead, a software package would translate the Boolean equations into a fuse map, generating a master tape from which further PALs may be programmed. (Please note that this design is only presented as an example and has not been prototyped and checked in practice.)

Recent Developments

Fig. 12 sums up the relationships between the various existing logic technologies. Recently, the clear divisions between the various families shown have become much less definite. In particular, the two ap-

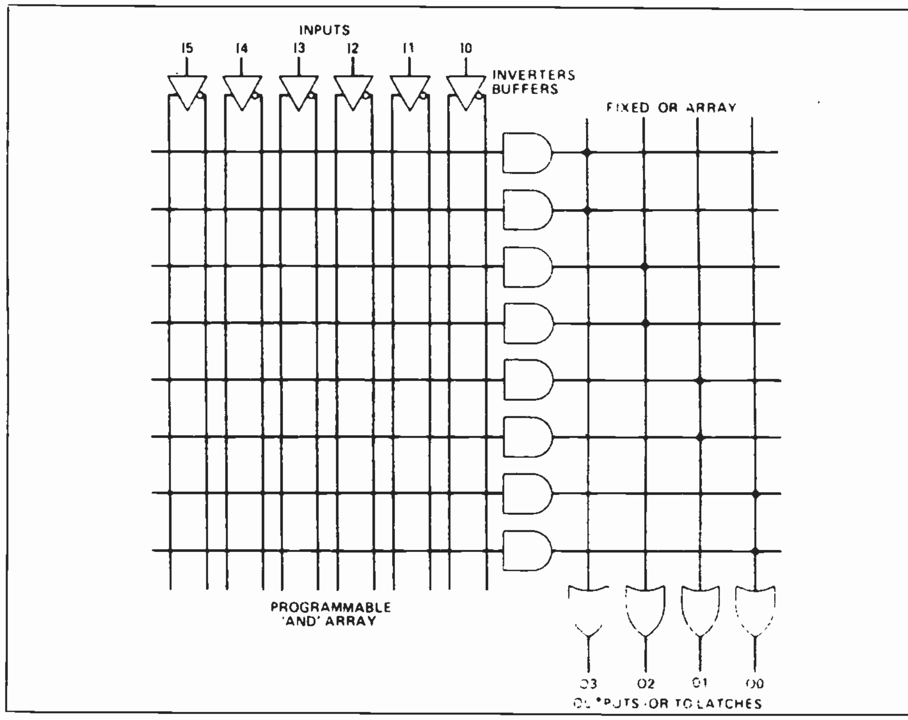

Fig. 7 Typical PAL arrangement.

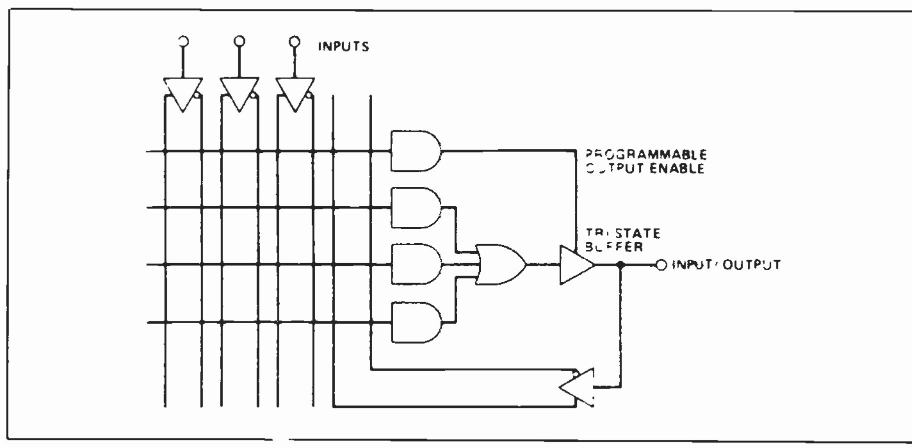

Fig. 8 Bi-directional I/O on PAL.

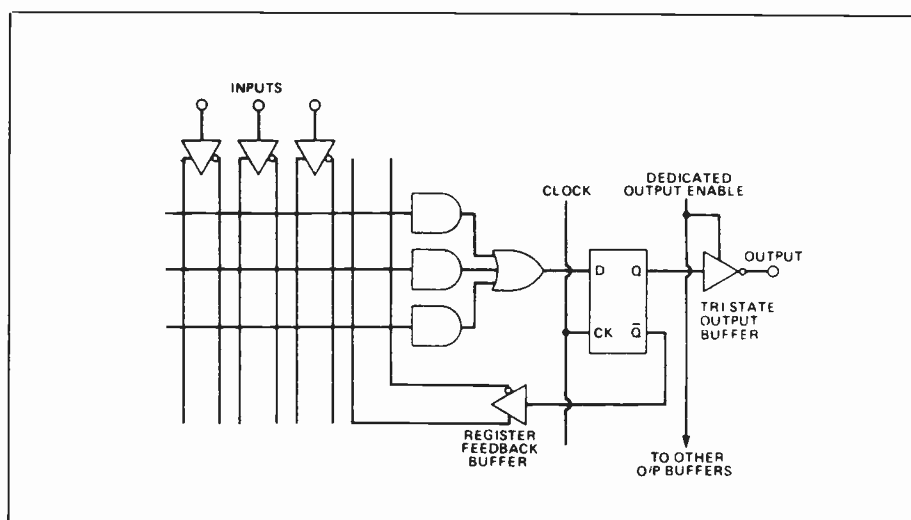

Fig. 9 Registered output on a PAL.

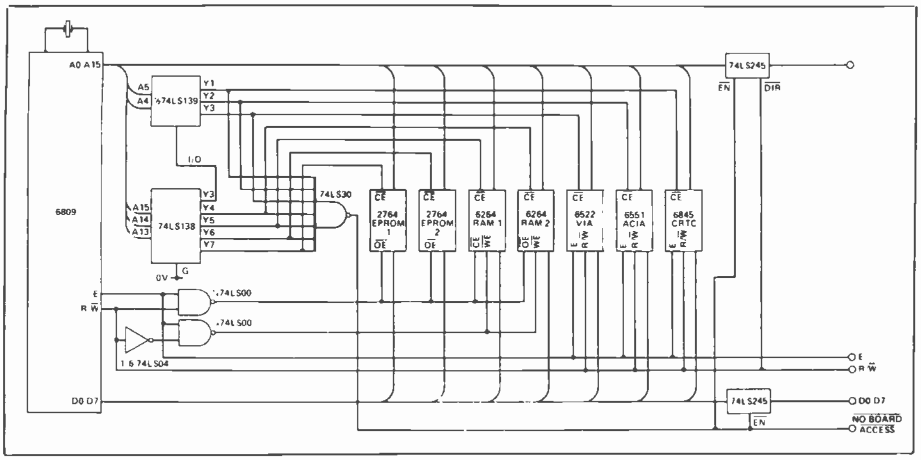

Fig. 10 Simple 6809 board with discrete TTL.

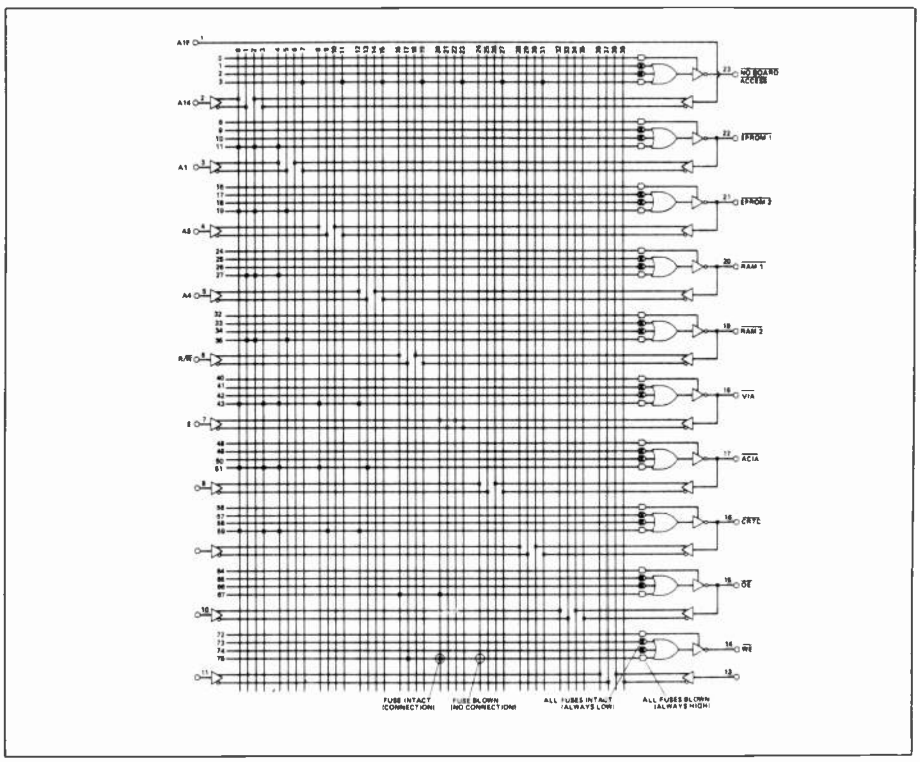

Fig. 11 PAL implementation of 6809 board logic (20L10 PAL).

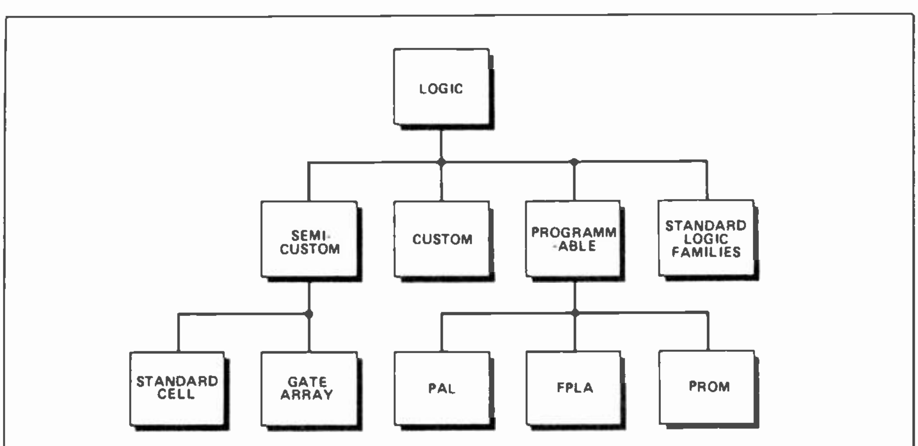

Fig. 12 The families of logic technologies.

proaches to semi-customizing, standard cell and gate arrays, are beginning to merge. This breakdown of the distinction becomes particularly noticeable to the customer as use is made of increasingly more sophisticated CAD software.

The designer of both standard cell or gate array devices is faced with almost indistinguishable development tools, the differences which are transparent being of relevance only at the manufacturing stage. From a customer point of view the only difference is in the price-volume relationship. Performance and interfacing requirements are very similar.

The facilities offered on many recent standard cell libraries and gate arrays are also becoming less distinctive. Gate arrays are now available with much more complex elements than the usual cells of p-channel and n-channel transistors. It is possible to find gate arrays with CPU and memory cells performing functions previously available only in standard cells. From the other side, standard cell libraries may now include blocks of gate arrays to allow last minute customization and even blocks of PAL to allow modifications after manufacture. Clearly, these enhancements to gate arrays and standard cells will eventually result in very similar types of semi-custom device.

A further area of recent advance is the development of eraseable programmable logic devices. These have the same relationship to standard PALs and FPLAs as EPROMs have to bipolar PROMs. In full production runs, these devices do not yet provide an economically viable solution to logic design but, in the initial stages of design, they greatly reduce the speed and cost of turning a series of development versions of a circuit. ■

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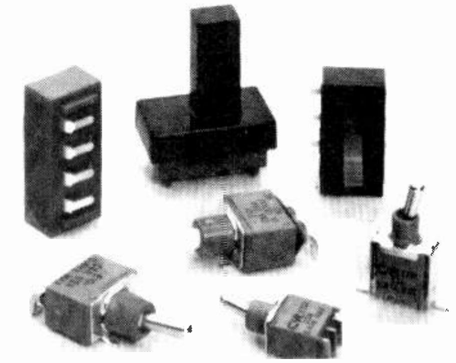

C&K Components announces the availability of surface mounted slide, toggle and pushbutton switches. The E series toggles, E010 and E020 Pushbuttons, ET Tiny toggles are sealed to withstand soldering and cleaning processes without special attention. They're available in various current ratings up to 7.5A and various actuators and mounting styles. C&K is represented in Canada by Avotronics Ltd., 230 Don Parker Rd, Unit 2, Markham, Ontario L3R 2P7, (416) 475-2024, and by Line Electronics, 1503 Dover Court Road, N. Vancouver, BC V7K 1K6, (604) 922-5315.

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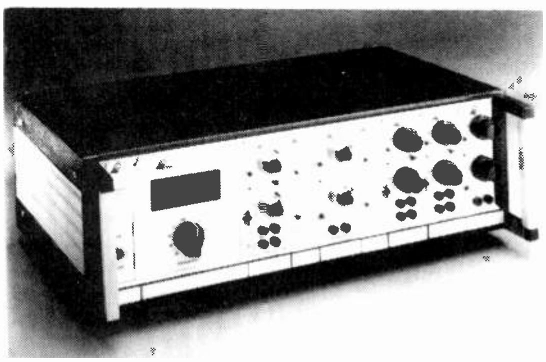

The new Aries AI 1000 Analog Signal Conditioning System consists of a series of amplifier modules for stress analysis and strain gauge transducers. Gain is variable up to 11,000 and frequency response to 10Khz. Other types of modules are available, as are digital displays, channel selectors, peak hold, filters, etc. From Durham Instruments, PO Box 426, Pickering, Ontario L1V 2R7, (416) 839-9960.

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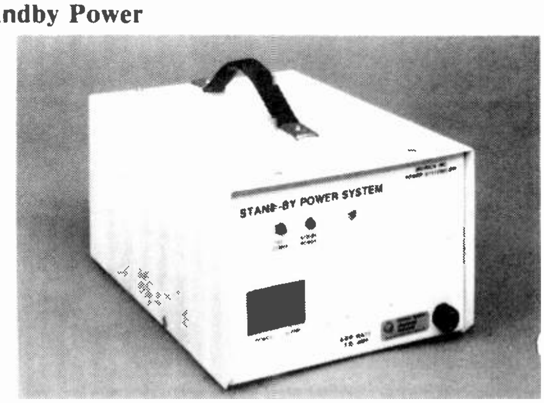

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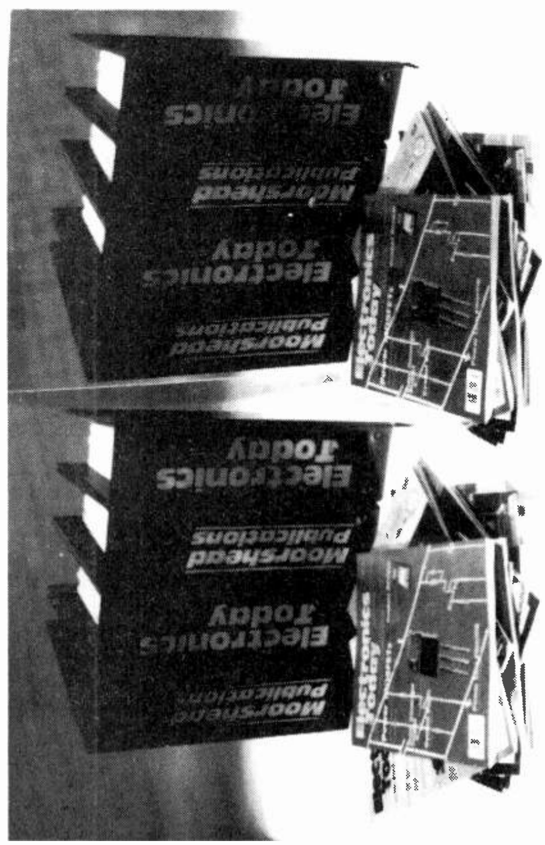

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Autowiper

Set the pace with a digitally-controlled variable delay for windshield wipers.

By A. Armstrong

THE AUTOWIPER is quick and simple to install and it requires just four connections to the motor wiring with no unsightly holes in the dashboard. It's also especially useful on the rear wiper of hatchbacks. The connections are 0V, the + 12V motor supply, and the normal speed motor wire, cut in two with both ends joined to the unit.

The time period is set by triggering a single wipe of the windshield and another after the desired interval has elapsed. The unit remembers the interval and keeps on working at this rhythm (give or take 10%) until cancelled or reset.

Principles

A timer starts when the switch is turned on briefly for the first time, and its state is stored on the second switch operation. The timer is then cycled repeatedly; the windshield wipers being operated once in each cycle. A third switch operation, if it occurs when the wipers are stationary, resets and restarts the timer. A fourth operation of the wiper switch stores the new time period (between third and fourth switch operations). If no fourth operation is received, the unit times out after about 30 seconds.

The timing is digital in nature, and uses a four bit binary counter. This provides 14 usable time periods, since both zero and terminal count are not valid time settings. In order that this quantization of available timings is not a nuisance, the speed of the clock oscillator is controlled by the state of the counter. The clock starts off fast when the time period is being set and slows as the period lengthens. In this way, the accuracy of the timer (expressed as a percentage of the required time period) remains constant. A limit is placed on the oscillator speed so that it does not use up too many possible states while the wipers are crossing the windshield the first time the switch is operated.

Earlier designs used an analogue timer, but in damp weather leakage currents caused a significant timing drift over a period of five minutes. The digital design is much less susceptible to this, though condensation on bare tracks can cause problems.

Construction

The first job is to link the top and bottom sets of tracks on the PCB. The board is laid out so that none of the pads on the top of the board connect to components, they are all simply links to the bottom. this simplifies both assembly and repair. The preferred method of joining the two sides is to use track pins. If these are unavailable, wire links may be used.

It's a good idea to spray the component side of the PCB with lacquer once the track pins are soldered on both sides. This will ensure that even the tracks which run underneath components are coated. This can prove to be important if the PCB is to be mounted in the engine compartment of a car, because condensation can sometimes occur under these circumstances.

The components may then be mounted on the PCB, starting with the passive components. The only one likely to be difficult is the relay, as some samples of these have pins which are very resistant to soldering. The most effective method of persuading them to solder is to clean them up with a glass fibre brush. Another solution which has worked is to pre-tin the pins with the aid of a corrosive flux. The flux must then be cleaned off the pins very thoroughly, or else the board will fail due to the tracks being eaten through every few months.

When all the components are correctly fitted, a bench test is in order. The best way to do this is with a test harness (Fig.3). Switch on the supply, and wait ten seconds for C4 to charge up. With the aid of a digital watch operate the switch twice, at a ten second interval. Time the flashing of the LED, and check that its period is between nine and eleven seconds.

If it is far out, then check that R5 to R8 and D2 to D5 are properly oriented. If nothing happens, or if the relay just switched on, check that both parts of the flip-flop switch over properly. Check that the clock oscillator works, and that a pulse appears on IC5 pin 10 when the switch is turned on. It might also be worth checking whether Q1 is switching but failing to operate the relay, this is always a possibility.

Once the board is shown to be in good working order, a liberal coat of lacquer should be applied to the underside, and allowed to dry thoroughly.

Installation

There are two points requiring careful consideration. The first is to find a place to mount the PCB, within reach of the wiring of the windshield wiper motor. The second is to discover which of the wires going to the motor is which. If you've ever tried to decipher car wiring harnesses you probably already know that they are like an overnight bag full of snakes.

The first of these depends on the individual car, so only general advice can be given. Any flat surface, at whatever angle, near to the motor, may be suitable. It should not be in direct line with any spray which may come in through the radiator grill, nor should it be somewhere where corrosion is obviously occurring. Hammond makes a series of small moisture-proof cases which are ideal for this (see Cabinetry For Electronics - March '86). If there is convenient access to the wiring inside the car (and there rarely is), then this is a preferable mounting place, especially if there is also a convenient plastic panel to attach the PCB to.

The only way to identify the wires non-destructively is to find a connector somewhere in the windshield wiper motor wiring. The positive connection can be found with the aid of a meter first of all, and then it should be possible to identify the standard speed connection to the motor by finding which one receives a continuous supply only when the wiper switch is in the standard speed position. This wire should be cut and connected to the unit (Fig.4).

The positive supply may be obtained via a tap-in connector, and the OV connection may be taken to any convenient bolt which passes through the metallic structure of the car. A quick final test is now all that is needed before the unit is ready for use.

Should the unit be used on any car in which the switch wire is not grounded by the park switch in the motor, then an external pulldown resistor may have to be connected to the terminals, as shown in the test circuit (Fig.3).

The operation sequence is: operate wiper switch to wipe windshield once.

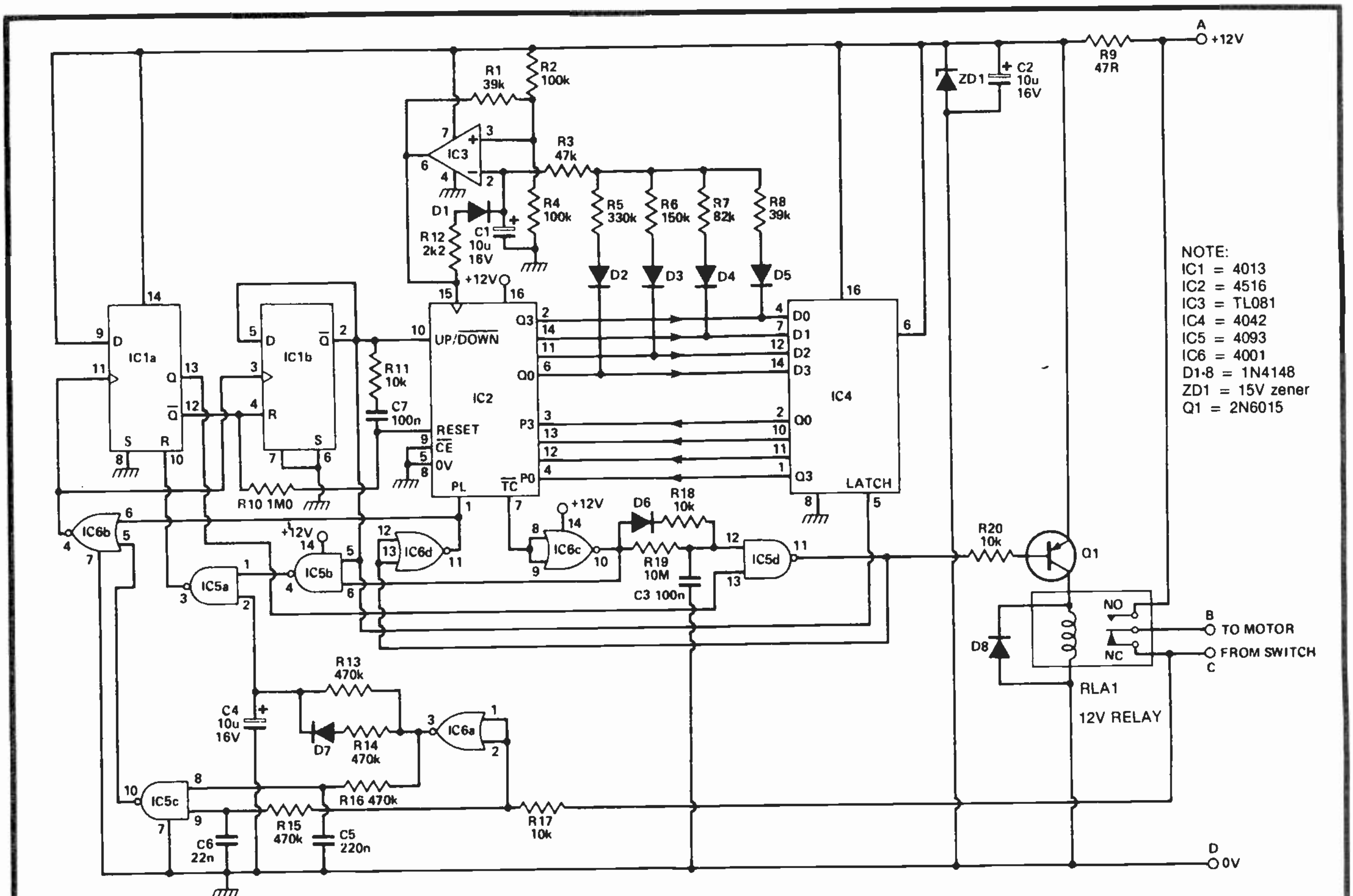


Fig. 1 Circuit diagram of the Autowiper.

When the wiper switch is switched on, a logic 1 is applied to the input of IC6a via R17 to protect the input. Because of the inequality of the time constants of R15/C6 and R16/C5, there is a brief period when both of the inputs of IC5c are at logic 1. This results in a brief negative going output pulse, which is inverted by IC6b which then clocks the flip-flop, IC1a. The inequality of the time constants ensures that a transition from logic 1 to logic 0 on R17 will not cause a clock pulse.

The fact that both inputs to IC5c have RC time constants means that electrical noise is rejected to a large extent. Should electrical noise or switch bounce prove to be a problem in use, then both time constants may be increased in proportion.

The first clock pulse switches IC1a so that its Q output goes to logic 1. This enables the relay drive, via IC5d. The Q output goes to the reset inputs of IC1b, and the counter, IC2, via R10. The counter is therefore allowed to start counting up as soon as C7 has discharged to logic 0 via R10. We get to the purpose of C7 later.

The oscillator which clocks the binary counter is derived from a standard configuration, but it has been designed so that the discharge path of C1 is separate from the charge path, and is connected externally to the oscillator part of the circuit. This means that the cycle time of the oscillator can be controlled by the voltages applied to the discharge resistors. These resistors, R5 to R8, are approximately binary weighted, and connected to the outputs of the binary counter. To limit the maximum oscillator speed to something useful, while leaving the slower speeds almost the same, an extra fixed discharge resistor, R3, is placed in series with the discharged path.

Clearly, if the counter is allowed to reach state 15 (1111) then there will be no discharge path for C1, and the oscillator will stop. This does not matter because when the counter reaches this state, the terminal (or carry) output, IC2, pin 17, switches to logic 0. This resets the first flip-flop, IC1a, via IC6c, IC5b, and IC5a, which means that the unit has timed out.

There is only one further point to make about the oscillator and counter. IC3 must have a sufficient slew rate to clock the CMOS counter used. A 741, for example, will not work because the counter will count up for a while, but normally stops when it is time for the third most significant bit to switch. TL081s and LF351s with a 13V/microsecond slew rate are perfectly adequate.

Back to the main sequence of operation. If a second clock pulse is applied (the wiper switch is operated again) before the counter reaches terminal count, then IC1b is clocked. This has the effect of latching the counter output in the transparent latch, IC4. The counter up/down input is switched to down, and the counter now counts down from whatever number it has reached until the terminal count bar output switches over. This now occurs at zero, because the counter is in the down mode. The down count takes the same period of real time as the up count took, since the oscillator is progressively speeding up rather than slowing down. When terminal count is reached, the relay is energized for a period set by the time constant of R19 and C3. This starts a wipe of the windshield, which is then completed by the park switch in the motor.

While the relay is energized, the counter is parallel loaded with the latched count data, so that a new down count can be started from the same number. Any clock pulse generated on the output of IC5c as a result of the wipe, is prevented from reaching IC1a by IC6b during this period.

The terminal count output is prevented from resetting the flip flops by IC5b as long as IC1b is set.

If the wiper switch is operated when the wipers are stationary, the resulting clock pulse from IC5c is allowed through to the flip-flops, and it switches over IC1b. A reset pulse is applied to IC2 via C7, with R11 in series to limit the peak current in the input protection diodes when it switches back the other way. IC2 is now allowed to count up, and the circuit is in the state it was in after the first operation of the wiper switch. It is waiting for a new time setting.

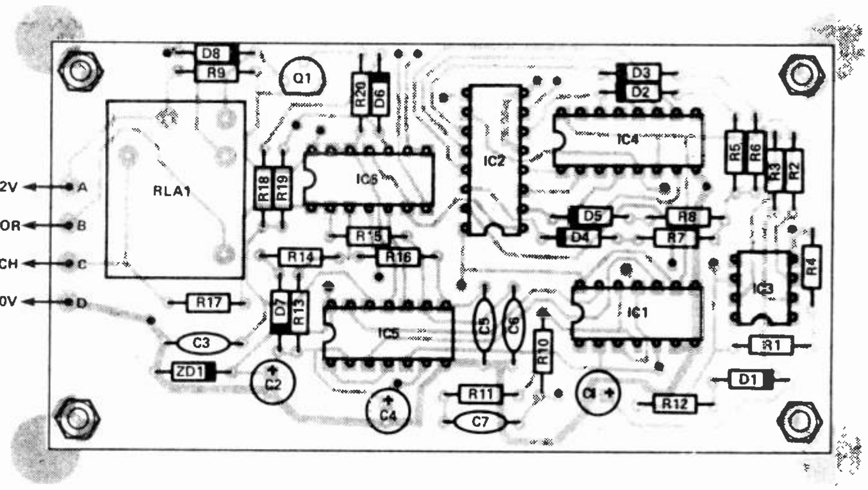


Fig. 2 Component overlay for the Autowiper PCB

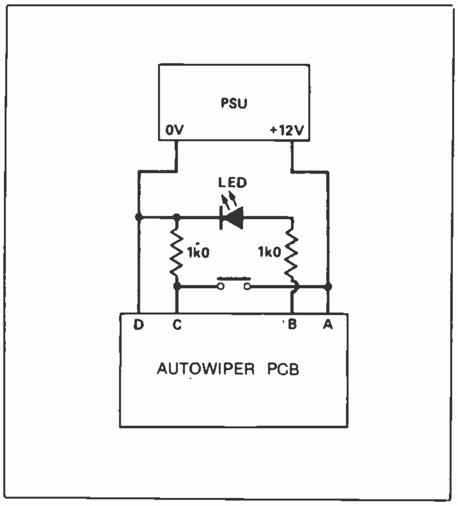


Fig. 3 Test harness circuit.

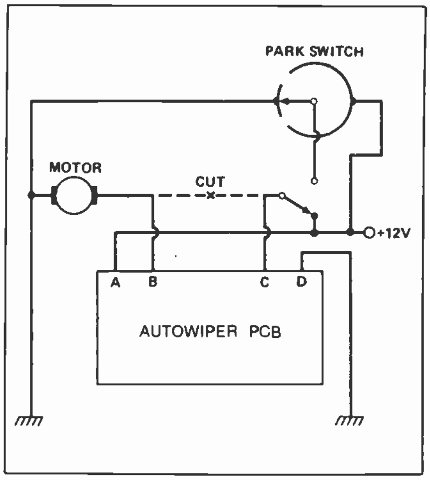


Fig. 4 Simplified wiring diagram.

Parts List

Resistors (all 1/4W, 5%)	
R1,8	39k
R2,4	100k
R3	47k
R5	330k
R6	150k
R7	82k
R9	47R
R10	1M0
R11,17,18,20	10k
R12	2k2
R13,14,15,16	470k
R19	10M
Capacitors	
C1,2,4	10u, 16V
C3,7	100n
C5	220n
C6	22n
Semiconductors	
IC1	4013
IC2	4516
IC3	TL081
IC4	4042
IC5	4093
IC6	4001
D1-8	1N4148
ZD1	15V
Q1	2N6015
Miscellaneous	
RLA1	12V relay

4-way, 0.2in pitch screw connector block; track pins for through-board connections.

Repeat after a delay of x. The intermittent switch will now operate at a period of x (+-10%), with the switch in the off position, until a third manual wipe is carried out, or the switch is turned on for several seconds continuously, or the ignition is turned off. It is always possible to switch the wipers on continuously (even if the accessory should malfunction), so there is no safety hazard.

In the event of a fault which causes the wipers to operate continuously (for example, the relay remaining on all the time), it is possible to return to normal wiper operation by disconnecting just the positive supply to the unit, pending a proper repair.

OUTPUTS

Quirks

There is one more important detail to mention. It is possible that, by mistake, a time period may be set which leaves the wiper stationary for only a small fraction of a second. If this happens, it is very difficult to flick the wiper switch during the stationary period to reset the circuit. If the circuit is allowed to run for a few seconds C4 will, on average, discharge rather than charge, and after a while IC1a will be reset via IC5a. (This part of the device has been nicknamed the 'anti-knickers-in-a-twist' circuit.)

To improve reliability, the power supply connections to the ICs are protected from spikes and reverse polarity connection by R9, ZD1, and C2. If the circuit should accidentally be connected to the power the wrong way round, the only damage likely is that R9 may smoke mightily.

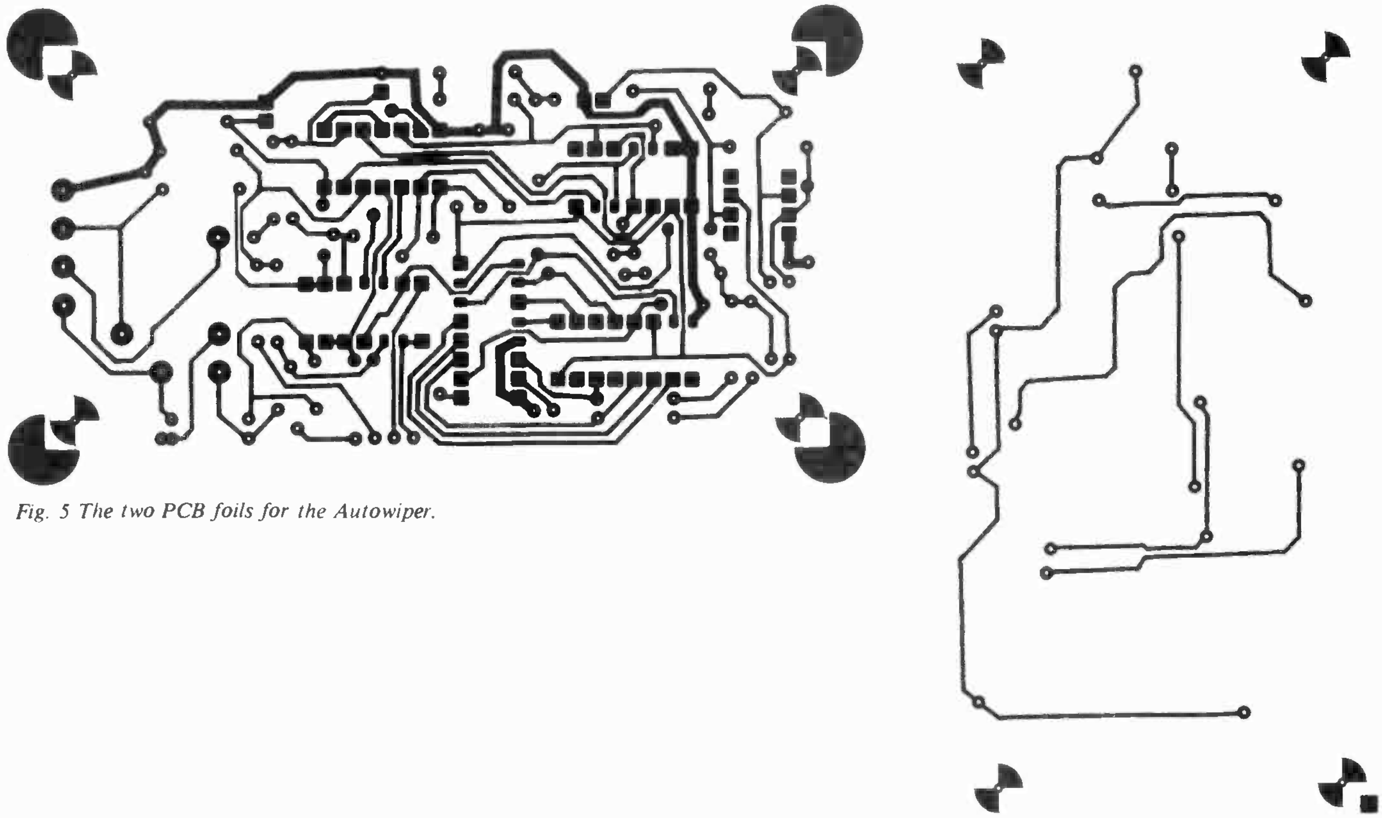
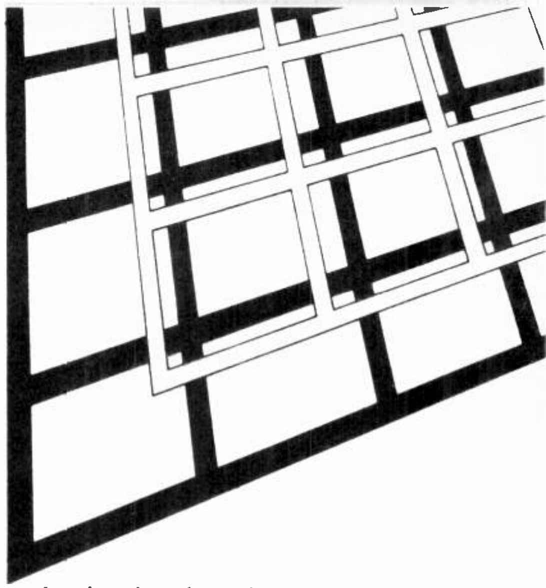


Fig. 5 The two PCB foils for the Autowiper.



PCB Layout Guide

It's not that difficult to get from a schematic to a printed circuit layout.

By Barry Porter

IN basic terms, a printed circuit board is nothing more than a support for the components of a circuit which happens to have builtin interconnections that enable the circuit to operate. In reality, it is something more than that. A well-designed circuit board can have considerable aesthetic appeal. It also assists in keeping the blood pressure of anyone called upon to carry out repairs within tolerable limits, and provides additional boozing time by accelerating the construction of your latest masterpiece.

The only difference between bad and good circuit board layouts is care. There is no excuse for boards in manufactured products being second rate, but there is even less reason for one-offs produced by home constructors to resemble a windy night at a spaghetti factory. Time is money to the manufacturer, but the electronics enthusiast should not suffer from this constraint.

The Birth Of The Board

The object of the exercise is to guide you through the design and preparation of the necessary artwork to send to a PCB manufacturer. Although it is possible to make your own boards, the expenditure of time and the amount of mess generated are unlikely to be justified by the end result, so unless you are prepared to invest a considerable amount of the folding stuff in specialized equipment, it is best to leave the difficult bit to a professional.

Circuit boards usually start their careers as circuit diagrams, and the stages necessary to translate a familiar schematic into a finished board begin as a number of very rough layouts, followed by one or more attempts to transfer these to graph paper at a defined scale. The successful graph paper layout is used as a master from which the various artwork layouts are generated. These consist of plastic drafting film masters for the copper tracks, a solder resist mask and the component identification screen. If the board is to be double sided, a separate artwork is normally provided for each side. The artwork will normally be produced at 2:1 scale with linear dimensions which are twice those of the final board, although for very large boards, it may be necessary to work same-size, and for very small layouts, a 4:1 scale is sometimes preferable.

To illustrate the various steps in the production of a set of artworks, we will start with a circuit for a high quality tape record amplifier (**Fig. 1**), and attempt to design a layout which fits a circuit board with the dimensions shown in **Fig. 2**. Any layout is made easier if you are free to choose the overall board size and the points at which connections to the outside world are made. The most difficult tasks involve fixed board dimensions, such as the design of a replacement board for an existing piece of equipment. Life is further complicated if the external connections are made via an edge connector with predetermined locations. Just to ensure that life retains some enjoyment, this is the situation that will be tackled during the course of this article.

Before getting too involved with the design of a specific board, a few basic rules may not go amiss. Circuit diagrams are usually drawn in a way that can almost be taken as a worldwide standard. Signal normally progresses from an input at the left hand side, through various transistor or opamp stages, to emerge at the right hand side. It is usually good practice to lay out a circuit board so that it bears a close resemblance to the original schematic.

Inexperienced PCB designers usually fall into one of two main traps: running low level inputs and high level outputs too close together, so that a circuit that worked in breadboard form becomes unstable, and getting the grounding arrangements wrong, causing hum loops.

Where possible, input and output signal paths should be well separated, particularly when there is more than about 15dB difference in their levels. Providing the operating impedances are low, it is normally quite safe to allow the inputs and outputs of low level circuitry to be within 0.5 of each other. If an area of track at ground potential can be placed between them, it is quite possible to reduce the spacing to 0.25. Power amplifiers are a different ball game, and a minimum input to output spacing of 3.0 should be allowed, but 6.0 or even more is to be preferred.

Bad grounding practice can cause problems beyond your wildest imagination, yet perfectly good grounding can be achieved very easily by ensuring that the input to output ground path of any circuit simply follows the signal through the various stages. The impedance of all ground connections must be kept as low as possible, which means using large areas of copper track wherever space allows.

One very popular way of introducing instability is to place a continuous strip of copper track at ground potential around the outer edge of a board. This is often the most convenient place for the ground track to be positioned, but it is essential that the circle is broken at one point so that as far as possible, the ground path follows that of the signal.

In designing a printed circuit board, the aim should be to arrive at a layout where the components are neatly positioned without compromising the performance of the circuit. As far as possible, the components should be placed in rows with correct spacing between the mounting holes. Before laying out any board, it is essential to have some examples of the components which will be used or obtain accurate dimensions from a data sheet. The appearance of many a board has been ruined because of an incorrect guess at the length of a capacitor, so pay special attention to your component sizes, as plenty of eager gremlins lie in wait for the unwary.

Some complicated circuits can only be laid out by using double-sided boards, but the additional cost of these is usually a sufficient incentive to extract the necessary effort to achieve a single sided layout. Whenever possible, the use of wire links should be avoided, more as a matter of designers' pride than because of their effect on circuit operation.

Getting Down to It

Let's look at the layout of the circuit in Fig. 1. Before starting any design work, it is wise to make sure that certain items are at hand:

1. One each of the various circuit components, or accurate details of their dimensions.
2. Lots of scrap paper for the initial rough design.
3. A supply of graph paper, slightly larger than the finished artwork, with scale markings at 1.00 and 0.1 inch. (None of yer metric stuff here; components invariably fit a 0.1 inch grid).
4. Matte surfaced plastic drafting film, same size as graph paper.
5. Drawing instruments: pencils, pens, stencils, compasses, rule scaled in tenths of an inch.
6. Talcum powder.
7. Supply of circuit layout materials (details later).
8. Roll of red transparent adhesive tape.
9. Scalpel with selection of blades.
10. Pair of good quality 6 inch tweezers with undamaged points.

Having collected together these tools of the trade, the time has arrived to leave the world for a few hours. Find somewhere where your concentration will not be disturbed, even if you have to send the family to Disneyland and gag the budgie.

The first step is to produce a very rough sketch of where the different parts of the circuit will fit onto the circuit board. If there are no constraints brought about by board dimensiors or edge connectors, it is quite easy to arrange the circuit parts in a reasonably compact and symmetrical manner. Working to predetermined dimensions, it is necessary to decide where various circuit elements should be placed to fit within the confines of the board, and if the external connections have been specified, these should be taken into consideration.

Fig. 3 shows the first attempt to fit the Fig.1 circuit on to the designated board. At this stage, the main consideration has been given to establishing a route for the signal input and output tracks, the placing of the three integrated circuits and connections to the multiturn potentiometers.

At first sight, getting a direct connection from the edge connector to the wiper of RV2 is likely to be a problem, but one that can be noted and dealt with as the design progresses.

The next task is to produce some rough layouts of separate parts of the cir-

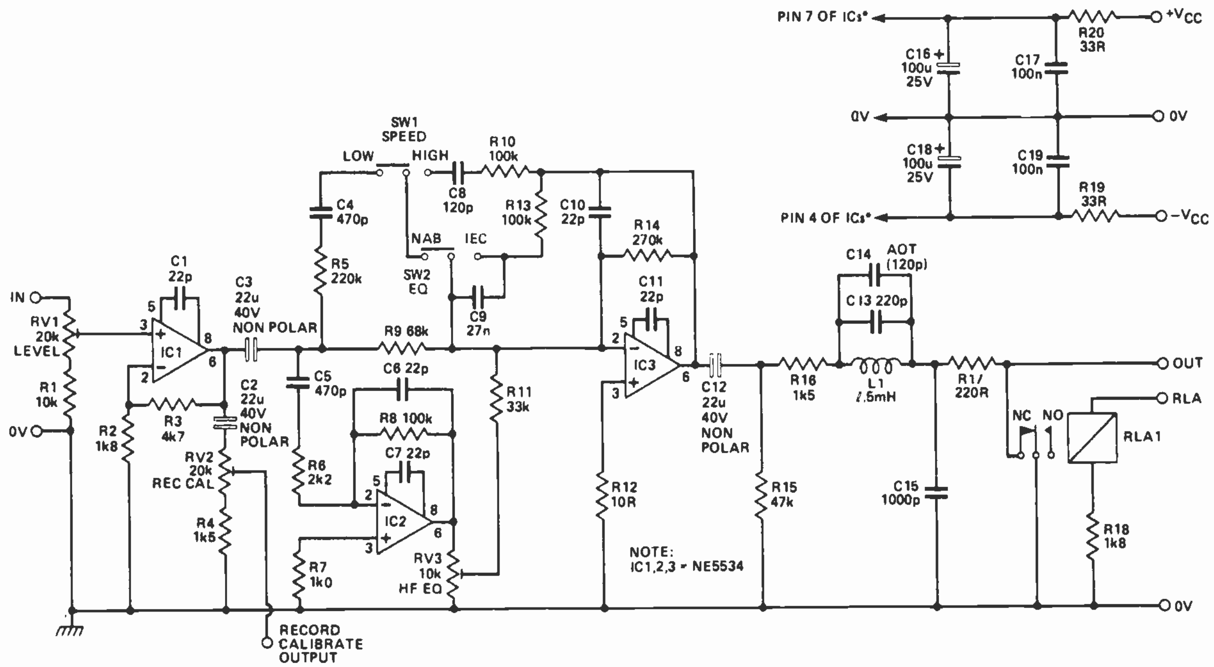


Fig. 1 Circuit used for layout exercise.

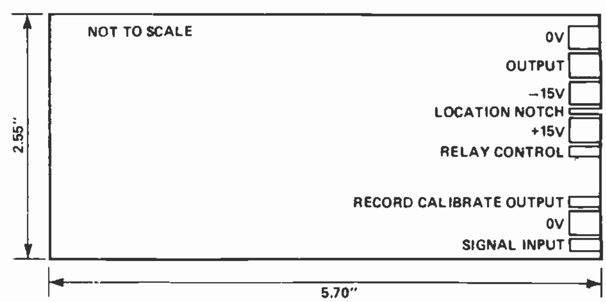


Fig. 2 Circuit board dimensions and edge connections.

cuit, this time putting in all components and the interconnecting tracks. At this point, it should be mentioned that most PCB designers produce their layouts and art work as it is viewed from the component side of the board. Some people prefer to work as though they are looking at the copper side, but this method can lead to problems, the most popular being ICs with reversed connections, easily identified by the emission of grey smoke if not discovered before the board is built and tested. Throughout this article it will be assumed that all views are from the component side.

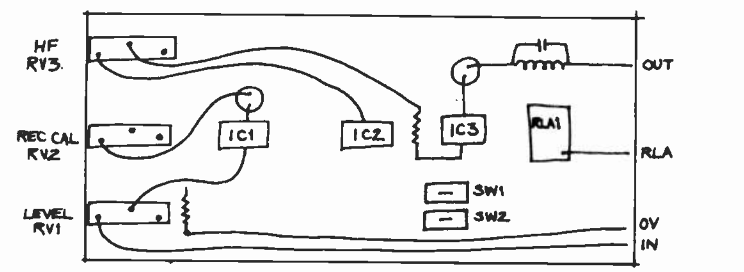


Fig. 3 First rough layout.

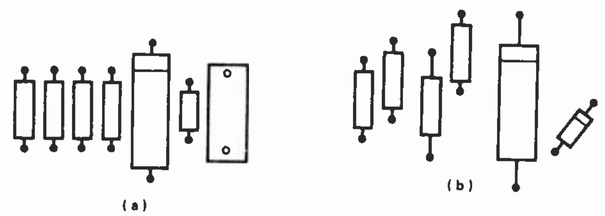


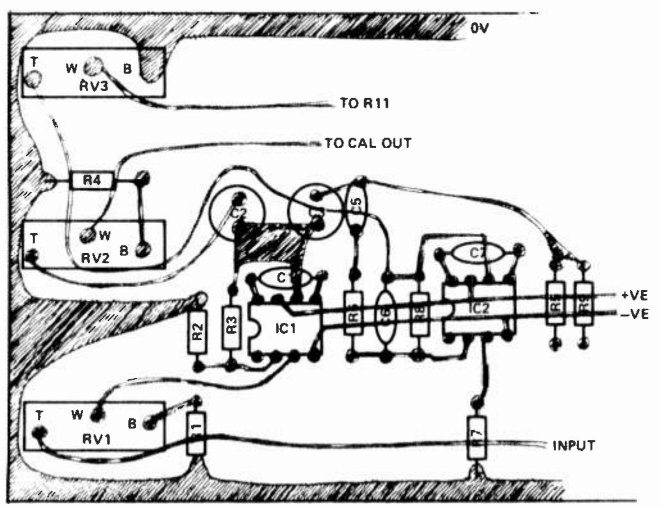
Fig. 4 Component spacing and layout. The right way (a), and the wrong (b).

As the next layout rough is prepared, account should be taken of the component sizes and spacing, especially with regard to resistors and capacitors. In order that the final result is as neat as possible, one aim should be to keep the ICs and their associated components in straight rows, and not staggered as shown in **Fig. 4b**, the spacing between normal 0.25 or 0.5W resistors is likely to be 0.15, and this does not leave sufficient space between the solder pads for the passage of a piece of track without the track without the track becoming too narrow for comfort or the pads requiring modification with a scalpel.

Without getting too involved in pad and track sizes at this stage, while doing the rough layouts, keep in mind that tracks passing between 0.15 spaced pads may cause problems at a later stage, so avoid the practice if possible without damaging the appearance of the layout.

The first rough layout of the record amplifier board is shown in **Fig. 5**. Although this has several areas which need correcting, for example the input and OV tracks will have to be reversed, and the output of RV2 is in danger of being trapped by the track going to R11, it is at least a starting point, and as such it forms a foundation of sorts on which to build.

Fig. 5 First attempt at input stage layout.



The remaining circuitry is shown in **Fig. 6**. Again, it contains a few problem areas, such as the nonappearance of the Record Cal track and the rather tortuous path from the bottom of C9 to pin 2 of IC3, but these can be sorted out at the next stage.

Slow on the Draw

Having produced a satisfactory rough layout with sufficient accuracy to establish that it is not necessary to use a double sided board, and that wire links will probably not be needed, it is possible to attempt a correctly scaled layout on graph paper.

From now on, everything must be related to the scale of the artwork, in our case, 2:1, so care must be taken to double every dimension. Experience has shown that this is not always as easy as it sounds. It is quite easy to draw small components with correct dimensions, simply by counting squares on the graph paper, but with larger items such as electrolytic capacitors, it is very easy to make a mistake, and the distance between mounting holes should always be checked by measuring them with a rule calibrated in tenths of an inch. The time spent doing this should not be considered as wasted, especially if you have ever suffered the sinking feeling when you realize that a component will not fit a board because of your own lack of care.

If your board dimensions are not fixed, you should be able to estimate an approximate size, which will give you an idea of the size of graph paper you need. With an established board size, an outline of the board should be drawn in ink to the correct scale and any fixed components, mounting holes or edge connector details added using a fine felt tipped pen or similar.

In our example, the only restraint apart from the overall board size and edge connector positions is the placing of the three preset potentiometers which are required to line up with similar controls on other boards in the recorder. The outlines and mounting holes of these are therefore drawn in ink, and then using a soft pencil, an attempt is made to transfer the rough layouts of Figs. 5 and 6 on to the double sized graph paper grid.

Although this may be done freehand, keep everything as neat as possible. This is the best way to ensure accuracy. It's worth repeating that, unless absolutely necessary, all components should be in neat rows and not scattered haphazardly round the board. If your circuit uses ICs, these should lie along the same line, and should be placed in the same direction, which normally happens automatically if the power rails are run between the rows of IC mounting pads, and don't approach each device from a different direction. The sign of ultimate neatness is when groups of polarized components, such as

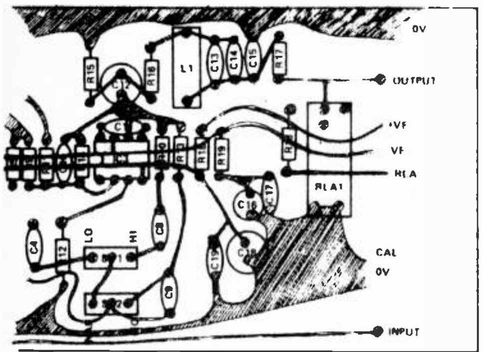


Fig. 6 First attempt at output stage layout.

diodes or electrolytic capacitors, all have their positive ends facing the same direction. Figure 7 shows some examples of how electrolytics and diode bridges may be laid out, (d) and (f) illustrating how they should be positioned for the best appearance.

If you are having a good day, you will achieve a satisfactory layout before your local graph paper factory has to start working overtime. do not be surprised if it takes three or four attempts before you are happy. It can often be beneficial to get an electronically inclined colleague to give your layout the onceover, as this can often result in the discovery of glaring mistakes which would prove expensive if not corrected.

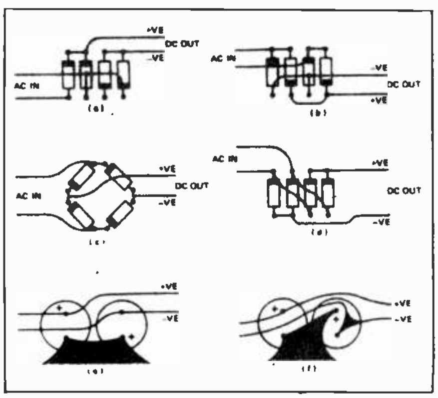


Fig. 7 Examples of diode bridge and electrolytic capacitor layout.

Getting the Bugs Out

Having arrived at an acceptable layout, you should now start again. Take another sheet of graph paper and draw the board outline and fixed component outlines in ink. Then, being careful to follow your previous pencil layout, draw just the component outlines in ink. By separating the components from the confusion of tracks, it is possible to get a good idea of how the final board will look. At this stage you should be quite objective: are the components evenly spread out over the PCB area, or are they in overcrowded clumps, leaving large areas of unused board? Is everything as neat as it could be, or are there staggered rows of components and wire links all over the place? Are all the component dimensions accurate, so that

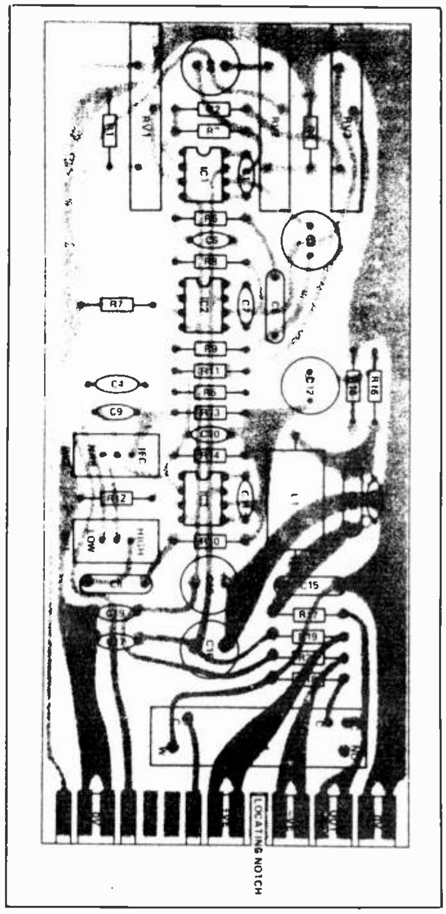


Fig. 8 The final layout from the component side.

everything can be correctly mounted? If you are not totally satisfied, now is the time to carry out any final corrections, so make any changes by drawing a new board outline, with the modified component placings, making sure that the movement of any component does not upset your carefully planned track layout. Once the final component positions have been established, the track layout should be added, using pencil or coloured ink, so that you arrive at a final layout master similar to the example shown in Fig. 8.

After a final check to ensure that the layout agrees with the circuit diagram, the first artwork master may be produced. Often referred to as the 'tape or dot' stage, this is simply a double-sided replica of the copper areas which will be on the finished circuit board, and is produced by sticking self adhesive opaque tape and other symbols onto a sheet of plastic drafting film, using the graph paper layout as a guide.

The first step is to lay claim to at least half the kitchen table to which you firmly attach the graph-paper master with masking tape. Take a sheet of drafting film which is at least an inch larger all round than the circuit board outline and firmly tape this along its top edge so that it covers the graph paper layout. If possible, use drafting film which is matt on both sides. If yours has one shiny side, this should be kept as the underside.

Those who have only been reading this to find out why you were told to purloin some talcum powder, take heart, your moment has come. If your drafting film is typical of just about every other sheet of drafting film in the universe, it will be covered with enough greasy fingerprints to keep the cops amused for years. This being the case, take your precious powder and give the sheet of film a light dusting and a quick rub with a piece of clean tissue before blowing any surplus away.

The Last Stage

You are now ready to begin the layout proper, for which you will require a supply of opaque adhesive pads, tapes and other shapes in an assortment of sizes. For working at a 2:1 scale, the following should be a minimum set:

PADS: 0.2' diameter and 0.15' diameter (the smaller ones for ICs).
TAPE: self-adhesive black crepe tape in widths of 0.06', 0.08' and 0.01'.
SHAPES: right angle elbows and T-pieces in the same three widths.

These materials should be available from any artist's supply shop.

The first stage is to place the pads in position on the film, and this is where a good pair of tweezers will prove invaluable. Make sure that each pad is placed accurately so that its central hole is aligned with the crossing point of the relevant graph paper lines. For maximum accuracy, the layout should be carried out over a precision grid placed on a light box. This can lead to mistakes, and the finished artwork should always be checked by placing it over the graph paper master. For most purposes, graph paper is sufficiently accurate to use as the guide for pad placement.

When all the pads are in position, place a second sheet of drafting film over the first, and place a further set of pads on this. Stick small pieces of 0.1' wide tape on each pad, covering the central hole. Draw in the corners of the circuit board, and you have created a solder resist mask. Return to the first 'dotted' sheet of film and add the interconnecting tracks, using

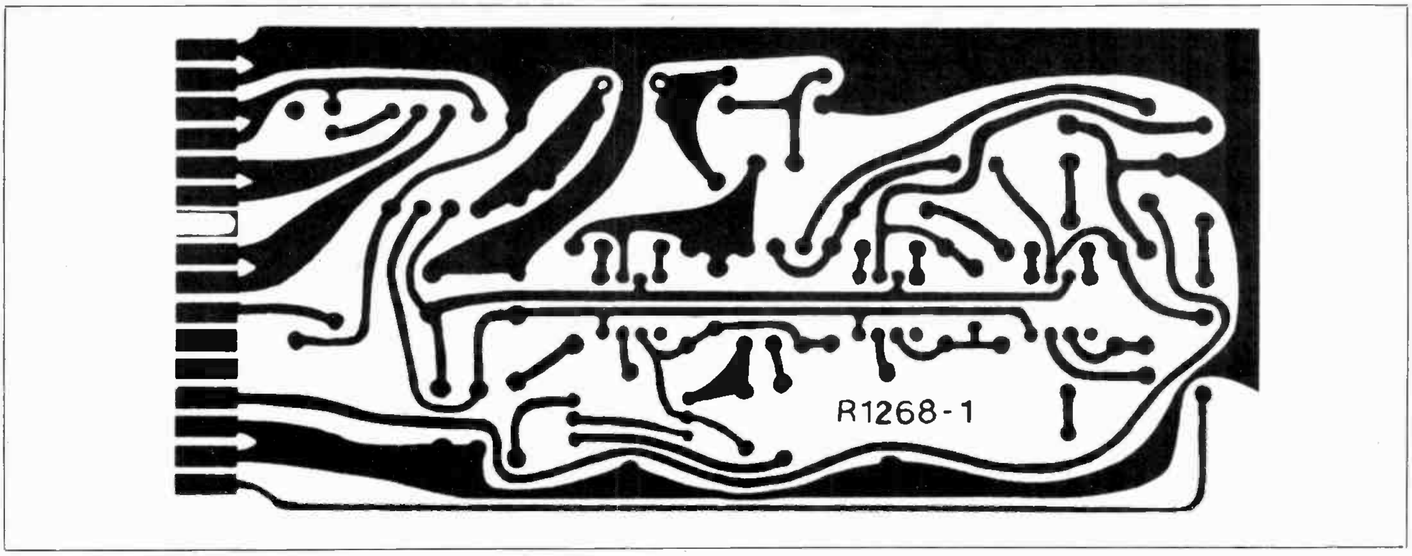


Fig. 9 The actual foil pattern — copper side.

suitable width tape. Where track density is fairly low, use at least 0.1' wide tape. For low impedance connections, such as ground or power supply rails, outline the copper area with tape and fill in with red transparent tape, which is considerably cheaper than track tape.

Don't forget to accurately mark the board edges; the accepted way of doing this is to mark each corner with a right angle using tape. Obviously, this is not necessary if copper is taken to the edge of the board. Be sure to show the scale of the artwork and finished board dimensions in an unambiguous way. Always put a board name or number on the copper layout, as this ensures that you don't end up with back to front boards. If, as suggested, your layout has been carried out as viewed from the component side of the board, the annotation must be on the reverse side of the track artwork. Letraset or similar lettering should be used, and covered with a strip of matt adhesive tape for protection. Double-sided boards require a separate artwork for the top tracks, and this is easily prepared if the bottom artwork is used as a guide for positioning both pads and tape.

The component identification artwork requires a further sheet of film which should be placed over the graph paper master. Using a 1.0mm drawing pen, draw in the component outlines, using a stencil for small circles and a raised edge rule for straight lines. Unless your handwriting is up to survey standards, component identification numbers should be added by using a 3.0mm stencil and appropriate sized pen.

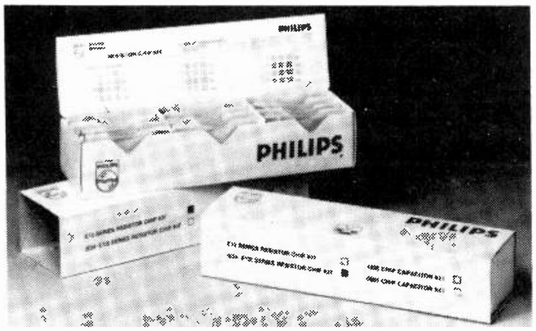
Once your artwork layers are complete, obtain a photocopy of the copper tracks on which to indicate the various hole sizes you require. As a guide to this, most resistor and capacitor mounting holes will be 1.0mm, and IC pads will require 0.6mm holes.

Now take your completed set of artwork and check everything at least twice before despatching them to your chosen PCB manufacturer.

Having just a few circuit boards made is not cheap, and a large proportion of the cost is in the photographic reduction work. This part of the process can often be carried out, at a considerable saving, by a friendly litho printing company who have their equipment in constant use and are usually less inclined to charge silly prices for what is, after all, a relatively simple operation.

Before placing your order with a circuit board manufacturer, establish what their total charge is likely to be, and don't be afraid to admit to your lack of experience and/or money. They are the best people to advise you about board thickness and copper weight, and to point out any shortcomings with your artwork – but don't blame them if, after all your efforts, your first circuit board explodes with a cloud of smoke. When that happens, it really is 'back to the drawing board...'. But it is still well worth the additional effort. It is a rewarding experience to turn out a good, well-planned circuit board. It's worth bearing in mind that there is no such thing as a professional circuit board designer who has not, at one time or another, made an error – so don't be too hard on yourself. If you really want to get it right, you may have to start from scratch and do it again until it's right. If you've been careful, and thought it all through, you'll get there. ■

Resistor Kits



Surface Mount resistors are available from Philips in kit packages of various sizes. The RCO1 KIT/E12 contains all values in the Philips E12 series, for instance. Each kit contains 100 pieces of each resistance value; resistors are 5 percent, 1/4 watt types with 60/40 surface mount contacts. From Elcoma Division, Philips Electronics Ltd., 601 Milner Avenue, Scarborough, Ontario M1B 1M8.

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Those who design transformers and inductors can have a lot of the work done for them by computer, using *Transformer and Inductor Design Software For The IBM PC Or Macintosh*. This menu-driven software does new designs or evaluates existing designs for efficiency, regulation, losses, inductions, temperature rises, etc. The software and manual costs $89 in US funds and can be obtained from the publisher, Marcel Dekker Inc., 270 Madison Avenue, New York, NY 10016, (212) 696-9000.

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Software for engineering and manufacturing will be the topic of E&M Software 86, a conference/exhibition to be held in the Chicago Hilton, September 23–25. Besides exhibitions of all types of technical software for CAE, CAD, CIM, CAM, production control, process control and distribution, there'll be 18 technical sessions and six workshops. For more information, contact the organizers, Tower Conference Management Co., 331 W. Wesley St., Wheaton, IL 60187, (312) 668-8100.

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According to the Technical Service Council of Toronto, the increasing complexity of technology means that employers are looking for technicians and engineers with specific job experience rather than just a general technical training. Communications skills and supervisory potential also enhance job chances.

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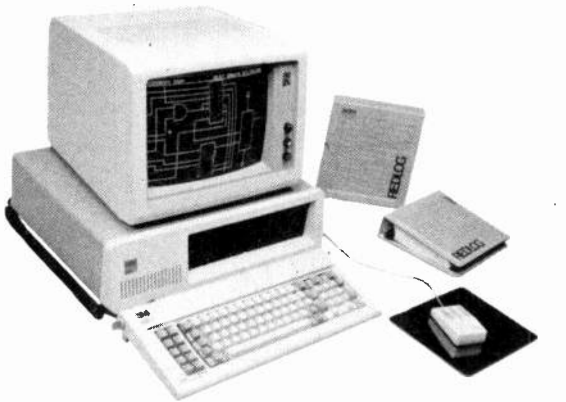
PCB Software



Redcad software for the IBM PC will design both schematics and PCBs. Input for the PCB design can come from the schematic files or can be input by the user via keyboard or mouse; 512 electrical symbols can be used per drawing and 511 components per PCB. Up to 16 layers can be used per PCB. The system requires a PC, XT, AT or compatible with 512K RAM, one floppy drive and one fixed drive. Contact CAD/CAM Graphics (1984) Limited, 700 Industrial Avenue, Ottawa, Ontario K1G 0Y9, (613) 526-0620.

Circle No. 47 on Reader Service Card.

A reminder that Mastertech Laboratories Inc., makers of the Microlab digital logic trainer (to be reviewed in the next issue) have moved, and their address is 302 Royal Trust Building, 612 View St, Victoria, BC V8W 1T5, (604) 388-6631.

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Thanks to all those who responded to our request for project manuscripts in the December issue. Just about everyone who sent in an idea was accepted; we had to turn down a few who submitted previously-published projects, but we asked them to submit something else. Again, if you have an article, circuit idea or project that you think might interest readers, write to The Editor, Electronics Today. Don't worry about literary polish; we're looking for ideas. If you're not sure about acceptance, it will save you effort if you send a brief outline instead of a completed manuscript.

Amprobe announces the DigiMatic DM-1, a three-phase microcomputer based chartless recorder. It can read 44 separate functions, including peak, minimum, times, sweep, etc. The readings can be read out up to 41 days later. The autorange covers 0-750V and 0-1000A. For complete information on Amprobe recorders, ask for catalogue AAD76 from Atlas Electronics Ltd., 50 Wingold Ave., Toronto, Ontario M6B 1P7, (416) 789-7761.

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Last month we reported on gallium arsenide devices and how they work. A press release from Bell-Northern Research arrived shortly after, detailing the new $3.5 million gallium arsenide laboratory in Ottawa. Prototypes are fabricated in a vacuum chamber with the operator observing through a built-in electron microscope. The new technology should allow operating speeds of several times that of conventional silicon.

According to StatsCan, we still import about twice the value of electrical and electronic goods as we export: in October of last year, for instance, we imported $1120 million and exported $610 million. Still, the shift over the last year favoured exports, which were up 15 percent. Imports were down about 5 percent.

Multimeter

Fluke has introduced the 8842 5 1/2 digit bench or rackmount multimeter, offering 0.003 percent DC accuracy and 0.08 percent AC accuracy. It also features 100nV resolution for DC voltage, 1uA resolution for DC current and 100 micro ohm resolution for resistance. The IEEE-488 interface and true-RMS option allow configuration to suit the user. From Allan Crawford and Associates, Test and Measurement Division, 5835 Coopers Ave., Mississauga, Ontario L4Z 1Y2, (416) 890-2010.

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Electronics Today

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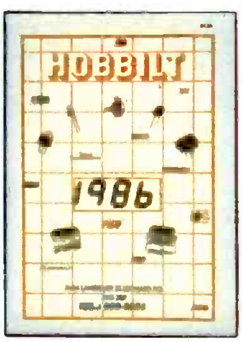

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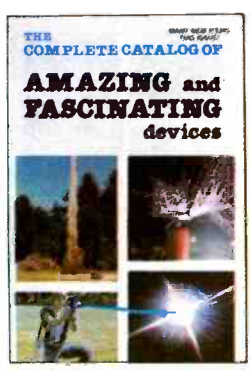

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