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LIGHTBULB SAVER

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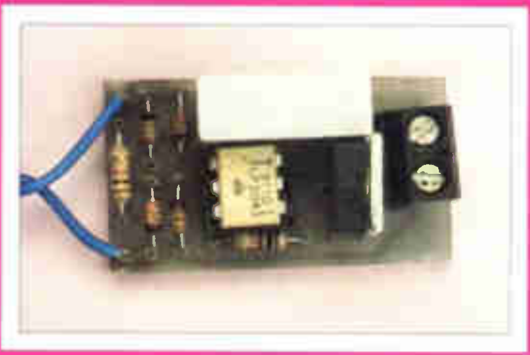

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VOL. 27 No. 8 AUGUST 1998

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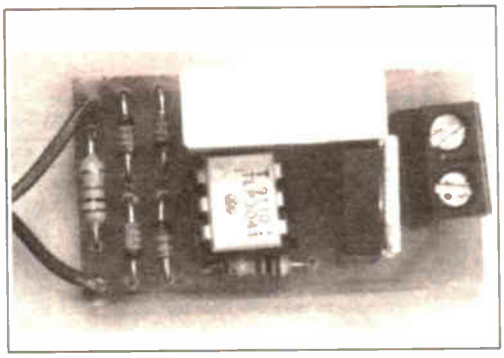
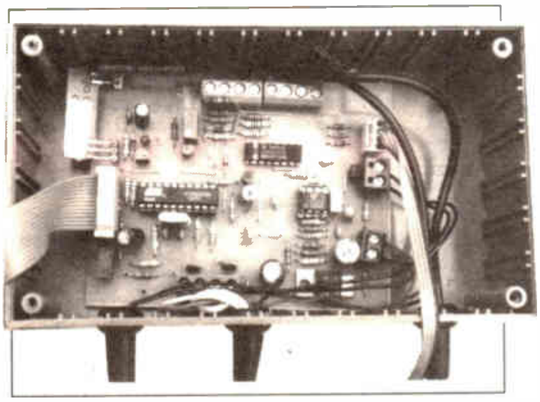




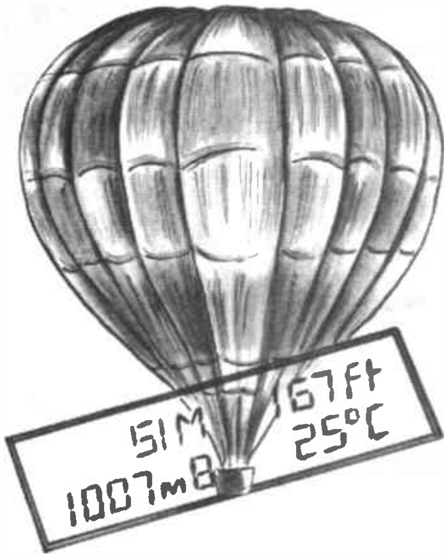
Projects and Circuits

Series and Features

Regulars and Services

Our September '98 issue will be published on Friday, 7 August 1998. See page 555 for details.

NEXT MONTH



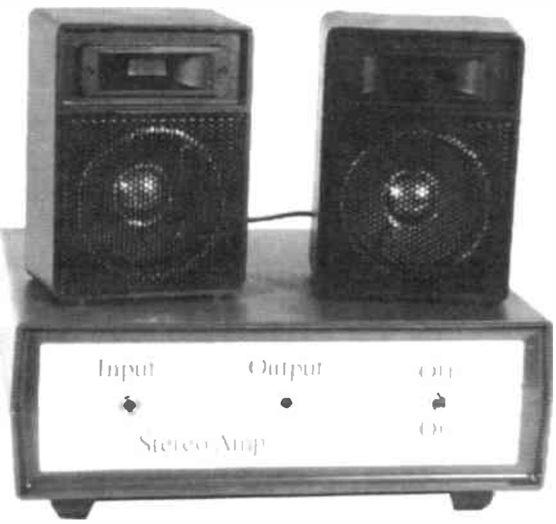
PIC ALTIMETER

The atmosphere – 5000 billion tons of air surrounding our planet, its effective pressure increasing the deeper we are below its surface.

Using a PIC microcontroller and a temperature-compensated pressure sensor, we describe how this pressure can be measured and interpreted as a relative height above sea-level.

The circuit is remarkably simple to build, with the microcontroller performing the sophisticated calculations. An intelligent liquid crystal display shows the pressure in millibars, and the height in both metres and feet. Ambient temperature is also displayed, with a choice of Centigrade or Fahrenheit scale.

Setting-up is kept to a minimum, requiring little more than an Ordnance Survey map and a glance at the BBC TV weather chart, plus an ordinary thermometer. You would also find it useful to have a hill near you!



PERSONAL STEREO AMPLIFIER

The audio quality available from even the cheaper personal stereo units is higher than one might expect, and the popularity of these gadgets is not surprising. By using headphones it is possible for the user to listen at high volume levels while causing minimal disturbance to those nearby. The audio quality of modern lightweight headphones is very good, and it is probably this factor that is largely responsible for the success of personal stereo units.

It is possible to further increase the usefulness of these devices by feeding the output to miniature loudspeakers rather than using headphones. Although the special loudspeakers are relatively efficient, the power available to drive them will normally be no more than a few milliwatts. It is not feasible to produce decent volume levels from such meagre output powers.

The obvious answer is to use a small battery powered amplifier to boost the output of the personal stereo unit to a level that will provide more satisfactory volume levels. The complete set-up remains quite small and portable, and the personal stereo unit can still be used on its own when maximum portability is required. Output powers of up to a few hundred milliwatts r.m.s. per channel can be provided by this Personal Stereo Amplifier. This will not give sound levels that rival a hi-fi system, or even one of the larger "Ghetto Blasters", but it is more than enough for many purposes.

MAINS SOCKET TESTER

With d.i.y. activity continually increasing there is the ever present danger of a wrongly wired mains socket. Unfortunately, a mistake in wiring a socket, which a previous occupant might have made, is likely to be just as dangerous as an incorrectly wired plug. One cannot be sure that the correct socket connections exist. This is especially true when an older installation is to be extended or modified. The old red wire could be connected to the Neutral, for example, somewhere down the line and the installation would still work.

It is also always wise to test a new socket following its installation to ensure that the connections have been made as it is often quite easy to trap the insulation rather than the conductor under the terminal screw. The test is usually carried out by plugging in a suitable load such as a table lamp, which may not be readily available. This simple tester can be built into a small plug and will provide an indication of not only the integrity of the wiring but also any mistakes in the connections.

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TAILOR MADE

Last month I was wittering on about how it's no longer possible to build projects for less than the cost of a similar commercial product, but that it is sometimes possible to build items that are not commercially available, or to build projects tailored to your specific requirements. Well, I am pleased to say that just about all the projects in this issue are not commercially available and a couple or them can easily be modified to meet individual needs – provided, of course, you understand the software involved and, hopefully, we have gone some way to helping on that score with previously published material, particularly the *EPE PIC Tutorial* series.

We are, in fact, rather surprised that no enterprising manufacturer has produced a "bulb saver light switch". The circuit we are publishing this month is simple and cheap to build; if it was manufactured as part of a light switch it would be even cheaper. It would then be easy to replace existing switches and save on bulbs, or to install them in new houses, etc.

We have shown the way on a number of projects over the years and maybe this is another idea that we will eventually see on sale in the local d.i.y. store. It will have taken some time to get there as we did publish a similar idea back in 1987!

ERRONEOUS

Everything we publish is usually read and checked twice by three different people before going to print. However, it never ceases to amaze us how easy it is to miss something. I am proud to say that, as far as mistakes in projects are concerned, *EPE* is second to none in its reputation for accuracy. We very rarely need to publish a *Please Take Note* because of an error (I bet we have to now I've said that). In the June issue, however, we showed the wrong heading on my Editorial (it should have been "Sci.Fi." not "By Leaps . . .", which was left over from the May issue) and last month there was a spelling mistake on our "Next Month" item.

A few months ago we went through a phase where we regularly had a mistake on the "Next Month" piece. We all read it, but silly errors still got through. Then for a few months we got it right – now the jinx is back.

Silly, isn't it, that once you have read something and not noticed an error – or worse if you wrote it in the first place – it's almost impossible to see it second time around. Just think how bad this must be if you are writing complex software or designing masks to make i.c.s from!

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see below), from all UK newsagents (distributed by Seymour) and from the following UK electronic component retailers: Maplin – all stores throughout the UK (and in S. Africa); Greenweld Electronics; Omni Electronics. *EPE* can also be purchased from retail magazine outlets around the world.

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Constructional Project

LIGHTBULB SAVER

BART TREPAK

Avoid the repeated expense of lightbulbs blowing at switch-on.

How many times have you been in a room which has suddenly been plunged into darkness because the lightbulb has blown? The answer is probably not very often, if at all, as bulbs tend to blow most often just as you enter the room and switch them on, rather than when they have been on for some time.

This is not due to some perverse manifestation of Murphy's Law and can be explained quite simply by considering the way that filament lightbulbs work and how they fail.

HOT WIRED

As most readers are probably aware, the incandescent lightbulb consists of a coiled filament (usually made of tungsten) inside a glass envelope. It operates when a current through the filament heats it up to a high temperature causing it to emit a lot of heat and glow with nearly white light.

Unfortunately, the high temperature also causes the filament to evaporate slowly and as the rate of evaporation of the filament material is not uniform along its length, it tends to become thinner in some places than others as the bulb is used.

This causes an increased resistance in these portions of the filament, which means that the power dissipation here is greater, resulting in localised hot spots and a higher rate of evaporation at these points.

Despite this, the manufacturer tries to ensure that the filament wire is sufficiently thick to last for at least the specified 1000 hours of operation for which most domestic lightbulbs are rated.

LIFE EXPECTANCY

The biggest factor in determining the life expectancy of the lightbulb, however, is not the rate of evaporation but the number of times that it is switched on from cold. The filament exhibits a positive temperature coefficient of resistance, which means that as it heats up its resistance increases.

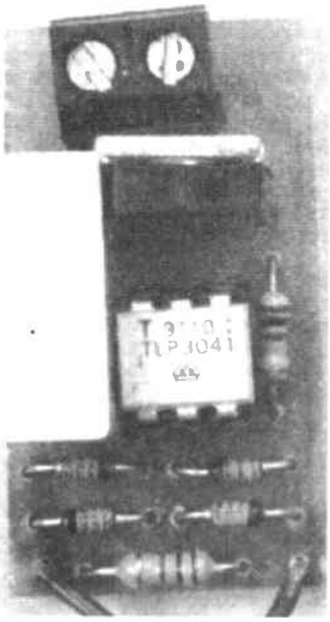
When first switched on, though, its cold resistance is quite low and it is not uncommon for a bulb to pass a current of up to ten or twelve times its rated current at this time. The filament is quite small and therefore has a low thermal inertia so that its temperature rapidly increases. Within five or ten mains half-cycles, the current will have settled down to its normal value but, by then, the damage may have been done.

The already weakened filament will have been stressed most at its thinnest point and the high switch-on surge current may rupture it, causing the bulb to fail, whereas the normal running current would not have done this.

This explains why bulbs most often fail during switching rather than while they are operating, so that anything that can be done to reduce the switch-on stresses will result in an increased bulb life.

DIMMER SOLUTION

One method of extending the life of the bulb would be to pre-heat the filament so that it is not switched on from cold by passing a small current through it while it is off, sufficient to keep it hot but not enough to make it emit light.



This method is sometimes used where bulbs are continually switched on and off all day, such as traffic lights and where the cost of replacing bulbs would far exceed the extra cost of the electricity used.

In a domestic situation, where bulbs tend to be off for most of the day and are only switched on for a few hours in the evening, this would obviously be a non-starter as the electricity bills would easily exceed the cost of replacement bulbs.

Another method would be to allow the bulbs to "fade up" to full brightness at a slower rate, which would require the use of a dimmer-type circuit. Dimmers tend to produce large amounts of radio interference which require the use of relatively expensive chokes to suppress.

However, having gone to the bother of making what is in effect a light dimmer, one may as well go the whole hog and fit a potentiometer to enable the brightness to be varied as well.

In many situations, though, a dimmer would be inappropriate and unnecessarily expensive, not to mention cumbersome to use. Instead of simply flicking a switch one would need to turn up the brightness by turning the potentiometer, while a circuit to do this electronically would be even more complex and expensive.

Of course the on/off switching could be done by means of a switch independent of the potentiometer but, if the dimmer setting were left at full brightness, the switch-on surge would still occur and no appreciable increase in the life of the bulbs would result.

ZERO VOLTAGE SWITCHING

The largest current surge at switch-on occurs when the switch is closed at the moment that the mains is passing through its peak voltage, as it does 100 times every second on a 50Hz supply. If matters were arranged so that, irrespective of the instant that the switch was closed, the bulb would switch on only when the voltage across it was zero, or at least very low, then the surge current through the bulb at this time would also be very small.

The filament would then be allowed a quarter of a cycle to warm up as the voltage increased before the first mains voltage peak was encountered. By this time, its resistance would have risen appreciably and the current surge would be very much reduced, improving the life span of the bulb.

Also, because radio interference would not be generated, chokes and capacitors would not be required and the circuit could be made small enough to fit into a standard switch box, and cheap enough to warrant its use in domestic situations.

IN ISOLATION

The circuit presented here uses a special (though readily available) opto-isolator to provide the zero voltage switching function. The TLP3041 consists of a light emitting diode (l.e.d.) and a photo-triac contained in a 6-pin dual-in-line (d.i.l.) package, as illustrated in Fig.1.

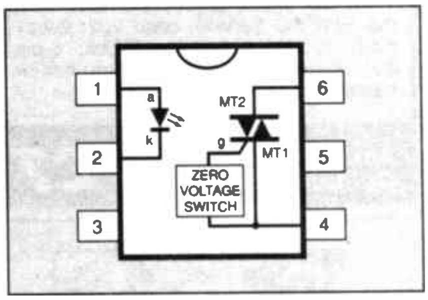


Fig.1. Internal circuit of the opto-triac.

This device is normally used in solid state relays, or where logic or computer circuitry is used to control mains equipment, and where isolation between the high voltage mains circuit and the low voltage control circuit needs to be maintained.

The photo-triac can be switched on by turning on the l.e.d. With a.c. supplies, on which this device is normally used, the triac will switch off automatically when the current through it falls to zero at the end of each mains half-cycle.

In this particular circuit, the electrical isolation offered by the device between its input and output is of little interest since both the control and the output circuits are at mains potential.

The device does have another feature, however, which is of use in this application because it contains further circuitry to ensure that the triac can only be switched on when the voltage across it is less than 40V maximum, irrespective of when the l.e.d. is switched on.

This may not sound very much like "zero voltage" but it should be remembered that this is a maximum value and most devices will have a much lower actual value above which switching will be inhibited. It is also a good deal less than the 325V peak mains voltage at which switching could normally occur and should, therefore, result in a noticeable improvement in the life of the bulb.

Consequently, it is a simple matter to use the existing light switch to control the current to the l.e.d. and the circuit will ensure that the triac will be switched on at or near the mains zero voltage point, as shown in the block diagram in Fig.2.

ZERO MEANS ZERO

This would work if a separate d.c. supply were available to energise the l.e.d., but unfortunately it is not. To be of use, the circuit has to be compatible

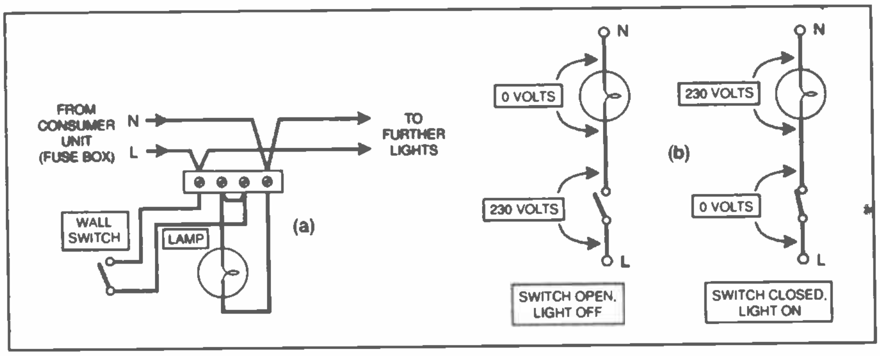


Fig.3(a) Domestic lighting circuit and (b) the effective voltages across its switch.

with standard domestic lighting circuits as nobody would want to rewire their house simply to increase the life of their bulbs.

In normal house wiring, the mains live and neutral are available at the ceiling rose and from this a pair of wires is run down the wall to the switch. One terminal of the switch is connected to the Live wire, while the other is connected to Neutral via the bulb, so that the switch and bulb are effectively in series across the mains supply, as shown in Fig.3.

This means that when the switch is off, the full mains voltage appears across it and could therefore be used to power a small circuit or light an l.e.d. (using a suitable current limiter). When the switch is closed, there is no voltage across it as the full mains voltage then appears across the bulb.

Replacing the switch with a triac does not alter this but at least now the triac will be off at the zero crossing, so that a voltage should be available. Zero voltage, however, means just that, so that at the very time when we would want an l.e.d. to light, there would be no voltage available at the wall box to supply the current.

The answer is to accept that the triac cannot be triggered at the zero crossing but only slightly later when the mains voltage across it has risen to a value such that sufficient current can be passed by an l.e.d.

The l.e.d. in the opto-triac has a forward voltage drop of around 1·5V and needs to pass a current of around 10mA to guarantee triggering the triac. Consequently, we would not have to wait very long into the half-cycle, but we cannot simply connect the l.e.d. across the triac switch.

True, that once the triac was triggered, there would only be the small forward voltage of the triac (around 1V or 2V) across the l.e.d. so that it would probably not be damaged. But what if the switch happened to be closed at some point outside the zero crossing window?

The voltage could then be as high as 325V (mains peak) so that the l.e.d.

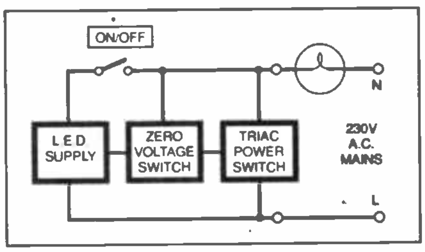


Fig.2. Block diagram for the Lightbulb Saver.

would disappear in a cloud of smoke long before it could even light, let alone trigger the triac at the beginning of the next half-cycle! The l.e.d. current **must** therefore be limited to less than 50mA, which is the maximum permissible for this device.

The obvious way to limit the current is to use a resistor and at 325V, a resistor of 13kΩ would be required to limit the maximum current to a safe value of, say, 25mA. But, in this case, the voltage across it and the l.e.d. would need to rise to around 130V before the current in the l.e.d. had risen to the 10mA required to trigger the triac.

By this time, of course, the zero voltage circuit would have cut in to prevent the triac from being triggered anyway, so that the light would never switch on. Even if the 50mA maximum permissible current for the l.e.d. were accepted (which is not good practice if reliability is desired) and a 6·8kΩ resistor fitted, the 10mA trigger current would not be reached until 68V, which would also mean that sufficient l.e.d. current would only be available when the mains voltage was outside the zero crossing window.

CAPACITIVE LIMITING

Luckily, as the supply is a.c. we can also use a capacitor to limit the current. A 100nF capacitor has a reactance of $1/2\pi fC$, which at 50Hz works out to around 32kΩ and would limit the maximum current to about 10mA.

This, however, appears to be even worse than the figures obtained for a resistor until it is remembered that a capacitor, as well as limiting the current, also introduces a 90 degree phase shift so that the current flowing through it leads the voltage. When the mains voltage crosses the zero value, the current will actually be at a maximum, which is exactly what we need to trigger the triac at this point.

We are not out of the woods yet, however, because l.e.d.s only work when the applied voltage has the correct polarity so that, in this case, the l.e.d. would only light during one half-cycle and not the other.

This can be overcome by fitting the l.e.d. into a bridge rectifier circuit to ensure that whichever way the current is flowing through the capacitor, it will always flow through the l.e.d. the correct way.

Note that the diodes forming the bridge only need to be rated to pass 10mA and the maximum reverse voltage will be the forward voltage of the l.e.d. (say 2V) so that any small signal silicon diode can be used.

PRACTICAL CIRCUIT

With the circuit as implemented in Fig.4, depending on the characteristics of the actual opto-isolator used, it is still possible for triggering to occur when the voltage across the triac is 40V. At this voltage, the energy stored in the capacitor could be sufficient to destroy the small triac in IC1 when it is triggered, as the capacitor will be virtually shorted out by the triac at this time. Resistor R1 has therefore been included to limit this current and its value is so low compared to the impedance of the capacitor that it has virtually no effect on the l.e.d. current.

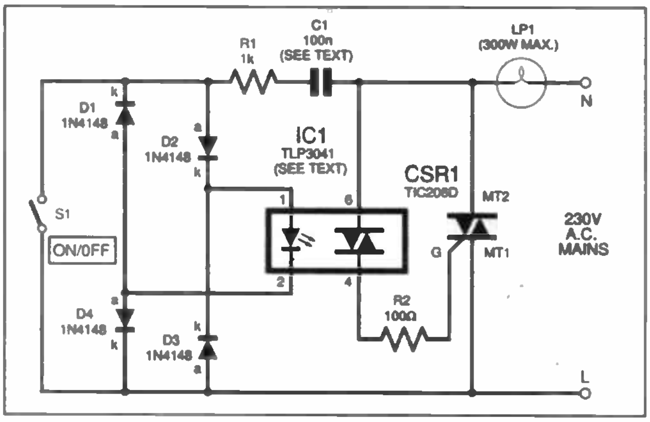


Fig.4. Final circuit for the Lightbulb Saver.

The maximum current which the triac inside the opto-isolator can handle is 100mA, which is not really sufficient for most domestic applications as it represents a power of only 25W. This device is therefore used to switch the gate current to a more powerful device (CSR1) which in turn controls the bulb. The device specified can pass 3A (750W) when mounted on a small heatsink. This current should be sufficient for virtually any domestic lighting situation.

The circuit is connected with the switch (S1) controlling the l.e.d. current connected across the input to the bridge formed by diodes D1 to D4. This means that the l.e.d. (and therefore the lightbulb) will switch on when the switch is opened and switch off when it is closed which is, of course, the opposite way from which it worked originally.

This is done to prevent a large switch-on surge current through the capacitor, which could occur if the switch was placed in series with the capacitor and switched on when the capacitor happened to be discharged or charged with the opposite polarity to the applied mains voltage.

It also enables the capacitor and resistor to function as a "snubber" network to absorb any transient voltage spikes which sometimes appear across the mains supply as these components are then connected directly across the triac.

High voltage transients can cause the triac to break down and conduct and even those which do not reach a sufficient voltage can cause the triac to be triggered, due to capacitive coupling between the gate and main terminal, if they are fast enough. Whilst this will not damage the triac, it will cause it to switch on, possibly at a point in the half-cycle other than the zero crossing, which is what we are trying to avoid.

Although this means that a small current will be flowing through the circuit continuously even when it is off, the power taken from the mains will be almost zero, as will be the cost.

As mentioned, the switch will appear to be working backwards with this circuit fitted, switching the lights off when the switch is in the on (down) position. This can, of course, be easily remedied by simply fitting the switch upside down in the wall box (i.e. the side of the switch marked TOP at the bottom).

CONSTRUCTION

Construction should not present any problems in view of the small number of components used. For easy fitting, the circuit should be built as small as possible, and for this reason the use of a printed circuit board (p.c.b.) is recommended.

A suitable board layout is shown in Fig.5. This board is available from the *EPE PCB Service*, code 202.

A stripboard layout may be cheaper but might lead to problems in fitting the circuit into the wall box, especially if this is the shallow "plaster depth" type. The complete circuit, including a terminal block for connecting to the light, measures only 4cm × 2cm × 2cm if built to the layout given, which should be small enough to fit virtually any depth of box.

The resistors and diodes are not critical but it should be remembered that the circuit operates at mains voltage and the triac and capacitor **must** therefore be suitably rated. Virtually any triac with a voltage rating of 400V or more may be used, with the type specified being perhaps the cheapest and most widely available.

It does have the slight disadvantage of having a non-isolated metal heatsink tab which will need to be suitably isolated so that it does not touch the metal wall-box. Alternatively, a type with an isolated tab may be preferred, especially if a small heatsink is to be fitted. Without a heatsink, the triac specified should be able to handle up to 300W, which should be adequate for almost all applications. For higher powers, an 8A device with a small clip-on heatsink or a piece of aluminium should be used.

The capacitor ***must*** be an X-rated 250V a.c. type suitable for connection across the mains supply. Most capacitors are rated at d.c. so that an ordinary 250V (d.c.) one **would definitely not be suitable** as the peak mains voltage can be as high as 370V and spikes above this value can easily occur. Even one rated at 400V d.c. could have a rating of only 100V or 200V on a.c. so that these should be avoided.

Use a d.i.l. socket for IC1, cutting off the unused pin 5.

OPTO-ISOLATOR

The opto-isolator is crucial and only the specified TLP3041 or MOC3041 zero crossing type can be used. There are many opto-isolators on the market, all in 5-pin or 6-pin d.i.l. packages, but most of these have a transistor or perhaps a thyristor output and would be destroyed if fitted in this circuit.

An opto-isolator with a triac output in a similar package (the MOC3020) is also available from many suppliers and may even be more easily found but this device does not have the zero voltage switching function and would therefore be unsuitable in this application.

Note that the MOC prefix is the one used by the original manufacturer of the device but, like many components, these types are now available from many different sources so that the prefixes may be different. An MOC3040, which is an almost identical device but requires a slightly higher l.e.d. current to guarantee triggering, might be suitable but it has not been tried.

The terminal block mounted on the board is used to connect the unit to the bulb (i.e. the two wires which are left in the wall when the switch is removed). The switch, however, should be connected to the circuit by means of flying leads soldered to the points indicated on the board (see Fig.6). This may be the switch which was removed from the wall but, since it will now only be carrying the

COMPONENTS

Resistors
R1 1k
R2 100Ω
All 0·25W 5% carbon film

See SHOP TALK Page

Capacitor
C1 100n 250V a.c. X-rated polyester

Semiconductors
D1 to D4 1N4148 silicon diode (4 off)
CSR1 TIC206D triac
IC1 TLP3041 or MOC3041 zero crossing opto-triac

Miscellaneous
Printed circuit board, available from the *EPE PC Service*, code 202; 2-way p.c.b. mounting terminal block, 6-pin d.i.l. socket;, small plastic potting box or heatshrink sleeving (see text).

Approx Cost Guidance Only £7

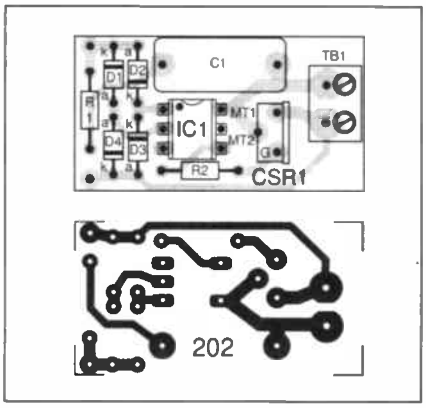


Fig.5. Component and full size p.c.b. track layouts. ***Beware, mains voltage exists on some of the copper tracks.***

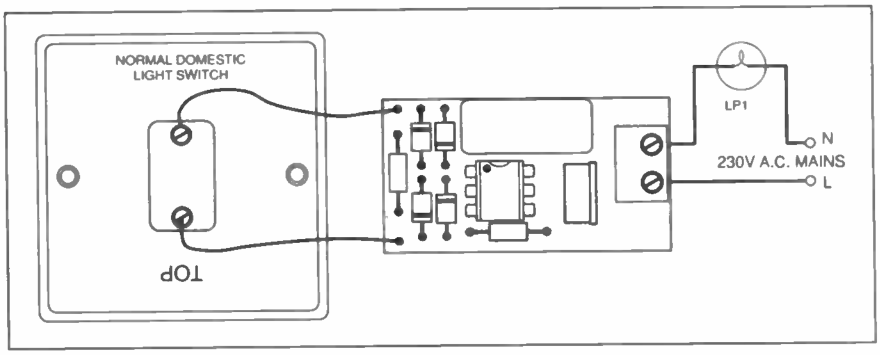


Fig.6. Connecting the Lightbulb Saver to the lighting system.

small l.e.d. current, almost any other type could be used, *provided it is suitably isolated.*

INSTALLATION

When the circuit has been completed, it should be checked carefully. Remember that you are dealing with mains voltages and so any mistakes can result in the instant vaporisation of your carefully built circuit!

The circuit operates at mains voltages and should not be handled when connected. Switch off the mains at the fuse box and remove the fuse before fitting or fault finding.

After testing it to make sure that it works, the unit should be insulated so that it will not touch the metal switch-box when it is finally fitted. Ideally, it should be fitted inside a small plastic box or potted in resin (except for the terminal block of course) but, as an alternative, it may be possible to place it inside some heat-shrink sleeving of suitable diameter. As another possibility, a few layers of insulating tape could be used.

When all is ready, the circuit may be installed. To ensure safety, the following procedure should be followed:

1. Select the light-fitting to which the unit is to be connected and switch it on.
2. Switch off the mains at the main fuse-box, remove the lighting fuse and put it in your pocket.
3. Check that the light selected does not light.
4. Remove the switch from the wall box.
5. Connect the two wires in the wall to the terminal block on the p.c.b. These may be connected either way around.
6. Connect two flying leads from the p.c.b. to the switch and re-fix to the wall-box.
7. Replace the fuse in the fuse-box and switch on the mains supply.

TESTING

There is relatively little to be done in testing the unit beyond simply ascertaining that the light can be switched on and off as all of the clever stuff is performed by IC1. If the light cannot be switched off but remains on permanently, then there is almost certainly a short circuit on the output pins, or the triac CSR1 is faulty.

If the unit fails to switch on then the fault may be due to incorrect component orientation, especially the diodes D1 to D4. Far less likely is a fault in either CSR1 or IC1. IC1 can be tested simply by removing the capacitor C1 and connecting a 9V PP3 battery with its positive clip to the free end of resistor R1 and its negative clip to terminal L. The polarity should not really matter as this will be taken care of by diodes D1 to D4 so that reversing the battery will also check these.

Note that the switch should be removed or left in the off position. Remember that the unit is connected to the mains so make sure you do not touch any part of the circuit board once you have switched on the mains supply.

Similarly, triac CSR1 can be tested by connecting a temporary switch across pins 4 and 6 of IC1 (the internal triac). The light should switch on and off as this switch is operated.

The unit is difficult to test directly to ensure that it is switching on only at the zero crossing because, to do so properly, it would be necessary to ensure that the mains was being applied at some other point in the half cycle, such as the peak. Since it is impossible to do this manually, a special circuit would need to be built to do it, which would hardly be worth the effort, especially as the i.c. was presumably tested for this at the time of manufacture.

We can, however, use a phenomenon which will quickly prove that the circuit is being switched on only at the zero crossing point and this relies on the fact that zero voltage switching also results in very low-level radio interference.

Most readers will no doubt have noticed that when a light is switched on in a room where a radio is playing, a short click may be heard in the loudspeaker. This is because whenever a current is suddenly switched on (or off), harmonics with frequencies extending to many megahertz are also generated and which can be picked up by a radio.

Since this circuit is supposed to switch at the zero crossing point, the current waveform should only rise sinusoidally in sympathy with the applied voltage, so no harmonics should be generated and therefore no clicks heard in the radio. In practice, the circuit switches at a slightly higher voltage than zero so that some interference will be generated, but this should be at a much lower level compared to a light being switched randomly.

Since the half-cycle lasts much longer than the zero crossing window, the chance of switching a bulb at a time other than the zero crossing is quite high and by switching the bulb on (by connecting a switch directly across the triac), the loudness of the resulting click can be gauged on a radio.

This can then be compared to the clicks obtained when the bulb is switched on via the circuit, which should be very much smaller, if they can be heard at all.

LONG WAVE, LONG LIFE

Note that the radio should be tuned to long wave as this is the band which suffers most from radio interference. This circuit may generate continuous low level interference when in close proximity to the radio when on this band, because it does not switch on exactly at the mains zero crossing but slightly later, as explained, but the initial click should not be as loud as that obtained without the circuit.

This is of course not a rigorous test but should at least indicate that the circuit is switching only near the mains zero crossing point and thus the initial current at switch on should be much lower.

The proof of the pudding is in the eating, however, and the real test will probably take many months before the realisation grows that it has been a long time since you had to change a lightbulb!

New Technology Update

Ian Poole reports on the development of an Optically Assisted Winchester disk drive.

Disk drive technology has made enormous advances in the last few years. It was only about ten years ago when a 40Mbyte drive was large. Now it would be so small as to be unusable. Today most new PCs arrive with disk drives which are up to about 4Gbyte, an increase of about 100 times!

Now these drives are a very cheap form of storage. A 4Gbyte drive can easily be picked up for less than £200, and looking in the advertisements in the magazines or by visiting a computer fair even better deals can be obtained. This is all a far cry from the first drive developed by IBM back in 1955. It stored only 5Mbytes and cost $50,000, but despite this it represented an enormous leap in technology.

Since this time the storage capacities of drives have increased considerably. The rate at which developments have been made has also increased to enable current demands to be met. A number of new ideas have been introduced. Not only have the surface materials which actually store the data been improved immeasurably, but also heads have been improved as well. Nowadays, magneto-resistive heads are widely used and these give a considerable improvement for reading data over the more traditional magnetic heads.

Forty Years On

Since its introduction the magnetic disk has provided excellent service. For many years people thought that it was only a stop gap and that other forms of storage would be developed and introduced. However the disk has become one of the major success stories of the computer industry, remaining in service for forty years, seeing many other technologies, including core memory, disappear into antiquity.

Despite the many improvements that have taken place with disks it appears that more developments will be required. Programmes are ever more memory hungry, and other techniques are becoming more commonplace that require storage. For example more images are being scanned and stored on disk. These and many other reasons mean that the pressure on disk drives to be able to store more data in smaller spaces is as high as ever.

Currently storage densities in pure magnetic based storage systems are beginning to hit an upper limit of about 10Gbits/in^2. Even if some of the problems causing this limit can be overcome it is believed that it will not be possible to progress beyond a density of between 20 and 40Gbits/in^2 because, at densities above this, the disk media cannot hold a stable domain, and data cannot be reliably held. This appears to be the physical maximum level of data that will be able to be stored using this form of storage.

Optical/Magnetic Storage

To overcome these problems a new form of storage which combines optical and magnetic techniques is being developed by the Quita Corporation in San Jose, California. It combines a variety of technologies, using an advanced laser light delivery system, an innovative head design, and a micro-machined mechanical assembly. Named the Optically Assisted Winchester (OAW) it is anticipated that it will quickly be capable of storage densities of around 40Gbits/in^2, and within ten years it will be capable of much greater storage densities.

The technology is as versatile as normal hard disk technologies. It will be possible to use it not only for single disk systems but also for stacked multiple disk drives as well as removable systems where security may be a requirement. These functions will enable it to meet the ever increasing needs for computer storage well into the next century.

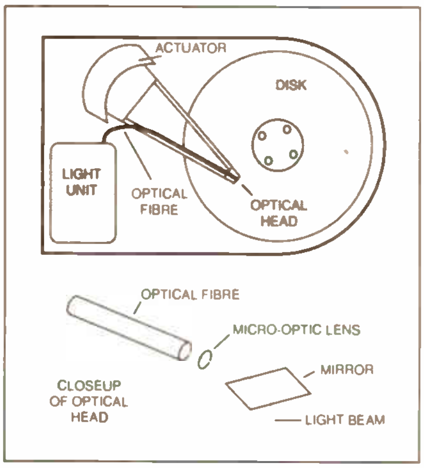


Fig.1. The Optically Assisted Winchester

The new disk drive looks very similar to a standard drive at first glance, having a small disk, an actuator and the supporting electronics. However, there is also an advanced light delivery system. This is based around an optical switch module that generates light pulses and switches them between actuator arms exceedingly quickly. Hair thin fibre optical cables take the light along the actuator arms to the read/write heads, see Fig.1.

The heads use micro-optic lenses to focus the light onto the media surface. These lenses themselves represent a major achievement as they are only 350µm in diameter. Once the light has passed through the lens it strikes a micro-machined mirror that deflects it onto the media surface.

In view of the very high degrees of accuracy that are required, two stages of positioning are employed. The first uses a standard form of servo system. Once this has positioned the actuator small currents are used to position the deflection angle of the mirrors. In this way the light beam can be very finely aimed. This enables much tighter track densities to be achieved, enabling much higher data densities to be attained. It is estimated that the system will be capable of achieving a figure of over 100,000 tracks per inch.

Plastic Disk

The media that is used is also crucial to the operation of the system. It is constructed in a very similar method to normal hard disk media, having a thin magnetic layer on a magnetically inert substrate. Instead of aluminium that is currently used, plastic is employed for the new drives. This is both cheaper and lighter, and also enables the disk to be preformatted. The magnetic layer is also different, it consists of amorphous rare earth transition metals. This coating will enable densities much greater than those possible with conventional storage media.

The way in which the reading and writing of the data is performed is of particular interest. To write the data a pulse of light is passed onto the surface of the disk. A small coil on the head is then activated to set the polarity of the magnetism in this area.

To read data the laser is switched to a lower power and polarised light is passed through the magnetised spot. The polarisation of the light is then changed according to the magnetisation of the area. This is detected and converted to give the electronic "1" or "0". In fact this operates in a very similar way to that used by current optical disks.

One of the advantages of this system is the anticipated cost. Firstly it uses some very similar techniques to existing drives. This means that current technology can be used in many areas, thereby reducing the overall cost increase.

Additionally, the costs for the new areas appear to compare very favourably with the high precision versions of existing technology drives that would be required to achieve a similar performance. This means that the price when these drives are introduced will be comparable to those using existing technology. The advantage will be that, with further development, they should be able to far outstrip present drives.

Electronics Principles 5.0

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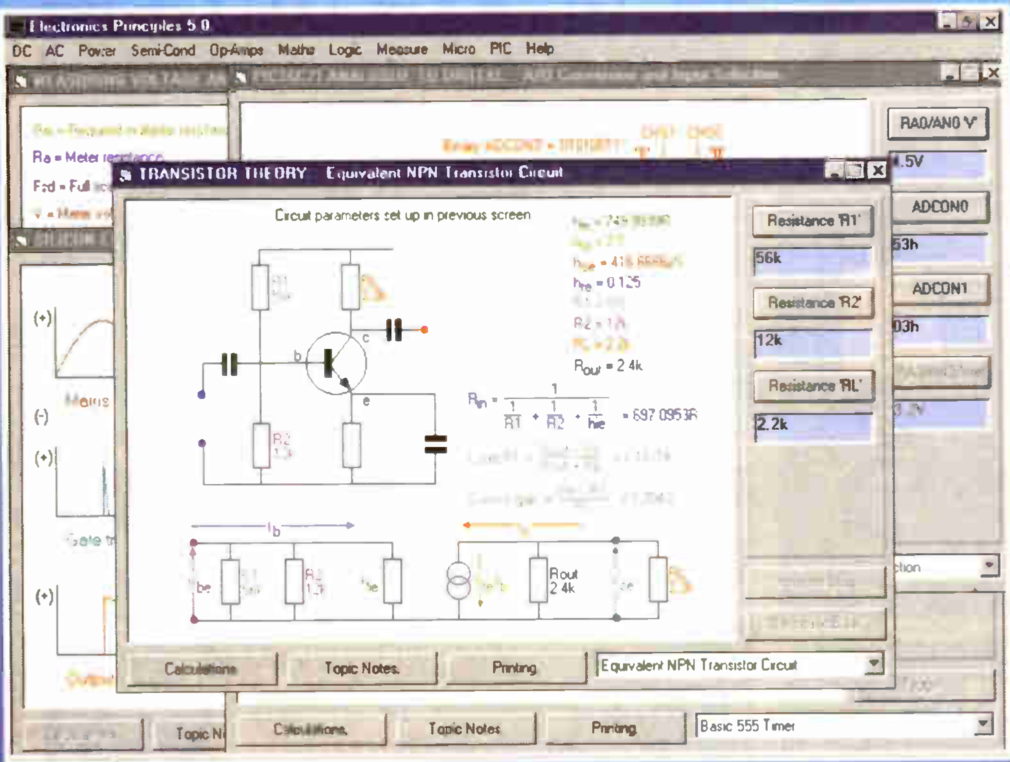


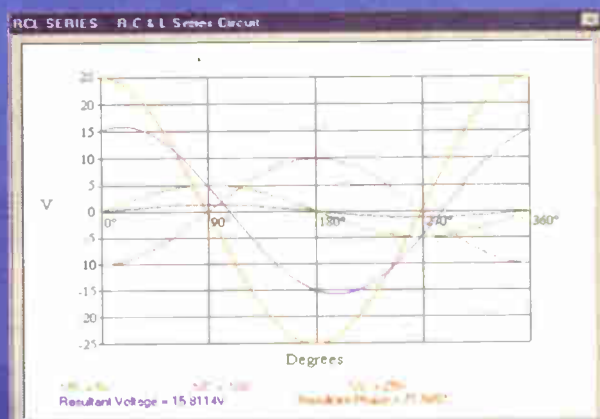
Electronics Principles 5.0 is a significant upgrade of our popular electronics educational software. Now containing even more analogue, digital and microcomputer theory, PLUS over a hundred new mathematics topics to further your understanding of formulae and calculations. Telephone for a comprehensive list of upgrade details.

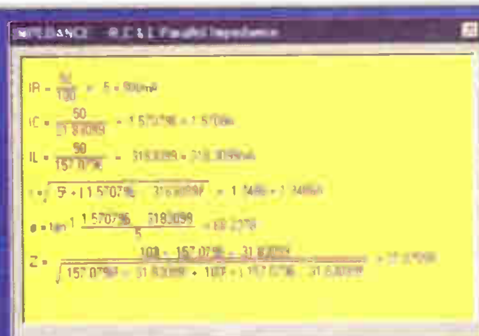
This software has been developed to teach electronics and is suited to both the complete novice and the more advanced student or hobbyist wanting a quick revision and access to hundreds of electronics formulae. It is extremely easy to use. Just select a topic, which is always presented as a default diagram (no blank screens!) and input your own values. Alternatively, use those from any standard electronics text book to see the results as frequency response curves, calculations, logic states, voltages and currents etc.

Graphics presentation has been enhanced and speeded-up with new menus and indexing which enables a quicker access and more informative description of the extended range of five hundred and sixty electronics and mathematics topics.

The PIC16C84 microcontroller hardware and instruction set has been introduced and brought to life through colourful interactive graphics where you can study the architecture of this device by changing the data values to simulate all of the registers, direct/indirect addressing, program/data memory and input/output port configuration. Along with those analogue to digital functions of the PIC16C71. If you would like to learn more about the principles of these popular microcontrollers then it could not be made easier.

Electronics Principles software is currently used in hundreds of UK and overseas schools and colleges to support City & Guilds, GCSE, A-Level, BTEC and university foundation courses. Also NVQ's and GNVQ's where students are required to have an understanding of electronics principles.





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BT'S HOME HIGHWAY

Barry Fox reports on BT's intent to get householders onto ISDN via Superport.

ALTHOUGH BT is now selling 2000 ISDN lines a week, all are to businesses. Despite six months of mass market advertising, most householders still do not know what ISDN can offer them, and those that do know cannot afford the necessary equipment. BT now plans a new service called Home Highway which uses technology developed by GPT and designed finally to drive ISDN into British homes.

Home Highway relies on Superport 128, a junction box, not much larger than an ordinary telephone socket, which fits on a subscriber's wall, connects to an ordinary copper phone line and delivers a mix of ISDN and ordinary telephone and fax services. So the subscriber no longer need pay several hundred pounds for a terminal adaptor that lets an analogue phone plug into an ISDN line.

BT launched ISDN in 1988, and took until 1997 to sell one million connections. Most were high capacity connections for large businesses. Heavy promotion, with radio and TV advertising over the last six months, has sold 2000 new lines a week, 1200 of them lower capacity ISDN2 lines for small businesses. Over 30 per cent of all new business lines are now ISDN, but next to no new consumer lines are ISDN.

ISDN on the Pot

Superport, says GPT, "clears the way to mass market ISDN". It works with modified software at the System X digital exchanges which GPT builds for BT. The exchange will convert all "plain old telephone service" (POTS) analogue calls into digital code, package the call code with ISDN data and send the mix down an ordinary copper wire pair into the home. The home junction box has four sockets, two for connecting digital equipment, such as a PC, and two for analogue POTS phones, modems or fax machines. The user can either connect two PCs to the ISDN sockets, each surfing the Internet at 64 kilobits/second, or one PC working at 128kb/s.

When analogue phones are plugged into the POTS sockets the junction box converts the call code from the exchange into analogue signals, while digitising speech from the phones. The POTS sockets work in the same way with an analogue modem or fax machine. The two sockets are allocated different numbers, so the subscriber can use one ISDN line for separate POTS phone or fax calls.

GPT has designed the boxes so that they can be sold through High Street shops, and fitted by DIY householders. (Superport replaces the existing phone socket and its converter circuit is powered from a mains socket.) BT need then spend only "a minute of two" switching the subscriber's line at the local exchange.

BT will soon start market trials of Home Highway, but only in a few hundred homes.

BIGGER L.C.D.S

TOSHIBA has developed a 13·3-inch prototype of a reflective low temperature polysilicon l.c.d., first showing it at the recent Electronic Display Exhibition '98, in Yokohama, Japan. This is the largest l.c.d. yet achieved.

Roll-over Beethoven!

"YOU sing or play the tune, Autoscore writes it down for you." So proclaims a press release from Wildcat Canyon Software Inc.

Whilst one might expect cries of disbelief from professional composers over the additional statement that "Composing music has never been easier", undoubtedly many would-be musicians may well find Autoscore an enormous help in formalising their tuneful aspirations.

With Autoscore and a Windows or Macintosh computer, you just sing or play a tune into a microphone and the software instantly translates these sounds into written-down notes on the screen. Once finished, you can edit, play back and harmonise-in additional tracks. Wildcat say that, unlike some other music software programs which require cumbersome and expensive MIDI hardware, Autoscore lets you "compose music quickly and easily right out of the box – no special hardware required".

The software is claimed to allow unprecedented ease of use and the programs have the ability to handle dozens of tracks at once. Two versions are available. Autoscore 2.0 Deluxe (US $119) has everything the average consumer needs to get started composing music on their computer and is supplied with a microphone and sequencer. Autoscore 2.0 Professional (US $249) includes such additional abilities as pitch-bend and volume tracking, customisable instrument filters, and the ability to connect to many popular studio music programs.

Wildcat's other products include the Internet Music Kit (US $49) that allows anyone with a web site to create an audio soundtrack for their web page.

For more information, contact Wildcat Canyon Software Inc., Dept. EPE, 1563 Solano Avenue, Suite 264, Berkeley, CA 94707, USA. Tel: (510) 527 5155. Fax: (510) 527 8425. E-mail: Sam@wildcat.com. Web: http://www.wildcat.com.

OBSOLESCENT PCS

By Barry Fox.

NOW it's official. PCs are going out of date so much faster every year that by the Year 2000, they will be only be good for six months use.

Livingston Rental leases IBM, Sun, Compaq and Hewlett Packard computer equipment round Europe to businesses which always want to have the latest technology. So Livingston has to track the speed at which rented equipment becomes obsolete and customers return it, asking for a newer model.

Despite seasonal peaks and dips the trend is inexorable. Useful life cycles of Windows desktop computers have fallen by around two months each year.

Three years ago, when PCs with Intel 486 chips were top of the range, their rental life was around 17 months. The Pentium 133, which replaced the 486, lasted a little over 14 months. Last year, 1997, the Pentium 166 was unwanted after 11 months and had been replaced by Pentiums running at over 200MHz. The latest PCs run at 300MHz. New software, with video content, demands the high speeds.

"Why bother about buying software to try and make today's PCs handle the Millennium date change", says Barry Watts, Livingston's business development consultant. "They will be on the scrap heap anyway. By 2000 desktops, laptops and handheld will be obsolete within six months".

Japanese company TEAC, which makes the CD-ROM and floppy disk drives that other manufacturers build into PCs, says it must now get products out of the laboratory and on sale within three months.

Manufacturers of consumer electronic equipment worry in case the digital TV revolution sucks them into the same spiral of accelerating obsolescence.

Nick Glover, Head of Technical Development at BREMA, the British Radio and Electronic Equipment Manufacturers Association, thinks not. "People expect a TV set to last for at least seven years. And when they buy a new one they keep the old set for another room. Thank goodness this kind of technological warfare is unique to the PC industry".

Q7 FOR HAMS!

RADIO communications specialists Icom have announced the launch of the IC-Q7, their latest hand-held 2m/FM transceiver. They say it will excite even the most seasoned Ham enthusiast.

The tiny IC-Q7 is a 300mW r.f. output transceiver incorporating a wide-band receiver covering 30MHz to 1300MHz, and is capable of reception in AM, FM and WBFM modes. It features an easy band-switching system where changing between operating bands can be done at the push of a button. The minimal number of controls includes eight function switches, a dedicated power switch, a rotary dial and a large built-in speaker. CTCSS encode/decode is fitted as standard, allowing quiet stand-by on busy channels. It has a drip-resistant body which provides protection from harsh weather or operation near water.

For more information contact Icom (UK) Ltd., Dept. EPE, Sea Street, Herne Bay, Kent CT6 8LD. Tel: 01227 741741. Fax: 01227 741742.

E-mail: icomsales@icomuk.co.uk

Web: http://www.icomuk.co.uk

PRICE CUTS BY ORDER

TRADE Minister Margaret Beckett has made an Order under the Fair Trading Act which should result in lower priced TVs, washing machines and other electrical goods.

The Mergers and Monopolies Commission has reported that price competition in these markets is muted. Mrs Beckett says that "I am determined that practices which restrict competition should be stopped. Retailers should be free to set their own prices and should not be refused supply because of their pricing".

The Order will make it illegal for suppliers to discriminate against retailers who sell at discounted prices.

VICOR CD

VICOR, specialists in power applications products such as power supplies and d.c. to d.c. converters, have announced the release of the latest edition of their applications manual, available for the first time on CD-ROM.

Netscape Navigator 4.0 and Adobe Acrobat Reader 3.0 are also included on the CD.

For more information contact Vicor UK, Dept. EPE, Coliseum Business Centre, Riverside Way, Camberley GU15 3YL. Tel: 01276 678222. Fax: 01276 681269. E-mail: vicoruk@vicr.com

Web: http://www.vicr.com.

Satellite Repair Manual

NO, this volume has not been issued by NASA or ESA, it's the fifth edition of Martin Pickering's extremely popular guide (and industry standard) to repairing domestic satellite receivers.

It could be said that what Martin Pickering doesn't know about satellite receivers isn't worth knowing. What he does know has become legendary. Having been at it since the start of consumer satellite TV, he has built up a massive database on satellite receivers. Not only on their faults, common and less common, but also on modifications and upgrades.

This fifth edition has been completely updated and now has an amusing yellow binding to protect 350 pages (says Martin!) – the previous edition had 240. In addition to receiver fault notes and general information, you'll find many useful button sequences for resetting parental lock codes, resetting installation choices to factory defaults and other less well known operations, practical information on LNBs, a list of manufacturers and suppliers addresses and other useful material.

This book will be as useful to the beginner as it will to the professional repairer since it contains a beginners' introduction to soldering and recognising components. It also expands upon the information supplied with the many satellite repair and modification kits available from SatCure. Pace and Amstrad models are dealt with comprehensively, as are Cambridge, British Telecom and dozens of other makes.

The *Satellite Repair Manual 5* is priced at £19.95 (Martin says you could recoup the cost with your first repair!) and is available from the publisher by mail order and from most satellite accessory suppliers.

It is published by SatCure, Dept. EPE, PO Box 12, Sandbach CW11 1XA. Tel: 01270 753311. Fax: 01270 761928.

E-mail: repairman@netcentral.co.uk

Web: http://www.netcentral.co.uk/satcure

BEBOP AWARDED

BEBOP BYTES BACK, that astonishingly interesting book on computers which we have been selling through these pages, has become the Winner of 1998 Small Press Awards for Computer/Internet in the USA.

Author Clive "Max" Maxfield is so delighted that he E-mailed us from the States to tell us the great news.

All the winners were displayed at Book Expo, which was attended by 35,000 booksellers and publishing industry members.

Congratulations Max, and to your co-author Alvin Brown.

LOWER-COST POWER

EXPERIENCED constructors looking to upgrade their workshop could well find that the new lower cost of top quality Kenwood PAC regulated power supplies suits their needs and pockets.

Feedback Instruments are stocking a range of six power supplies, which includes instruments with 20V, 30V or 60V output at currents from 1A to 3A. All have low ripple and low noise characteristics, simultaneous setting and display of voltage and current with a 3-digit display for each, and floating output terminals. Prices now start from £122 for the PAC20-3.

For more information contact Feedback Instruments Ltd., Dept. EPE, Park Road, Crowborough, East Sussex TN6 2QR. Tel: 01892 653322. Fax: 01892 663719. E-mail: feedback@fdbk.demon.co.uk. Web: http://www.fbk.com.

MORE PICS

MICROCHIP'S latest PIC17CXXX microcontrollers add 16-bit performance to their OTP family. The three devices include 10-bit A/D converters and two high speed USARTs in 64- and 84-pin packages.

They have also released version 2.10 of their popular MPLAB-C17 C compiler, and confirmed that the PIC16C84 continues to be in current production.

For more information contact Arizona Microchip Technology Ltd., Dept. EPE, 505 Eskdale Road, Winnersh Triangle, Wokingham, Berks RG41 5TU. Tel: 0118 921 5858. Fax: 0118 921 5835. Web: http://www.microchip.com (the site's recently been enhanced – make a visit to "Planet Microchip"!)

Microsoft Challenged

By Barry Fox

EIGHT of the world's largest electronics companies are ganging up on Microsoft. Grundig, Hitachi, Matsushita/Panasonic, Philips, Sharp, Sony, Thomson and Toshiba, have agreed a Home Network standard which lets any audio or video device connect to another, as easily as plugging into the mains.

Once connected, the equipment handshakes so that one remote can control everything, and signals pass freely from one device to any other. The big eight will make the standard "open" so that other manufacturers can make compatible equipment. This challenges Microsoft's plans to make Windows the future home control standard.

Macro Maplin

MAPLIN, the electronics mail order retail chain, and the SEI-Macro Group, one of the UK's leading electronic component distribution groups, have embarked on a joint trading initiative that will extend "large business customer" type service benefits to trade customers.

Under the arrangement, Maplin will have access to over £15 million of inventory held in the UK by the SEI-Macro Group. Macro will also make Maplin's product and service information available to its customers.

For further information, contact Maplin Electronics, Dept EPE, PO Box 777, Rayleigh, Essex SS6 8LU. Tel: 01702 554000. Fax: 01702 554001.

China's Image Advances

Barry Fox tells a tale of interactive piracy that may have mixed benefits.

CHINA'S roaring trade in pirate CDs has revived a dead technology and let the Chinese government create a home-grown video standard which is cheaper and easier to manufacture than VHS. Chinese manufacturers now get the chance to sell video hardware without paying royalties to Japan and the West.

Five years ago Philips, Sony and Panasonic launched Video CD, a conventional CD which stores 75 minutes of digitally coded video, of VHS quality. The code is compressed to the MPEG-1 standard which squeezes pictures and sound into the 1·5 MBit/s data stream normally used for CD stereo. VCD flopped in the West when news leaked of DVD, the digital video disk which uses a high density CD to store over 135 minutes of high quality video, compressed to the more demanding MPEG-2 standard. But CD pressing plants in China switched from making pirate music disks to pornographic VCDs for Japan and pirated copies of Western movies for the Chinese. The Chinese plants can buy the Western computer circuitry needed to encode movies for $300.

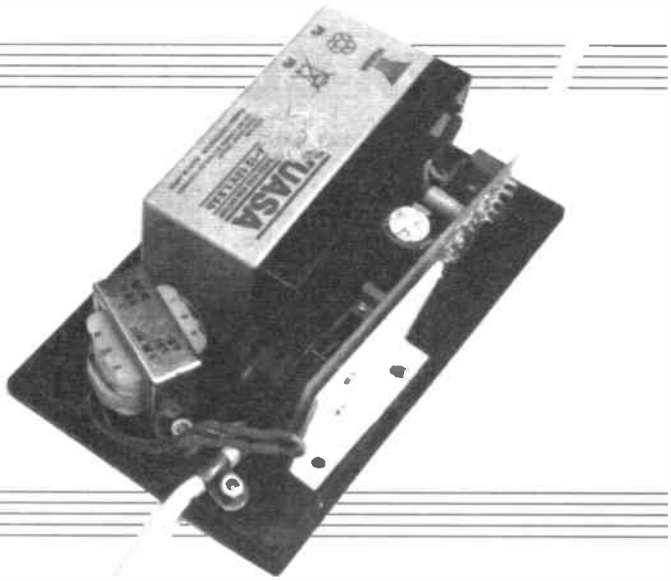
Six local factories, Shinko, Idall, Mulata, SAST, SMC and Chang Hong, make VCD players which sell for under $100 in China. The only high tech component is the MPEG decoder chip which comes from C-Cube in the US. There is no competition from imports because the State Quality Inspection Bureau has arbitrarily branded Japanese VCD players inadequate.

The Ministry of Electronic Industries now wants to modify the existing Version 2 Video CD standard set by Philips and the Japanese. China's Version 3 will make the disk interactive, so that it can be used for education in schools and village homes. Borrowing a technique used for DVD, the disk can record movies at a bit rate which varies with the amount of detail and movement on screen. If the disk is spun at higher than normal speed like a modern CD-ROM, the bit rate increases to give much clearer pictures. This reduces playing time to 40 minutes, but the Version 3 VCD player will have an autochanger which seamlessly plays a movie spread over three disks.

Consultant Howard Woo, is working in China for Philips. The Dutch company already has a joint venture factory in Beijing which makes 60,000 VCD players a month. Woo estimates that 25 million VCD players are already in use in China, and owners have 15,000 disks to choose from. Many are current movies copied from video tapes and disks bought in Hong Kong, transferred to VCD and sold for a few dollars each.

Woo believes the Chinese government has a hidden agenda for setting the new VCD standard. "China does not want to pay royalties to foreign companies" he says "So the Ministry will set a royalty for Version 3 which exactly matches whatever percentage Philips, Sony and Panasonic try to charge for the basic technology. China will then allow some imports and call it quits".

FLOAT CHARGER



ANDY FLIND

Don't get caught flat in an emergency. Keep your sealed lead/acid batteries in tip-top condition.

In recent years small sealed lead/acid batteries have become widely available, and are becoming recognised as a useful alternative to nickel-cadmium cells for many applications. Unlike earlier liquid-filled types, these cells have the electrolyte in the form of a jelly which allows them to be used in any position without spillage.

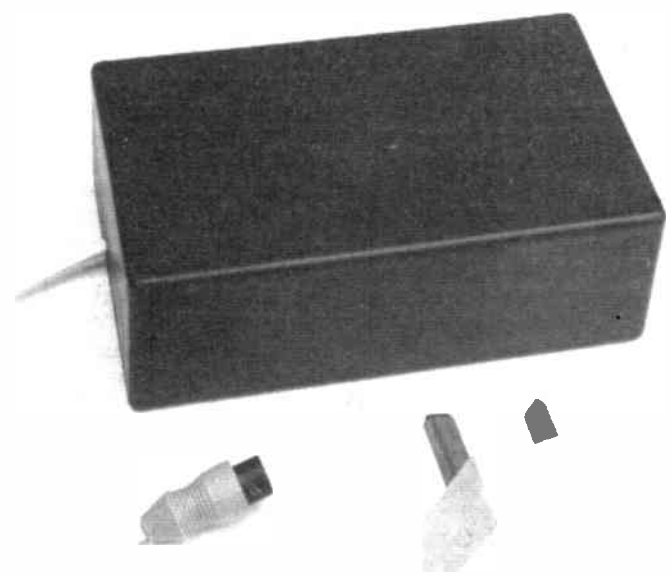
They are available in a wide range of capacities and usually have a nominal voltage of either 6V (3 cells) or 12V (6 cells). They can provide very high output currents and do not exhibit the "memory" effect of NiCads, making them ideal for situations where they are to be continuously topped up by a "float" charger, ready to supply emergency power when required.

Where the application requires a heavy current at infrequent intervals this can often be provided by the battery so the charger needs to provide only a small "trickle" current, making it simple and cheap to construct. Typical applications of this type would be emergency lighting and intruder alarms, though readers will doubtless be able to think of many others.

FLOAT CHARGING

A "float" charger for this type of battery needs to produce a precisely regulated voltage output, usually between 13·5V and 13·8V (for a 12V battery), and it should have a current limit to prevent excessive charging currents if the battery is in a discharged condition. Over-voltage and high charging currents can both lead to venting of gases by the battery, giving rise to early failure and possibly even a risk of explosion. *Periodic recharging of these batteries with a cheap car battery charger is not recommended!*

An excellent regulator can be built using the versatile L200CV adjustable regulator, and at least two circuits for this have already been published. The standard form of such a circuit is shown in Fig.1. The voltage is set by resistors R1, R2 and preset potentiometer VR1 whilst resistor R3 sets the maximum current output so the circuit maintains both current and voltage to within acceptable limits for the battery.



SELF-DISCHARGE

A problem with this circuit is that if the supply fails a small current flows back from the battery into the charging circuit. Part of this current flows through the voltage-setting resistors whilst some flows through the regulator i.c. itself. The value of this current is around 15mA, and though this might not sound much it is in fact sufficient to completely discharge one of the smaller batteries in about three days.

Lead/acid batteries have a much lower self-discharge rate than NiCads, and it would be a pity if an emergency supply that might otherwise remain viable for weeks were to be lost in such a short time in the event of a sustained power failure. In addition, one of the few ways to damage these batteries is by deep discharge, so a circuit modification to prevent any possibility of this happening is needed.

A diode in the output would prevent back-feeding from the battery, but the voltage would then have to be raised to compensate for the drop across this and diode voltage drops vary with temperature and diode type. Since the unwanted leakage current through both the voltage-setting resistors and the i.c. flows to "ground", the solution adopted by this project is the use of a transistor to break the circuit to ground in the event of a supply failure.

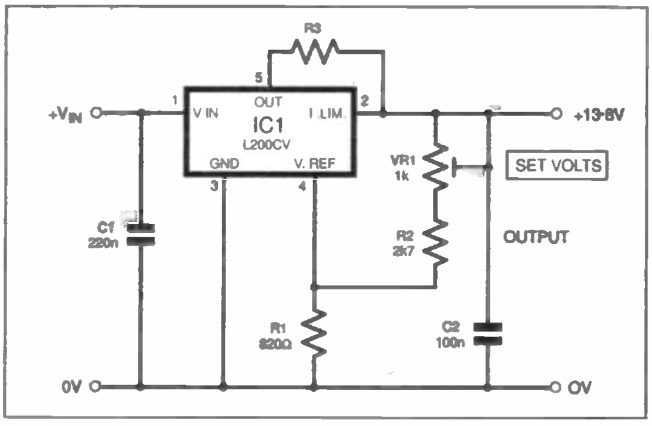


Fig.1. Simple standard charger circuit diagram using the L200CV adjustable voltage regulator chip.

CIRCUIT OPERATION

The full circuit diagram for the Float Charger is shown in Fig.2. Much of this circuit is standard and a full-wave rectified supply is provided by transformer T1, which has a centre-tapped secondary, together with two rectifier diodes D1 and D2 and capacitor C2. Resistors R3, R5 and preset VR1 set the output voltage from IC1 whilst R4 sets the maximum current.

Whilst the mains supply to the transformer is present diode D3 provides a half-wave rectified supply to capacitor C1 which is used to drive transistor TR1 into saturation. This transistor provides the regulator circuit with a path to the negative supply rail. TR1 is a ZTX653, which is a switching type.

The emitter-collector voltage across TR1 when it is saturated is very low and is fairly constant with temperature. If the supply fails, after a very short period TR1 will turn off and break the circuit to prevent any loss from the battery, which can then hold its charge more or less indefinitely.

COMPONENTS

Approx Cost Guidance Only £23 excluding lead/acid batt.

See SHOP TALK Page

Resistors

R1, R2	10k (2 off)
R3	820Ω
R4	4Ω7 (see text)
R5	2k7

All 0·6W 1% metal film

Potentiometer

VR1	1k 18-turn cermet preset, end adjust

Capacitors

C1	10μ radial elect. 25V
C2	2200μ radial elect. 25V
C3	220n resin-dipped ceramic
C4, C6	100n resin-dipped ceramic (2 off)
C5	100μ radial elect. 25V

Semiconductors

D1, D2, D4	1N4004 1A rect. diode (3 off)
D3,	1N4148 signal diode
TR1	ZTX653 *npn* transistor
IC1	L200CV 2A adjustable voltage regulator

Miscellaneous

T1	230V mains transformer, with 15V-0V-15V centre-tapped sec.
B1	12V sealed lead/acid battery (see text)
FS1	panel mounting 20mm fuseholder, with fuse rated to suit application (see text)

Printed circuit board available from *EPE PCB Service*, code 199; ABS plastic case, size 158mm × 95mm × 54mm approx; 5-way p.c.b. mounting screw-terminal block; heatsink (see text); optional bridge rectifier (see text); multistrand connecting wire; solder tag; solder etc.

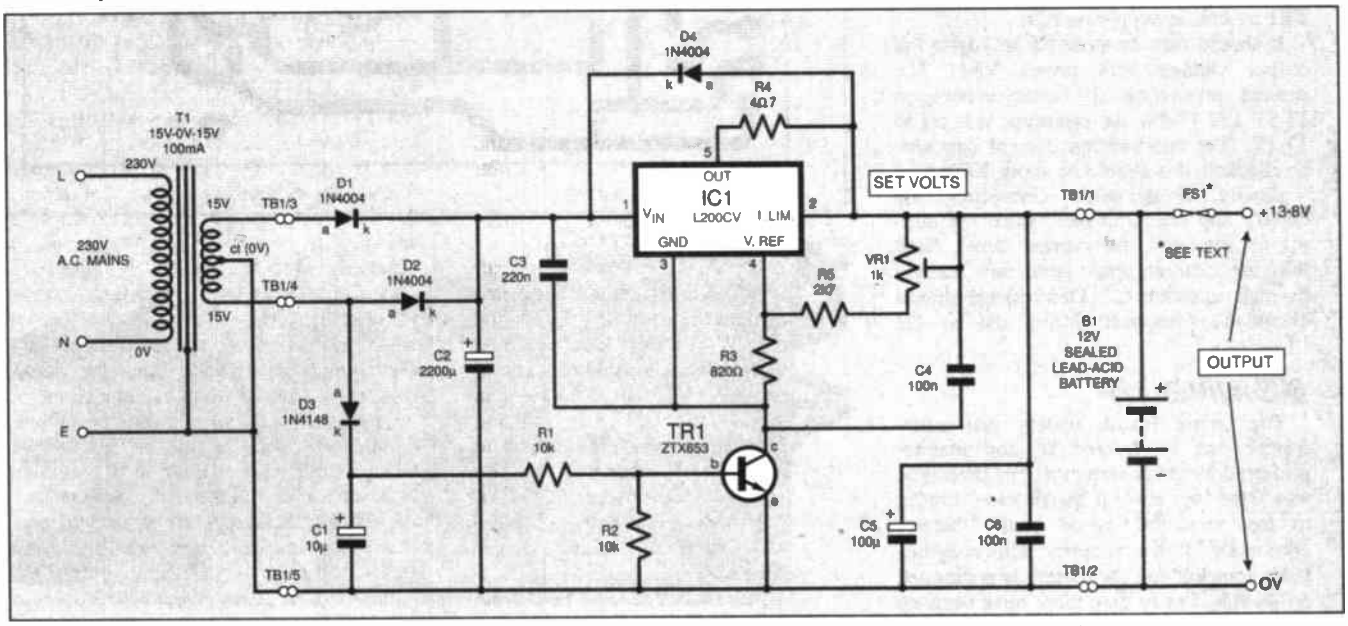


Fig.2. Complete circuit diagram for the Float Charger for sealed lead/acid batteries.

Capacitors C3, C4, C5 and C6 ensure operational stability of the circuit. Diode D4 is intended to carry most of the charging current which flows into C2 if a charged battery is connected before the mains supply, in preference to allowing it to flow in the reverse direction through IC1.

The prototype was designed to supply a 12V 1200mA/H battery with a maximum current of 100mA, though modifications for other voltages and currents will be described later.

CONSTRUCTION

Construction is straightforward, with most of the components mounted on a small printed circuit board (p.c.b.) as shown in Fig.3. This circuit board is available from the *EPE PCB Service*, code 199.

For ease of construction the resistors and diodes should be fitted first, followed by components with high profiles such as the capacitors and the terminal block TB1 for external connections. The voltage regulator IC1 and its heatsink should be

*The p.c.b., mains transformer and battery are mounted on the lid, which now forms the base panel. The battery is mounted on its side using Blu-Tack. Also, a series of vent holes **must** be drilled in the case "top".*

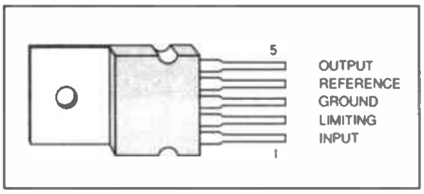
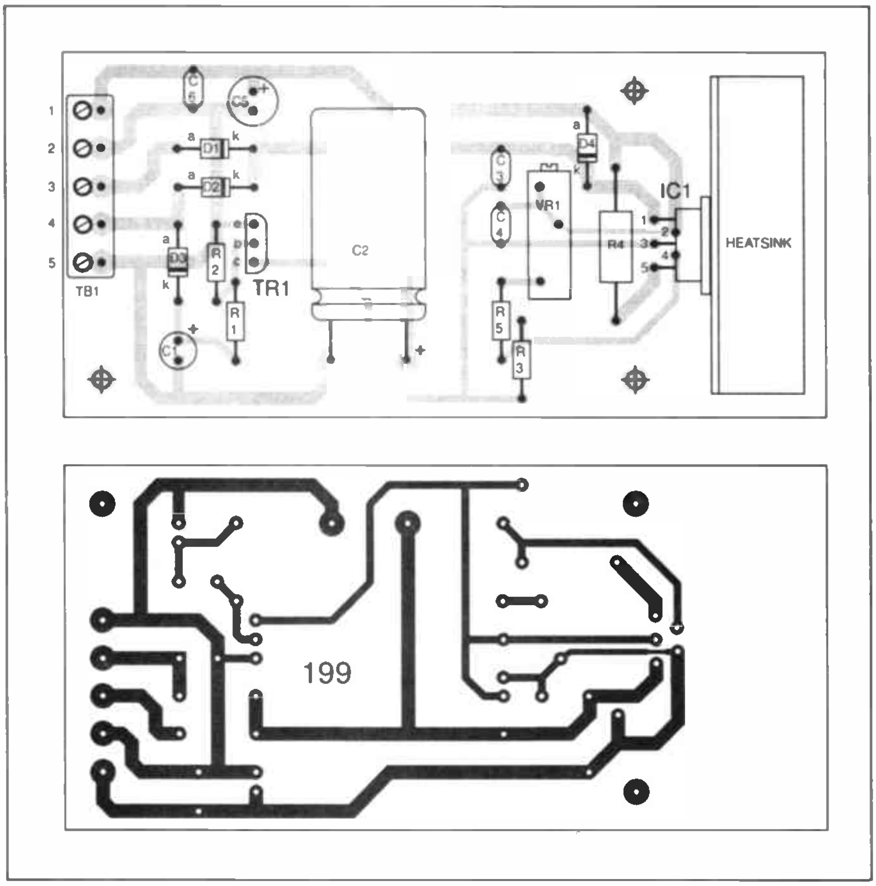


Fig.3 (right). Float Charger printed circuit board component layout and master. Pinout details for the regulator (IC1) are shown above.



bolted into position before soldering to avoid placing strain on its connections. For this low-current version the heatsink need be no more than a piece of aluminium bent into an "L-shape".

TESTING

The completed board can be safely tested with a d.c. bench power supply if required. A voltage between 15V and 20V should be applied, negative lead to TB1/5 ("common") and positive supply lead to TB1/4 immediately above it so that diodes D2 and D3 are energised. This will turn on TR1 as well as supplying IC1.

It should now be possible to adjust the output voltage with preset VR1. The desired output for a 12V battery is between 13·5V and 13·8V, the prototype was set to 13·7V. The short-circuit current can also be checked, this should be about 100mA.

Finally, it is worth connecting the battery and checking that, when the supply is removed, no current flows back into the charger apart from any leaking through capacitor C2. This leakage should eventually disappear during use as C2 "forms".

BOXING UP

The circuit board, battery and transformer can be housed in any manner preferred by the constructor. The prototype was fitted into a small plastic case, similar to that used for many small "battery eliminator" power supplies. This is admittedly compact and the battery is positioned on its side, but to date there have been no problems.

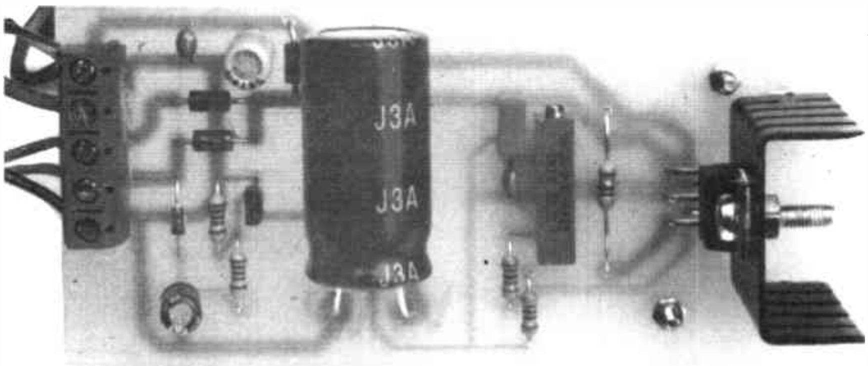
Only a small amount of internal wiring is needed and this is shown in Fig.4. The mains transformer metalwork is earthed via one mounting lug and a solder tag, as is the negative side of the output, at the terminal block TB1/2.

The prototype relies on the fuse in the mains plug for input protection so this should have a rating of 3A or lower. A separate input fuse could be incorporated into the project if this is preferred.

The output ***must*** be fused (FS1) with a value to suit the application, as even the 1200mA/H battery is stated as being capable of supplying up to 45A. It is easy to imagine the fireworks this would generate in the event of an unprotected short-circuit!

UP GRADING

As mentioned earlier, this project can be easily modified to supply other voltages and currents. For use with a 6V battery, VR1 should be a 500 ohm pot. with a one kilohm (1k) resistor for R5. This will



The finned heatsink bolted to the voltage regulator on the prototype p.c.b.

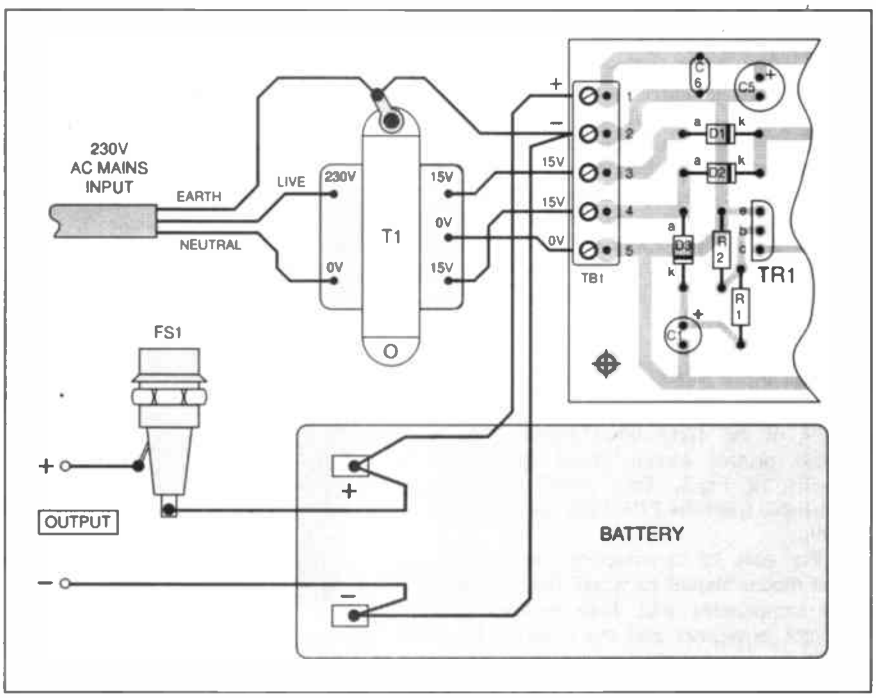


Fig.4 (right). Interwiring between components and p.c.b. terminal block.

provide an adjustment covering the suggested range of 6·75V to 6·9V, a setting of 6·85V should prove suitable.

A higher maximum current can be set by reducing resistor R4, using the formula $R4 = 450/I_{MAX}$ (I in mA) to obtain the value required. Note that the full output current flows through this resistor so it must be capable of handling this current. It will also dissipate heat, about half a watt at 1A and one watt at 2A.

However, the low values of resistance needed for these currents (0·45 ohms and 0·225 ohms respectively) mean that resistor R4 will almost certainly be a suitably rated *wirewound* type or consist of several resistors connected in parallel which will share the current and the dissipation. Space is provided on the p.c.b. to allow the use of such resistors or combinations of them to be used.

Higher output currents will require a larger value for capacitor C2 to keep ripple within acceptable limits. A rough guide to the correct value can be gained from $C = I \times 10$, where C is in µF and I is in mA, to keep the ripple voltage below 500mV. Again space is provided on the board to accommodate a capacitor physically larger than that used by the prototype.

BRIDGING THE GAP

If a different voltage or higher current output is required transformer T1 will need to be altered to a suitable type, which may not have a centre-tapped secondary winding. If this is the case, Fig.5 shows how the board can be used with a bridge rectifier, replacing diode D1 with a link, omitting D2 and applying an a.c. input to diode D3 anode.

The input voltage to IC1 should always be at least two volts *above* that of the output for correct operation, and this difference should take into account the "headroom" required for ripple at full current. Since the rectified output from the transformer is normally closer to the peak value of the transformer secondary voltage than the stated value, a 15V transformer should normally be suitable for use with a 12V battery and a 9V type should be adequate for a 6V unit.

At higher currents a larger heatsink will be required by IC1. A guide to the wattage of heat to be dissipated can be gained by subtracting the output voltage of regulator IC1 from the input voltage and multiplying this difference by the maximum current.

The p.c.b. is bolted to a L-shaped ***plastic*** *bracket and mounted vertically on the base (lid) panel.*

The space on the end of the p.c.b. should allow the fitting of various types of heatsink. The mounting tab of IC1 is internally connected to pin 3 (negative) so it is ***most important*** to prevent the heatsink from coming into contact with other parts of the circuit, or to use an insulating mounting kit for IC1.

TAKE CARE

Two precautions should be observed when using this project. The first is that it should *not be used* to supply voltage-sensitive equipment *without a battery* being connected.

This is because when the supply fails and transistor TR1 disconnects the negative connection to IC1, the stored energy from capacitor C2 appears at the output. When a battery is connected this energy is simply soaked up without a corresponding voltage rise. If the battery is not present a potentially damaging voltage rise may occur.

The second precaution is that under certain conditions (usually high charge or discharge currents) sealed lead-acid cells can vent potentially explosive gases. They should *NOT*, therefore, be operated in *completely sealed* enclosures. If the project is to be housed in a small case, such as that of the prototype, some vent holes ***must*** be drilled to allow any such gases to escape safely.

Provided these two conditions are observed this design should enable constructors to use sealed lead/acid batteries without problems whilst obtaining maximum reliable life from them.

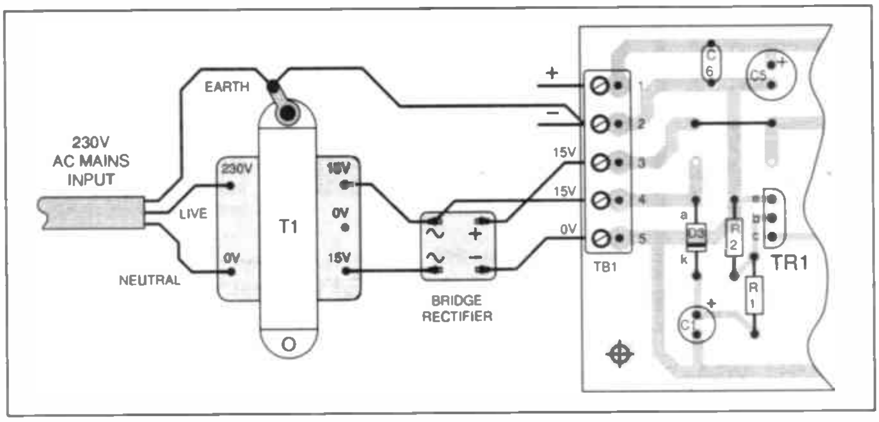


Fig.5. Modification and interwiring details for using a bridge rectifier in place of diodes D1 and D2. Note the link in place of D1.

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by Mike Tooley

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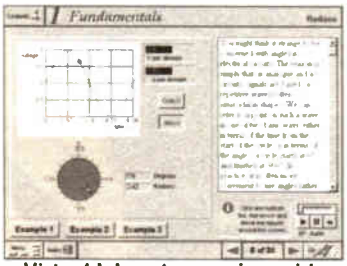
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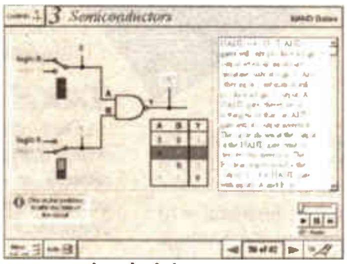
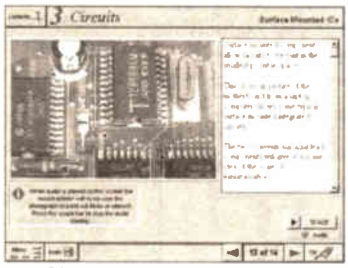

Logic laboratory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by Mike Tooley

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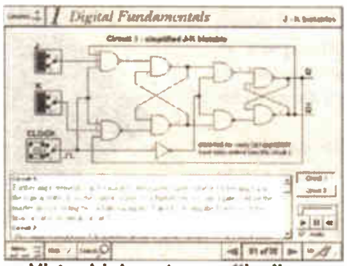
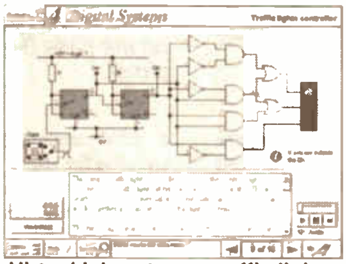

Virtual laboratory – flip-flops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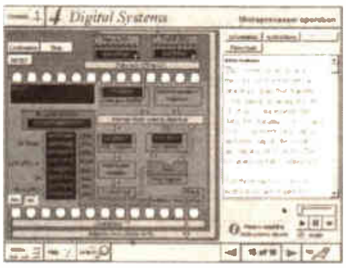
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John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

ENLIGHTENED BYTES

Dear EPE,

Perhaps I can shed some light on the "byte" subject (*Readout*, May '98) having been around personal computers for some time.

The statement that any number of bits can be called a byte is quite true and byte size is entirely dependent on the capability of the processor. This capability is generally governed by the Accumulator or Working register, but it ain't necessarily so. In the PIC, for example, there are 5-bit, 8-bit and 14-bit units which can all be addressed as a whole chunk.

Confused? We should be! The general acceptance of eight bits being a byte size has grown up because of the information it represents, i.e., the ASCII coding. Whilst strictly speaking this can be contained in seven bits there is no 7-bit processor to my knowledge. In addition, the minimum number of bits needed to represent ASCII and coincide with binary multiples is eight. Because ASCII coding is used to present actual characters on the screen or represent them in a file, the 8-bit byte was used to indicate to prospective buyers of computers the capacity of any particular machine in terms of storage and memory availability and, as such, has become the standard by which machine and peripheral equipment capacities are measured.

To further confuse the innocent, there are *words* and *long words* to contend with which are governed by the processor's instruction coding. At work I use a computer with a word length of 64 bits, whereas on a PC the word length is 16 bits with a long word of 32 bits. All of these could be called a byte because the processors involved can operate on the stated bit multiples as a single unit, but to avoid confusion and obviate pedanticism, the following table is the standard accepted for bit multiples in personal computers:

4 bits = 1 Nibble
8 bits = 1 Byte
16 bits = 1 Word
32 bits = 1 Long Word

Perhaps a *Ringo* might be used as the 64-bit term (Beatles' fans will understand!).

Colin Dietrich, via the Net

We agree with the first four definitions, but what a Starrtling suggestion for the fifth!

PIECES OF EIGHT

Dear EPE,

Originally the word *byte* was a contraction of *by-eight* and was understood to mean eight bits.

Ari Ercole, University of Cambridge, via the Net

Seems plausible, especially as bit *is a contraction of* binary digit.

★ LETTER OF THE MONTH ★

PATENTLY DIFFICULT

Dear EPE,

In your April '98 issue, you had an article on patenting ideas, *Patent Pending* by Steve Arnott. If only that article had been published earlier.

I had previously seen an advert on TV which gave me the idea for an invention. Having designed and built the prototype, I set about finding a way to get it on the market. The local library had information on patenting but not on market and licensing agreements. To my surprise my local Citizens Advice Bureau could not help either.

Then I remembered Trevor Baylis O.B.E. had been on Tomorrow's World with his wind up radio (real name *BabyGen*). Contacting TW, to my surprise they supplied me with his address. I wrote to him and received back a nice letter saying that he is in the process of trying to start an academy for inventors that will provide confidential, professional help and support for all inventors. He was unable to send me further information at that time.

Steve Arnott also mentioned James Dyson (vacuum cleaner fame) in his article. Writing to James, I again received a nice letter plus the phone number for a university – trying the number several times I just got the dreaded answering machine.

By now I am pulling out in frustration what little hair I have left. I then wrote to Tony Blair to point out the lack of help for people like myself and the money and job losses this is creating. His press secretary wrote back saying they would pass my letter to the relevant authority, namely the DTI.

The only thing left for me to do was to offer the idea to a company advertising in the national press (under a disclosure agreement as Steve Arnott suggested). They phoned me for an hour and half and now wish to take up my invention. I have since found that they are an American company and I am now waiting for contracts from the USA, and the invention looks set to go abroad with the rest of them.

I have now written to Bob Symes at the Institute of Patentees and Inventors, hoping they will advertise themselves more openly, and have asked for their advice.

So thanks to *EPE* and Steve Arnott for the address that no-one else, including the Government, could supply me with. I really wish your article had appeared one month earlier and then the invention could have stayed in the UK.

If anyone has invented something, no matter how small, take Steve's advice and don't disclose it to anyone. I don't feel my idea is a silly one, and it looks set to take off. One piece of advice I can offer is: don't ever give up, it does not happen overnight. Good luck to anyone who invents!

Please pass on to Steve Arnott my sincere thanks for a great article, and thanks to you all at *EPE* for thinking of including such an article in a great magazine. Many, many thanks!

If any readers would like to support Trevor Baylis in his quest to open an academy for inventors, then write to him for a support form: Trevor Baylis O.B.E., PO Box 5, Twickenham, Middx TW2 6RZ.

Jeff Brown, Yeovil, Somerset

We wish you every success Jeff, and to Trevor Baylis' academy as well.

HEXING THE BYTE

Dear EPE,

In various old books I have found the following definitions of a byte:

* A set of six bits, used to encode a character from a larger character set, is called a byte. Bytes of up to eight bits are commonly used. *Computers in Context* – R. Cunningham-Green.

* A character consisting of initially eight bits of information ... previously the 6-bit character had been standard ... occasionally byte is synonymous with character: in this use a byte can have six bits or even one bit. The possibility of a big-byte with nine bits was much discussed. *Computing – A Dictionary of Terms, Concepts and Ideas* – C.Cook, ISBN 09-912320-7, 1976.

* A character or byte, comprising (typically) four to eight bits. *Digital Computer Systems Principles* – H. Hellerman, 1967.

* Refers to the group of bits used to designate a single character. *Introduction to Computers* – P. Rude and J. Page, ISBN 0-07-054203-1, 1974

* A basic unit of information usually consisting of eight binary bits. *Basic Principles of Digital Computers* – V. Robinson, ISBN 0-87909-066-9.

* An 8-bit word is called a byte. *Success in Electronics* – T. Duncan, ISBN 0-7195-4015-1.

From the above it appears that the definition of a byte in the early years was six bits due to the simple computers that were used. It seems a pity that the term "big-byte" isn't used any more; perhaps the Pentium III could be called a big-byte computer.

M.J. Chilvers, Great Yarmouth, Norfolk

Your mention 6-bit bytes reminds me of another word which is commonly used to mean different things – hex. The word actually means six and is used as such when talking about, for example, a hex buffer, i.e. a digital integrated circuit having six buffers within it.

It is also used in the context of numbers expressed to the base-16: we say that a number "is in hex", when in fact we should say that it is in hexadecimal. *To actually be in hex the number would need to be expressed to the base-6.*

YET OTHER BYTES

Dear EPE,

Alan Winstanley's comment in *Readout* June '98 that "Microsoft know a thing or two about computers" made me smile. It was rather like saying that a chef who cooks vegetables knows a thing or two about horticulture. In fact, all Microsoft software was written for the Intel family of processors, with the notable exception of a version of Windows NT for the DEC Alpha processor. Both Intel and DEC Alpha have 8-bit bytes.

However, you invited readers to enter the fray, and there were processors in the past that used different sizes of byte. The DEC 10 mainframe of the late '70s had a 36-bit word, which provided a sign bit and 35 bits for binary numbers, or packed five bytes of seven bits into the same word. ICL's 1900 series of processors in the early '70s had 24-bit words, which held four bytes of six bits. In the '60s, IBM had the 1401 processor, which had six usable bits and a parity bit to each *character*: the term *byte* was not even in use then.

J.F. Warren, Bath

Fascinating!

COLOUR BLIND

Dear EPE,

Having read Martin Baxter's letter (*Readout* June '98) regarding the long established positive to negative electricity flow convention, it does seem to me that, possibly to bring the convention into general agreement with up-to-date knowledge, the colour codes should be changed about, the negative (minus) symbol then being red, and the positive black.

Until the conventions relating to electricity power supply mains wiring was changed, red signified danger, live etc., and in my personal opinion, did so more aptly than the revised colour brown does now, which colour more naturally and conventionally is suggestive of earth.

That electrons actually proceed from negative (cathode) to positive (anode) is perhaps in no other case better demonstrated than in the case of CRTs – Cathode Ray Tubes.

G.K.D. Lester,
Leicester

Regarding your first point, I cringe at the thought of swapping red and black as much as I do at the thought of the UK swapping road conventions so that we drive on the right – both are equally capable of generating carnage.

Interestingly, red, black and green are still used on the mains electricity supply before the "domestic" box. It is consumer equipment that uses (suffers from?) the brown-blue-green coding. Apparently, the colours were chosen so as to be more readily distinguished by those who are colour-blind – would anyone who is so care to comment?

OF MICE AND LICE

Dear EPE,

I built the *Micro PEsT Scarer* (July '97) with some trepidation as we have a dog as well as a thriving colony of mice in our 400-year old listed cottage. Our spaniel is 11 years old and may have lost some high frequency sensitivity as she did not appear to notice the PEsT being turned on.

The l.e.d. blinked merrily and I trusted that the oscillator was working, not having sophisticated instruments to measure it. However, I was recently listening to Radio 4 on long wave and have had the satisfaction of hearing a beat frequency whistle when the PEsT is turned on. This only happens when it is within a foot or so of my receiver, so I am not worried about interference to my neighbour's reception.

In theory, I am hearing the sixth harmonic of 32kHz, at 192kHz, beating with the 198kHz of R4-LW (curses on the man who took it away from 200kHz!). It was most comforting to have this proof of successful operation.

The best proof, though, is that the mice have promptly departed, as also did a colony of wood lice – an unexpected benefit.

Jim Marten-Smith,
Croscombe, Wells

Do readers know of other creatures that are affected by ultrasonic transmissions? Is there any evidence that bats, for example, are troubled by them? We know that moles are supposed to retreat from them.

SELL BY

Dear EPE,

Having now passed the male sell-by date, I can look back at over 60 years of experiment and electronic employment, from the humble crystal set to modern circuitry and therefore relate to the comments of Mr McGuiness in your April '98 issue.

To be fair, we of that era grew up with the much slower advance in electronics, in my case the years before WWII were only involved in crystal sets and the early valved radios, while a few rich experimenters delved into the mechanics of mechanical TV.

Components were relatively inexpensive, a 2V filament valve around 25p, a 120V HT battery 35p, but if you were lucky enough to have a job, wages might be around £1.50 a week – in 1941 I was getting £1.35 for a six day week. Components were therefore highly treasured, the best performance possible achieved from them and, in the process, a better understanding of their capabilities. The most satisfying circuit I have ever built was my first 0-V-1 receiver.

Postwar brought a surfeit of Service equipment, often huge, heavy and power hungry but a source of many components; originally very expensive. Magazine articles dissected some of these units and gave us a good basis for TV, oscilloscopes etc., and surplus test equipment gave an impetus to real understanding of the then circuits.

Today we take a multi-legged i.c., stick it on a p.c.b. or prototype board and if it does not work as expected, dump the lot and try something else – the age of throwaway radio is a commercial example. Letters sent in by some erstwhile experimenters to various magazines indicate that while not really understanding the basic principles of the project they have built, they lack the patience and real interest in solving problems – many older experimenters will tell you that ideas on problems often come during the night, whether many spouses appreciate this I could not say.

The advent of published projects with a minimum of information and with p.c.b.s and components supplied does not help this situation if faults appear and a situation arises where a most sophisticated piece of equipment is being built while the experimenter lacks any trouble-shooting experience.

The ability to solder properly, preferably using a temperature controlled iron is a most necessary requirement and this cannot be practised in the first instance on densely printed p.c.b.s. Simpler circuits built on Veroboard etc. are an ideal way to learn this art, although the end product may not be the latest all-singing all-dancing project.

Finally, can a PC, however good the software is for projecting the design and simulation of a circuit, really be considered capable of testing every circuit? Who has never built an RF design from a printed source and found that it does not work as anticipated because stray inductance, capacitance etc. have not been taken into account?

It can be argued that if any training source, whether educational, commercial or hobbyist is not prepared to have available at least an oscilloscope, multimeter, counter, signal generator and variable p.s.u.s as a minimum requirement, then there is little hope for the future. Second-hand equipment at reasonable prices is always available, often at radio rallies. Or (horror of horrors), why not build them ourselves, as many did in the past? But of course not many magazines publish these types of circuits nowadays.

Norman L. Smith,
Stoke on Trent

It is hoped that you don't actually include EPE *in the category of mags that give inadequate information. We try extremely hard to make the information we offer clear and understandable. Discretion has to be used, however, about what depth of description we go into with projects. They are, after all, intentionally varied in their complexity to suit different levels of knowledge amongst our broad-based readership.*

We also hope that you have not overlooked our fairly frequent presentations of test gear projects. There's not a lot of test gear suited to hobbyist workshops that has not been published in recent years. Subjects cannot be repeated too frequently, of course, but we do recognise the need to repeat (in updated form) some subjects from time to time in order to cater for recent newcomers to electronics.

Suggestions are welcome, though, and if any of you want to tell us what you are missing, do so! We have ears, eyes and E-mail and we use them all – so there's really no excuse for not contacting us!

WEBBED PIC

Dear EPE,

Thank you for publishing my *Dice Lott* project in the May '98 issue. It looks very nice and it is really great to see it now in its final form in the magazine. You all seem to show great enthusiasm for PICs and your *PIC Tutorial* (until now I found l.c.d. programming rather elusive)!

It appears that *EPE* is really taking the PIC on board. I wonder, therefore, if your readers might be interested in the web site I have set up for PIC users (especially beginners) which is at: **http://members.aol.com.LearnPIC**.

The web site was originally intended as a supplement to my *PIC Beginners Guide* published by Butterworth-Heinemann in May this year (in which I naturally recommend *EPE* as a regular source of PIC projects and ideas) but is completely general in scope and does not rely in any way on knowledge of the book.

John Morton,
Radley, Oxon.

Yes, we do have a great deal of enthusiasm for PICs and try to encourage others to do so as well – as you appear intent on doing too. Glad you like our presentation of your work. Good luck!

Another PIC site worthy of readers' attention is David Tait's. He has an astonishingly thorough site full of info, software and links to other PIC sites. You will find it at **http://www.man.ac.uk/~mbhstdj/piclinks.html**.

HOT TIPS

Dear EPE,

In the main, I agree with Mark McGuiness (*Readout* April '98) and fully endorse the last paragraph in his letter, but must take him to task over his assertion that many of us are "switching off our soldering irons and switching on a PC instead".

Let me state unequivocally that computers are no substitute for soldering irons. Invariably, the power lead of a standard PC is too short to facilitate comfortable handling, while the temperatures achieved by this piece of kit are of little use for anything other than soldering choc-blocks. All my previous attempts to raise the tip temperature, (indeed to *find* the tip) have resulted in system failure. Truly a one-shot hot-shot.

Irony aside, two serious requests for your readers: firstly, can anyone help me with a circuit to reproduce the sound from a large ship's horn, super-tanker type – two-tone in the low registers with an output that can be amplified by a separate unit?

Secondly, a circuit to achieve stereo sound from a modern TV, to be added on to the existing board and powered by the set?

Someone out there has the answers – may the farce be with you!

Robert Owen,
Liverpool

Have you overlooked the fact that modern computers have fans built in? You'll never do successful soldering with a fan nearby!

As to horns though: in the days when I knew Liverpool it still had shipping and I would have suggested using a tape-recorder as the starting point (actually a wire-recorder, in my day!), although of course super-tankers were undreamed of then.

Tragic, isn't it, that the atmosphere of a once great port now needs to be electronically simulated. Can any readers offer sources or circuits? If so, and the latter are your own design, send them to our Ingenuity Unlimited *column for possible inclusion. You could even earn a bit of money from them.*

Ain't life a hoot!

Whether you are positive, negative or just plain controversial – write to us!

Techniques
ACTUALLY DOING IT!
by Robert Penfold

LIKE practically every pastime, electronic project construction tends to throw up the odd puzzle every now and then. I suppose that these built-in "Chinese" puzzles help to make the hobby more challenging and interesting, but they are probably not viewed in that way by the average beginner.

Although you may occasionally encounter a problem that seems to be totally baffling, there is usually a simple and straightforward answer. In this month's *Actually Doing It* we will consider some of the more common examples of puzzles that bring in requests for help from readers.

Socket To Me

Although sockets probably represent the most basic of electronic components they can still produce a few surprises. One problem is simply that there is now a huge range of available types, plus variations on each type, and you have to be careful to obtain precisely the right socket for your project. Make sure you do not inadvertently order (say) a printed circuit mounting socket when it is a panel mounting type that is required.

Jack sockets certainly seem to have proliferated over the years. When I first became involved in electronics there was just the standard (6·35mm) variety, but now there are additionally 2·5mm and 3·5mm types, plus stereo versions in each size. At one time there was a major problem with the 3·5mm plugs and sockets due to physical incompatibilities. This seemed to revolve around the length of the plugs, and there were two distinct sizes in circulation.

The real problem arose if you tried to use a "short" plug with a "long" socket. In some cases everything seemed to be all right, but the plug did not actually connect to the socket properly. In other instances the socket would simply spit out the plug after a few seconds!

This problem is not very common these days, but it does crop up occasionally. In recent times I have encountered several microphones and computer sound cards that refused to "talk" to each other due to incompatible 3·5mm jack connectors. If you are failing to get any input to or output from a project the input or output connectors are the first things to investigate.

Jack connectors are by no means the only ones that give occasional problems with unreliable connections. It is something that can happen with virtually any type of connector, and I have recently had problems with phono sockets that barely connect to most phono plugs. There seems to be no easy solution to this kind of problem, and it is just a matter of replacing either the plugs or the sockets with a different make in the hope of obtaining better results.

Switch

Probably the main cause of problems with jack sockets is that they exist in switched and plain varieties. Standard jack sockets are usually fitted with a two-pole on/off switch, but the two smaller sizes of jack socket mostly have only a single pole switch. Either way, the intended purpose of the switch is to turn off an internal loudspeaker when a pair of headphones is plugged into the jack socket. This is a feature that is little used these days, and the tags associated with the switch contacts are often left unused.

Many beginners seem to get worried when confronted with components that have tags or pins that connect to nowhere. In the vast majority of cases there is no error, and I would guess that most projects have at least one component with "spare" pins or tags.

Constructors sometimes run into difficulties with insulated (plastic bodied) switched jacks because they assume that the two pairs of tags simply connect together internally, and that it is safe to use either set. Checking the socket using a continuity tester is likely to confirm this belief. Unfortunately, if you choose the wrong set of contacts the socket effectively disconnects itself when the plug is inserted! The correct method of connection for an insulated jack socket is shown in Fig. 1. This also shows connection details for open construction switched 3·5mm jack sockets.

Socket And See

It is clear from some readers' letters that the apparently baffling results they are obtaining is simply due to something like a switch or socket that has some crossed over connections. As I have pointed out on many previous occasions, it is usually quite easy to sort out the connections to mechanical components such as plugs, sockets and switches using a continuity tester. This is just a matter of testing for continuity between each tag and all the other tags.

With a switch this process should be repeated at each setting of the switch, or in the case of a switched socket it should tried with and without the plug in the socket. You can also check which tags of the plug connect to which tags of the socket. In this way you soon determine the function of each tag, and check that everything is functioning properly.

If the component in question was bought from one of the large component retailers it is worth looking in their catalogue to see if there is a connection diagram for it. This could save you some time and effort.

Unlike most plugs and sockets, there is no standard method of tag numbering for jack connectors. With most other types of connector each pin is given a number which is normally included in wiring and circuit diagrams. This can help to avoid confusion, but it does not guarantee hassle-free wiring.

Symmetrical Confusion

Many connectors are symmetrical, which leads to confusion about whether they are shown viewed looking at the front, or the tags at the rear. In general, connectors are shown looking at the side to which you will make the connections, or

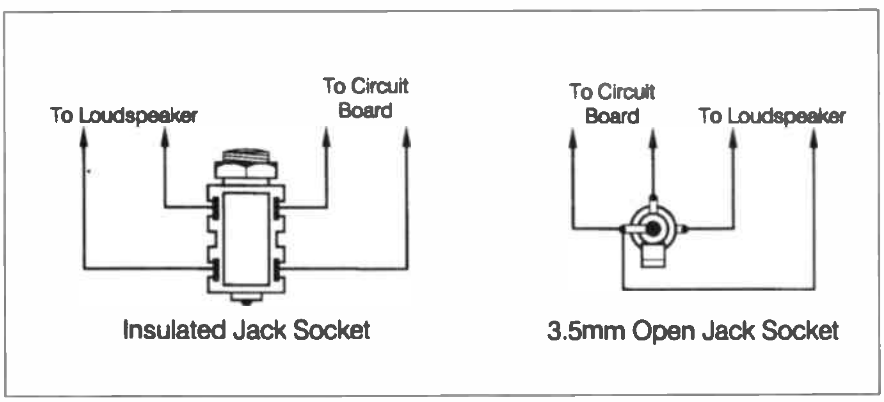


Fig.1. Connection details for insulated and open 3·5mm jack sockets. The two sets of tags on an insulated socket are not interchangeable.

looking onto the tags at the rear in other words. Unfortunately there are a few exceptions, and computer connectors are sometimes shown as front views.

Ideally the main text or captions would always state whether connectors are shown as front or rear views, but this information is often lacking. This is where pin numbers are more than a little useful, because they are marked on most connectors. The numbers are inevitably very small, so you will probably need a magnifying glass or a loupe in order to see them. By comparing the pin numbers on a diagram with the numbers on the socket itself, there should be no difficulty in determining their relative orientations.

Lead Astray

Virtually all semiconductors are available in more than one encapsulation, and in most cases the various versions of a device have a different suffix on the type number, or even a totally different type number. There are one or two exceptions though, and I have to admit that I do not know why certain transistors are available under the same type number with more than one encapsulation style.

The main offenders these days are junction gate field effect transistors (j.f.e.t.s) such as the 2N3819 and BF244. These originally had a TO92 plastic encapsulation with the leadout configuration shown in Fig.2(a).

Unfortunately, the early leadout diagrams for the 2N3819 showed the drain and source leads the wrong way round. Intriguingly, 2N3819s connected round the wrong way often worked quite well! This is apparently due to the virtually symmetrical structure of j.f.e.t.s.

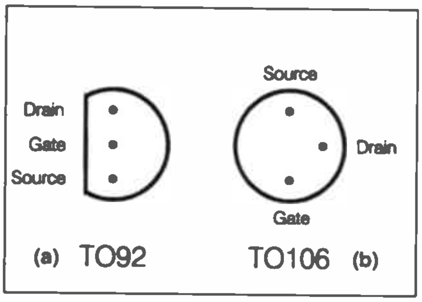


Fig.2. Leadout diagrams for both styles of 2N3819/BF224 j.f.e.t.s. These are base views.

Most 2N3819, BF244, and similar j.f.e.t.s are still supplied in TO92 encapsulations, but there are some "budget" devices which have a different plastic case and the leadout configuration of Fig.2(b). Most of these components carry exactly the same type number as the standard TO92 versions, but the type number is sometimes slightly different (KE3819 instead of 2N3819 for example). I have used quite a few of these budget f.e.t.s over the years and they have always worked every bit as well as the "real thing."

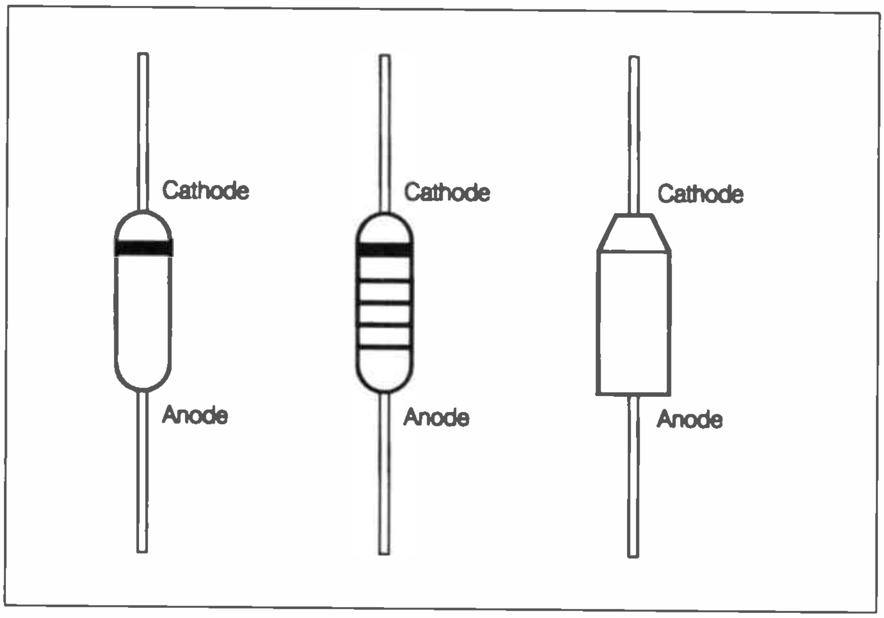


Fig.3. Three methods of indicating the polarity of a diode.

It is perhaps worth making the point that Fig.2 shows base views, as is the convention for transistor leadout diagrams. In other words, they are shown as viewed when looking onto the leadout wires. This is the opposite of the convention for integrated circuit pinout diagrams, which are normally top views.

Getting the Point

In component overlays the polarity of a diode is normally indicated by a band at one end of the body to indicate the cathode lead. This normally ties in nicely with the actual diode, which also has the band marked at one end of the body. However, from time to time you may be faced with a diode that has several bands or none at all.

Some diodes are marked with four or five coloured bands. In some cases the bands indicate the type number of the component using a colour code based on the resistor colour code (yellow – brown – yellow – grey for a 1N4148 for example).

Some diodes have additional bands, which have no obvious meaning. One of the bands should be much thicker than the others, and this one indicates the cathode lead in the usual way (Fig.3).

Larger rectifiers often have their polarity indicated by a tapering of the body at the cathode end, and this method is now used for some smaller rectifiers and even diodes. You are most likely to encounter this type of encapsulation when using Zener diodes, but it may well be used for other types as well.

It is also used for diacs, which are found in power controller circuits to trigger thyristors and triacs. This could give the impression that diacs have to be connected the right way round, but they are actually bi-directional, and the pointed end of the casing is irrelevant.

Requests for sources of supply for obsolete parts seem to form a large percentage of the readers' letters I receive these days. Unfortunately, some of the parts for many "golden oldie" projects are simply not available any more. For some projects there are near equivalents, or more modern versions that can be used in place of the obsolete components.

Alternatives

This is a list of useful alternatives for some parts of yesteryear.

For TIS43 or any obsolete unijunction transistor (u.j.t.) use a 2N2646 (but you may have to tweak the value of the timing capacitor).

For BC650 low noise high gain *npn* transistor use BC550.

For 2SJ49 power MOSFET use 2SJ114

For 2SK134 power MOSFET use 2SK400

For 2SB646A power MOSFET driver use 2SB716

For 2SD666A power MOSFET driver use 2SD756

For 40673, 3N140 and 3N141 dual gate MOSFETs use any modern dual gate MOSFET (if you can find one), but you may have to improvise with a surface mount type.

For 40, 50, 75, and 80 ohm high impedance loudspeakers use a 64ohm type.

For obsolete general purpose *npn* silicon transistors use BC547.

For obsolete general purpose *pnp* silicon transistors use BC557.

No No I.C.s

There are numerous specialist integrated circuits that are no longer available, and have no current alternatives. Even where a similar device is currently available, using it in place of an obsolete part is likely to require a complete redesign of the project, with no guarantee of eventual success.

As we always advise, do not start buying the components for an old project unless you are certain that they are all still available.

TEACH-IN '98

An Introduction to
DIGITAL ELECTRONICS

Ian Bell, Rob Miles, Dr. Tony Wilkinson, Alan Winstanley

TEACH-IN is a series designed to support candidates following City and Guilds (C&G) 726 Information Technology, with reference to the following specific syllabuses: ***7261/301 Introductory Digital Electronics, *726/321 Elementary Digital Electronics, *726/341 Intermediate Digital Electronics.**

Even if you are not undertaking the City and Guilds syllabus, there is much to be learned from *Teach-In*.

Lab Work

Throughout *Teach-In*, attempts are made to involve the student with practical "Lab Work" experiments and demonstrations, and complex mathematics will be avoided unless really necessary – and even then, plenty of help is to hand! We make a point of identifying practical components in special sections of *Teach-In*, so that you will learn to recognise parts.

Part Ten: SHIFT REGISTERS, THE FINAL STORY

IN THE last part we considered shift registers, and the way in which you can send data through them. In this part we look at other tricks you can play with these useful devices.

Shift Registers in a Loop

Consider a shift register connected in a loop (i.e. SDI and SDO are wired together). If we use the flip-flop's set and reset inputs to set up a particular bit pattern in the register at power-on then this pattern will circulate as the register is clocked. An example of this is shown in Fig.10.1 in which the shift register is initialised to 1000 and produces an output sequence of four repeated 4-bit patterns.

The output sequence, waveforms and state diagram are also shown in Fig.10.1. Note that the circuit cycles through only four states although 4 bits are capable of holding 16 different states. The circuit in Figure 10.1 is a counter, it cycles through a fixed sequence of states. Counters like this, built from shift registers are often called *ring counters* to reflect the way in which the shift register is connected head to tail to form a ring.

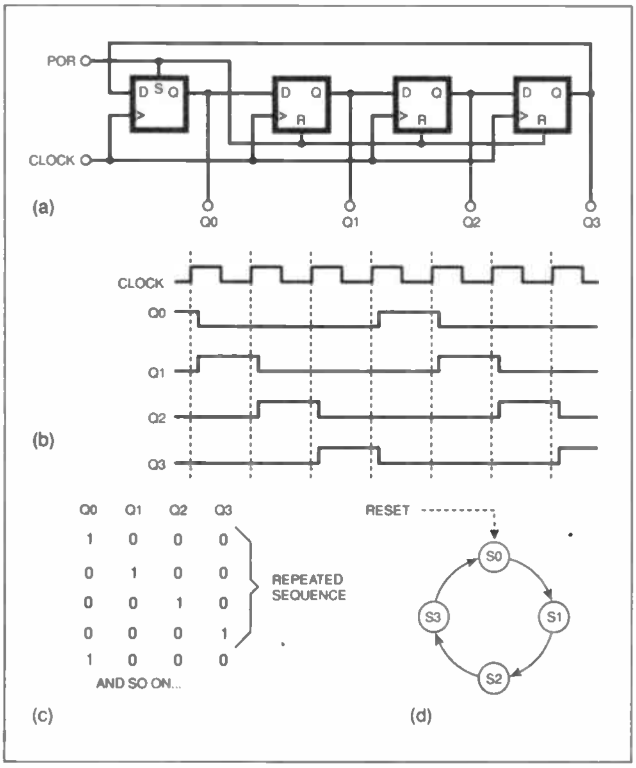


Fig.10.1. Ring Counter: (a) circuit diagram; (b) timing waveforms; (c) output patterns and (d) state diagram.

The state diagram in Fig.10.1(d) is basically the same as that for a 2-bit binary up counter, but the circuit is obviously different, as is the output sequence. To fully define a circuit we need to specify its *state coding* and *output coding*.

Both circuits in Fig.10.1 and Fig.10.2 cycle through four states for which we have chosen arbitrary names (S0, S1, S2 and S3). They differ in that the binary counter *codes* the states as a binary number (*binary coding*) and the ring counter *codes* the states such that we are in state *n* if bit *n* is 1 with all the other bits 0. The ring counter is said to use "one-hot" state coding.

If we connect an l.e.d. to each output from the ring counter we would see the light "jump" from one l.e.d. to the next as the counter counted up. The lit l.e.d. corresponds to the "hot" bit. If we connect l.e.d.s to the outputs of a binary counter we would see the binary bit patterns which represent the states as the counter counts.

Lord Faversham Wills is interested in creating a moving light display for his next family disco. He will use a ring counter to achieve this.

In all our circuits so far we have connected our outputs (Q0, Q1 etc) directly to the flip-flops. This means the outputs in any particular state are the same as the state code for that state. We need not necessarily do this – we can apply an output coding. Put simply, we use a combinational circuit to connect the values in the flip-flops to the outputs we require.

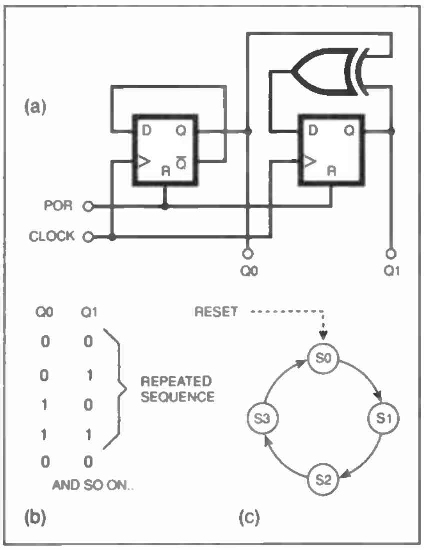


Fig.10.2. Binary counter: (a) circuit diagram; (b) output patterns and (c) state diagram.

Check Out: Opto-Electronics

The branch of electronics related to opto-electronics technology is one of the most fascinating and interesting to experiment with. It involves a variety of opto-electrical transducers – devices which convert electrical energy into light, or vice versa.

Light Emitting Diode

The light-emitting diode (l.e.d.) is probably the most ubiquitous example: unsurpassed for reliability, these universal solid-state indicators are manufactured in a variety of shapes, sizes and colours. They seldom fail and use very little power compared with, say, a filament bulb.

The actual electro-chemistry utilised by the manufacturer offers the ability to provide *red, yellow, green, orange, blue* and now even a *white* l.e.d. By incorporating different l.e.d. "chips" into the same moulding, multi-colour devices can be created and l.e.d.s are also used, of course, as "segments" within a seven-segment or alpha-numeric display.

Dot-matrix style "intelligent" displays include additional logic circuitry which decodes signals before displaying them. The first digital watches of the 1970's (debuted to the world in a James Bond film) used seven-segment leds and had a voracious appetite for batteries – the joke of the time was that they needed "a jump-start on a damp morning!"

Infra-Red

Infra-red (IR) devices rely on light which is invisible to the human eye. IR components are sensitive to wavelengths of 770nm to 950nm (nanometres): your TV remote control is a typical example where an IR emitter transmits control signals to an IR detector fitted on the TV set. Intelligent IR detectors are produced which incorporate an amplifier and decoder, all in one transparent package.

Light is also used as the ultimate safe method of isolating one part of an electrical system from another. For example, a low-power digital system might generate logic-level control signals which are needed to control a mains-powered load.

By using an opto-isolator (or opto-coupler), the control signals are used to drive a low-power opto-emitter whose light signals are then received by an opto-detector mounted in the same package. This in turn controls the mains load via, say, a triac (a solid-state bi-directional controller rectifier) so there is no direct connection between the mains and the digital control system.

Opto-couplers are usually made in dual-in-line packages, and other types include a transistor or logic level output, which might be used to avoid direct connection to an external copper wire telephone line, for example.

Photo-sensitive

Photo-transistors and photo-Darlingtons are light-sensitive devices which are triggered into conduction by the application of light. A photo-diode responds to light by generating a tiny current of a few microamps, when light of a suitable wavelength strikes it.

Such a device forms the receiver in a fibre-optic system, which uses a plastic fibre as the medium to transmit signals, for many miles if necessary. A light-emitting diode will be used as the transmitter to send light signals into the fibre, either at visible light or IR wavelengths.

The many advantages of using light as a transmission medium are illustrated by the fact that the UK Energis communications network uses fibre-optic cables wrapped around National Grid overhead power cables, in order to transmit data around the country. This avoids the expense of laying underground wires, and since light cannot be affected by electrical interference, the system is infinitely more reliable than copper wire, and faster, too.

Laser Diode

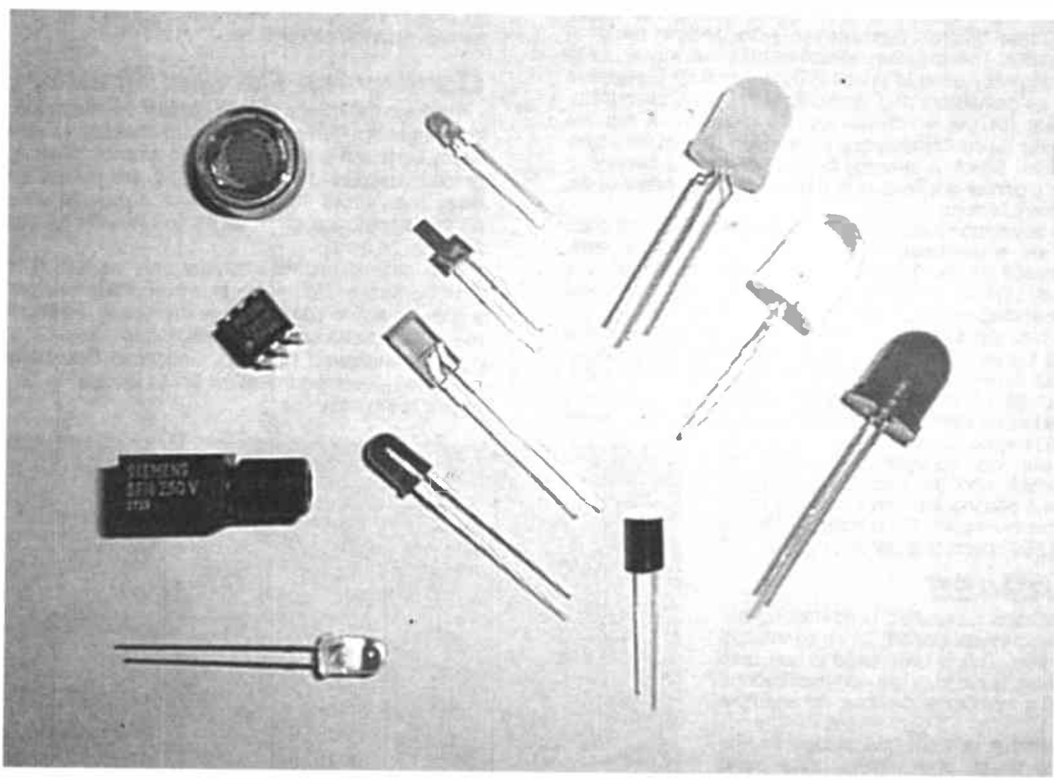
Laser diodes are highly developed devices which produce a pure visible light of such intensity that it may be used for high-precision cutting or engraving. For instance, the ultra-precise resistors used in test equipment may be "laser trimmed" for accuracy, or lasers may be used as "laser pointers" for lectures or presentations.

Lasers are the ultimate solution for range-finding, and are used by surveyors or earthquake monitoring stations, car speed traps or weapons targetting systems. Laser products of all forms can be extremely dangerous if abused ignorantly – as the saying goes, "do not stare into laser with remaining eye."

Light-Dependent Resistor

Less glamorous opto-electronic components include light-dependent resistors (l.d.r.), which are small cadmium-sulphide sensors whose resistance falls when incident light levels increase. They form an ideal light-level monitoring device, and a typical application might be to control lighting which turns on automatically at night.

Be sure to check the "Opto-Electronics" section of a major supplier's catalogue to see the variety of devices now available to the electronics user.



A range of opto devices; the left hand column from top to bottom are an ORP12 light dependent resistor, a d.i.l. opto-isolator, an infra-red fibre optic emitter and a phototransistor. The remaining devices are various types of l.e.d. surrounding a silicon photodiode.

Sending Data in Serial and Parallel

When you wish to send data from one place to another you can send it as either *serial* or *parallel* data. Serial data can be used to transfer data over long distances, particularly where modems are used. Parallel data is more often used to send data between items of equipment which are close to each other.

Serial Data

There are numerous serial data standards and ways of working. As we saw in Part 9, a clock signal is required to *synchronise* the transmission and receipt of the stream of bits which makes up our serial data. If both the sender and the receiver are synchronised by means of a clock signal the data transfer is referred to as *synchronous*. If there is no clock signal the two systems each have a clock and count from the start of a data frame. In this case the transfer is referred to as *asynchronous*.

The asynchronous data transfer is less efficient, because there must be a gap between each packet of data and the next, to allow the clocks at each end to re-synchronise.

When considering serial data transfer, a UART (Universal Asynchronous Receiver/Transmitter) chip is often used to move the data around. This can be loaded with parallel data which it sends down a serial output. It also contains the receiver to convert an incoming serial bit stream into parallel data. Popular UARTS include the CDP6402 and 16550.

Serial RS232C

Perhaps the most common form of serial interface in use is often referred to as RS232. This has been around since the very early days of computing. It is one of a family of serial protocol standards which were laid down by the Electronic Industries Association in the United States. The current version is at Revision Level C and in Europe it is also known as V24, this being the number of the CCITT (Comité Consultatife International Télégraphique et Téléphonique) recommendation which also defines it.

The full standard defines the kinds of plugs and sockets to use (e.g. the familiar 25-way D-type) and the role of each of the signals in the connector. It also defines the voltage levels to be used in the signals and the form the data may take.

Up to 8 data bits are sent, with a single *start* bit at the start and one or two *stop* bits. In addition a ***parity bit*** can be added to the data which allows single bit errors to be detected. RS232 operates at the voltages +12 volts (which means space or 0) and −12V (which means mark or 1). This can be a problem in that digital system uses levels of 0V and 5V to denote logic states. The simplest way of solving this is to use a line converter such as the popular MAX 232 series. These generate the required voltages internally, and are powered from a single 5V supply.

The problem with RS232 is that the signal standard is widely abused, with many different forms of connector and pin designation for the signals. This is further complicated by the way in which RS232 was originally used to connect Data Terminal Equipment (DTEs) such as computers and terminals with Data Communication Equipment (DCEs) which are usually modems. A modem converts a serial digital signal into a form which can be sent over another medium which is usually, but not always, a telephone line. Whether a printer is a DCE or a DTE is largely a matter of the whim of the manufacturer.

RS232 is asynchronous, in that the source and destination must agree on a particular rate at which the data is sent. This is expressed as the ***baud*** rate, baud being either "Binary Asynchronous Unit of Data" or a tribute to teletype pioneer E.Baudot depending on which history book you read.

The baud rate gives you the number of bits per second which are sent, and the rate starts at 75 baud (very slow) and progressively doubles through 150, 300, 600. 1200, 2400, 4800, 9600, 19·2 kilobaud, 38·4 kilobaud and so on. Other baud rates have also appeared as modems have been created which can transfer data at other, specific, rates.

To find out the approximate number of characters which can be sent down a serial connection in a second you can divide the baud rate by 10. For example a 9600 baud line could send around 960 characters per second.

Serial RS485

The RS485 serial standard is interesting because it allows several stations to be connected to the same wire. This is often used in networks where you want to run a single communications cable around a number of devices, for example in a factory.

For this system to work one station on the network has to be the master, and send commands out which are addressed to specific devices. All the devices will receive the serial data, but only the one to whom the message is addressed will respond.

Ethernet

Ethernet signals are used to network computers together. The data is sent serially onto the network and has a clock signal superimposed upon it. This technique, called "*self clocking data*", makes it possible to send large sequences of bits without the sender and recipient clocks getting out of step and corrupting the data values.

Ethernet devices "fight" over the network in that there is no master, but if two stations start to talk at the same time they will notice that they are competing and then back off.

Modems and Serial Data

A **modem** (MODulator/DEModulator) is used to transfer serial data over a communications medium. A serial data stream is simply a sequence of transitions between the 0 and 1 states. This data stream is sometimes sent directly over the connection, in which case the data transfer is called *baseband*. However, it may be necessary to modulate the signal so that it can be sent over the communication medium. Modulated signals are sometimes called *broadband*.

The early telephone modems were made from a pair of oscillators, which produce different frequencies. The modem would produce one tone or the other, depending on whether a 0 or a 1 was being sent. At the receiving end a pair of tuned filters produce a 0 or a 1 depending on what was heard.

Lord Faversham Wills could use this as a way of talking to his gamekeeper over long distances. If they each have two whistles, a high one and a low one, they can send streams of 0s and 1s to each other. (It helps if the gamekeeper is good at binary arithmetic and understands the ASCII character codes.)

Using just two frequencies and a single amplitude (volume level) is easy and cheap to implement, but it is not able to send data very quickly. Current modems transmit more than one bit at a time, because they use different frequency, amplitude and phase for each data item. Modern modems are in fact extremely complex devices which make use of Digital Signal Processing (DSP) techniques to cram as much data as possible into the limited bandwidth of a telephone line.

Telephone modems are not the only kind, data signals are also modulated for radio transmission and, in a broadband data network, to be transferred at a particular frequency over a backbone cable.

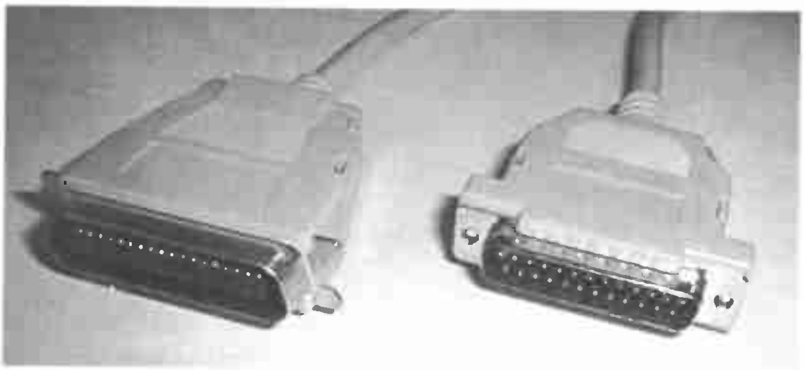
Parallel Data

A parallel data bus is made up of a large number of data signals and a set of control signals. The Faversham Wills Domestic Command System described in Part 8 is an example of a parallel data transfer system.

Centronics Parallel Printer

Perhaps the most common parallel interface was developed by the printer firm Centronics. It uses 8 data bits to indicate the ASCII character which is to be printed. In addition there is a **strobe** line, which is used to clock the data into the printer, and **Ready** and **Busy** lines which the printer uses to provide status information. All the signals are given at 5V levels, which limits the distance they can be sent.

The original parallel interface only allowed 8 bits to be sent from the host to the printer. However, the printer port has become a popular way to connect other devices to a computer. In order to make it easier to send information from the device into the computer an improved standard, Enhanced Capabilities Port (***ECP***) has been developed to allow 8 bits of data to be sent from the printer to the host.



PC printer lead; (left) Centronics-type printer connector, (right) 25-way D-type connector.

To illustrate this look at Fig.10.3. Here we have a 2-bit binary counter with an output circuit which gives the same sequence as the ring counter. We also have a ring counter whose output is coded to give binary.

Johnson Twist

A subtle twist on the idea of the ring counter is to invert SDO before it is fed back into SDI. This is shown in Fig.10.4. The counter is reset to 0000 at power-on and gives an output sequence shown in Fig.10.4(b).

This circuit is called a *"twisted-ring counter"* or *"Johnson Counter"*. Using *n* flip-flops gives us *2n* states, unlike the basic ring counter which has *n* states for *n* flip-flops. If you look at the output states in Fig.10.4(b) you will see that we no longer have a single "hot" bit.

However, by careful study of the patterns you will find that you can decode 10 different "hot" bit outputs by using a single 2-input AND gate per output (note that for this to work you need to use the $\overline{Q}$ or inverted outputs as well as the Q outputs). As an example, the first state (0000) is the only state where both the first and last outputs are 0 together, therefore an AND gate connected to the first and last $\overline{Q}$ signals will decode that state.

The popular 4017 chip uses a 5-stage Johnson counter decoded to give a 1 of 10 output.

When you build a Johnson ring counter you may not need the inverter shown in Fig.10.4. If the shift register uses D-type flip-flops just use the $\overline{Q}$ output from the final stage. If JK flip-flops are used, cross over (twist) the outputs of the final stage as shown in Fig.10.5.

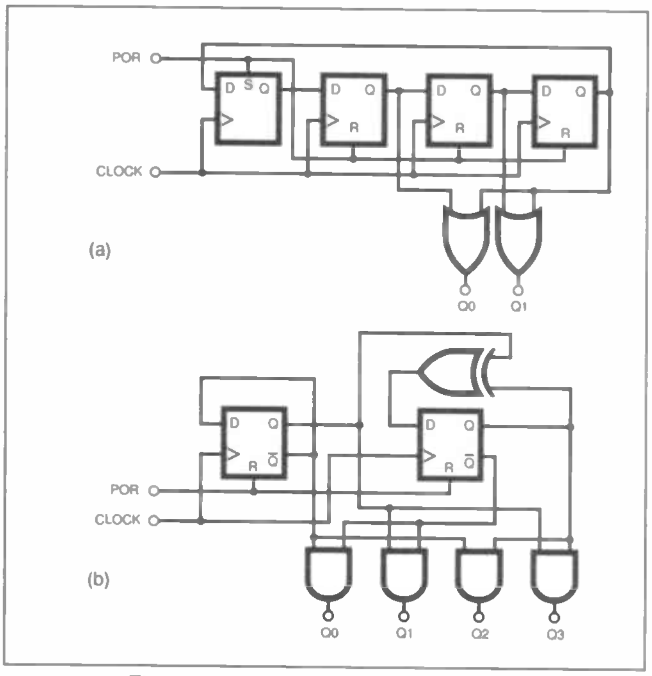


Fig.10.3. Ring counter and binary counter: (a) 4-bit ring counter with output coding to produce 2-bit binary; (b) 2-bit binary counter with output coding to produce a 4-bit "1-hot" code.

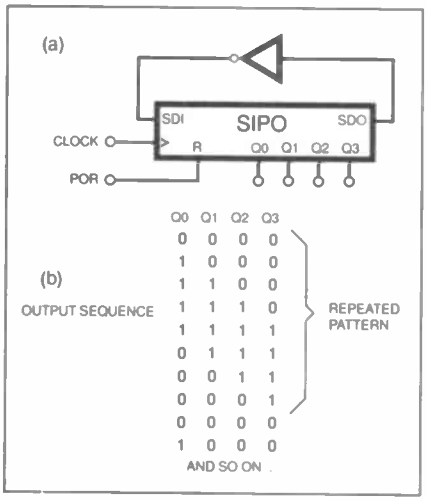
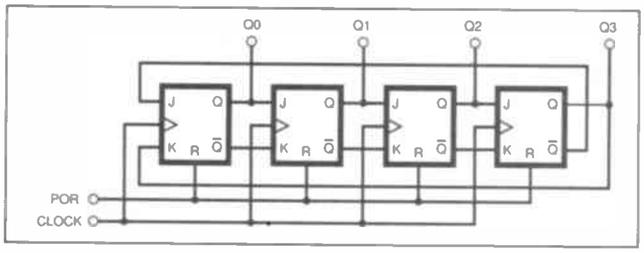


Fig.10.4 (left). A 4-bit Johnson counter: (a) circuit diagram; (b) output sequence.

Fig.10.5 (right). A 4-bit twisted-ring counter using JK flip-flops.



- THE AUTHORS -

Teach-In has been co-written for *Everyday Practical Electronics* by Ian Bell, Rob Miles and Dr. Tony Wilkinson, who are lecturers in the Department of Electronic Engineering at the *University of Hull*, England. Regular readers will know Alan Winstanley, of course, as our Web master and On-Line Editor and as the author of several columns in *EPE*. Alan has co-ordinated the series.

RETURN OF ANALOGUE ELECTRONICS – THE OP.AMP

Lord Faversham Wills has recently been pondering analogue and digital signals, with specific reference to his nephew, who is presently teaching himself to play the trombone. A trombone is a brass instrument which can play different "musical" notes by means of a sliding section of the tubing. As Lord F has discovered, the slide can occupy an infinite number of possible positions, making it possible to play an infinite number of notes. Thus we can say that a trombone is an '"analogue" instrument.

At present, his Lordship is trying to persuade his nephew to switch instruments and instead learn the piano. A piano has the advantage that only preset note frequencies can be produced, making it "digital" in nature. (You can also obtain electronic versions which can be played through headphones!).

In the early parts of this course we described how electronic signals are essentially analogue in nature. However, we then moved on to a strictly digital interpretation of the analogue values. In this part of the course we are going to re-visit the analogue world, and look at the ways digital and analogue can interact.

Analogue Electronics and Amplifiers

We are going to start our consideration of analogue signals with a look at the way in which these signals can be amplified.

An amplifier is an analogue device which produces a larger copy of an input signal, where "larger" may mean increased *voltage, current* or *power*. In this discussion we will only consider voltage amplifiers.

A voltage amplifier multiples the voltage of its input signal by a constant factor called the ***gain***. The symbol for an amplifier is shown in Fig.10.6.

For an amplifier with a gain of A we can write $V_{OUT} = A \times V_{IN}$. The gain may be positive or negative, if it is negative we have an inverting amplifier. Fig.10.7 shows typical amplifier input and output signals, in this case for amplifiers with gains of 2 and −2.

Note that the signals are measured with respect to ground (0V) and that the signals contain both positive and negative voltages. This is in contrast with the logic circuits we have studied so far, which use positive voltages only.

In order to handle signals of both polarities amplifiers commonly have two power supplies – one positive and the other negative. However, it is

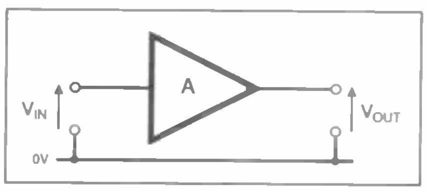


Fig.10.6. Amplifier symbol.

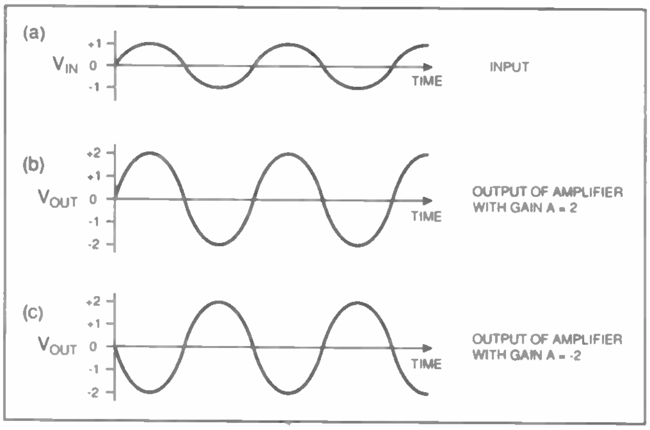


Fig.10.7. Amplifier gains.

possible to design "single supply" amplifiers in which the signals are referenced to a point half way between the ground and the supply voltage.

In general amplifiers cannot output voltages larger than their supply voltages so as the magnitude of the input is increased the output increases until part of the waveform reaches the supply voltage, at which point it can increase no further. This results in clipping of the waveform at which time the amplifier is said to *saturate*. This is illustrated in Fig.10.8.

Input is as V_{IN} in Fig.10.6, gain $A = 20$, supply is $\pm 15V$, therefore clipping occurs at $\pm 15V$.

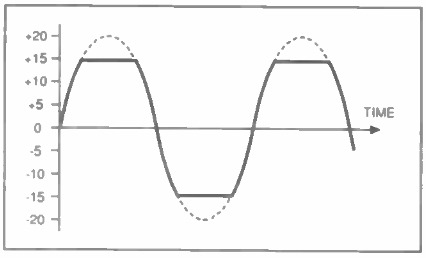


Fig.10.8. Example of clipping.

Differential Amplifiers

It is often convenient to have an amplifier which amplifies the difference between the inputs rather than just the signal at a single input. By doing this, errors (e.g. "drifting" with temperature or interference "pick up") which affect both inputs equally are cancelled.

Such amplifiers are called ***differential amplifiers*** and have an input given by: $V_{OUT} = A(V_{INP} - V_{INN})$ where V_{INP} is the signal at the non-inverting (+) input and V_{INN} is the signal at the inverting (−) input. The symbol of the differential amplifier is shown in Fig.10.9.

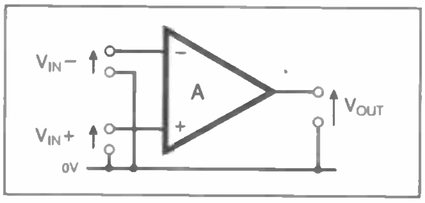


Fig.10.9. Differential amplifier.

Operational amplifiers **(op.amps)** are differential amplifiers with very high gain (for op.amp chips this is usually at least 100,000 but sometimes more than 20 million). The key thing about op.amps is that they are usually used in closed loop configuration where a proportion of the output is fed back to the inverting input.

This negative feedback results in an amplifier which has a much smaller gain than the op.amp itself, but this gain depends only on the feedback components, not on the op.amp's gain (assuming its gain is large). This technique leads to the "classic" inverting and non-inverting op.amp amplifier circuits shown in Fig.10.10.

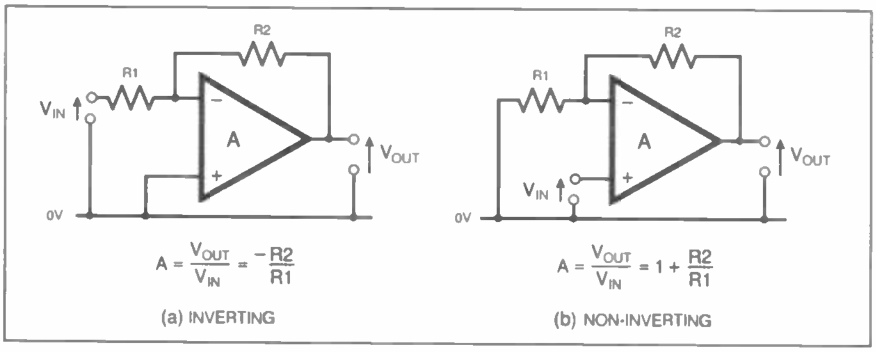


Fig.10.10. Inverting and non-inverting op.amps.

There is a situation where the large gain of an op.amp is used directly – in comparators. Comparators are circuits which compare two analogue voltages and output one of two voltage levels (i.e. effectively a digital signal) depending on which of the inputs is largest.

In effect comparators are amplifiers which are switched between positive and negative saturation. Although you can use an op.amp as a comparator it is better to use a device designed specifically for this purpose. Usually one of the comparator's inputs is connected to a fixed reference voltage and the other to an input signal. In this case the comparator acts as a 1-bit analogue-to-digital converter!

From Analogue to Digital . . .

Usually we need more than one bit conversion to get a sufficiently accurate digital representation of our analogue signal. Note that the more bits that we use the greater the resolution of our conversion.

Remember that we are taking an analogue input value which can have an infinite number of possible values and converting it into a pattern of bits which represent an approximation to that value. The more bits we use, the greater the resolution (i.e. the closer our approximation).

Audio CD players represent the music as a sequence of digital values created from the analogue input signal level. They use 16 bits of resolution to reproduce high quality sound. Lower quality sound applications often work from 8 bits.

To make an analogue-to-digital converter (ADC) with greater resolution we can use several comparators. This is illustrated in Fig.10.11.

The chain of equal-value resistors connected to V_{REF} provides a set of equally spaced reference voltages (this is a *potential divider* circuit). Thus the comparators switch on in turn as V_{IN} is increased from 0 volts towards V_{REF}. This is shown in the Table 10.1.

The logic circuit converts the comparator output code to binary, it is in fact a priority encoder. This type of ADC is called a ***"flash"*** ADC. This design is very fast, however the problem with the flash ADC is that for n bits of resolution you need 2 raised to the power $n - 1$ comparators. For large numbers of bits this is a lot of

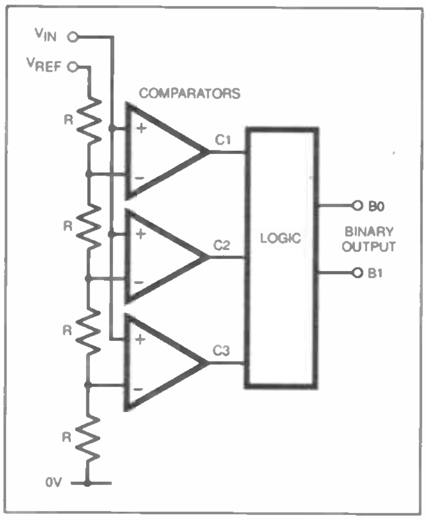


Fig.10.11 (above). 2-bit ADC.

Table 10.1. Comparator and binary outputs.

V_{IN}	COMPARATORS C3	C2	C1	BINARY OUT B1	B0
BELOW $V_{REF}/4$	0	0	0	0	0
$V_{REF}/4$ TO $V_{REF}/2$	0	0	1	0	1
$V_{REF}/2$ TO $3V_{REF}/4$	0	1	1	1	0
ABOVE $3V_{REF}/4$	1	1	1	1	1

comparators! Later on we will investigate some simpler circuits.

. . . and Back to Analogue

Before taking the subject of ADC any further we need to consider the opposite process – digital-to-analogue conversion (DAC). Typically this uses a set of binary weighted components (we will use resistors but transistors can also be used). Consider the circuit in Fig.10.12.

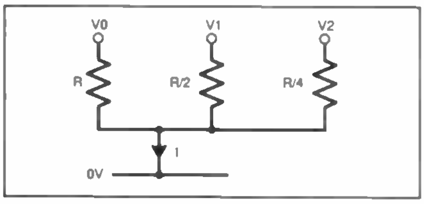


Fig.10.12. A 3-bit DAC with binary weighted resistors.

If the three voltages V_0, V_1 and V_2 are digital signals which switch between 0 and a fixed logic high voltage V_H which is the same for all three inputs then the current I is given by:

$$I = \frac{V_0}{R} + \frac{2V_1}{R} + \frac{4V_2}{R}$$

$$\text{Thus: } I = \frac{1}{R}(V_0 + 2V_1 + 4V_2).$$

So the value of I is directly related to the binary value on $V_2V_1V_0$. For example, if $V_2V_1V_0 = 101$ in binary then

$$I = \frac{5V_H}{R}$$

and if $V_2V_1V_0 = 110$ in binary then

$$I = \frac{6V_H}{R}$$

We now have a current flow which accurately reflects the binary value. What we would really like is a voltage, which represents the binary value.

We could insert a resistor in the circuit (where I is labelled in Fig.10.12) and measure the voltage across it. Unfortunately our extra resistor will itself affect the flow of current and so we would not get an accurate conversion.

What we would like to do is make the extra resistor very small so that its value doesn't affect our output. From Ohm's Law we then find that the voltage that is produced across this resistor is extremely small. The op.amp comes to our rescue in the circuit shown in Fig.10.13.

This circuit doesn't actually use a small resistor as such, instead it balances the current I with the current flowing through its feedback resistor. Exactly what is happening is perhaps beyond the scope of this course, we advise you just to use the circuit!

However, if you really want to get a feel for what is happening, here goes! Because the op.amp has such a high gain, for any output voltage (which must be less than the supply) the voltage between the inputs must be very small. (e.g. for a 15V supply and a gain of 1 million the voltage between the inputs will be 15µV or less (unless the op.amp is deliberately pushed into saturation).

Since the voltage difference is so small we can treat it as being zero in comparison with the logic input voltages V_0 V_1 and V_2 – thus I in Fig.10.13 is the same as in Fig.10.12. We refer to the inverting input of the op.amp in this circuit as a virtual earth.

Another key fact about op.amps is that they have very high input impedance. This means that virtually no current flows into the op.amp inputs.

Thus all of the current I flows through the feedback resistor, R_F. Since the input end of R_F is at almost 0V the voltage across R_F is equal to the output voltage. So

$$V_{OUT} = I \times R_F$$

but from before we have

$$I = \frac{1}{R}(V_0 + 2V_1 + 4V_2).$$

$$\text{So: } V_{OUT} = \frac{R_F}{R}(V_0 + 2V_1 + 4V_2)$$

In this way the output voltage reflects the binary value on the inputs. If we want to have greater resolution we achieve this by adding more resistors to the input, which are driven by additional bits.

Making a Better ADC

Once we have a working DAC we can make an ADC by comparing a DAC output with the analogue input to be captured and changing the digital value until the two analogue values are equal. The simplest way of doing this is to connect a counter to a DAC, start the counter at zero and increment the counter until the DAC output just exceeds the analogue input. The value in the counter then represents the analogue input. This is illustrated in Fig.10.14.

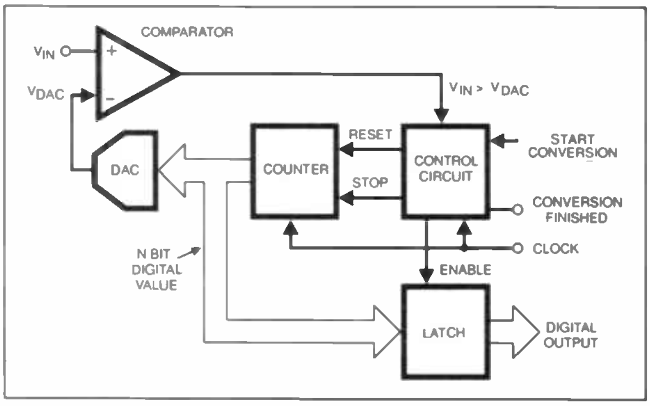


Fig.10.14. ADC based on a counter and a DAC.

The use of a counter is not the best way of performing the conversion as it will take up to 2 to the power n – 1 clock cycles to resolve a value to n bit resolution. A faster technique involves setting or resetting each bit in turn, starting at the most significant bit. This only takes n clock cycles. Note that this approach is always going to be slower than our original "flash" converter as some clock cycles will always be needed.

It is interesting to note that the joystick interface in the IBM PC captures the joystick position by a counter based technique using a comparator. A capacitor in the converter is discharged through the resistor in the joystick. A comparator compares the voltage on the capacitor with ground. When the two are equal the counter stops counting.

The longer the capacitor takes to discharge, the higher the resistance of the variable resistor in the joystick, and the bigger the value in the counter when it eventually stops.

Fortunately, there are many standard ADC and DAC chips. In the **Labs** for this part you will use an ADC chip to capture values and display them. In the next *Teach-In* we will couple the ADC outputs to a DAC and produce the digital equivalent of a piece of wire!

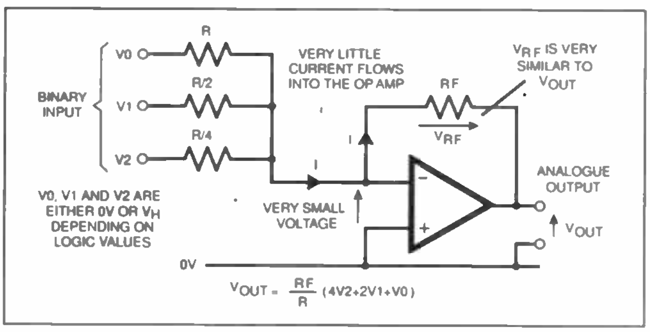


Fig.10.13. A 3-bit DAC converter using an op.amp.

MEET-IN

The **University of Hull** and **EPE** are organising a *Teach-In 98 Meet* which (subject to response) will take place early in September this year in Hull.

Hull will be presenting some *Teach-In* related material and making space in their hardware laboratories for you to "bring out your dead" in the form of labs which might not have worked quite right!

If you are interested in attending, send your name and address to: **Rob Miles, Department of Electronic Engineering, The University of Hull, Cottingham Road, Hull HU6 7RX**

Or visit our web page:

http://www.epemag.wimborne.co.uk

LAB WORK 10

Objectives: Demonstration of a Johnson ring counter. Simple demonstration of infra-red fibre optics and analogue-to-digital conversion using an ADC chip.

THE *Lab Work* assignments in this part use two 74LS194 4-bit universal shift registers in the way we described in the previous Lab. These shift registers have a bi-directional operation so that data can be shifted left or right, depending on how the two mode pins S0 and S1 are connected (see Lab Work 9 for further detailed information).

Lab 10.1 Build a Johnson Counter

The circuit of Fig 10.15a shows how we can have more fun with the shift-register circuit of Lab 9.3 (Fig 9.28), which should be assembled on a solderless breadboard along with the clock generator circuit based around the 4046 (Fig.9.26). A Johnson ring counter can be created by inverting the Q3 output of IC2 and feeding the inverted result to the DSR (data shift right) of IC1. S0 should be high and S1 low to produce a shift-right serial counter. Now add an inverter gate into the circuit, using say a 74LS04 or 74HCT04. Pinouts were given in Lab Work 8, and you should remember to pull up any unused inverter inputs.

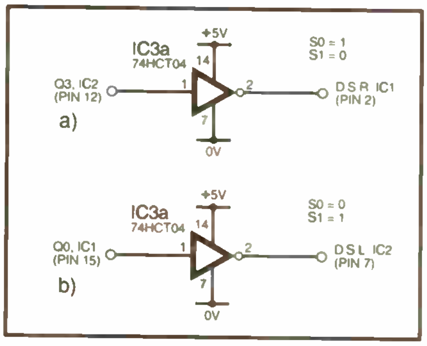


Fig.10.15a. Build a Johnson counter by adding an inverter to the universal shift register of Lab.9.3.

Fig.10.15b. Modifying the Johnson counter to count "left".

Hook the circuit to a 5V supply and power it up. It is probably a good idea to reset the shift registers by using a flying lead to take their reset pins (pin 1) low briefly. Watch an 8-bit pattern develop across the eight l.e.d.s with each successive clock pulse, and then it will restart again. The sequence will shift from left to right, i.e. from 00000000 (00 in hexadecimal) to 11111111 (FF hex). See the separate panel on "Hexadecimal numbers".

● To force the Johnson counter to count in the other direction, change S0 to low and S1 to high, in order to produce a shift-left serial register. The inverter should then be connected between Q0 of IC1 and the DSL (data shift left) of IC2 (see Fig.10.15b)

Lab 10.2 Fibre Optic Demonstration

This Lab is intended (only) as a simple demonstration of the operation of an infra-red fibre optical link. It offers some experience of handling these types of opto-electronic components but you can safely skip this section if you do not wish to buy the specialist fibre-optic parts we suggest, as the components themselves are not particularly cheap, although in this field the ones we picked are budget-priced.

The previous experiments using universal shift registers demonstrate a simple form of serial communication (see Fig.9.28), with one shift register (IC1) transmitting data serially into IC2 via the data shift right pin of IC2, and IC2 shifting data serially into the data shift left pin of IC1. The serial connections are of course made using copper wires pushed into the breadboard, but it is possible to exchange these for a solid-state fibre-optic link, see Fig.10.16. The part numbers are designated to follow on from Fig.9.28.

Components D9 and D10 are infra-red (IR) fibre-optic emitters which are buffered by an inverter. These devices can be considered as ordinary light-emitting diodes, but operating at a wavelength which makes the light invisible to the human eye. They are fitted to one end of a 1mm plastic fibre, into which they transmit IR light. It is perfectly acceptable to use some budget 1mm diameter plastic "sheathed" fibre, say a one metre length or more if you can afford it. D11 and D12 are two infra-red detectors or photodiodes which are IR receivers placed on the other end of the fibre.

You Will Need

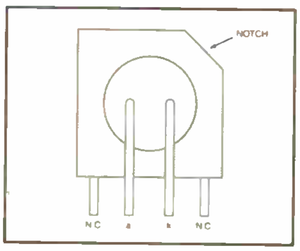
Resistors
- 330 ohm (8 off)
- 10k
- 2M2 (4 off)
- 390 ohms (2 off)
- ORP12 light-dependent resistor (l.d.r.)

Potentiometer
- 4k7 miniature enclosed preset

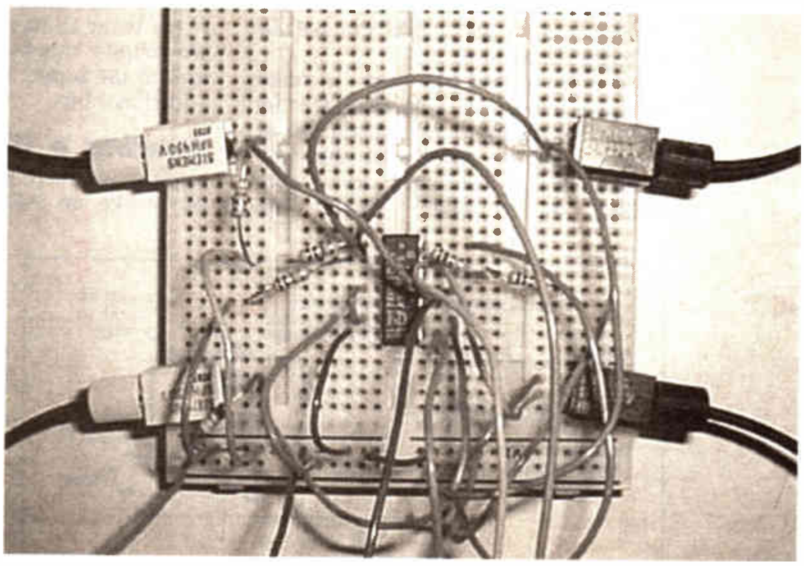
Capacitor
- 150p polystyrene

Semiconductors
- 74LS04 or 7HCT04 hex inverter buffer (2 off for Lab 10.3)
- 3mm red l.e.d. (8 off for Lab 10.3)
- Siemens SFH450V infra-red fibre optic emitter (optional – see text – 1 or 2 off) e.g. Farnell 212-787
- Siemens SFH250V infra-red fibre optic detector (optional – see text – 1 or 2 off) e.g. Farnell 212-805, Maplin CZ04E
- ADC0804 8-bit ADC (e.g. Farnell 396-187)

Miscellaneous
- 1mm sheathed plastic optical fibre to suit (e.g. Maplin XR56L); solderless breadboard; 5V regulated power supply.



Connections to the SFH450V and 250V.



The IR fibre-optic link of Fig.10.16.

Unlike ordinary diodes, IR photodiodes generate a tiny photocurrent of a few microamps when subjected to light of the appropriate wavelength. Notice also that photodiodes are usually connected in a reverse-biased mode as shown, and we have added an inverter buffer to clean up the resulting signal. Thus, light signals produced by the IR emitters will be transmitted down a fibre, detected at the reception end and converted to simple digital signals.

It is easy to add this in to the universal shift register demonstration described earlier. We recommend constructing the IR fibre-optic link on a separate breadboard. The parts we suggest are made by Siemens and are designed for p.c.b. mounting, but we found that they will fit onto a breadboard if all four pins are carefully orientated. (Two of the four pinouts are simply to help with securing the component in place.)

It is best to slice the ends of the fibre as cleanly as possible by using a scalpel or similar. Then feed one end into an IR emitter as far as it will go, and tighten down the plastic locknut to grip the fibre in place. Do the same with the other end, which is fitted into the corresponding photodiode. Take care to observe correct polarity of the IR set – see inset diagram.

Hook interconnecting wires from this breadboard over to the shift register circuit, not forgetting that a 5V power rail is also needed for the fibre optic circuit. Remove the "cross over" serial connection copper wires between the two shift registers (the encircled connections depicted in Fig.9.28).

Now power up the circuit and the 8-bit pattern should be seen to count on D1 to D4, after which the infra-red fibre optic will transmit "shift-right" serial data into IC2, and the count sequence will then continue across D5 to D8.

For economy, you can demonstrate operation just by using the "shift right" function of the shift registers, in which case only one fibre optic set (D9 and D11) is needed. The photo shows both IR sets fitted.

● If you have fitted the second IR fibre optic set (D10 and D12), you can experiment further by selecting S0 and S1 accordingly, to demonstrate a count sequence in the reverse direction. Also try experimenting further with pseudo-random sequence generation and other applications, using the fibre-optic as a simple serial link.

● Even if you don't build this Lab, be sure to read "Check Out: Opto-Electronics" in the main tutorial. Some advantages of using fibre-optics as a means of communication are discussed.

Lab 10.3 A/D Conversion

An ADC (analogue-to-digital converter) chip is used to digitise an analogue signal. Such signals come in a variety of forms, perhaps from a simple temperature sensor using a thermistor (a thermally-sensitive resistor) or even a light-dependent resistor.

If a microprocessor is used to control a system, it can only process digital signal sources, not the "wavy lines" produced in

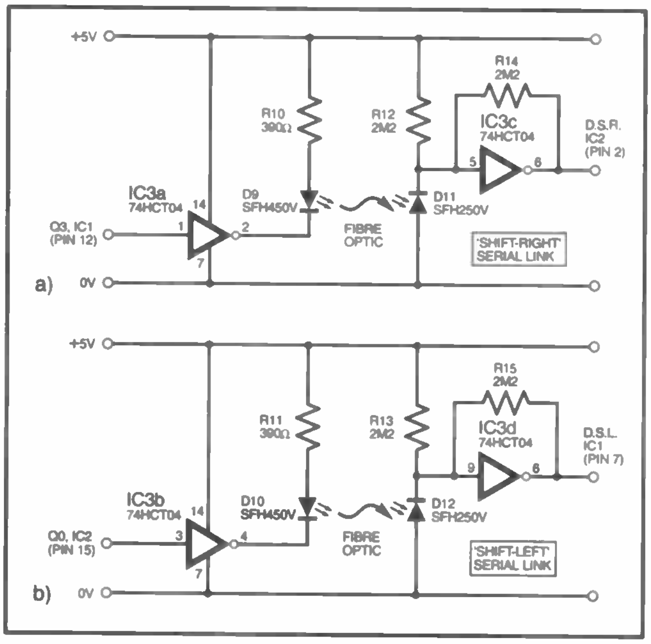
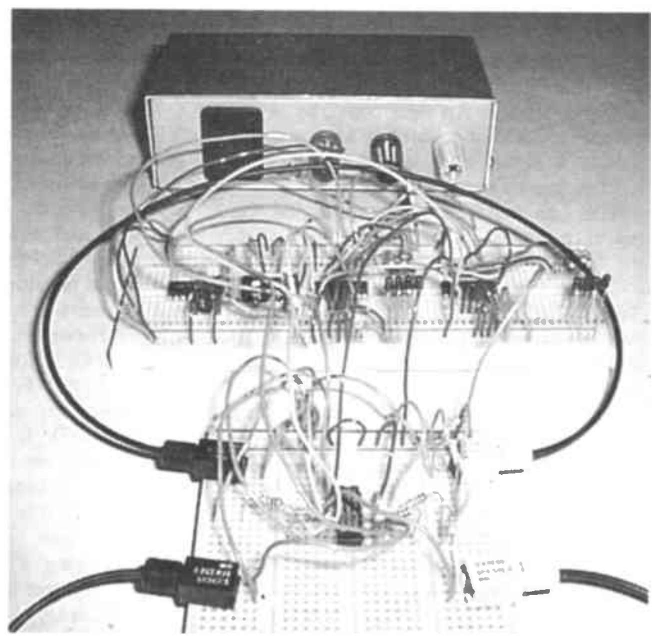


Fig.10.16. Simple demonstration of a fibre-optic link. Only one fibre set needs to be built to show the basic principle.



Shift register breadboard linked into the IR fibre-optic link to demonstrate serial communication.

Hexadecimal Numbers

Just as everyday humans use decimal (base 10) to count, and digital systems use base 2 or binary (0 or 1), the hexadecimal numbering system uses base 16. This is used to convert any 4-bit binary number (of which there are sixteen possible combinations) into a single character.

The great advantage is that it makes our lives much easier when we start to deal with lengthy binary numbers, such as the outputs from the ADC0804 chip used in the demonstration (Fig.10.17).

Hexadecimal uses 16 individual alpha-numeric characters, 0 to 9 and A to F, to represent the 16 possible states of a 4-bit number. The possible counts are as follows (D0 to D3 represent the first four output bits of our ADC chip in this example):

D3 8s	D2 4s	D1 2s	D0 1s	Decimal equiv.	Hexadecimal equiv.
0	0	0	0	0	0
0	0	0	1	1	1
0	0	1	0	2	2
0	0	1	1	3	3
0	1	0	0	4	4
0	1	0	1	5	5
0	1	1	0	6	6
0	1	1	1	7	7
1	0	0	0	8	8
1	0	0	1	9	9
1	0	1	0	10	A
1	0	1	1	11	B
1	1	0	0	12	C
1	1	0	1	13	D
1	1	1	0	14	E
1	1	1	1	15	F

This system can be applied to any binary number. Instead of saying "1111" we could simply say "F". And just so everyone knows we're talking hexadecimal, it's common to denote this with a dollar $ prefix or H suffix, so we would actually write $F or FH ("H" for hexadecimal).

Applying this principle directly to our ADC0804 chip is very simple. It is 8-bits wide, so we divide this into two 4-bit numbers and convert each to hex: if the binary number "11111111" is output by the chip, this becomes FFH (or $FF), and something like 10111001 becomes B9H ($B9) in hexadecimal. And if you had binary 1110111001, this translates into 3B9H ($3B9).

"Hex" is much easier to handle than long binary numbers, and its use is widespread when dealing with microprocessor systems. Hex even finds its way onto the World Wide Web: it is used for specifying text or document colours in HTML.

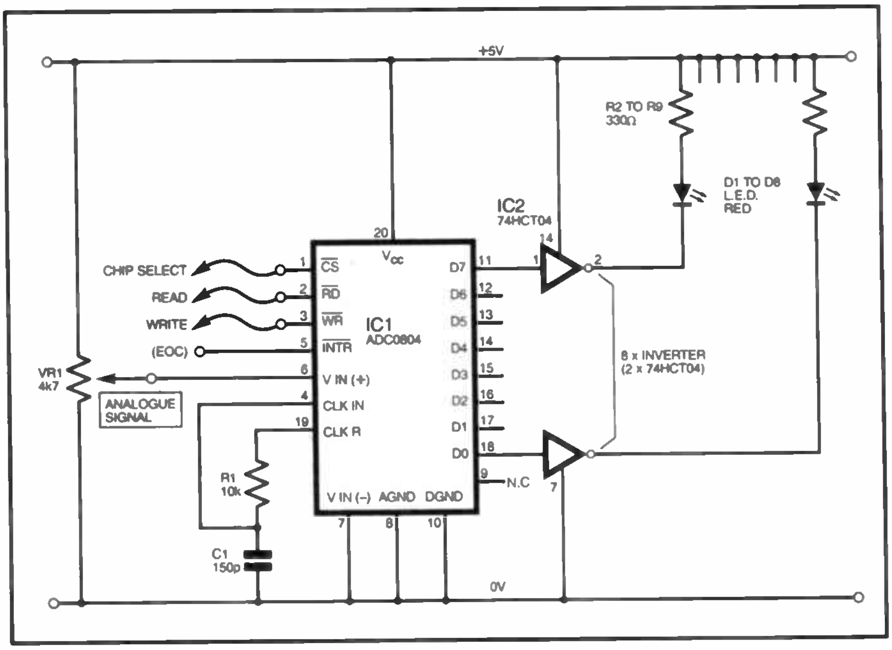


Fig.10.17. Demo circuit for the A to D converter.

analogue signals. An A/D converter is the primary method of converting analogue signals to a digital code which can then be used as data by a microprocessor.

This Lab demonstrates how a digital signal is produced by a typical A/D chip, the National ADC0804. This is housed in a 20-pin d.i.l. package and has an 8-bit "resolution", so that the analogue input will be converted to an 8-bit number. This makes the device compatible with many microprocessors. Fig.10.17 shows the demo circuit, IC1 is the A/D chip which runs from a 5V supply. An analogue input signal is input at pin 6, and in this demo a clock for the internal sampling logic is controlled by an external R/C network on pins 4 and 19.

Pin 1 is the $\overline{CS}$ (chip select) and pin 3 the $\overline{WR}$ (write strobe) pin. The device will start a conversion when both pins are at logic 0 for at least 100ns. The result of the conversion process is output when both $\overline{CS}$ and $\overline{RD}$ (read) are taken low. Furthermore, another signal is output at the end of conversion (EOC), at pin 5 $\overline{INTR}$ which changes from high to low when conversion is completed; it returns to logic 1 when either the data is output or a new conversion is started.

Breadboard

The 8-bit digital output is seen on pins 11 to 18 (D7 to D0), which outputs a binary number 00 (hex) to FF (hex) at the end of the conversion. We used a set of inverter buffers to display the result on a set of l.e.d.s.

More adventurous readers can go ahead and assemble this simple demo on the breadboard. By now you should be able to confidently work out the interwiring from the chip pin-outs and circuit diagram, allowing for unused logic gate inputs (pulling them up via a resistor) etc. and checking the polarity of the supply rails carefully,. to avoid damaging any device.

The analogue signal is generated manually using a 4k7 variable resistor (VR1), which can be a preset type inserted directly into the breadboard. Also, it is best to use 3mm l.e.d.s.

Check the interwiring carefully and set VR1 midway. Hook $\overline{CS}$ and $\overline{WR}$ to 0V and power up the circuit. Probably, all the l.e.d.s will illuminate. The chip will then update (refresh) the l.e.d. display when the read and write pins are alternatively taken low. Select write ($\overline{WR}$ low), alter the preset resistor, then "read" ($\overline{RD}$ low) the latest value on the display. However, during our experiments we found that by letting the $\overline{WR}$ pin float (unconnected) and sending $\overline{RD}$ low, the display would generally change in accordance with the analogue input: changing VR1 would change the l.e.d. display. If there appears to be no change then reset the power supply. In fact a complete 8-bit range from 00 (hex) to FF (hex) was displayed by altering VR1.

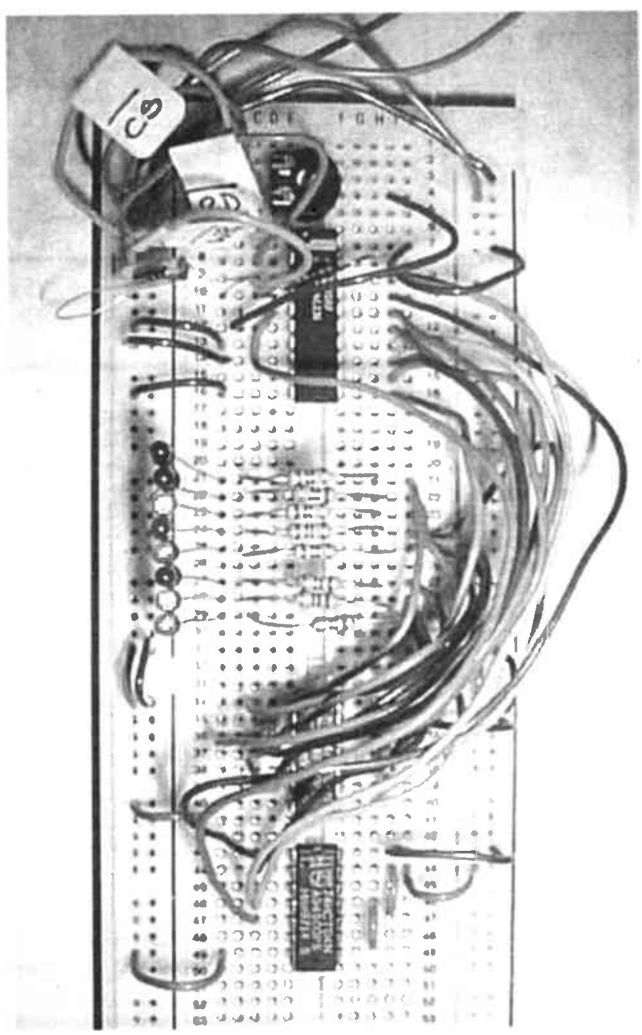
A light-dependent resistor, such as the popular ORP12 type, can be used with a 33k resistor as a potential divider, in order to provide an analogue voltage which is proportional to incidental light levels. If you have a similar l.d.r. available, you could substitute this for the preset resistor, and you will create an eight-bit digital count of light levels. (We had great fun using the ADC to display a digital reading of the ambient lighting, controlled by the lab's dimmer switch.) A thermistor could also be used to provide a temperature-sensitive digital signal.

- This A/D chip is a "successive approximation" converter. It takes eight comparisons to complete a conversion, controlled by an 8-bit shift register. The shift register is clocked by an internal clock whose frequency is approximately 1/1.1RC. The clock is not synchronised with the chip select, read and write strobes, so to be safe, it is best to allow 16 clocks for a conversion.

- Don't worry if you don't fully understand all the features of the suggested device: they only become relevant once you put the ADC to work, by sampling analogue signals at speed and outputting the result to, say, a microprocessor-controlled system. A breadboard demonstration like this is very basic, and in practice there are many other considerations too, related to noise which system designers also have to bear in mind.

- Further reading: information about the ADC0800 series is published in the National Semiconductor data sheet and the application notes contained in their "linear" data books.

In the final part of *Teach-In '98* we examine digital-to-analogue converters (DACs) along with more practical demonstrations, including a brief look at operational amplifiers (op.amps).



The photograph shows the breadboard construction of the A to D converter with l.e.d. readout of the digital output.

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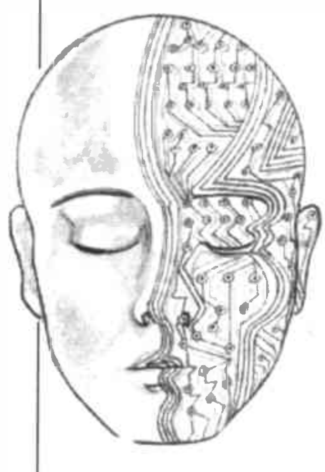

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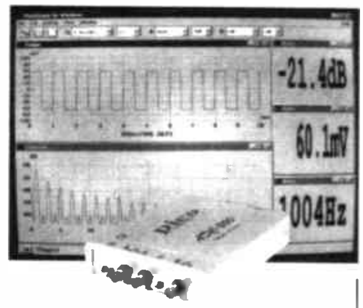

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Vehicle Reversing Alarm – A Beep For Your Jeep

THOUGH a standard feature on many commercial and public service vehicles, a reversing alarm is not a normal fitting on a family saloon or small van. An alarm provides additional warning to pedestrians in the vicinity of the vehicle, especially when reversing out of a narrow driveway or in a car park, etc.

The system shown in Fig.1 was designed to be self-cancelling and can be switched on as required, to avoid creating a night-time nuisance. It connects easily to the wiring loom feeding the rear direction indicators and gearbox-operated reversing lights and is activated by momentarily pressing the hazard warning light switch with reverse gear selected (reversing lamps on). This causes the relay RLA to "latch" via contacts RLA1.

Transistor TR1 only allows this to happen if the reversing lights are already on, and diodes D1 and D2 preventing the indicators and reversing lights from inter-reacting. Disengaging reverse gear causes the relay to "unlatch", silencing the audible alarm.

A standard CMOS 7555 astable multivibrator, IC1 gives a square wave output of equal mark/space ratio, with a frequency of about 1Hz. The output from pin 3 of IC1 is used to reset IC2, which provides an audible bleep via capacitor C5 and the loudspeaker LS1. VR1 allows the volume to be preset.

LS1 can be any small speaker or ex-telephone earpiece, mounted in a weatherproof enclosure under the rear bumper or behind a tail lamp assembly. *(This could be an ideal application for a Mylar polyester cone waterproof loudspeaker, mounted in a small box. A.R.W.)* The rest of the components can be mounted in a small box in the luggage compartment, and the interval and tone frequencies can be adjusted to suit. Wiring can be spliced into the loom using "Scotch-lok" connectors and the circuit should be fused as shown.

Andrew R. G. Calder, Leigh, Lancs.

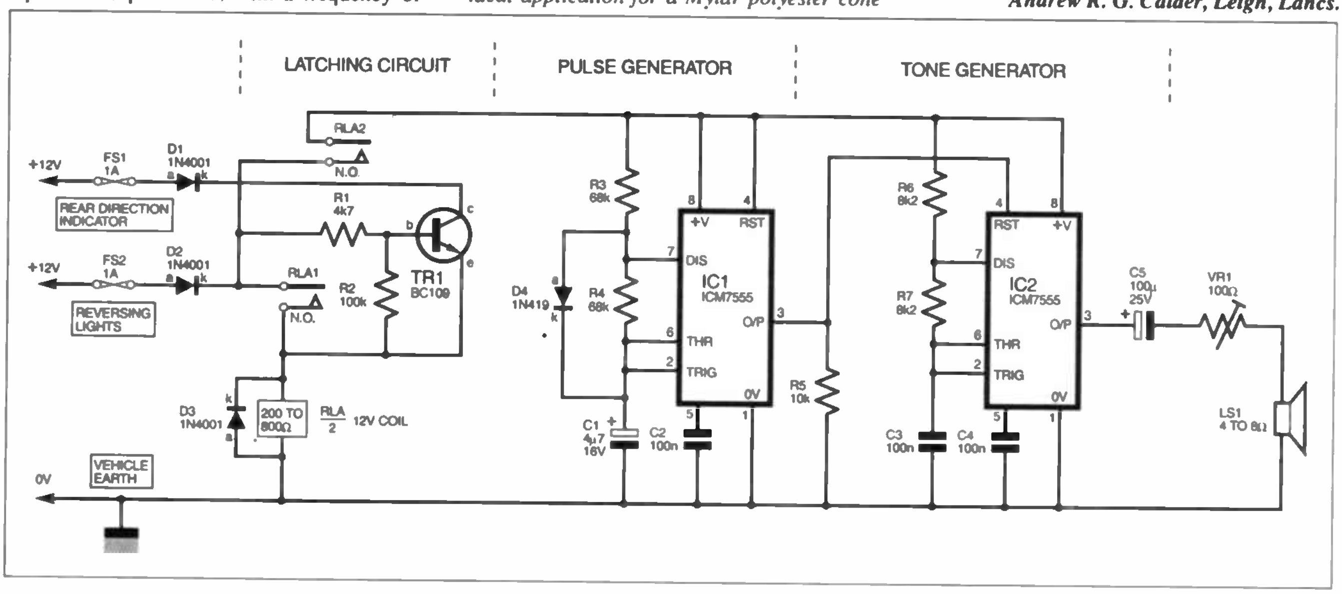

Fig. 1. Circuit diagram for the Vehicle Reversing Alarm.

Ultra Low-current L.E.D. Flasher – A Quick Flash

IN THE simple circuit of Fig.2, IC1 is a 7555 CMOS timer wired in astable mode. When the voltage across capacitor C1 reaches two thirds of the supply voltage, via R1 and D1, pin 7 switches over and acts as a current sink, consequently C1 rapidly discharges.

However, diode D1 blocks any discharge and therefore C1 discharges through l.e.d. D2 which illuminates briefly before the charging cycle repeats. The components shown give a quick flash once every second and the current consumption averages at 300μA at 12V.

Paul Brigham, Sunderland.

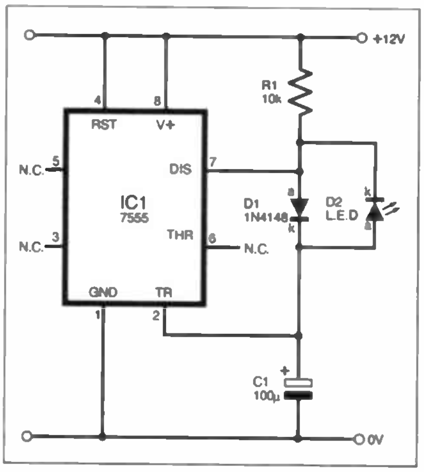

Fig.2. Circuit diagram for an Ultra Low-current L.E.D. Flasher.

Versatile Alarm Extender – Add More Loops

THE circuit diagram of Fig.3 adds up to eight extra loops to a simple fire or burglar alarm system which has only one loop. Each loop can then be programmed for either open or closed contact modes.

The circuit revolves around a 74LS688 (or 74HC688) which is an 8-bit comparator: it will compare the 8 bits on its "P" inputs with the 8 bits on its "Q" inputs and if the values are the same then its "P=Q" output pin (19) will be low, otherwise it will be high. Should your alarm require a high input, then the inverter IC2a on the '688 output will provide this.

The eight P inputs are pulled high via 10k resistors and the loops, including the alarm switch contacts S2 to S9 are between the P inputs and 0V, regardless of being open or closed types. The Q inputs are also pulled high. An open loop contact (P high) needs the relevant d.i.l. switch set to OFF (open) allowing the 10k resistors to pull the corresponding Q input high, and a closed contact (P low) will need the relevant d.i.l. switch set to ON (closed) thus pulling it low.

On the 74HC688, pin 1 ($\overline{G}$) is the Enable input which can be tied to ground, or used to enable the circuit after the alarm has been set. The resistors could be s.i.l. packs.

M. Saunders,
Leicester.

Electronic Toggle Switch – Simple Control

THE circuit of Fig.4 utilises the set/reset action of a JK flip-flop to provide a "toggle" action from a non-latching switch.

One half of a 7476 is used, configured with both the RS (pins 3 and 2) and JK (pins 4 and 16) inputs tied at logic 1. In this state, a low clock input causes the output (pin 14) to toggle alternately between a set and reset state, i.e. 0 and 1, for every clock pulse received.

The clock pulse is generated by switch S1 which, when closed, takes pin 1 low, clocking the flip-flop. The capacitor C1 is used for de-bounce purposes to prevent false triggering.

The circuit could be used as part of a larger system by substituting the l.e.d. with a buffer transistor and relay.

Paul Brigham,
Sunderland.

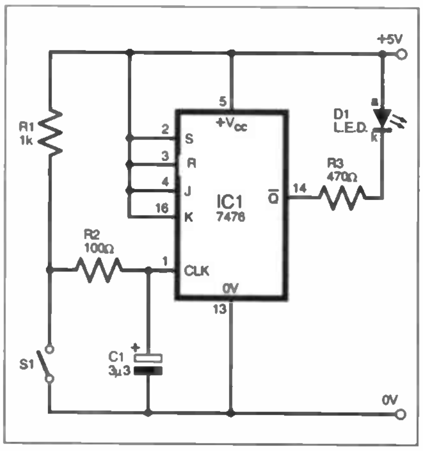

Fig.4. Circuit diagram for a simple Electronic Toggle Switch.

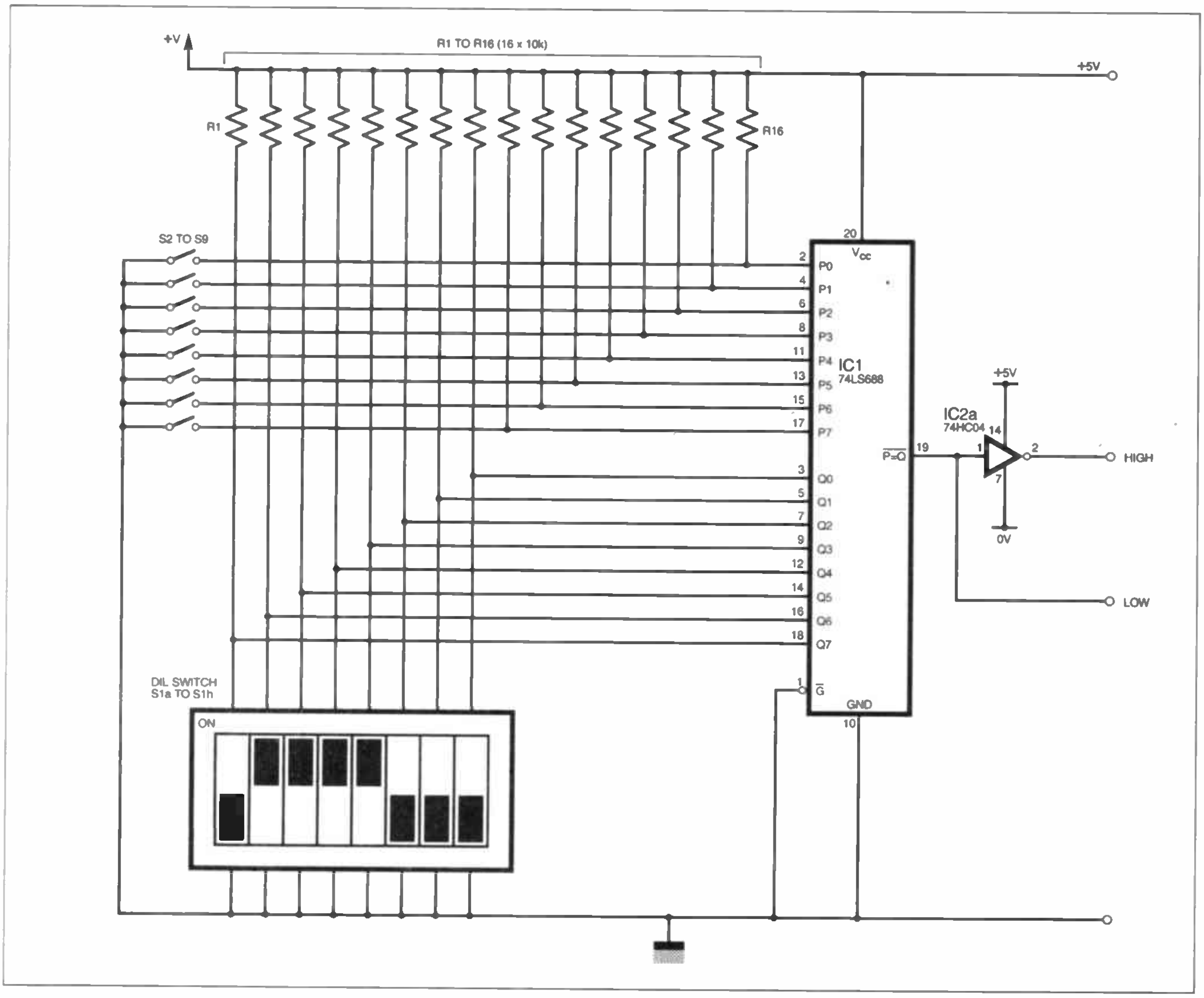

Fig.4. Versatile Alarm Extender circuit diagram.

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GIANT INSULATORS Just in this week are some giant ceramic insulators, each one measures 130mm high and about 170mm diameter. Finished in a high gloss brown and black glaze. In the base of each insulator is a threaded hole approx 1" diameter, rather like a mop/broom head thread. If you are into shortwave radio, crystal sets or high voltage experiments then these are for you. (We've got one as a door stop) Not too sure what their original purpose was, all we know is they were made for export about 25 years ago, never exported and been in store since then. **Price is £8 each ref INSX**

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APRIL '97

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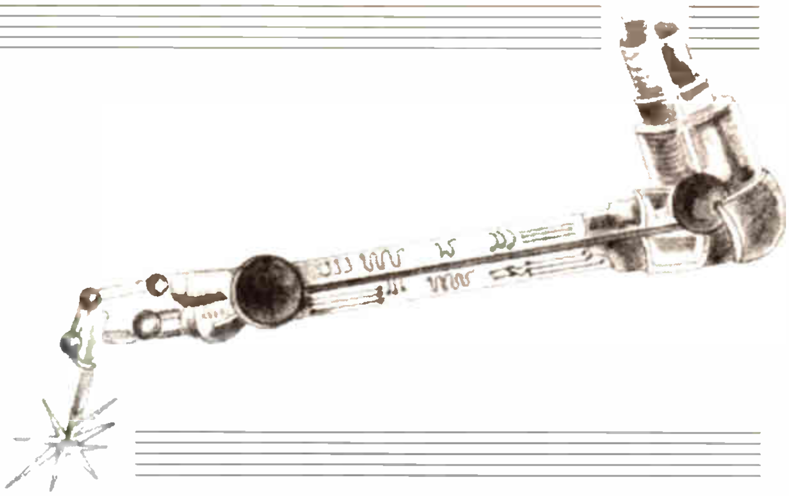


ALAN WINSTANLEY

We check out moving coil and digital panel meters, try the very latest in light-emitting diodes – white! More on wirewrap sockets too.

Mini Stroboscope

There is always something new happening in electronics, and I have been trying the latest in light-emitting diode technology in the shape of an ultra-bright 41 candela device, and a white light l.e.d. too! The following query sparked off my interest.

I'm about to wire a houseboat which has very little power generation capability (namely, a windpower module into a 12V lorry battery) and am wondering about low-draw lighting possibilities. Someone's suggested a series of l.e.d.s of differing colours to approximate white light but I wonder whether this is possible.

C.R., on the Internet.

This query set off several trains of thought. In fact, a white light-emitting diode is indeed available, but they are not exactly cheap, at some £6.00 each plus VAT in one-off quantities. (Farnell 947-155 – see later). They really do produce a pure white light, though the "multi-chip" chemistry behind their operation is partially revealed by the fact that I noticed a blue border around the spot of white light produced, when it shone onto a white surface. Incidentally, blue l.e.d.s themselves are static-sensitive (according to Panasonic's l.e.d. advert in the American Digi-Key catalogue).

In lighting terms, and economy apart, these devices would probably not be suitable for providing usable levels of illumination – I've offered further suggestions later on – but when I demonstrated one to the Deputy Editor, he suggested the idea for an interesting project: a mini strobe lamp using a white light-emitting diode rather than a xenon tube.

Because a semiconductor light-emitting diode has near instantaneous response times ("optical rise and fall times" in the region of the 20s of nanoseconds), then a white l.e.d. could form an interesting battery-operated mini stroboscope by driving it from a bipolar 555 or CMOS 7555, see Fig. 1. It's incomparable with a high power xenon-tube stroboscope, of course, but is fun and interesting to build for simple strobe experiments held in complete darkness. Furthermore, it's completely safe to construct as no dangerous high voltages are involved.

The SI unit of luminous intensity is the candela (symbol cd) and the specified device has a luminous intensity of 1 candela at 20mA typical (25mA maximum) forward current, with a forward voltage of 3·5V to 4V, and it has a useful 60° viewing angle. The l.e.d. could be driven directly by a 555 astable as shown, taking care to use a series resistor to limit the current (and drop any "surplus" voltage) to a safe level; 180 ohms is theoretically the absolute minimum value to be used.

Unofficially, in order to increase the light output of an l.e.d. it is not unusual to over-drive it using very narrow pulses, in the hope that the excessive forward current will be endured for such a short period that the device will not be damaged, and whilst I did run the l.e.d. with a 120 ohm resistor for many minutes with remarkable results, I cannot guarantee the long-term effect of doing so. (I did get spots before the eyes in the process, though.)

The two preset resistors (fine and coarse controls) provide the interval between flashes, and by switching another capacitor in parallel into the timing circuit, the interval range can be adjusted. In this design the timer chip sinks current through the white l.e.d. into its output (pin 3) for a brief period, and the result is a short, stroboscopic pulse of xenon-like white light.

With the values shown, the mini strobe will pulse at frequencies from 1Hz, up to what the human eye perceives as virtually continuous illumination. Also try mounting the l.e.d. into a reflector (e.g. from an unwanted torch); ElectroValue Ltd. list chromed plastic reflectors for 5mm l.e.d.s which can be made to push-fit (I tried one of those, too). More affluent experimenters could try running several white l.e.d.s in parallel from one chip to increase the light output! I hope the circuit provides a bit of fun, now back to our boat owner.

Another example of how light-emitting diode technology is advancing is symbolised by another device also listed in the current Farnell range. It's made by Toshiba, and is a 10mm Ultrahigh Bright l.e.d. with a rated light intensity of a staggering 41,400 mcds (41 candelas).

A scrutiny of the specifications reveals how this startling light intensity is achieved: it has a viewing angle of only 4°. The device is moulded in a glass-clear package, and when experimenting with one on my bench, I found that the l.e.d. "chip" projected a square spot of yellow light over a distance of 25 feet.

It is maybe worth considering using these Toshiba devices, or similar, to illuminate the boat at strategic places, and arranging a diffuser or other arrangement

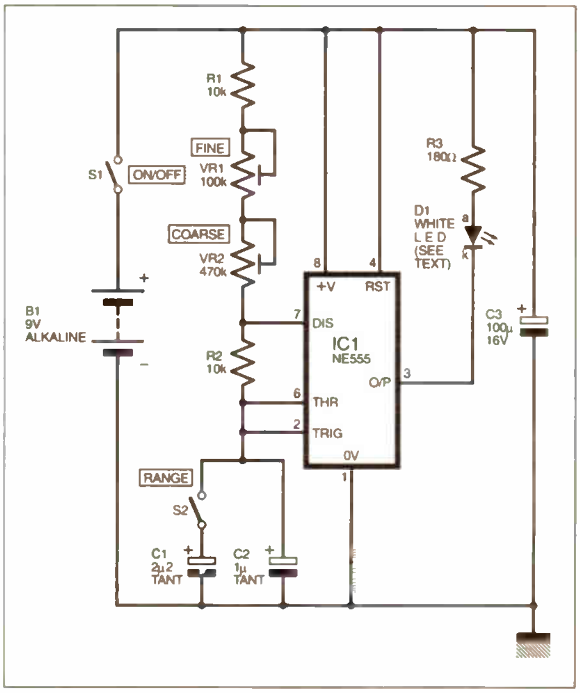


Fig. 1. Simple battery operated mini-strobe.

to compensate for that very narrow viewing angle. The forward voltage is about 2V and the maximum forward current is 50mA. They still cost nearly £2.50 each all-in, but it might be worth experimenting. The only other solution I could think of was to use good old filament bulbs: to save power, maybe a PIR sensor on a timer would help ensure they only illuminate when there is movement in the vicinity. Other ideas are welcome!

Pricey Postage

Following on with component queries, my thanks to reader ***A.A. King of Darlington*** who has followed *Teach-In '98* and writes:

As a student new to modern electronics (although I had some experience thirty-odd years ago), one comment I would like to make is related to materials. In each of the monthly Teach-In *articles you write, a list of parts required for the* Lab Work *practical experiments is given. For people like me who have no items in stock (not even a resistor!) we cannot justify ordering £1 worth of parts and incurring a disproportionate postage charge thereon. May I suggest that you include a list of parts required for, say, the first four months of the project, and perhaps the following four months supply at month three. This would give us the opportunity of ordering what we need instead of guessing (probably wrongly) and ordering lots of things we may never use. Having got that off my chest, congratulations on a well thought-out course, which I am enjoying as a hobby.*

Several points here: unfortunately the problem concerning postage and packing charges is not a new one – it has been with us 25 years or more. The problem is more the fact that the price of electronic components is falling all the time, and postage and packing isn't (on the contrary); you can do a lot with a handful of modern parts worth only a few pounds which cost as much again in postage and handling. Sometimes postage can become disproportionate to the order value, especially if you don't carry stocks of common parts yourself.

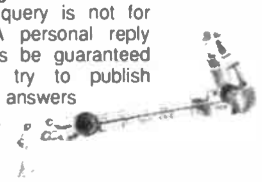
However, everybody has to start somewhere, and there is no getting away from the fact that you will probably have to mail out for parts initially. If it wasn't for the indispensable and valiant support of our mail-order advertisers, all of whom work very hard to keep readers supplied, hobby and educational electronics would be much less accessible. It is also worth checking *Yellow Pages* to see if there are any small local shops as there are often one or two independent stores in larger towns.

Companies including Maplin Electronics plc are opening stores all the time, though they do not usually stock the more esoteric parts: however you can order in-store and have them delivered to your door a few days later, post free. Also you should really consider doubling up on some orders to gradually build up a small stock.

As far as *Teach-In Lab Work* goes, in the event it wasn't possible to publish a comprehensive parts list in advance for the simple reason that the series content had not yet been entirely finalised. Even if we were able to publish a full parts list, and suppliers "kitted up" for it, there is another section of our readership which understandably would not wish to purchase everything in advance, especially if parts would not be used for months. (Conversely, *Teach-In '93* featuring the *Mini Lab* was designed in modular form: yet some readers demanded to be able to buy the entire series' worth of parts in one parcel, because they couldn't wait to solder everything into place on the main board, even though some of the modules would not be used for eight months.)

CIRCUIT THERAPY

Circuit Surgery is your column. If you have any queries or comments, please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk.** Please indicate if your query is not for publication. A personal reply cannot always be guaranteed but we will try to publish representative answers in this column.



Experience has shown that we can't please everyone, no matter how hard we try!

Farnell Comes to Terms

Seldom do I boast, but an "I told you so" is hereby awarded. Whilst RS Components (previously called Radio Spares, not to be confused by American readers with Radio Shack/Tandy) have always had a very strong foothold in industry and education, many other readers including myself have always enjoyed arch-competitor Farnell's personable and highly efficient service instead, which during the latter half of 1997 and early '98 changed to include no minimum order charge for credit card or cash orders, and free delivery. In fact Farnell went out of their way to stress that all such restrictions had been removed.

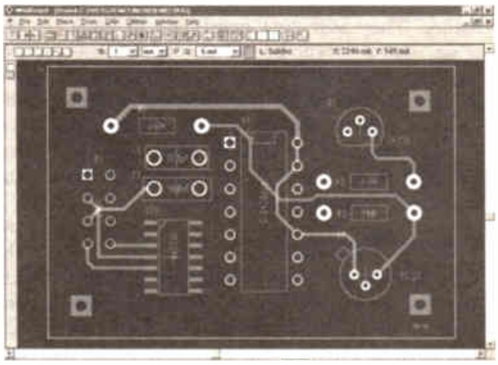
Whilst warmly welcoming this from the readers' perspective, I questioned how long this could possibly last, and predicted they would inevitably be flooded with tiny orders for a pound or two with free postage to boot. As some readers are finding out to their disappointment, what is claimed to be the world's largest catalogue-based component distributor re-instigated a £10 minimum value for credit card and cash sales from 1st April. What a pity! Contact Farnell Sales on 01132 636311. Internet users check **www.farnell.com**

Wirewrap Sockets

In May '98 *Circuit Surgery* I commented on the lack of availability of long-legged i.c. sockets, used for wire-wrapping. My thanks to reader ***Mr. B. Balet of Castlecove, Republic of Ireland*** who notified me that:

ElectroValue have everything for wirewrapping, including long-tailed sockets from 6 to 40 pins, wire, tools etc. They do not presently supply the plastic combs but that is no problem for me as I make them myself – some pieces of 1·5mm perspex, a drill and some superglue are all that you need!

Mr. Balet is right – turned-pin wirewrap sockets are indeed listed in their current catalogue. Contact ElectroValue on 01784 433604.



IVEX PCB CAD REVIEW

ROBERT PENFOLD

WinDraft and WinBoard software go under the microscope

ANYONE wishing to obtain printed circuit CAD (computer aided design) software is certainly "spoilt for choice" these days, with at least a dozen packages to choose from. Many of these have been reviewed in *EPE*, but WinDraft and WinBoard from Ivex Design International are two electronic CAD programs that we have not scrutinised previously. WinDraft is used to draw circuit diagrams, and WinBoard is used to produce the printed circuit designs.

The programs are designed for use together, with WinDraft acting as a front end to provide a schematic capture facility for WinBoard. In other words, the circuit is drawn up in WinDraft, and in the process a set of component interconnections (a netlist) is produced. These are then carried on into WinBoard and used when designing the circuit board. However, the two programs are not dependent on one another, and can be used as stand-alone schematic and board drafting programs if preferred.

Both programs are only available for PCs, and they do not require a particularly advanced set-up. The minimum requirements are an 80486DX processor with eight megabytes of RAM, Windows NT/95 or Windows 3.1 plus Win32s, and 10 to 15 megabytes of hard disk space. A SVGA display with a resolution of at least 800 by 600 is also needed, as is a mouse or other Windows pointing device.

A 133MHz Pentium PC fitted with 16 megabytes of RAM and running Windows 95 was used when reviewing this software. This proved to be more than adequate to run the program smoothly.

BACK TO THE DRAWING BOARD

As always with this type of software, the way in which it is used, and how much of it will actually be needed depends on the way in which you work. Some users will start with an existing circuit diagram, and will need nothing more than an electronic version of a conventional drawing board. WinBoard can be used at this basic level if desired.

When WinBoard is initially run you have the option of editing an existing design, loading a netlist, or starting from scratch. This third option takes you into the main program, which then enables the design to be drawn up manually.

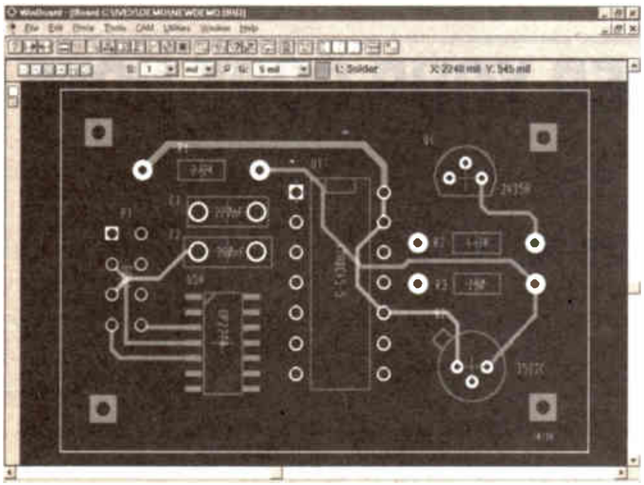
The general layout of the screen follows the Windows convention, with the menu bar and toolbars along the top of the screen, and a status/information line across the bottom of the screen. Apart from the usual scrollbars the rest of the screen is used for the board design.

A substantial library of over 800 predefined component symbols is provided with the program, and it is possible to design your own symbols. This is achieved using the module editor which has a large repertoire of pad shapes including ovals and rectangular pads. Symbols for surface mount components are easily produced.

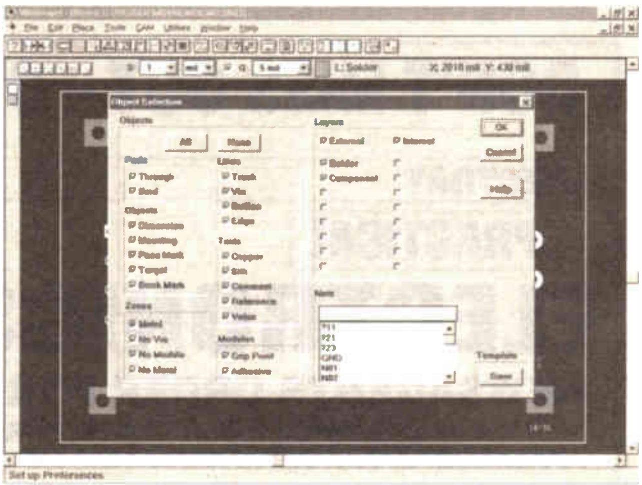
It is possible to draw quite complex components such as multi-way connectors and integrated circuits having large numbers of pins, but producing your own library of components seems to be a bit convoluted and quite time consuming. As with most printed circuit design programs, it is best to use the supplied libraries of components as far as possible.

TRACKS

The board is drawn up by placing the component symbols onto the drawing area, and then adding the tracks, which are routed manually. A wide range of track widths is available, and multi-layer boards can be accommodated. In addition to normal tracks there is a flood-fill feature that enables a large area of the board to be



WinBoard has a conventional Windows screen layout. The two small buttons near the top-left corner of the drawing area enable the current layer to be changed quickly (more buttons appear if more layers are enabled).



This is one of the set-up screens. Amongst other things, the object selection screen provides total control over which objects are displayed on the screen.

selected and covered with copper. Good editing facilities are essential with this type of software, and making changes to board designs is certainly very easy with WinBoard.

Left clicking the mouse on a component enables it to be dragged around the screen, and rotation of components is accomplished using the cursor keys. Moving track nodes is equally straightforward, as is adding new nodes into an existing track. If a component is moved once it has been connected to a track, it remains connected to the track that stretches or contracts as necessary. This process is known as "rubber banding." Block moves are also possible, enabling large sections of the design to be shifted. Parts of the board can be copied via the Windows clipboard.

PRINTING

Finished designs can be output to the Windows printer, and there is good control over such things as the layer or layers to print, scaling, etc. Test printouts produced neat and accurate results using 300 d.p.i. inkjet and 600 d.p.i. laser printers. Provided you have good quality Windows drivers for your printer or plotter there should be no difficulty in getting high-class results from WinBoard. For professional users there are NC drill, Gerber and Pick & Place. output facilities that produce files for use in the printed circuit manufacturing process.

CAPTURING THE COMPONENT

The alternative to using WinBoard as a simple electronic drawing board is to start with a netlist rather than starting with a blank screen. The netlist can be produced from a circuit diagram produced using WinDraft, using the facilities within the WinDraft program. This method of working sounds wonderfully simple, but things tend to become convoluted with any system that uses schematic capture.

Each symbol used by the schematic editor must have both a theoretical symbol for use in the circuit diagram, and a physical outline and pad arrangement for use in the board design. Things can get quite involved when multi-section devices are used, such as quad gates. Using schematic capture is not usually too tortuous provided the supplied set of symbols is adequate for your purposes. Designing your own symbols is not for the fainthearted.

The Ivex programs handle things in a reasonably straightforward manner, and you do not have to be a dedicated professional user in order to make use of the schematic capture facility. Netlists for WinBoard do not have to be produced using WinDraft, and they can be imported in OrCAD, Tango, and a range of other formats. Netlists produced using WinDraft will normally have a physical symbol assigned to each component, but this may not be the case with netlists from other sources.

AUTOMATIC ASSIGNMENT

It could obviously take a very long time to manually assign a physical symbol to dozens of resistors, capacitors, etc. Fortunately, this is not normally necessary, and an automatic assignment feature can largely do the job for you. Any awkward components can be manually edited, and assigned or reassigned with the correct physical symbols. There was insufficient time to thoroughly test this feature, but it seems to work quite well.

RATS NEST

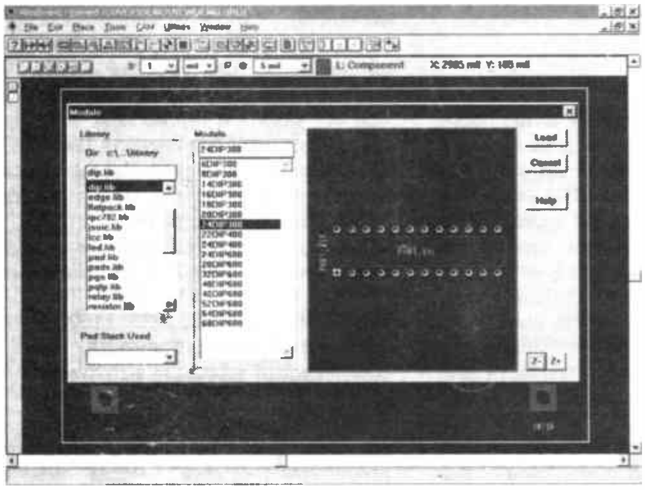
Once the importation process has been completed you are faced with the normal WinBoard screen, complete with all the components in the design. The program makes no attempt at automatic component placement, and the first job is to shift the components into positions on the board that will make routing reasonably easy.

To make this process easier the "rats nest" can be displayed on the screen. This is just a set of interconnections indicated by lines which run direct from one pad to the next, often crossing over other net lines and components on the way.

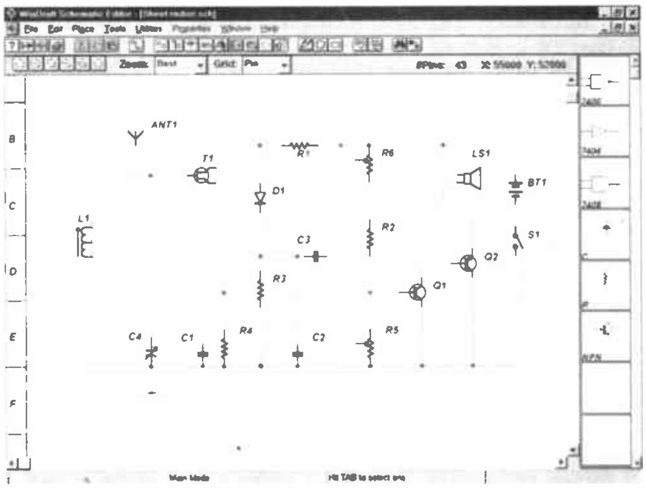
Once the components have been placed the board is routed in much the same way as when starting from scratch, but the net lines aid the routing process. Each time a track is routed the corresponding net line disappears from the screen. Of course, the main advantage of the netlist method is that you cannot alter the set of interconnections laid down in the netlist. The program will simply refuse to add in any tracks that would produce invalid connections. However, you can edit nets "on the fly" so that any last minute changes to a design can be implemented.

To complete the design the outline of the board is added, and the silk screen layer can be edited if required. In most cases it is necessary to move some of the component numbers into better positions, and to adjust the orientation of others. When components are rotated, any text associated with them is rotated as well, resulting in some sideways and upside-down text.

Manipulating the text is very simple, as it is just a matter of dragging it into place using the mouse, and rotating it by pressing the cursor keys. In either case the text strings can be edited singly or in groups. Text is available in a wide range of sizes, widths and line widths, and it can be slanted and mirrored if required. These parameters are all easily changed on existing text strings.



Selecting WinBoard symbols is very easy even though there are hundreds to choose from. They are stored in libraries of various types (resistors, transistors, etc.), and a preview facility lets you see what you have selected before it is placed into the drawing.



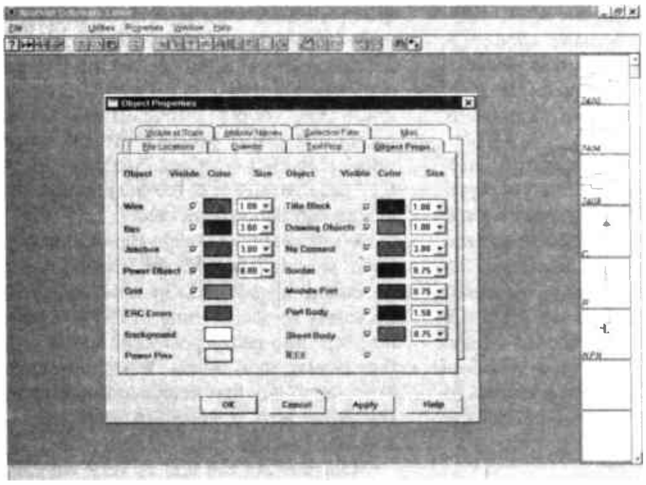
The WinDraft screen layout is again fairly conventional. The symbol palette down the right-hand side of the screen is a common feature in schematic capture programs.

UP FRONT

WinDraft is the obvious candidate if WinBoard is to be used with a front-end program to provide schematic capture. As already pointed out, netlists in various formats can be imported into WinBoard, but netlists from WinDraft probably represent an easier and safer option. The screen layout of WinDraft is similar to that of WinBoard, but there is a palette of circuit symbols down the right-hand side of the screen. Over 10,000 predefined symbols are provided and you can produce your own.

Only about half a dozen symbols are shown on the screen at any one time, but an additional scrollbar gives access to the rest. A symbol is added to the drawing by left clicking on it in the palette, and then left clicking somewhere on the drawing area. Further clicks are used if several copies of a symbol are needed.

Once the symbols have been added they can be dragged around the screen, part numbers can be edited, etc. The editing facilities are similar to those of WinBoard. Interconnections are added using



WinDraft has a slightly more modern user interface than WinBoard. This is the Microsoft Office style object properties control box. "Clicking" on one of the eight tabs at the top brings up the appropriate controls.

WinDraft has a search facility that enables the desired component to be located very quickly. This search for a 4017 in the CMOS library proved successful.

a system that is very similar to the manual track routing in WinBoard. WinDraft is a fairly conventional schematic capture program, and anyone familiar with this type of software should find it very easy to use.

In common with most programs of this type the quality of the diagrams produced is a bit basic. However, they are perfectly adequate for most purposes, and by changing the default settings it is possible to produce fancier results.

CONCLUSIONS

The shareware version of the program reviewed here is not supplied with printed manuals, but there are three on-disk manuals in Microsoft Word format (together with a Word document viewer). There are separate reference manuals for WinDraft and WinBoard, plus a "Getting Started and Tutorial" book covering both programs. Although some 97 pages long, it is well worthwhile printing out this third manual and working through the tutorials.

Each reference manual is nearly three hundred pages long, so it would probably be more practical to use these in their software form. Printed reference manuals are supplied with some commercial versions of the programs, and they can be purchased separately. The manuals are quite easy to follow and detailed, and are backed up by good built-in help systems.

It would be wrong to conclude from the low starting price of this software that it is a basic printed circuit design system aimed at beginners. There is no built-in auto-router, but this facility is available as an add-on (which was not tested and is therefore not reviewed here). It has most of the advanced features found in expensive p.c.b. design packages, but there are one or two omissions such as Windows metafile output for example (although there is a basic export facility via the clipboard). It has more than enough features to satisfy most part-time professional and amateur users though.

WinBoard works well as a basic printed circuit drafting program, or in conjunction with a schematic capture program such as WinDraft if a more sophisticated set-up is required. It is possible to adjust track widths, pad shapes and sizes, screen colours, and just about everything else, but it is possible to largely ignore the complexities and use the programs in a relatively simple fashion if that is all you need.

Both programs score well in the usability stakes, and are easier to learn and use than much of the competition. Running under Windows 95 this software was very stable.

VERSIONS

The Ivex software is available in several versions, but they differ only in the maximum number of pins that can be handled. Like most electronics CAD software, the cheapest version seems to offer much better value for money than the more expensive offerings. The shareware version can only handle 100 pins, which is enough to try out the programs and evaluate them, but little else. Anyone in the market for printed circuit design software should certainly give the shareware version of this software a thorough try out.

The 200-pin version is very inexpensive, and should be just about adequate for some educational and home users. For serious use a pin limit of at least 400 to 500 is needed, but the cost soon starts to rise if you opt for this sort of limit. This brings the programs up against some stiff competition, but they remain worthy contenders. As I have pointed out on previous occasions, there is no single printed circuit design program that stands out above all the others.

The best program for the job depends on the type or types of board you will be designing, and the way you like to work. WinDraft and WinBoard are unquestionably programs that can be recommended, and they should certainly be considered by anyone who is intending to buy this type of software.

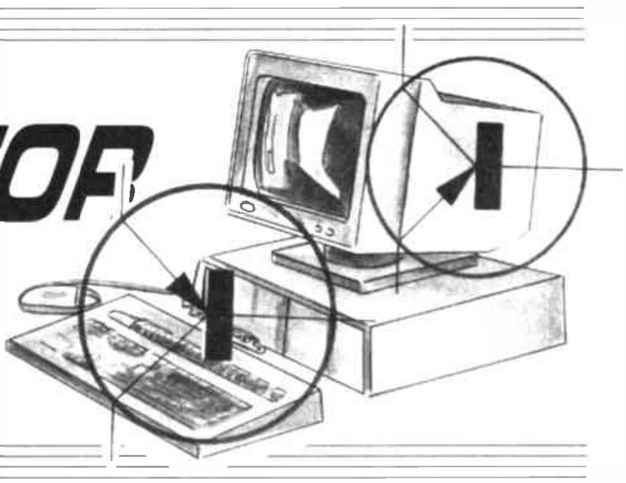
WinDraft and WinBoard are available from: The PC Solution, 2a High Road, Leyton, London, E15 2BP. Tel. 0181 926 1161, Fax 0181 926 1160, E-mail: **info@ThePCSol.Demon.co.uk.** Free 24 hour technical support is also available via the web.

The shareware versions of the programs can be downloaded from **http://www.ivex.com.** Prices for the commercial versions are provided in the table below. These prices include VAT but exclude delivery.

Product	Description	Price
WinDraft	Full product with printed manuals	£464.12
WinBoard	Full product with printed manuals	£464.12
WinDraft P650	Limit of 650 pins, with printed manuals	£205.62
WinBoard P650	Limit of 650 pins, with printed manuals	£205.62
WinDraft P200	Limit of 200 pins, software manuals	£19.95
WinBoard P200	Limit of 200 pins, software manuals	£19.95
Pin Upgrade	WinDraft or WinBoard, per 100 pins	£46.94
Printed Manual	WinDraft or WinBoard	£17.62

Constructional Project

PC TRANSISTOR TESTER



ROBERT PENFOLD

Put your PC to practical work with this short series of low-cost basic test gear projects.

THIS PC Transistor Tester connects to the parallel printer port of a PC, and provides a digital readout of d.c. current gain via the monitor. The unit is an "improved" version of a design first featured in the September 1996 issue of *EPE* (*Interface*, page 690).

It is also the first of several PC test gear projects having their origins in past articles in the *Interface* series. This PC Transistor Tester, in common with the other designs to be published, is very simple and quite inexpensive to build but offers a high level of performance.

There is a big advantage in basing test gear projects on a PC in that it provides a sophisticated digital readout at virtually no cost, provided you already have access to a PC. Where necessary, the PC and the software can effectively provide much of the control logic for the unit.

Both *npn* and *pnp* transistors can be checked using this system. There is no *npn/pnp* switch, but there are separate test sockets for each type of device. You simply connect a test device to the appropriate socket and its gain is displayed on the screen of the PC monitor.

Provided your PC has a bi-directional printer port the screen will also show whether an *npn* or *pnp* transistor is being tested. For both types of transistor the gain range covered is from 25 to over 1000, which covers all normal bipolar transistors.

Note that field effect transistors (f.e.t.s) have very different characteristics to bipolar devices, and that this Transistor Tester is unsuitable for use with any type of field effect device.

IT'S FIXED

Most transistor checkers work on the basis of feeding a fixed base current into the test device and then measuring the resultant collector current. A small base current causes a much larger collector current to flow. The d.c. current gain is simply the collector current divided by the base current.

There is a slight flaw in this type of system, which is that the gain of the test component is not being measured at a particular collector current. A high gain component is tested at the much higher current than a low gain device.

This might not seem to be of great importance, but it has to be remembered that the gain of a transistor varies significantly with changes in collector current. In general, the higher the collector current the higher the current gain.

High gain transistors are tested at relatively high collector currents, which produces rather optimistic results. Of more importance, low gain transistors are tested at quite small collector currents that produce unrealistically low current readings.

Results therefore have to be treated with caution, especially when checking lower gain components. It would clearly be much better if tests were made at a constant collector current and a variable base current. This would avoid any exaggeration of the gain differences between high and low gain components.

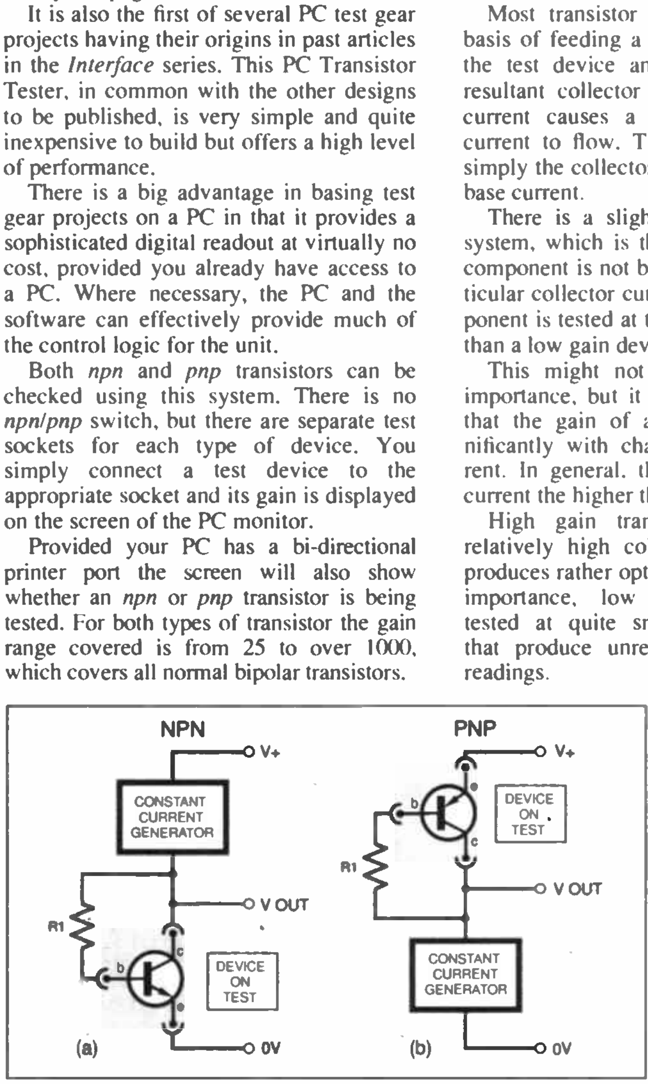


Fig.1. Basic test circuits for npn *and* pnp *transistors.*

The PC Transistor Tester described here provides reliable results by operating with a fixed collector current of 10mA. There is no need for any manual adjustment of the base current as the circuit always adjusts itself for the minimum base current that supports a collector current of 10mA.

One complication with this approach is that there is not a linear relationship between the base current and gain of the test component. The higher the gain of the test transistor, the lower the base current that flows. This problem is easily overcome in the computer-based system, since the computer can do the necessary calculations and convert the base current into an equivalent current gain figure.

HOW IT WORKS

The basic test circuits for *npn* and *pnp* transistors are shown in Fig.1. If we take the *npn* test circuit first, Fig.1a, the collector (c) load is a constant current generator. As one would expect, this sets the current at which the gain measurement is made.

As the ideal test current varies from device to device, a compromise figure has to be chosen. A current of 10mA is not so high that small transistors would risk being damaged, but is high enough to give good results with medium and high power transistors.

The test component is provided with a base (b) current by way of resistor R1, and it is essential to the operation of the unit that the base current is taken from the collector of the test device and not direct from the positive supply rail. A negative feedback action stabilises the circuit with a base current that is just sufficient to maintain a 10mA collector current.

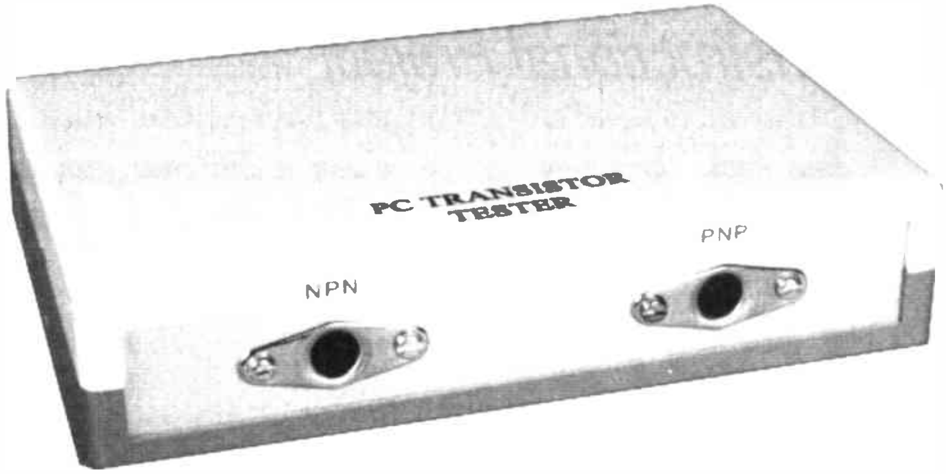
A higher base current would take the test device's collector voltage much lower, which would reduce the base current. Conversely, a lower base current would result in the collector voltage going much higher, producing a higher base current.

This gives the right basic action with a current flow through resistor R1 that reflects the gain of the test component, but how can this be converted into a voltage that can be measured by the computer? The voltage across R1 is proportional to the current flowing through it.

By measuring the voltage across resistor R1 we can effectively measure the current flowing through this component. The potential at the collector of the test device is not quite the same as the voltage across R1, due to the 0·7V or thereabouts at the base of the test transistor. However, we can arrive at the right answer by measuring the collector voltage of the test component and deducting 0·7V from this in the software.

The *pnp* test circuit, Fig.1b, is much the same as the *npn* type, but things have to be rearranged slightly as *pnp* devices require a supply of the opposite polarity to *npn* types. This produces a slight complication because the output voltage is now referenced to the positive supply rail and not to the zero volt supply rail.

Fortunately, there are two easy solutions to this problem. Processing the output voltage using an inverting amplifier having unity voltage gain produces the desired result, as would an appropriate software routine. In this case the hardware solution has been adopted.



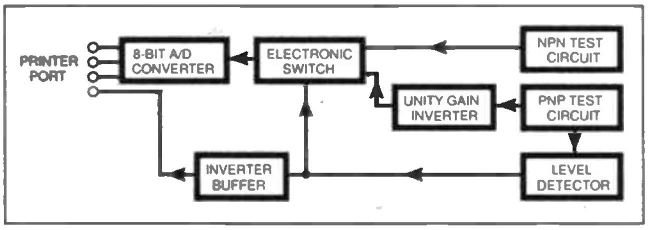


Fig.2. System block diagram for the PC Transistor Tester.

SYSTEM OPERATION

The block diagram of Fig.2 shows the general arrangement used in the PC Transistor Tester interface. The basic *npn* and *pnp* test circuits are entirely separate, and are both continuously active. For the reason explained previously, the *pnp* test circuit is followed by a unity gain inverting amplifier.

The two output voltages are fed to an eight-bit analogue-to-digital converter via an electronic changeover switch. Normally this couples the output from the *npn* test circuit through to the converter, and if an *npn* device is tested its gain will be displayed on the monitor's screen.

If a *pnp* transistor is tested, the electronic switch must be changed over to the alternate position. This is achieved automatically by a simple voltage detector circuit.

Under standby conditions the output potential from the *pnp* test circuit is virtually zero, but there is always a significant increase in the output voltage when a serviceable device is tested. The level detector detects this increase and its output switches the electronic switch to its opposite state. This couples the output of the *pnp* test circuit through to the analogue-to-digital converter.

An input of the computer's printer port can be used to monitor the output of the voltage detector via a simple inverting buffer stage. A simple software routine monitors this input and indicates on the screen of the monitor whether it is a *pnp* or an *npn* device that is being tested.

A/D CONVERSION

The full circuit diagram for the PC Transistor Tester interface appears in Fig.3. IC1 is the analogue-to-digital converter chip, and it requires no discrete components whatever. The pinout functions are indicated in Fig.4.

Although it is an 8-bit converter, it interfaces to the computer via just three lines and a ground (0V) connection. In order to achieve this the data must be read from the converter in serial form. Also, in order to take a reading the chip select ($\overline{CS}$) input at pin 5 is taken low.

The converter is a successive approximation type and it takes 32 system clock cycles to complete a conversion. This equates to no more than 17 microseconds.

Where necessary, a timing loop must be used to ensure that the converter is not read prematurely. This will not normally be necessary when using software written in an interpreted language such as GW-BASIC. There is no form of "end of conversion" status output on the TLC548IP (IC1) incidentally.

Once the chip select input has been taken low, the most significant bit of data (bit 7) can be read from the data output at pin 6. A clock pulse is then supplied to clock input at pin 7, and the next bit of

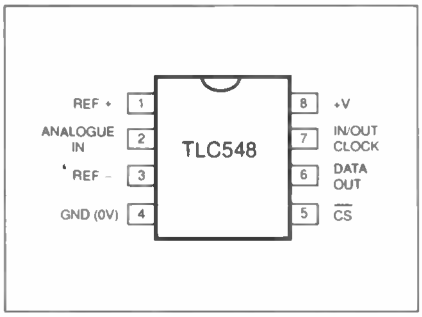


Fig.4. Pinout details for the TLC548 analogue-to-digital converter i.c.

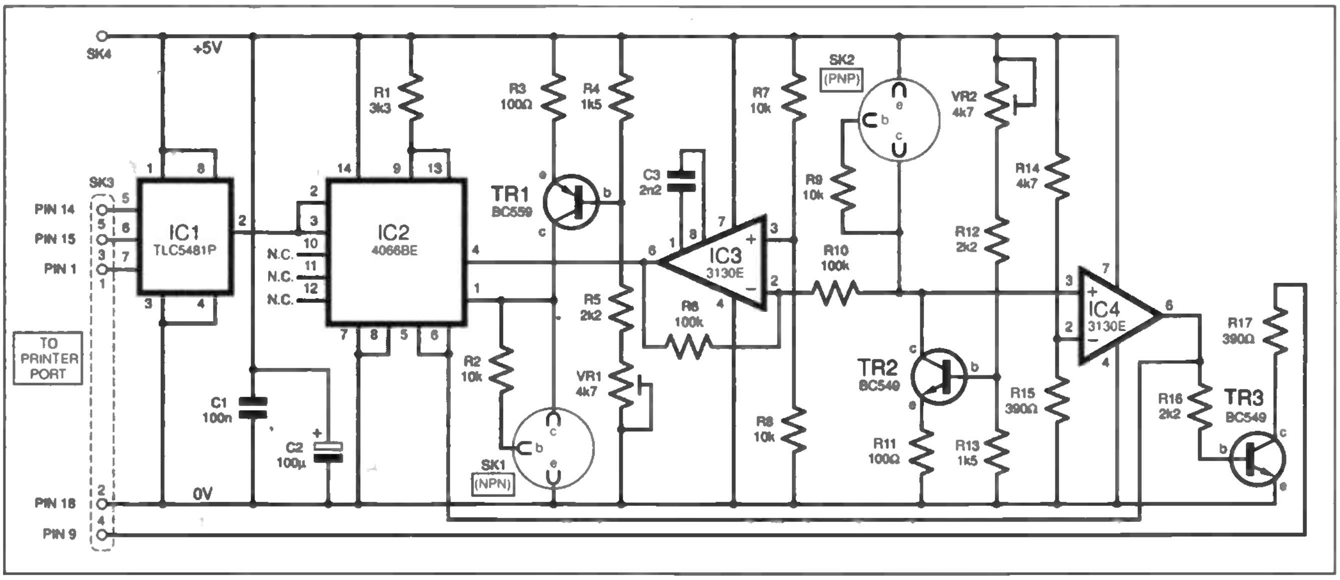


Fig.3. Complete circuit diagram for the PC Transistor Tester.

data is read from the data output. This process is repeated until all eight bits of data have been read. The chip select input is then returned to the high state.

As will probably be apparent from this, the clock signal is not a simple pulse train from an oscillator, but is a software-generated signal on a handshake line. The full scale input voltage is equal to the reference potential applied to pin 1, which in this case is the 5V stabilised supply.

MAIN CIRCUIT

The electronic switch, IC1, is a 4066BE CMOS quad s.p.s.t. bilateral analogue switch, see Fig.5. A changeover action is obtained by using two of the switches with complementary control signals.

A third switch, in conjunction with resistor R1, acts as an inverter that provides the anti-phase control signal for one of the switches. The fourth switch is left unused and its three pins of IC2 are left unconnected.

Transistor TR1 is used as the constant current generator in the *npn* test circuit. It operates in a standard configuration, and preset potentiometer VR1 is adjusted to provide precisely the required output current of 10mA. Resistor R2 is the "test" transistor base feed resistor and its value of 10 kilohms gives convenient scaling. If the value read from the converter is doubled it gives a figure that is, more or less, equal to the current flow through R2 in microamps.

The constant current generator used in the *pnp* test circuit is a complementary version of the one used in the *npn* circuit, but is otherwise identical. Preset VR2 is adjusted to give the correct output current from the collector (c) of TR2.

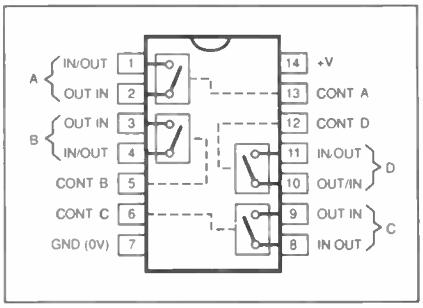


Fig.5. Pinout details and internal structure for the 4066 analogue switch i.c.

The inverting amplifier is based on op.amp IC3. The CA3130E is not an internally compensated device, and discrete compensation capacitor C3 is therefore needed to ensure stable operation.

Note that the CA3130E is suitable for use in single supply d.c. amplifiers and that it will also operate efficiently from a supply potential as low as 5V. Most other operational amplifiers will not work properly in either the IC3 or IC4 positions of this circuit.

IN COMPARISON

Although IC4 is an operational amplifier, it is used in this circuit as a voltage comparator. A reference potential of just under 0·5V is supplied to its inverting input (pin 2) by resistors R14 and R15. Its non-inverting input (pin 3) connects to the output of the constant current generator, and under standby conditions it will be at virtually 0V. This sends the output of IC4 low, which in turn disconnects the output of the *pnp* test circuit from the analogue input of IC1.

When a *pnp* transistor is connected to the unit, even if it is a low gain device, the voltage fed to IC4's non-inverting input is higher than the reference level at the inverting input. This sends the output of IC4 high, and connects the output of the *pnp* test circuit to the analogue input of IC1.

If *npn* and *pnp* test transistors are connected to the unit simultaneously, IC4 will connect the output of the *pnp* test circuit to the converter, and it is the gain of the *pnp* component that will be displayed on the monitor. If the computer has a bi-directional printer port, the type of transistor under test will be shown on-screen.

Transistor TR3 is an open collector switch that drives the most significant data input/output of the printer port. When switched to the input mode the data lines of the printer port are taken high by internal pull-up resistors. TR3 switches on when the output of IC4 goes high, and it then pulls the data input low. R17 is a current limiting resistor that protects the printer port during the periods that it is set to the output mode.

The circuit requires a 5V stabilised supply. The standby current consumption is a mere 4mA, but the consumption rises to about 14mA when a transistor is being tested.

While it would be possible to power the circuit from its own mains power supply circuit, it is cheaper and easier to tap off the +5V supply from the PC. Unfortunately, there is no +5V output on a standard PC printer port, but a +5V supply can be obtained from the keyboard socket or the games port. Both methods are described in detail later.

CONSTRUCTION

The circuit board for the PC Transistor Tester interface is a piece of 0·1in. matrix stripboard, which measures 50 holes by 21 copper strips. The topside component layout and details of the breaks required in the underside copper tracks are shown in Fig.6.

COMPONENTS

See SHOP TALK Page

Resistors

R1	3k3
R2, R7, R8, R9	10k (4 off)
R3, R11	100Ω (2 off)
R4, R13	1k5 (2 off)
R5, R12, R16	2k2 (3 off)
R6, R10	100k (2 off)
R14	4k7
R15, R17	390Ω (2 off)

All 0·6W 1% metal film

Potentiometers

VR1, VR2	4k7 min carbon preset, horizontal (2 off)

Capacitors

C1	100n ceramic
C2	100µ radial elect. 10V
C3	2n2 polyester (5mm lead spacing)

Semiconductors

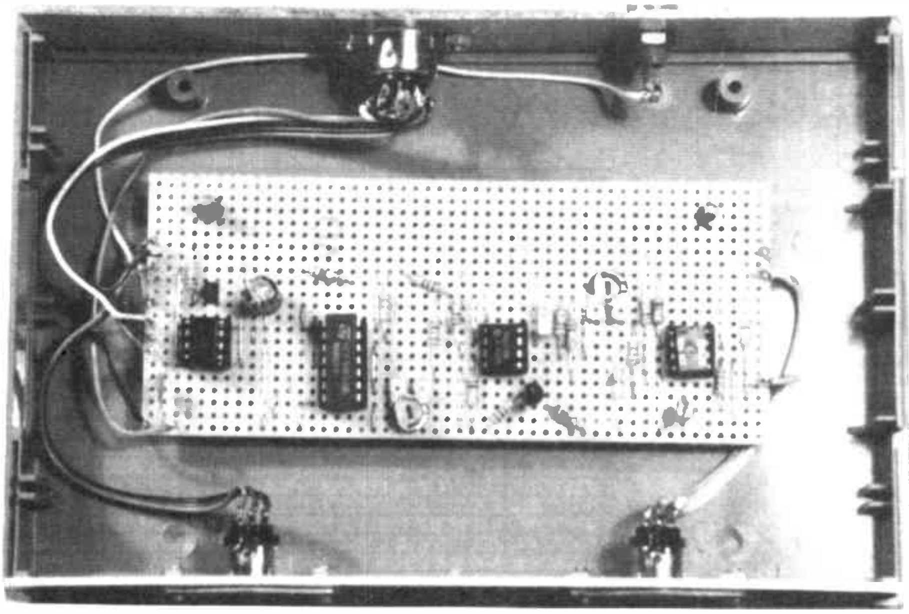
TR1	BC559 *pnp* transistor
TR2, TR3	BC549 *npn* transistor (2 off)
IC1	TLC548IP serial 8-bit A/D converter
IC2	4066BE CMOS analogue switch
IC3, IC4	CA3130E CMOS op.amp (2 off)

Miscellaneous

SK1, SK2	3-way minature DIN socket (2 off)
SK3	5-way 180 degree DIN socket

Plastic or metal case, size to choice; 0·1 inch pitch stripboard, size 50 holes by 21 copper strips; 8-pin d.i.l. i.c. holder (3 off); 14-pin d.i.l. i.c. holder; 4mm terminal socket; interconnecting cables (see text and drawings); multistrand wire; solder pins; solder, etc.

Approx Cost Guidance Only £14
excluding case and cables



Interwiring from circuit board to case mounted components.

Construction of the board follows along normal lines, starting with the smallest component working up to the largest, and is largely straightforward. However, be careful not to overlook any of the numerous link-wires.

Note that IC1 has the opposite orientation to the other three integrated circuits, and that it could be destroyed if it is fitted the wrong way round. All four integrated circuits are MOS devices and should be mounted on the board using d.i.l. sockets, they require the standard anti-static handling precautions.

HARDWARE

Virtually any medium sized case should accommodate the circuit board. Sockets SK1 and SK2 are mounted on the front panel, and miniature three-way DIN sockets are probably the best choice. Most small transistors will connect direct to these quite easily, but it will be necessary to make up a set of test leads to permit the tester to be used with power transistors, surface mount devices, or other "physically awkward" transistors.

The computer connectors could be connected direct to the circuit board, but the neater solution is to fit sockets on the rear of the unit and make up connecting cables. A 5-way 180-degree DIN socket is suitable for the five connections to the printer port, and a 4mm terminal socket will suffice for the +5V supply connection. The wiring diagram of Fig.6 assumes that these types of connector are used.

Wiring details of the cable that is needed to connect the printer port to the PC Transistor Tester are shown in Fig.7. This cable should be no more than about two metres long. It can be made from either a 4-core screened lead or from ribbon cable (the latter being the easier to use). It has a 25-way male D-connector at the computer end, and a 5-way 180-degree DIN plug at the end that connects to the Tester.

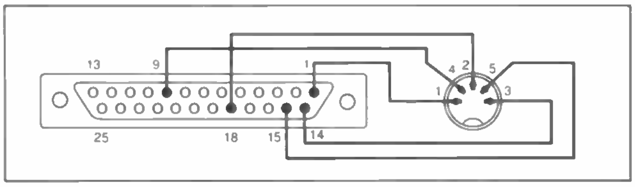
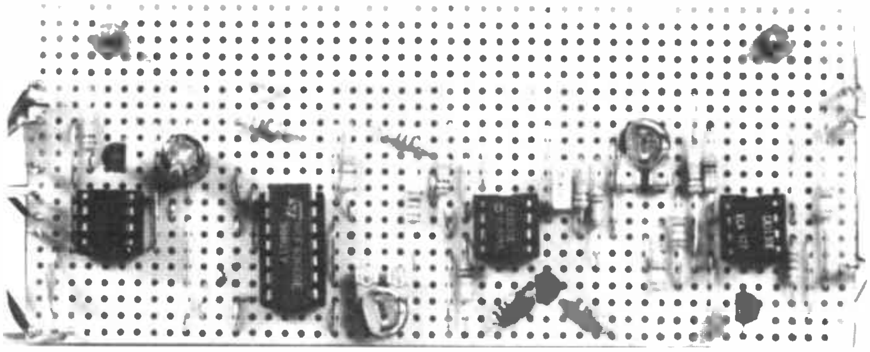


Fig.7. Cable wiring details for linking the Tester to the PC printer port.

If the PC has an unused games port, this represents the easiest way of obtaining a +5V supply for the interface. The connection to the games port is made via a 15-way male D-type connector, and the +5V supply is available at pin 1 – see Fig.8.

The alternative method used for many commercial peripherals is to tap off the +5V supply from the keyboard socket. A ready-made cable for this purpose seems to be difficult to obtain at present, but it is not difficult to make your own.

It is just a matter of making up a short extension cable, as shown in the bottom illustration of Fig.8, and tapping off the +5V supply from pin 5 of the plug. A 5-way (180 degree) DIN line socket is


Layout of components on the completed circuit board.

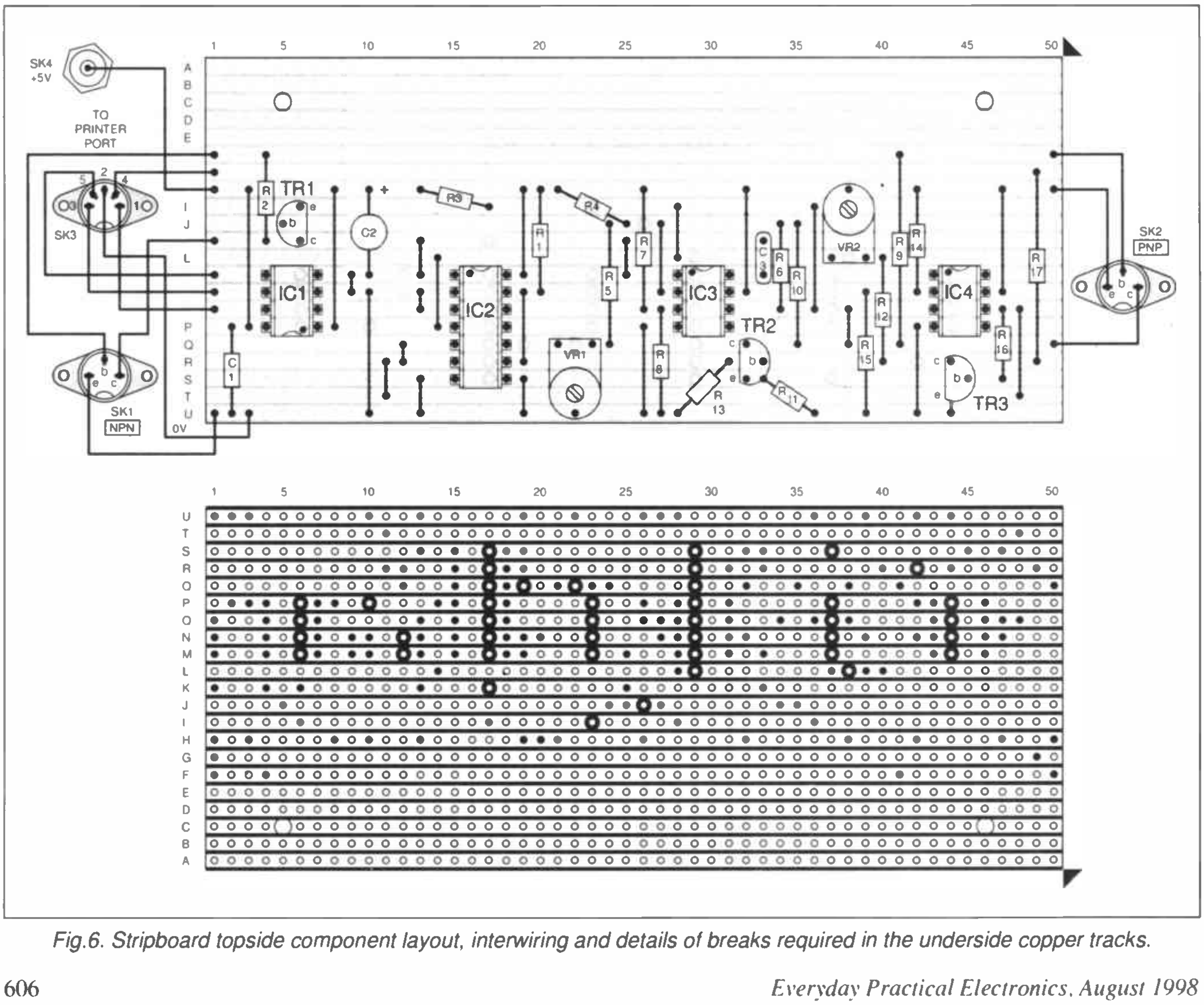


Fig.6. Stripboard topside component layout, interwiring and details of breaks required in the underside copper tracks.

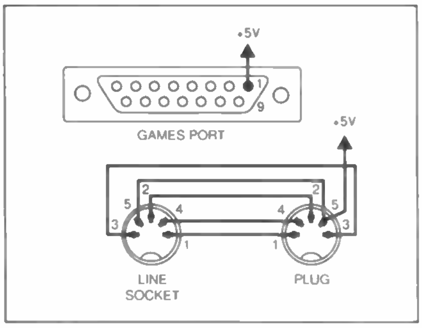
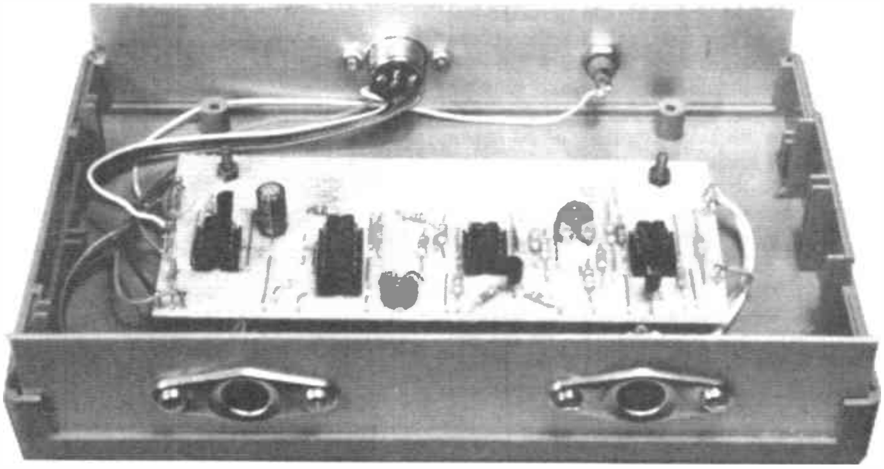


Fig.8. Tapping off the required +5V supply from the games port or the keyboard socket.



Internal layout and wiring inside the low-profile case.

used at one end of the cable, and an ordinary plug of the same type is fitted at the other.

SOFTWARE

The GW-BASIC/QBasic program for this project is basically the same as the one featured in the September 1996 issue. The majority of the program in Listing 1 is concerned with reading the converter, which is a rather convoluted process due to the eight bits having to be clocked out and read one at a time.

The addresses assigned to variables Port1, Port2, and Port3 at the beginning of the program are correct for a parallel port that has its base address at &H278. These must be changed to the appropriate addresses for ports which have a base address of &H378 or &H3BC.

Lines 50 to 70 clear the screen and print "DC CURRENT GAIN" on the screen, just above the screen area that will display gain readings. Next the data lines are set as inputs and the port is read.

The next two lines check to see if the returned value is greater than 127 (D7 high) or less than 128 (D7 low), and each result calls up a different subroutine. These subroutines print "NPN TRANSISTOR" or "PNP TRANSISTOR" at the top of the screen, as appropriate (see below).

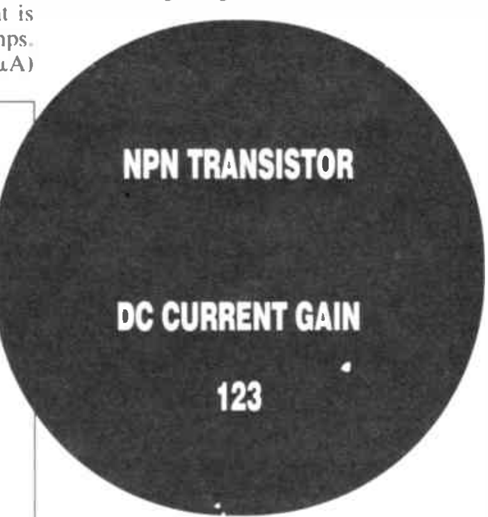
The program then goes into a long routine that reads the converter bit-by-bit and reassembles the bits into a complete byte. Refer to the *Interface* article in the November 1995 issue of *EPE* for a full description of this process.

Once the converted value has been assembled, it is doubled at line 520, and then 69 is deducted from it at line 540 to compensate for the base/emitter voltage of the test device. This gives a figure that is equal to the base current in microamps. Dividing the collector current (10000μA) by this figure at line 550 gives the current gain of the test component. Integer division is used here to avoid a decimal point followed by long strings of meaningless numbers.

In theory the circuit can read current gains as low as 20, but due to imperfections in the hardware only readings down to about 25 are reliable. Lines 560 to 580 are used to suppress readings of less than 25. Readings of 25 or more are printed on the screen at line 590. The program then loops back to line 80 so that new readings are continually taken and displayed. There is no built-in means of exiting the program, but the usual Control-Break method will bring things to a halt.

Listing 1: PC Transistor Tester program

```
10 REM transistor tester program
      (TLC5481 A/D converter)
20 PORT1 = &H278
30 PORT2 = &H279
40 PORT3 = &H27A
50 CLS
60 LOCATE 8,25
70 PRINT "DC CURRENT GAIN"
80 OUT PORT3,32
90 TYP = INP(PORT1)
100 IF TYP>127 THEN GOSUB 610
110 IF TYP<128 THEN GOSUB 640
120 OUT PORT3,1
130 OUT PORT3,3
140 OUT PORT3,2
150 X = INP(PORT2) AND 8
160 X = X*16
170 OUT PORT3,3
180 OUT PORT3,2
190 Y = INP(PORT2) AND 8
200 Y = Y*8
210 X = X + Y
220 OUT PORT3,3
230 OUT PORT3,2
240 Y = INP(PORT2) AND 8
250 Y = Y * 4
260 X = X + Y
270 OUT PORT3,3
280 OUT PORT3,2
290 Y = INP(PORT2) AND 8
300 Y = Y * 2
310 X = X + Y
320 OUT PORT3,3
330 OUT PORT3,2
340 Y = INP(PORT2) AND 8
350 X = X + Y
360 OUT PORT3,3
370 OUT PORT3,2
380 Y = INP(PORT2) AND 8
390 Y = Y/2
400 X = X + Y
410 OUT PORT3,3
420 OUT PORT3,2
430 Y = INP(PORT2) AND 8
440 Y = Y/4
450 X = X + Y
460 OUT PORT3,3
470 OUT PORT3,2
480 Y = INP(PORT2) AND 8
490 Y = Y/8
500 X = X + Y
510 OUT PORT3,3
520 X = X * 2
530 OUT PORT3,1
540 X = X - 69
550 X = 10000\X
560 LOCATE 10,30
570 IF X<25 THEN PRINT "      "
580 IF X<25 GOTO 80
590 PRINT X
600 GOTO 80
610 LOCATE 5,26
620 PRINT "NPN TRANSISTOR"
630 RETURN
640 LOCATE 5,26
650 PRINT "PNP TRANSISTOR"
660 RETURN
```



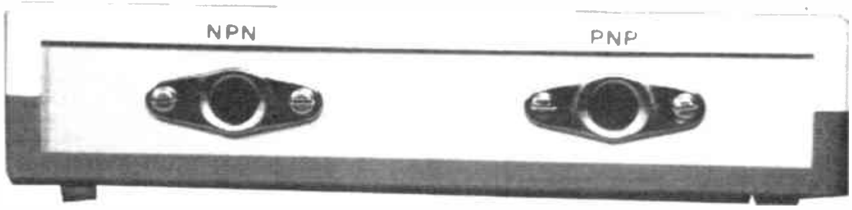
Part of a typical screen display.

ADJUSTMENT AND USE

The unit will not give accurate results until presets VR1 and VR2 have been given the correct settings. With an *npn* transistor connected to SK1 and a *pnp* type connected to SK2, use a multimeter to measure the voltage across resistor R3. Adjust preset VR1 for a reading of one volt, then use the multimeter to measure the potential across resistor R11 and adjust VR2 for a reading of one volt. The unit is then ready for use.

With the system up and running, but no test components connected to test sockets SK1 or SK2, no gain reading will be displayed. The screen should show the test device as an *npn* type, which is the default mode of the interface. Testing a few *npn* transistors should produce some sensible gain figures. With a *pnp* transistor connected to SK2 the screen should again indicate a realistic d.c. current gain figure, and the on-screen heading should indicate the change to *pnp* operation.

If the gain readings are shown correctly, but the *npn/pnp* heading does not alter, the printer port probably does not support bi-directional operation. Leaving resistors R16, R17, and transistor TR3 on the circuit board is unlikely to do any harm, since R17 will prevent a high output current flowing from data line D7 on the printer port. However, it might be best to "play safe" and remove them anyway.



Front panel showing DIN Test sockets.


The power input socket and computer link DIN socket on the rear panel.

HIGH POWER

Although the unit measures current gain at a respectably high collector current of 10mA, this is still quite a low operating current for power devices. Therefore, when testing higher power devices bear in mind that the measured gain might be somewhat lower than the gain that would be produced in a practical application.

An 8-bit converter gives the system quite good resolution, but by measuring the base current rather than the collector current the resolution is higher towards the low end of the range and worse at the high end. It is still more than adequate at high gains though, with a resolution of about four at gains in the region of 200, and a resolution of about 25 at gains of around 500.

SHOP TALK
with David Barrington

Lightbulb Saver

So far, we have drawn a blank on finding a source for the TLP3041 version of the "zero-crossing" triac opto-isolator called for in the *Lightbulb Saver* project. All is not lost though, as the alternative MOC3041 device appears to be fairly readily available from advertisers.

If any readers do experience sourcing difficulties, the MOC3041 is currently listed by **Electromail** (☎ ***01536 204555***), code 301-628. A similar device listed by Maplin (code RA56L) seems to have an identical specification and may be suitable for this circuit. However, we must stress that it has not been "in-circuit" tested.

The 206D power triac is a very common device and most of our component advertisers should carry stocks. Almost any triac with a voltage rating of 400V or more may be used here, with the type specified being probably the cheapest and most widely available.

We now come to the ***X-rated*** capacitor. This ***must*** be rated for continuous operation across the ***a.c. mains*** supply and the one used in the prototype model was purchased from **Maplin**, code JE09K. As the article points out, most capacitors are rated at *d.c.* so you ***MUST*** check its ***a.c.*** rating with your supplier before purchasing.

The small printed circuit board is available from the *EPE PCB Service*, code 202 (see page 620).

Finally, remember that the circuit operates at mains voltages and should NOT be handled when connected up. You must switch off the mains at the fuse box and remove the fuse before fitting the unit or carrying out any fault finding.

Float Charger

No problems should be encountered when ordering components for the *Float Charger* unit. A suitable mains transformer, with 15V-0V-15V secondaries, for this project would be the sub-miniature, wire-ended type from **Maplin**, code YN13P.

If you wish to use the same ABS plastic case as used in the model, this also came from the above company, code BZ74R. The components are a tight fit in this case and you can, of course, use a larger *plastic* box if you wish.

Ranging from several amp/hours to over 20A/H, the prices of non-spill sealed lead-acid batteries vary quite considerably. As the unit is designed for the lower rating (1·2A/H) type, it should not prove to be too expensive. Also, advertisers like **Bull Electrical, Greenweld** and **ESR** etc. often offer Yuasa non-spill batteries at "special discounts" and are certainly worth contacting.

The Float Charger printed circuit board is available from the *EPE PCB Service*, code 199 (see page 620).

PC Transistor Tester

Finding the components for the *PC Transistor Tester* project should be trouble-free. Having said that, the serial 8-bit A/D converter type TLC548IP does seem to be a little elusive and the one in the model came from **Maplin**, code GX06G.

Note that the CA3130E op.amp is suitable for use in single supplies and will operate efficiently from a supply as low as 5V. We understand that most other op.amps will not work properly in this circuit.

If you don't want to go to the trouble of typing in the software program for the Tester, it is available on a 3·5inch disk from the Editorial Offices, order as PIC-Disk 1. See *EPE PCB Service* page 620 for postage charges.

If you are an Internet user, it is also available *Free* from our FTP site: **ftp://ftp.epemag.wimborne.uk/pub/TransistorTester**.

Time Machine Update

The *Time Machine* revised software is available on a 3·5inch disk from the Editorial Office, order as PIC-Disk 1. See *EPE PCB Service* page 620 for postage charges.

If you are an Internet user, it is also available *Free* from our FTP site:
ftp://ftp.epemag.wimborne.co.uk/pub/PICS/timemachine
(Filename RUG810).

That clears the constructional projects and now we turn our attention to some interesting components raised in *Lab Work 10* and *Circuit Surgery* features that will no doubt set readers searching. But first, it is sad to report, but not unexpected, that Farnell have reinstated their £10 minimum order charge for credit card and cash purchases. So, it might pay to lump the "special" components attributed to them in *Lab Work* and *Surgery* together to form a single order.

Teach-In '98 – Lab Work 10

The Siemens SFH450V infra-red fibre optic emitter (code 212-787), the SFH250V infra-red fibre optic detector (212-805) and the ADC0804 8-bit ADC (396-187), for the *Lab Work* demo circuit (Fig.10.16), all came from **Farnell** (☎ ***01132 636311***). Internet users check: **http://www.farnell.com**.

The 1mm sheathed plastic optical cable came from **Maplin**, code XR56L. They also carry the infra-red optic detector, code CZ04E.

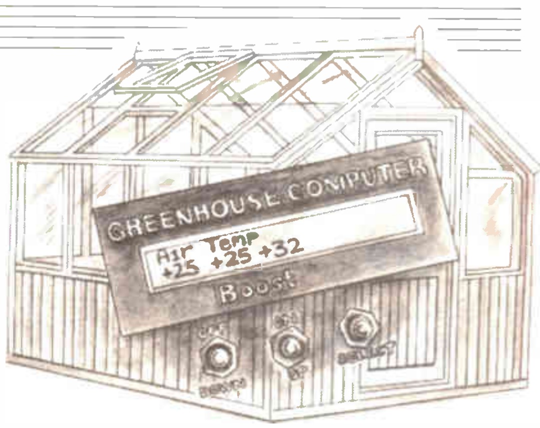
Circuit Surgery

Readers will be interested to find that the 5mm "white" light-emitting diode (code 947-155) and Toshiba 10mm ultra high brightness l.e.d. mentioned in *Circuit Surgery* all came from Farnell (see above). Two versions of the Toshiba l.e.d. are available: yellow 623-465 and orange 623-453.

We notice that a cheaper version (0·4 candelas – less bright) of the white light l.e.d. is listed by **Maplin**, code NU73Q.

Constructional Project

GREENHOUSE COMPUTER



COLIN MEIKLE

Part 2

Microcontrolled heating and watering for your plants, includes optional Radio Link.

LAST MONTH we presented the overall system and described the construction of the control board and power supply units. We continue this month with the testing of the two boards, final assembly and setup menus.

We then move on next month to present the option of a Radio Link feature, so you can, if you wish, view and log the conditions in your greenhouse from the comfort of your home.

TESTING

Test both boards individually before assembling the full system, it will save time in the end! Before applying power to either board, visually check them for shorts and check the correct orientation of all polarized components, etc., and that no solder shorts exist between tracks. This is especially important with the power supply.

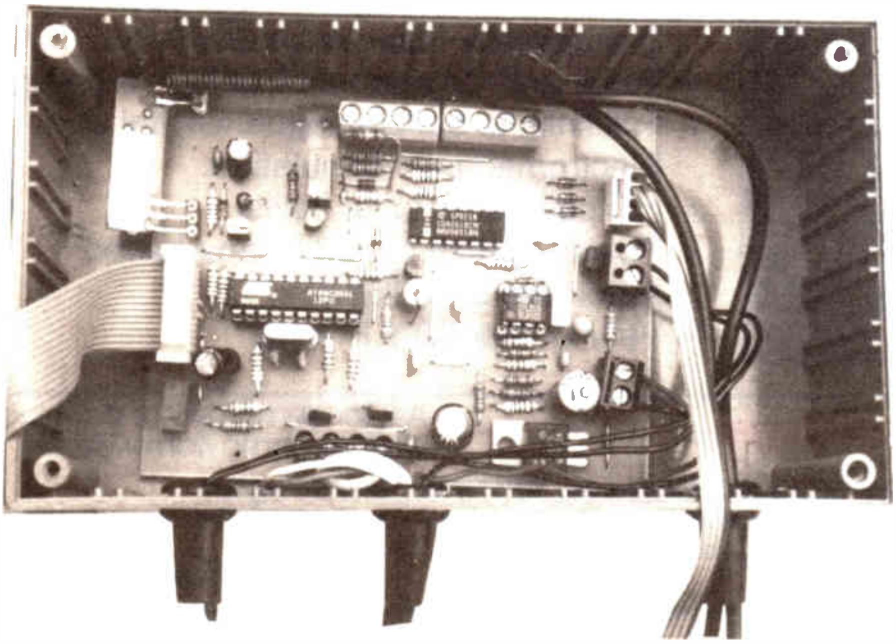
Place the PSU in its box and connect the mains cable as shown in Fig.10.

Do not connect the battery or make any of the other connections yet.

Take the usual safety precautions when testing the PSU, treating all signals as potentially live. Switch off and unplug before connecting any equipment and while working on the unit. If you are in doubt about the mains wiring consult a qualified electrician.

Connect a meter to TB11 (measuring volts d.c.), place the lid on the case and switch on the power. At either setting of switch S4, the meter should read 18V approximately. Repeat with the 18V connection on TB9 (pin 5). With no load on the power supply, the actual voltages may be somewhat higher than expected. (Shorting pins 1 and 2 on TB9 will cause relay RLB to turn on, causing the voltage to fall to the expected value.)

Next connect the batteries, switch on the mains power for 30 minutes for them to charge a little. Now disconnect one of the battery connections and connect a meter in series, set to a milliamps d.c. range. With switch S4 set to Normal the current should read 15mA, and 3mA with it set to Standby.



MAIN BOARD TESTING

Referring to the main board, in Fig.8 and/or Fig.10, temporarily omit the processor (IC1) and the l.c.d. module X2.

Using a meter, ensure there are no shorts between the 5V line and ground (IC1 socket pins 10 and 20 respectively), or across the power input connector TB4.

If you have a bench power supply set it between 12V and 14V and, if available, set its current limit to 100mA. If you don't have such a supply, use this design's own power supply.

Connect the supply to TB4. Turn on the power and verify that there is 5V across pins 10 and 20 on the IC1 socket. Turn the power off, plug in the processor and the l.c.d. Check that the l.c.d. is connected correctly.

Attach a 4·7 kilohms resistor to TB1 in place of each of the temperature thermistors, (i.e. pins 5 and 6, and pins 7 and 8, respectively).

Turn on the power and adjust the l.c.d. contrast control, VR2 – a temperature reading should appear on its screen. If nothing is seen, recheck that IC1 and the l.c.d. are connected correctly and that there is still 5V across pins 10 and 20 of IC1.

If the display remains blank, try reducing the value of R4 (or replace it with a link wire) and check that the display you are using can work from a single supply (some displays need negative voltage for the contrast – a facility not offered by this design).

To initially calibrate the temperature, adjust Reference preset VR1 until the display reads +25°C (first/leftmost number). Fine adjustments can be made later when the thermistors are connected.

If switches S1 to S3 are not connected, connect them now, also connect the two l.e.d.s (D9 and D10) so that the output to the relays can be monitored.

WATER LEVELS

By default the watering functions are disabled (therefore only the temperature is displayed). To test the soil moisture/watering functions, watering requires to be enabled; refer to the Setup section to enable it.

When enabled, the display should give details about the soil moisture and water reservoir level. When the soil moisture probe connections at TB3 are shorted, the moisture level should read zero (or close to it). When a 4k7 resistor is put across TB3, the reading should be approximately 25.

Attach the soil probes and put them in some slightly damp soil (i.e. the soil should be at the dryness level at which you want the watering to come on). The value displayed will depend on the type of soil and distance between the probes.

If the reading is very low (less than five), you may have to decrease the value of resistor R20 to give a better range. Similarly, if the value is very high, increase the value of R19. (Try adjusting the distance between the probes first, as this will be easier.) If the soil is now dampened, the reading should decrease.

With the water level probes open, the reservoir level should be displayed as LOW; when they are shorted together the display should read OK. In the LOW condition, l.e.d. D10 should come on, and turn off for OK.

Replace the temporary resistors across TB1 with the thermistors. The display should now give the correct temperature reading. Reading from left to right, the three figures show the temperature in order of Current, Minimum and Maximum.

If the temperature is incorrect and adjusting VR1 does not correct the problem, you are probably using the wrong thermistor. Check the thermistor's resistance and "B" value is the same as in the components list.

Referring to the Setup section, go through the menus trying out the various options, you should be able to get the temperature l.e.d. (D9) to light by setting up an appropriate temperature.

If the l.e.d.s stay on even with the heating and watering disabled, transistors TR3 and TR4 could have been inserted into the p.c.b. the wrong way round.

Note that the watering function has a built-in timer to stop it being retriggered more than once in a specified period (about four hours), so do not be alarmed if you can only get this to work once! (Turn the power off and on to reset it.)

FINAL ASSEMBLY

First prepare the cases that will house the power supply and the control boards. The location of cable outlets etc. will depend on your particular layout, so give this some thought before drilling any holes (refer to Fig.1 and the photographs). All connections to the p.c.b.s are made via connectors, which makes connecting up the system much simpler.

Both units must be built into waterproof boxes if they are to be used in a greenhouse (you should still take care to protect them from water). All the power supply cable inlets should be made with waterproof cable glands, to ensure this box is watertight. If you find it difficult to make the box watertight, you will have to find a dry location for it in your greenhouse.

Switch S4 should be set for the Standby battery charge rate if the watering option is not being used. Otherwise set it to Normal mode.

Note that the mode switches (S1 to S3) should be positioned below the l.c.d.

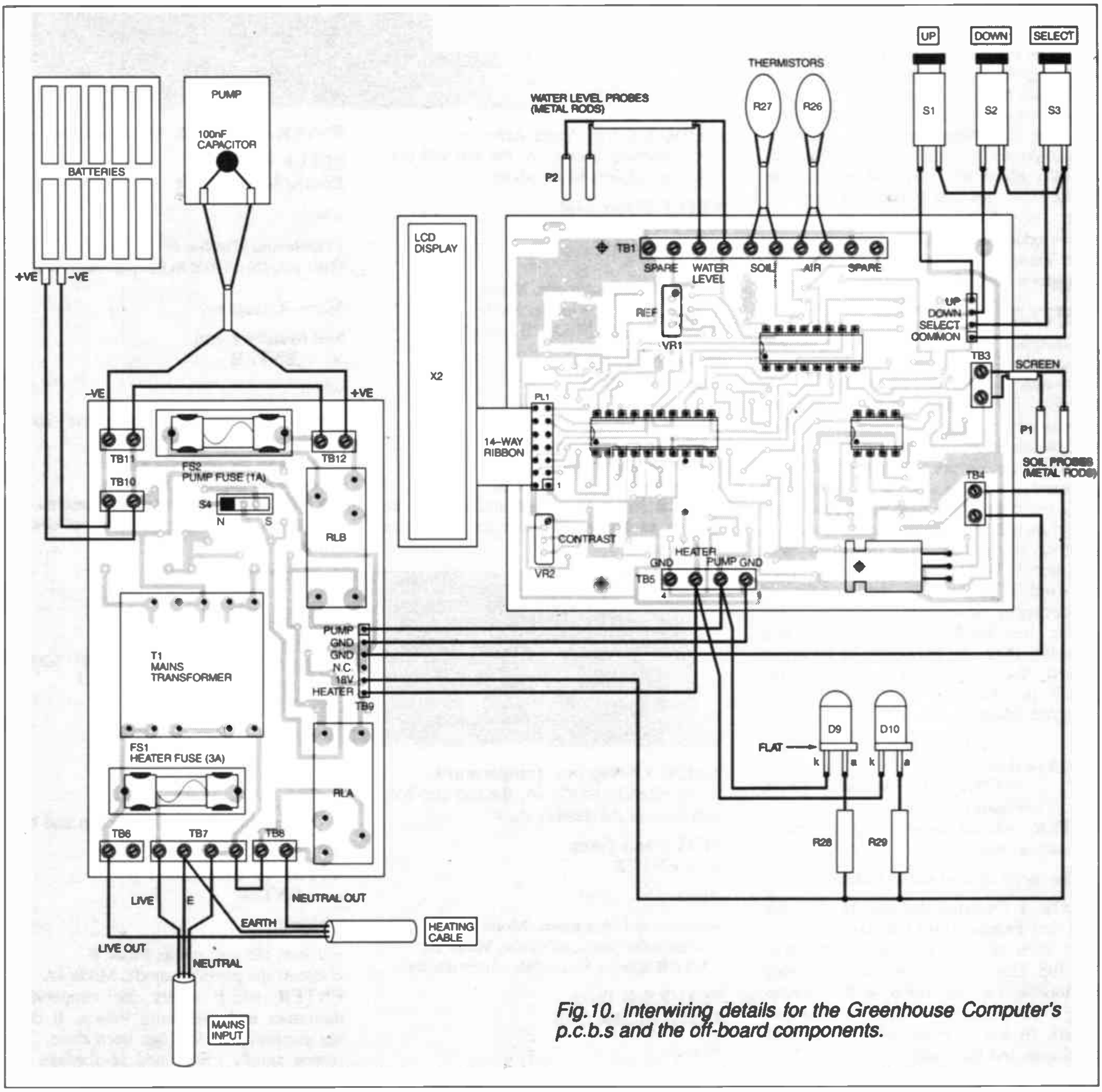
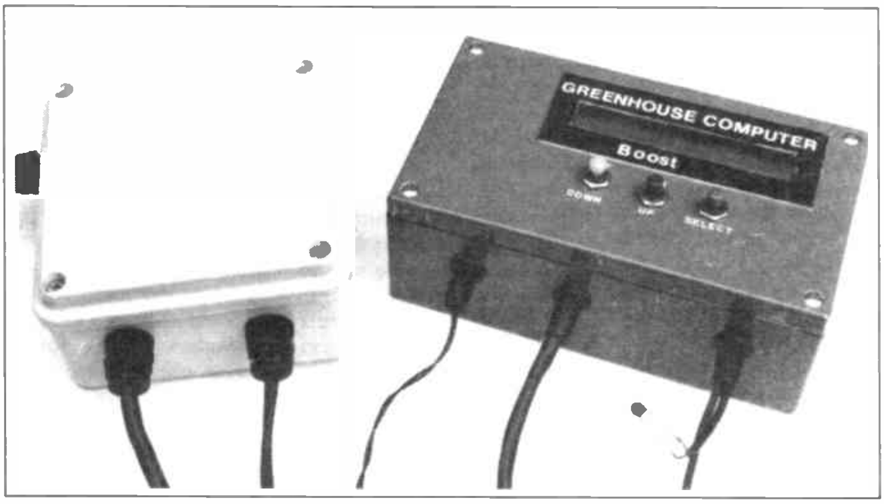


Fig.10. Interwiring details for the Greenhouse Computer's p.c.b.s and the off-board components.



When the controller is in Setup mode the switch function will be shown on the bottom line of the display. These functions should be in line with the appropriate switch.

Plan out the layout of your system – the details in Fig.1 last month are only a suggested setup. Measure the distances between the various components and cut the cables to the correct lengths. Connect up the complete system on your bench and verify that it works correctly.

Inter-connections between the boards and other components are shown in Fig.10, which should be followed carefully. **Use suitably rated wire for the connections to the batteries and pump as these may carry several amps.**

Use good quality cables, connectors and cable glands. Ensure that the heating cable is properly earthed.

SETUP MENUS

Changing the settings is done via the Setup menu. Note that the unit's response to switch presses is not always instantaneous. The software always completes the routine it is currently processing before the switch is tested. In most instances, the response occurs when the switch is *released* rather than when actually pressed.

To enter the Setup modes, first press the Select switch. The Setup menu contains a number of choices, most of which have sub-menus. When you are at the top level, the word SETUP will be shown at the top left corner of the display.

The top level of the display will normally show the parameter to be set or altered, the bottom line will show the button functions, as in the photos, for example, where:

< = On/Up button (middle), selects next menu item
> = Off/Down button (left), selects previous menu item
ENTER = Enter button (right), selects the item shown

The menu options are as follows:

MODE 1 (Normal/Default Mode). Air and Soil Temperature Display

In each of two temperature displays, the top line shows the medium being monitored, i.e. Air Temp or Soil Temp. The lower line shows three temperature values, in left to right order of Current, Minimum and Maximum.

In this mode the up-down buttons turn the boost mode on and off, see Using Boost section. Pressing Select steps the display on to Mode 2A.

Right: Initial screen for Mode 2.

MODE 2. Setup Water Amount

On entering Mode 2A, the top and bottom lines of the display show:

SETUP Water Amt
> < ENTER

where:

> selects the next mode, Mode 3A
< selects previous mode, Mode 7
ENTER selects Mode 2B, which shows:

Water Amt +nn
> < ENTER

where:

+ nn shows the amount value
> increases the amount value
< decreases the amount value
ENTER stores the value and returns the display to Mode 2A, with its options as above.

Left: Initial screen for Mode 3.

MODE 3. Setup Soil Temperature

On entering Mode 3A, the top and bottom lines of the display show:

SETUP Soil Temp
> < ENTER

where:

> selects the next mode, Mode 4A
< selects the previous mode, Mode 2A
ENTER selects Mode 3B, which shows:

SETUP Soil Temp
Enable Disable Quit

where:

Enable and **Disable** select Mode 3C
Quit selects an exit to the previous menu

Mode 3C displays:

Soil Temp +nn
> < ENTER

where:

+nn shows the temperature value below which the heater is switched on
> increases the temperature value
< decreases the temperature value
ENTER stores the value and returns the display to Mode 3A with its options as above.

MODE 4. Watering

On entering Mode 4A, the top and bottom lines of the display show:

SETUP Watering
> < ENTER

where:

> selects the next mode, Mode 5A
< selects the previous mode, Mode 3A
ENTER selects Mode 4B, which shows:

SETUP Watering
Enable Disable Quit

where:

Enable and **Disable** select Mode 4C
Quit selects an exit to the previous menu

Mode 4C displays:

Soil Moisture +nn
> < ENTER

where:

+nn shows the moisture value above which the pump is switched on
> increases the moisture value
< decreases the moisture value
ENTER stores the value and returns the display to Mode 4A with its options as above.

MODE 5. Temperature Reset

On entering Mode 5A, the top and bottom lines of the display show:

SETUP Clr Min Max
> < ENTER

where:

> selects the next mode, Mode 6
< selects the previous mode, Mode 4A
ENTER which clears the temperature minimum and maximum values. It does not confirm that this has been done. The screen simply clears and re-displays the same details.

MODE 6. Exit Setup
On entering Mode 6, the top and bottom lines of the display show:

SETUP Exit
> < ENTER

where:

> selects the next mode, Mode 7A
< selects the previous mode, Mode 5A
ENTER returns the display to the default mode, Mode 1, in which the soil and air temperatures are displayed.

MODE 7. Boost
On entering Mode 7A, the top and bottom lines of the display show:

SETUP Boost
> < ENTER

where:

> selects return to Mode 2
< selects the previous mode, Mode 6
ENTER selects Mode 7B, which shows:

Boost +nn
> < ENTER

where:

+nn shows the value by which the temperature is to be boosted
> increases the temperature value
< decreases the temperature value
ENTER stores the value and returns the display to Mode 7A with its options as above.

PRACTICAL TIPS

Thermistors:
You must protect the thermistor. The easiest way the author found was to solder on the wires, slide it inside a one-inch tube (part of a pen case) and fill the tube with an epoxy resin (Araldite).

Water Spray:
Use a combination of car brake pipes and plastic tubing. Drill an array of tiny (0.8mm) holes in the brake pipe to form a spray, join the pipes together with plastic tubing.

You can use one length of PVC tubing and drill holes where you need the water spray, although using metal pipes will allow you to adjust the position of the sprays easily. In the future, if you no longer need a spray, you can replace it with a solid tube.

Alternatively, you can buy spray jets (microjets) from DIY/gardening shops. These microjet systems have a number of accessories that you may find useful e.g. valves, spray nozzles, T-pieces etc.

Siphoning Problems:
Try to keep the reservoir at the same level or below the watering level, otherwise the water may siphon out of the reservoir (depending on the type of pump).

Pump:
Use a standard car windscreen washer pump, this works well enough for a small area, it is also easy to get tubing to fit.

Probes:
Probes can be made from any metal which will not corrode in the damp soil, stainless steel is ideal. Use a block of wood or similar to keep them the same distance apart, to give consistent readings.

Heating Cable:
Only use proper heating cables intended for this purpose and ensure that they are earthed. These cables can be obtained from gardening shops/suppliers.

Multiple Heating:
The easiest way to heat multiple seed trays and pots is to build a large box and fill the bottom with two inches of sand. Line the box with polythene to stop the wood becoming damp. The heating cable is buried in the sand (dampen the sand, so that the heat is distributed evenly).

Take care to ensure that the thermistor is positioned away from the cable. Pots and seed trays can simply be placed on top of the sand. Try to keep the sand covered, to stop it drying out quickly.

Right: Screen for Mode 2B, water amount setting.

SETUP EXAMPLE

The following is an example of using the Setup procedure, in this instance, water amount. It is assumed that the screen is displaying Mode 1 (the default mode for air and soil temperature).

1. Press the Select switch. The display should change to show Mode 2A (see earlier). The top line shows the parameter that can be changed (water amount), the bottom line shows the button functions
2. Press the Select switch, to display Mode 2B
3. Now set the water value using the Up/Down buttons. When you have the correct value press ENTER (you will now be returned to the Water Amount Setup menu, from where you can move forwards or backwards through other mode functions
4. Press the Up switch until EXIT Setup appears. Press Enter once. After a second or so you will be returned to Normal operation (if you press it more than once you may be returned to the Setup menu. If so use the Up/Down buttons to find EXIT Setup again.

IN USE

Using the controller properly may take a little practice. Go through the menu options so you know where they all are. When setting the watering option remember that the computer will not water the plants more than once every four hours, approximately. Therefore, do not assume your system is not working if you put the probes in dry soil and it does not turn the pump on.

To avoid this (e.g. for testing), disconnect the battery backup from the power supply board and turn the mains power off and on again to reset the internal timer. This will, of course, reset all of your other settings.

In normal operation, the data displayed on the l.c.d. will depend on which options are enabled. If the watering option is disabled the display will show air temperature, followed by soil temperature; this is the default. If the watering option is enabled the soil moisture and water reservoir level will also be shown.

USING BOOST

Boost control is an option to allow two levels of temperature setting. For example, you may want to boost the temperature of the heating during seed germination. You may wish to keep the normal temperature for seedlings at 15°C. However, to germinate the seeds, the temperature may have to be higher e.g. 20°C.

You could go into the Setup menu and change the temperatures as required, but boost allows you to have these levels preset.

Using the Boost On and Boost Off facility you can switch between them.

For example, go into the mode for Setup Soil Temperature and set it to 15°C, then step on to Setup Boost and set its temperature to 20°C. In normal operation the temperature will be maintained at 15°C. When you want to germinate seeds, press the On switch while in the default mode and the soil temperature is being shown. The word BOOST will be shown on the display when the soil temperature is being displayed. When the seeds have germinated press the Off switch (while in default mode) to return to normal operation (15°C).

Note that if the soil heater is disabled, Boost will not work.

If you are not intending to use the Boost function, set the boost temperature to 0°C.

WATERING INSTRUCTIONS

There are two adjustable parameters for controlling the plant watering. These are the amount of water delivered in each watering (controlled by the time for which the pump is on). The other parameter is soil moisture, i.e. when to water. Both must be set up for the watering to work correctly.

The setup menu options for watering are:

Water AMT:
Controls how long the pump is on for, the higher the number the longer the pump will be on.

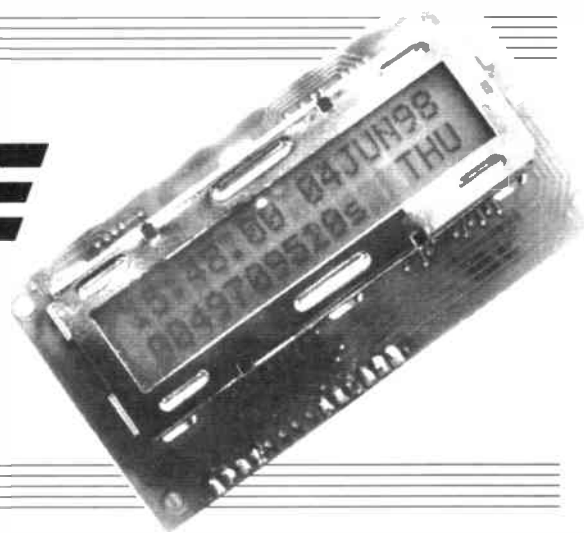
Watering:
Controls whether the watering feature is enabled or not and sets the soil moisture level. The lower the number the wetter the soil will be.

These parameter can only be set by trial and error; the values themselves are meaningless as they will change from setup to setup.

Next month: We conclude with the optional Radio Link.

Project Modification

TIME MACHINE UPDATE



JOHN BECKER

Abridged Millennium countdown without switches!

MILLENNIA rarely happen! That, perhaps, is why there has been considerable interest in the *EPE Time Machine* published in the November '97 issue (see *Back Issues* page if you want a copy).

Of course, the term *Time Machine* inspires the imagination as well, principally in an H.G. Wellsian fashion. Are we not all fascinated by the thought of travelling forwards or backwards in time? To experience the great events in history and to discover the wonders that have yet to be revealed – what an experience!

The *EPE Time Machine* title, though, simply played with words in order get attention – but it *does* deal with time and it *is* a machine (anyone care to challenge me on that last point?). It is a PIC-controlled design which picks up radio signals from a transmitter at Rugby, and extracts and displays the extremely accurate clock and calender data held within them. With this data, external equipment can be turned on and off at user-set times.

But, with the excitement of the forthcoming Millennium at hand, it also shows a countdown of the seconds remaining until precisely midnight on Millennium's Eve. From then on it counts down the seconds until the start of New Year's Day in 2100.

WE'LL DRINK TO THAT!

Well, it is this countdown in particular that has attracted a lot of attention, not just from you the readers, but also from commercial interests.

Spaced a few weeks apart, we were recently contacted separately by representatives of two major drinks companies, Courvoisier and Coca Cola. They wanted to know if our *Time Machine* could be modified to simply show the timed countdown without the additional equipment control facilities and its pushbutton switches and, if so, could we do the modifications for them. They had in mind using an abridged version in widespread advertising campaigns.

We said that it *could* be modified but that, regretfully, we do not offer a modification service for our published projects. Personally, I also felt that I could not take on any additional work by offering my out-of-hours services.

As sometimes happens, though, I became intrigued about how a circuit could be modified to suit other needs. Examining the code out of idle interest one evening, I found that I was making changes and that the changes were quite simple, and then that the changes had all been made! Such is obsession!

Ironically, over a week then had to be waited before testing it – Rugby was undergoing its annual maintenance period with the transmitter turned off! But now, here for you all at large (including Courvoisier and Coca Cola if your PR teams are watching), is the abridged version.

The revised l.c.d. screen layout is shown in the title photograph: *time* – top left, *date* – top right, *weekday* – bottom right, and *countdown* – bottom left.

WHAT'S INVOLVED

The amended software can be run in the full hardware version without any component deletions. Alternatively, if you are about to build the *Time Machine* just for use with the shortened software, you can omit the keypad (S4 to S15), transistors TR1 to TR4, resistors R10 to R24, l.e.d.s D6 to D9 and diodes D10 to D13.

There is one significant change, however. The microcontroller (IC3) ***must*** be the PIC16F84. You ***cannot*** use the originally specified PIC16C84.

The reason is the number of SRAM data registers available. The 'C84 has 36 and the 'F84 has 68. The revised software requires 42 registers to accommodate the fact that the Rugby decoding and Millennium countdown calculations are occurring in parallel with the shortened version. In the original, the two procedures never occurred at the same time (see its published text), and the same registers were used for both functions.

Had I been designing from scratch, I might have figured out a way to not need the additional six registers. As a modification in an idle moment, though, the extra time involved to significantly reprogram was not justified – a decision based in part on the ready availability (and usefulness) of the relatively-new 'F84.

TIME ZONES

Now, just to pre-empt questions from those in other time-zones, a reminder that the *Time Machine* software is written to display UK time as transmitted by Rugby. Whilst Rugby can be picked up across much of Europe (but *not* elsewhere), the software does not convert the timings to suit their respective time-zones.

It *could* be made to do so, but that implementation would be entirely up to you. This is a challenge which (this time) I really must resist!

What would be needed is an additional routine following that which decodes the Rugby data. In it you would need to add the extra minutes and hours difference between your time-zone and the UK.

This' would require each time and calender value to be constantly monitored and checked for roll-over following the corrective addition, and updated accordingly, i.e. minutes, hours, days, day of the week, day of the month, month and year would all need to be checked and corrected appropriately. The code for this would be quite complex, although a similar routine is already used in the default clocking routine which takes over when the Rugby signal is not being received.

It would also be necessary to monitor for any differences between time-zones changing over between summer and winter corrections in relation to the UK's GMT and BST change-overs. This would add further complexity to the software. Whilst the EU intends to standardise the dates of seasonal time changes across Europe, so far as is known this has not yet been implemented.

OBTAINING SOFTWARE

The revised software is available on disk from the Editorial office and our web site. See *Shop Talk* and the *EPE PCB Service* pages for details.

At the time of writing, the seconds remaining until 00:00.00 on 01 Jan 2000 are M minus 50,189,534 and counting!

VIDEOS ON ELECTRONICS

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(All videos are to the UK PAL standard on VHS tapes.)

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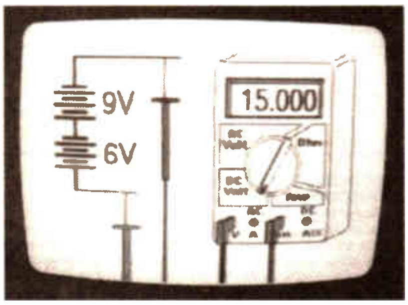

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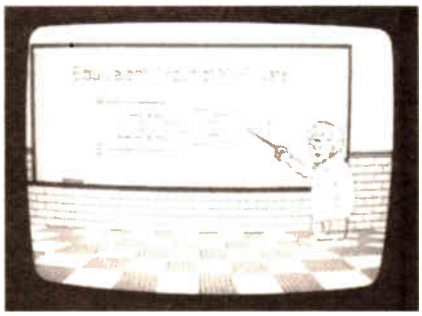

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Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

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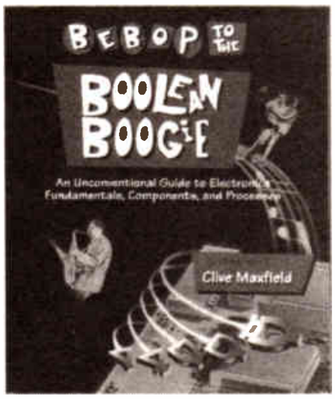
An Unconventional Guide to Electronics Fundamentals, Components and Processes

The Foreword by Pete Waddell, Editor, *Printed Circuit Design*, reads:

"Personally, I think that the title of this tome alone (hmmm, a movie?) should provide some input as to what you can expect. But, for those who require a bit more: be forewarned, dear reader, you will probably learn far more than you could hope to expect from *Bebop to the Boolean Boogie*, just because of the unique approach Max has to technical material. The author will guide you from the basics through a minefield of potentially boring theoretical mish-mash, to a Nirvana of understanding. You will not suffer that fate familiar to every reader: rereading paragraphs over and over wondering what in the world the author was trying to say. For a limey, Max shoots amazingly well and from the hip, but in a way that will keep you interested and amused. If you are not vigilant, you may not only learn something, but you may even enjoy the process. The only further advice I can give is to 'expect the unexpected'."



This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean algebra and Karnaugh maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day....

By importing these books ourselves we have managed to make them available in the UK at an exceptional price.

Bebop Bytes Back

By Clive "Max" Maxfield and Alvin Brown

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An Unconventional Guide To Computers

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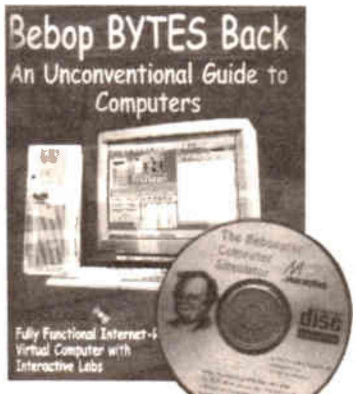
The Foreword by Lee Felsenstein reads:

"1. The more time you spend with this book and its accompanying CD-ROM, the more you'll get out of it. Skimming through it won't take you where you want to go. Paying serious attention, on the other hand, will teach you more about computers than you can imagine. (You might also see a few beautiful sunrises.)

2. The labs work on two levels: on and under the surface. When you're performing the labs you'll need to look for patterns that build up from individual events.

3. When you're done, you won't look any different. You won't get a trophy or a certificate to hang on your wall. You'll have some knowledge, and some skill, and you'll be ready to find more knowledge and develop more skill. Much of this will be recognisable only to someone who has the same knowledge and skill."



This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

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Robert Penfold

Designing your own PIC based projects may seem a daunting task, but it is really not too difficult providing you have some previous experience of electronics. The PIC processors have plenty of useful features, but they are still reasonably simple and straightforward to use. This book should contain everything you need to know.

Topics covered include: the PIC register set; numbering systems; bitwise operations and rotation; the PIC instruction set; using interrupts; using the analogue to digital converter; clock circuits; using the real time clock counter (RTCC); using subroutines; driving seven segment displays.

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Contains all of the everyday information that anyone working in electronics will need.

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R. M. Marston

A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s and other devices used are inexpensive and readily available types, with universally recognised type numbers.

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OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold

The first part of this book covers standard operational amplifier based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signal generator, simple video fader, and many more.

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R. A. Penfold

Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.

The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

The emphasis is on a practical treatment of the subject, and all the circuits are based on "real" CMOS devices. A number of the circuits demonstrate the use of CMOS logic i.c.s in practical applications.

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AUDIO AND MUSIC

INTRODUCTION TO DIGITAL AUDIO (Second Edition)
Ian Sinclair

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J. Chatwin

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Along with the electric guitar, sections are also included relating to acoustic instruments. The function of specialised piezoelectric pickups is explained and there are detailed instructions on how to make your own contact and bridge transducers. The projects range from simple preamps and tone boosters, to complete active controls and equaliser units.

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R. A. Penfold

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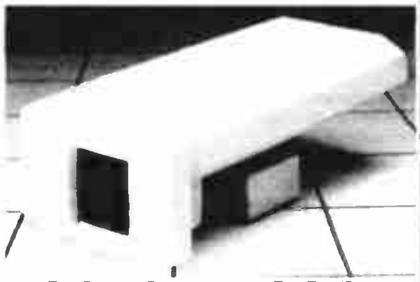

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DIGITAL PROPORTIONAL B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc £20 each. sold as seen ref LOT2DP

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9.95 ref BAR31

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

HIGH POWER DC MOTORS, PERMANENT MAGNET

12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front

£22ea REF mot4

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: editorial@epemag.wimborne.co.uk**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details.

Please check price and availability in the latest issue.

Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
B.F.O. and Bat Band Converter	MAY'96	984a/b	£5.80
Versatile PIR Detector Alarm		988	£6.76
Mind machine Mk III – Tape Controller		989	£6.70
Midi Analyser		992	£6.74
Countdown Timer (Teach-In '96)		993	£9.44
Sarah's Light	JUNE'96	996	£7.17
Home Telephone Link		997 (pr)	£10.72
*PulStar		998	£6.60
VU Display and Alarm		999	£7.02
Ultra-Fast Frequency Generator	JULY'96		
and Counter – Oscillator/L.C.D. Driver		994/995 (pr)	£12.72
Timed NiCad Charger		100	£6.99
Single-Station Radio 4 Tuner		101	£7.02
Twin-Beam Infra-Red Alarm – Transmitter/Receiver		102/103 (pr)	£10.50
*Games Compendium		104	£6.09
Mono "Cordless" Headphones	AUG'96		
– Transmitter/Receiver		990/991 (pr)	£10.16
Component Analyser (double-sided p.t.h.)		105	£12.18
Garden Mole-Ester		106	£6.07
Mobile Miser		107	£6.36
Bike Speedo		108	£6.61
*PIC-Tock Pendulum Clock	SEPT'96	109	£6.31
Power Check		110	£6.42
Analogue Delay/Flanger		111	£7.95
Draught Detector		112	£6.22
Simple Exposure Timer		113	£6.63
Video Fade-to-White	OCT'96	114	£6.98
Direct Conversion 80m Receiver		116	£7.52
Vehicle Alert		117	£6.55
10MHz Function Generator – Main Board		118	£7.33
– PSU		119	£5.39
Tuneable Scratch Filter	NOV'96	115	£7.83
*Central Heating Controller		120	£7.85
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– Step-Up Regulator		124	£6.12
EPE Elysian Theremin	DEC'96		
(double-sided p.t.h.)		121	£22.00
*PIC Digital/Analogue Tachometer		127	£7.23
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*Earth Resistivity Meter	JAN'97		
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*PIC-Agoras – Wheelie Meter	APRIL'97	141	£6.90
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– Receiver		143	£6.04
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– Interface		148	£5.91
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*PIC-A-Tuner		149	£7.83
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– Closer		151	£4.47
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*PIC Digilogue Clock		156	£7.39
Narrow Range Thermometer		158	£6.37
Micropower PIR Detector – 1	JULY'97	152	£6.69
Infra-Red Remote Control Repeater			
(Multi-project P.C.B.)		932	£3.00
Karaoke Echo Unit – Echo Board		159	£6.40
– Mixer Board		160	£6.75
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*PEsT Scarer		162	£6.60

PROJECT TITLE		Order Code	Cost
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*PIC-OLO		164	£7.02
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*PIC Noughts & Crosses Game		165	£7.82
Micropower PIR Detector – 3			
Alarm Disarm/Reset Switch		166	£5.72
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Remote Control Finder	OCT'97	168	£6.32
Rechargeable Handlamp		169	£6.23
*PIC Water Descaler		170	£6.90
*EPE Time Machine	NOV'97	171	£8.34
Auto-Dim Bedlight		172	£6.63
Portable 12V PSU/Charger		173	£6.61
Car Immobiliser	DEC'97	175	£7.00
Safe and Sound (Security Bleeper)		179	£7.32
Surface Thermometer	JAN'98	174	£7.64
Disco Lights Flasher		178	£8.30
Waa-Waa Pedal (Multi-project PCB)	FEB'98	932	£3.00
*Virtual Scope – Digital Board		176	£14.49
Analogue Board (per board)		177	£7.34
*Water Wizard		180	£7.69
Kissometer		181	£7.67
**EPE PIC Tutorial	MAR'98	182	£7.99
The Handy Thing (Double-Sided)		183	£6.58
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*Audio System Remote Controller – PSU		185	£7.05
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(Multi-project PCB)		932	£3.00
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Tone Control		190	£7.78
20W Amplifier		191	£8.58
*Dice Lott		192	£8.05
EPE Mood Changer	JUNE'98	193	£7.75
*AT89C2051/1051 Programmer			
Main Board		194	£8.50
Test Board		195	£8.69
*Reaction Timer **Software only**		–	–
*PIC16x84 Toolkit	JULY'98	196	£6.96
*Greenhouse Computer			
Control Board		197	£9.08
PSU Board		198	£8.10
Float Charger	AUG'98	199	£6.59
Light-Bulb Saver		202	£3.00

EPE SOFTWARE

Software programs for *EPE* projects are available on 3.5 inch PC-compatible disks or via our Internet site. Those marked with a single asterisk * are all on one disk, order code PIC-DISK1, this disk also contains the *Simple PIC16C84 Programmer* (Feb '96). The *EPE PIC Tutorial* (**) files are on their own disk, order code PIC-TUTOR. The disks are obtainable from the *EPE PCB Service* at £2.75 each (UK) to cover our admin costs (the software itself is *free*). Overseas (each): £3.35 surface mail, £4.35 airmail. All files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

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NOTE: You can order p.c.b.s via our Internet site on a *secure* server: **http://www.epemag.wimborne.co.uk**

SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY

THE *Net Work* column is specially written for readers having access to the Internet. You can find details of what the magazine has to offer by browsing our web site **www.epemag.wimborne.co.uk**, where there are photos of projects from the current and earlier editions. You can, of course, also subscribe (or renew your subscription), order Back Issues and printed circuit boards by using the secure server which we provide as an additional service to readers. Access this by checking our web site home page.

The latest files related to this month's projects are held on our FTP site for free distribution at:
ftp://ftp.epemag.wimborne.co.uk/pub/TransistorTester.

The Time Machine's updated software is at sub-directory: **/pub/PICS/timemachine**, filename **RUG810**.

We are also pleased to announce that due to the tremendous interest in our PIC-based projects, a new EPE PIC Mirror Site has been opened by Thomas Stratford at:
http://homepages.nildram.co.uk/~starbug/epepic.htm.

More Secure

The average consumer is not known for being a terribly rational buyer. In earlier editions of *Net Work*, I commented on some of the present trends for purchasing on-line. I previously said that if you pay for a restaurant meal, or buy petrol on a charge card as I do, then purchasing on-line is very probably much safer than signing the sales ticket in the restaurant or filling station.

Why? Two reasons: when transacting at a check-out in person, you are creating a hard copy of the sales transaction – a carbon copy which is retained by the store. This can, and almost certainly will, end up in a bin somewhere, before it is eventually incinerated (maybe). It contains details of your purchase, your credit card number and expiry date, plus, the date and time of your transaction as well.

Unlike in France, there is no way that an individual can endorse the transaction using a PIN number, and scams involving magnetic-strip credit cards are legion (and are likely to remain so until smart cards are introduced). The second reason for concern is that the sales ticket contains a copy of something which you cannot easily render on the Internet – your hand-written signature.

All of these personal details can be intercepted by anyone else, days or even weeks afterwards. There are celebrated cases in the United Kingdom of schoolboys who found a sackful of credit slip copies in the bin of a local restaurant, and managed to clock up a whole string of purchases by forging the credit card details they discovered. More recently, a British bank was berated for dumping confidential customer data in its dustbin, outside in the street.

The paradox is that the consumer blithely signs a credit card transaction slip without a second thought about the personal data they provided to the "merchant".

When dealing with a "secure server" (the URL commences with **https://** and a padlock symbol displays on the browser to signify this), then any information is encrypted and it is rendered unintelligible without the decryption software and powerful passphrases needed to unlock it. The bottom line appears to be this: there are many easier ways in everyday life in which private data can be acquired for unlawful reasons, and none of them involves scanning millions of E-mails in the hope they may contain transaction data. In my opinion, it is safer to use a properly-certified secure server on the Internet than it is to give your card to a restaurant waiter or garage, and you face far greater risks of theft or fraud at street level in any case.

One precaution that is worth taking, however, is to avoid quoting comprehensive credit card details in ordinary E-mail. The prime reason is the simplicity with which those details can then be forwarded to someone else, perhaps by accident. As an example, a reader – a customer of a major electronics distributor – contacted me with a query on component availability, and he quoted the contents of an E-mail he had received back from the supplier. The supplier had, in fact, re-quoted the customer's credit card details back to him, and these were accidentally included in the E-mail forwarded to me. Obviously the data was destroyed immediately, but it illustrates the ease with which sensitive data can be mailed out with just a few mouse clicks. In my view, this is more of a risk than, say, transaction data being hoovered up by a hacker.

Get SET

News surfaces occasionally about Secure Electronic Transactions (SET), a system proposed by two of the major credit card providers (Mastercard and VISA, with American Express waiting in the wings) whom together form the controlling body SET LLC. They are working towards standardising a method of secure transactions which protects both the seller and the consumer. The security systems involved are still undergoing development and there have been some successful trials in the USA: more information is on **www.setco.org**. It will have been a long time coming – with SET in Europe lagging behind – but without a doubt, with the increasingly widespread acceptance of telephone banking and the QVC shopping channel on satellite TV, then shopping by Internet is here to stay. By the year 2000, you will hopefully see the "SET" logo appearing on web sites everywhere, which should dispel the last remaining doubts of those worried-looking consumers. In the meantime, I am perfectly happy to purchase several hundred dollars' worth of books on-line via a secure server at Amazon.Com, or software from San Francisco which is delivered a week later, or software upgrades fetched by FTP and charged to my credit card, with no problems about security at all.

Latest Links

A variety of links are suggested this month as a starting place for your surfing. These URLs are already made for you on the *Net Work* on-line version of our web site. Remember too that all links are preserved on the popular Net Work A-Z Index of URLs (**www.epemag.wimborne.co.uk/netwkaz.htm**). If you are stuck for a place to look, try the Index first for inspiration.

First, some PIC-related pages: Picpoint is entirely devoted to PIC microcontrollers, and is a definite bookmark, see **www.picpoint.com** which is an excellent resource. This links to Rickard's PIC Wall at **www.efd.lth.se/~e96rg/pong.html** (a 4MHz PIC running at 12MHz and playing 'Pong'!). EPE's own Technical Editor has a few ideas too: John suggests **www.e3g.com**, the world's largest on-line electronics resource. John also recommends Arizona's site **www.microchip.com**, which has been rebuilt under the banner of "Planet Microchip".

Those who are still struggling with Karnaugh Maps (as described in *Teach-In '98*) may be relieved to hear that Clive Maxfield (of "*Bebop Bytes Back*" fame) has published an in-depth tutorial of K-maps, be sure to bounce over to **www.maxmon.com** and check in the "library". Last month I mentioned FTP software, including the popular WS_FTP Pro loved by Windows users. The new UK distributor for this popular product by Ipswitch Inc. is Open Access Ltd. at **www.openaccess.co.uk**.

Electronix Express is an American vendor of parts whose web site has some very useful links at **www.elexp.com** whilst Scott Johnston suggests you try his Homepage at **http://www.users.globalnet.co.uk/~metad/eee.htm** which has a very impressive list of academic sites and more. Finally, my thanks to Simon Davis who suggested several music synthesiser sites including **www.synthfool.com** (The Internet Synth FAQ) and **www.hyperreal.org/music/machines**. More links next month. You can contact me at **alan@epemag.demon.co.uk**.

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Everyday Practical Electronics reaches nearly twice as many UK readers as any other independent monthly hobby electronics magazine, our audited sales figures prove it. We have been the leading independent monthly magazine in this market for the last thirteen years.

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All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Everyday Practical Electronics Advertisements, Mill Lodge, Mill Lane, Thorpe-le-Soken, Essex CO16 0ED. Phone/Fax (01255) 861161.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

Miscellaneous

EXPLORE THE (4th) DIMENSION, hear eerie sounds generated on Earth/in space/from UFOs. Special scientific receiver converts carrier emissions, 10Hz to 14kHz into audio. A.E. for info: P.O. Box 694, Saint Helier, JE4 9PZ, Jersey, Channel Islands (UK).

ANYONE REPAIRING TOYOTA/other engine management control units, car spares marketing/distribution company seeks supplier. Malcolm Jackson, Phone/Fax 0181 467 6671.

PRINTED CIRCUIT BOARDS – QUICK SERVICE. Prototype and Production. Artwork raised from magazines or draft designs at low cost. PCBs also designed from schematics. Production assembly also undertaken. For details send to P. Agar, Unit 5, East Belfast Enterprise Park, 308 Albertbridge Road, Belfast, BT5 4GX, or phone/fax 01232 738897.

VALVE ENTHUSIASTS: Capacitors and other parts in stock. For free advice/lists please ring. Geoff Davies (Radio). Tel. 01788 574774.

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HUGE RANGE OF INEXPENSIVE SCIENCE AND COMPUTING CD-ROMs for your PC. Lists from: P.O. Box 10642, Dept. PE1, London SW10 0ZR.

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EPE NET ADDRESSES

EPE FTP site: **ftp://ftp.epemag.wimborne.co.uk**
Access the FTP site by typing the above into your web browser, or by setting up an FTP session using appropriate FTP software, then go into quoted sub-directories:

PIC-project source code files: **/pub/PICS**

PIC projects each have their own folder; navigate to the correct folder and open it, then fetch all the files contained within. *Do not try to download the folder itself!*

EPE text files: **/pub/docs**
Basic Soldering Guide: **solder.txt**
EPE TENS Unit user advice: **tens.doc** and **tens.txt**
Ingenuity Unlimited submission guidance: **ing_unlt.txt**
New readers and subscribers info: **epe_info.txt**
Newsgroups or Usenet users advice: **usenet.txt**
Ni-Cad discussion: **nicadfaq.zip** and **nicad2.zip**
UK Sources FAQ: **uksource.zip**
Writing for *EPE* advice: **write4us.txt**

Ensure you set your FTP software to ASCII transfer when fetching text files, or they may be unreadable.

Note that any file which ends in **.zip** needs unzipping before use. Unzip utilities can be downloaded from : **http://www.winzip.com** or **http://www.pkware.com**

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80	Asstd. small stand offs, I/throughs etc	£1.00
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SP12	30 x 1N4002 diodes	SP136	3 x BFY50 transistors
SP18	20 x BC182 transistors	SP137	4 x W005 1·5A bridge rectifiers
SP20	20 x BC184 transistors	SP136	20 x 2·2/63V radial elect. caps.
SP21	20 x BC212 transistors	SP140	3 x W04 1·5A bridge rectifiers
SP22	20 x BC214 transistors	SP142	2 x Cmos 4017
SP23	20 x BC549 transistors	SP144	3 x TIP31A transistors
SP24	4 x Cmos 4001	SP145	6 x ZTX300 transistors
SP25	4 x 555 timers	SP146	10 x 2N3704 transistors
SP26	4 x 741 Op.amps	SP147	5 x Stripboard 9 strips x 25 holes
SP28	4 x Cmos 4011	SP151	4 x 8mm Red Leds
SP29	4 x Cmos 4013	SP152	4 x 8mm Green Leds
SP33	4 x Cmos 4081	SP153	4 x Yellow Leds
SP36	25 x 10/25V radial elect. caps.	SP154	15 x BC548 transistors
SP37	15 x 100/35V radial elect. caps.	SP156	3 x Stripboard, 14 strips x 27 holes
SP39	10 x 470/16V radial elect. caps.	SP160	10 x 2N3904 transistors
SP40	15 x BC237 transistors	SP161	10 x 2N3906 transistors
SP41	20 x Mixed transistors	SP165	2 x LF351 Op.amps
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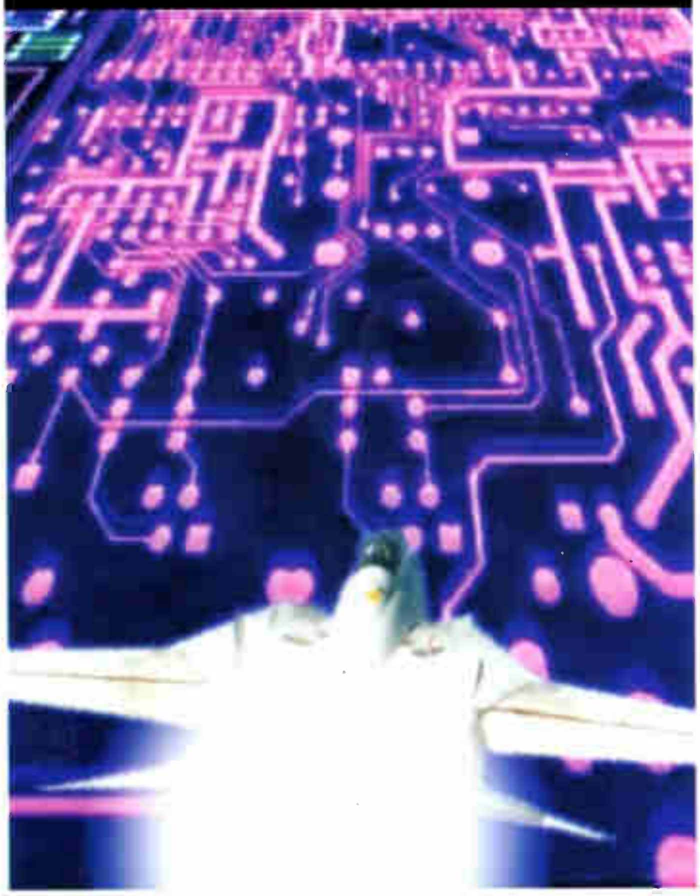

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