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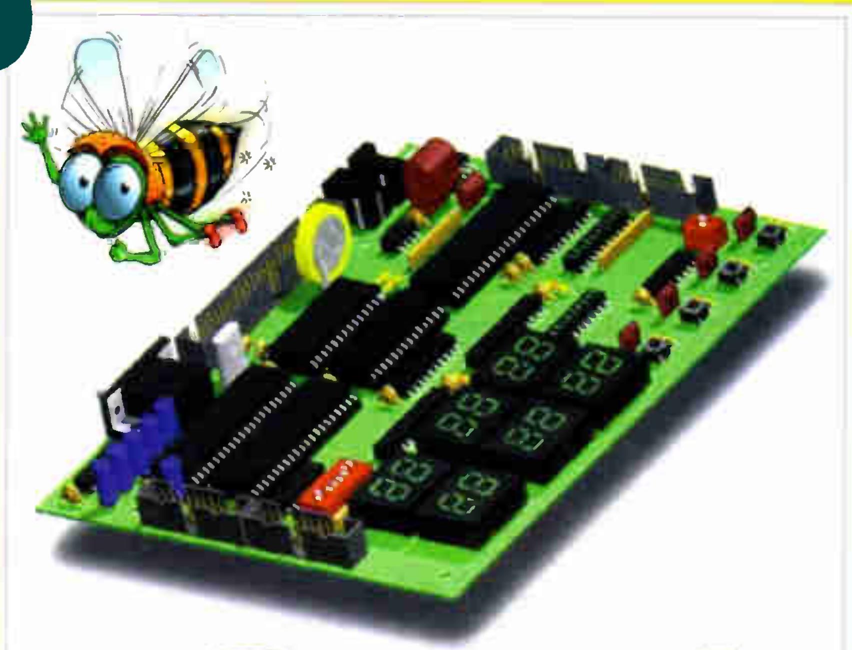

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VOL. 27 No. 11 NOVEMBER 1998

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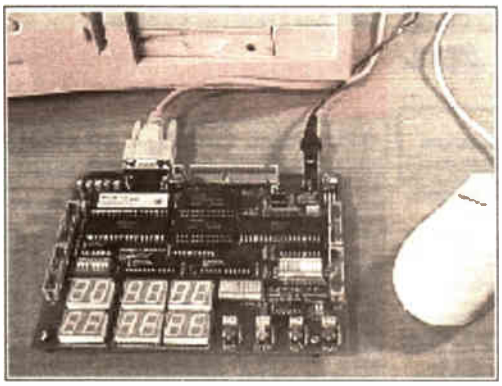

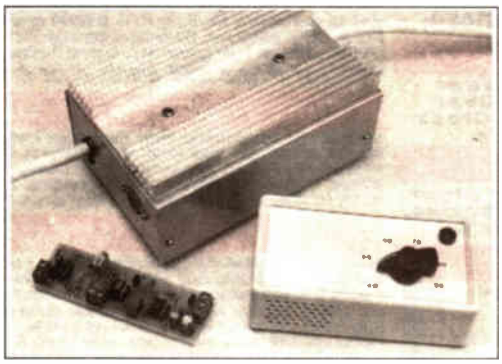

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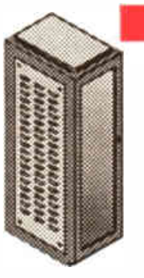

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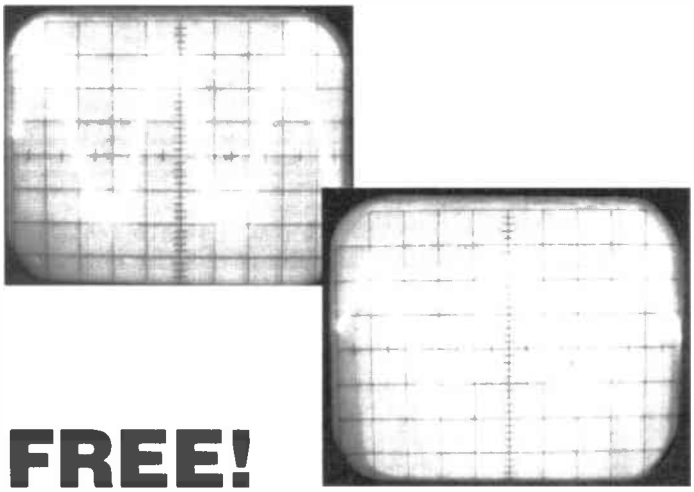

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VOL. 27 No. 11 NOVEMBER '98

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ON-LINE

Our *Chat Zone* is now open and soon we will have an electronic version of *EPE* on the web. Alan Winstanley has been gradually expanding our *EPE* web site since its inception more than two years ago, we are sure you will agree it is an excellent site and a very valuable addition to the magazine. The new *Chat Zone* allows any reader to post messages, requests, etc., or just to chat with fellow enthusiasts. It opened on 9th September and the first message appeared almost instantly.

We have a long list of planned additions to the web site which will ensure its continued expansion and development well into the future. I must say that if you are interested in electronics the web is a very valuable resource. The first place to go is our web site, which links to hundreds of other sites.

E-MAG

Our next development on the web is equally exciting; in conjunction with Clive (Max) Maxfield and Alvin Brown in the States we are about to launch an electronic version of *EPE* on the web. This E-mag (Electronic magazine) will be a sort of international version of *EPE* based on a server in the USA and modified from the printed UK edition to appeal more to international readers.

The E-mag version of *EPE* will be published monthly, a couple of weeks after the printed issues, and will consist of the core projects which can be downloaded and printed out in your home. There will be a charge for this via a credit card transaction over a secure link on the web and everything will be protected by a sophisticated password system recently developed in the USA.

So, if you want to be one of the first people to view this new site, log on to **www.epemag.com**, it should be live in mid October. You will find that parts of this issue can be viewed free of charge whilst we get the E-mag off the ground and to enable new readers around the world to see exactly what *EPE* is all about. From next month's issue the whole thing will be live and, using a credit card, anyone will be able to gain almost instant access to the magazine and print out each E-mag issue, using a PC.

This represents an amazing leap forward for us and should bring our constructional projects "instantly" within the grasp of many hundreds of thousands of new readers around the world.

We don't see the E-mag version ever replacing the printed magazine, but it will surely provide much of what *EPE* is all about to those who find it difficult, for reasons of distance and cost, to get hold of regular copies of *EPE*. We don't believe any other hobbyist electronics magazine in the world is presently doing this – another World First for *EPE*.

PhizzyB

Of course, our exciting new PhizzyB Computers series is also a World First. A virtual computer educational system plus a hardware realisation. It's also by Max, Alvin and Alan Winstanley and starts in this issue. You can see an animated Max on this month's *Free* CD-ROM, which we hope you find valuable.

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see right), 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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All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

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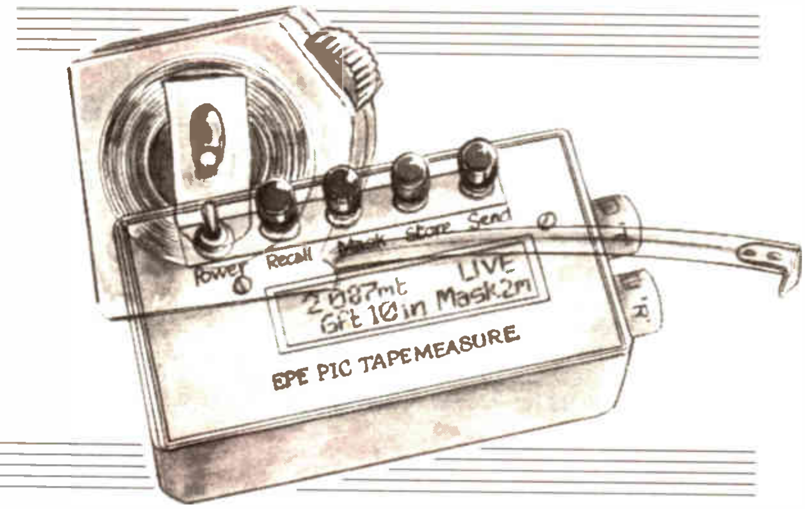


PIC TAPE MEASURE

JOHN BECKER

Microcontrolled ultrasonic distance calculator with data recording and foreground masking.

QUITE naturally, many of you will be wondering how PIC devices can be used to update some of your favourite designs. PICs are, as we are proving on frequent occasions, extremely versatile devices and can be used in many circuits to replace quite a few conventional logic chips.

Recently, the author's eye fell on his earlier *Ultrasonic Tape Measure* (*EPE Sept 92*) and began to speculate about how it too could be simplified using a PIC. The result (after about an hour with a soldering iron and *many* hours at the computer), is before you now – a PIC16C84-controlled ultrasonic tape measure.

Not only is it an update on the previous design, it is a quite significantly more advanced instrument. Taking advantage of the PIC16C84's internal EEPROM (electrically erasable programmable read only memory), a data store and recall facility has been programmed in as well. There is also a masking option that allows foreground echoes to be ignored.

The device can record and recall 30 or 32 (see later) distance measurements, allowing several readings to be taken before copying them to paper – ideal when taking measurements in difficult to access locations!

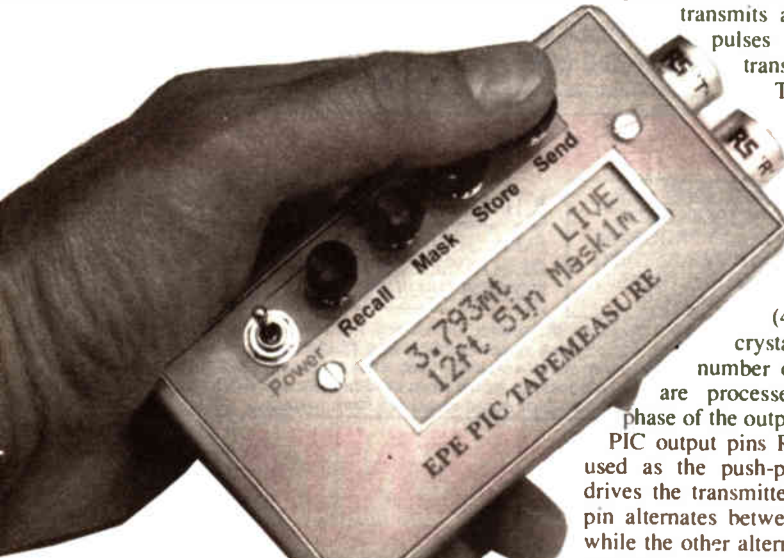
There is a choice of two software programs for the unit. The Standard program requires no adjustment to the timing and calculation factors and assumes a rigidly fixed speed of sound. The Extended program allows fine tuning of the calculation values and requires a small amount of setting up to be done via the software and the panel function switches.

The electronics hardware is identical for both programs.

CIRCUIT DIAGRAM

The complete circuit diagram for the PIC Tape Measure is shown in Fig.1.

In a nutshell, the PIC microcontroller (IC2) is the mastermind that controls the whole operation. When prompted by the pressing of Send switch S2, the PIC transmits a series of 40kHz pulses via the ultrasonic transmitting transducer TX1.



The pulses are accurately generated in software at a rate deter-mined by the controller's operating frequency (4MHz as set by crystal X1) and the number of commands that are processed between each phase of the output signal.

PIC output pins RA0 and RA1 are used as the push-pull source which drives the transmitter transducer. One pin alternates between high and low, while the other alternates between low and high.

Solid objects within the path of this signal reflect it back to the ultrasonic receiving transducer, RX1. The echo signals are at a considerably lower amplitude than those transmitted and require a fair amount of amplification in order to be recognisable by the PIC as logic signals.

AMPLIFICATION

The 40kHz echo signals receive two stages of a.c. amplification. A gain of ×100 is provided by op.amp IC1a, as set by resistors R1 and R4. Op.amp IC1b provides a further gain of about 47, as set by R5 and R6.

Capacitor C6 then feeds the amplified signal to transistor TR1, whose purpose is to provide logic-level pulses to the PIC at pin RB7. Between them, resistor R7 and preset VR1 set a basic d.c. bias on the base (b) of TR1, determining the response sensitivity.

The output from TR1's collector normally rests at 5V, but swings between 5V and 0V in the presence of suitably strong echo signals. Immediately the PIC has finished transmitting the brief chain of 40kHz pulses, it starts a 2-byte counter (16-bits) which increments at a known rate. When the PIC recognises that pin RB7 has changed its logic state from high to low in response to an output from TR1, the counter is stopped.

CALCULATIONS

The software now goes into its calculation routine, in which it converts the count value into two distance values, one in metric (metres to three decimal places) and one in imperial (feet and inches). These measurements are displayed on a 16-character 2-line liquid crystal display module, X2. Metres are shown top left, followed by letters "mt". Feet and inches are shown bottom left, complete with letters of "ft" and "in" (see photographs).

The transmission and echo conversion process continues for as long as the Send button remains pressed. You can, therefore, pan around a room and just generally view its dimensions until you are ready to accept a measurement. At this moment, releasing the switch will cause the last measurement read to stay on the l.c.d. screen. It will remain there until Send is pressed again, or Recall switch S5 is pressed, or the unit is switched off.

While Send is pressed, the sampling rate is normally a little under once per second – depending a bit on the mask and distance values.

MEASUREMENT RECORDING

The measurement shown is not yet recorded in the PIC's EEPROM memory. That action occurs when Store switch S3 is pressed. Since the switch status is only read by the PIC when it has finished its calculation and display, the measurement recorded is always the one just completed. This ensures that an incomplete measurement is never stored (i.e. one caught in the middle of transmission).

The information is stored as the count value achieved, not in metres or feet. Consequently, only two bytes of EEPROM memory are used. The PIC has 64 bytes of this memory available and up to 32 measurements can be recorded with the Standard program.

With the Extended program, 30 measurements can be stored, the other bytes being reserved for timing and counting values.

Each time a measurement is stored, a record counter is incremented. This is displayed on the top right of the l.c.d. so that you know how many readings you have taken. Immediately in front of this value the message "SAVED" appears.

It is not possible to step the counter back in order to store another measurement at this count location. Thus, if you make a recording in error, you must remember that the value at this location is to be disregarded when you examine the recordings later.

PLAYBACK

To play back the stored recordings, the Recall switch is used. Each time it is pressed, a Recall counter is incremented. The 2-byte data from the EEPROM at the equivalent address to the count (count × 2) is read and converted to metric and imperial as before.

The Recall counter value is also displayed at the top right in place of the Record counter value. Immediately in front of it the message "SHOW=" appears.

EEPROM RESET

A facility to reset the Record and Recall counters to zero during normal use has not been included. With the Standard program, they are automatically reset at the moment of switching on the unit. With the Extended program, the Recall counter is reset at each switch on, but the Record counter is only reset when the full EEPROM measurement data contents are reset. The EEPROM measurement data remains intact until intentionally reset. This can be done at switch-on. If the Store button is pressed and held down immediately prior to and during switching on, all stored measurements are cleared, and the Record and Recall counters set to zero.

MASKING

The masking facility allows foreground echoes to be ignored within a timing/distance range set via the Mask switch S4. This allows you, for example, to read the distance of a far wall when a clutter of furniture is between you and the wall. Without the facility, the echoes from the furniture would be those read by the "tape measure".

To an extent, however, the facility has to be used with discretion since it is possible that too long a masking distance

Front panel display window and function buttons. A recalled measurement is shown.

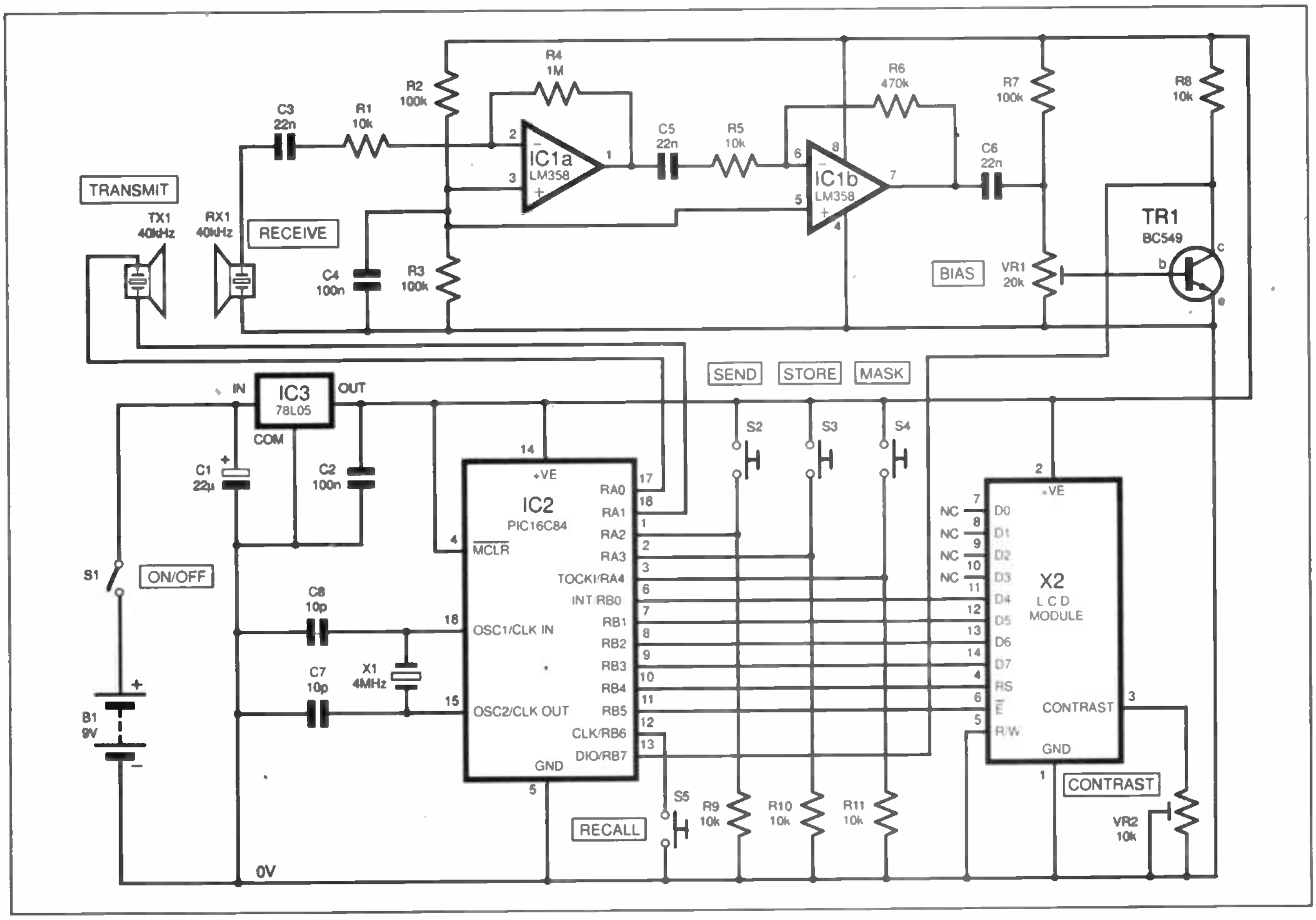


Fig. 1. Complete circuit diagram for the PIC Tape Measure.

could allow multiple reflections to be read, i.e. those that ricochet around the room before returning to the unit.

Inclusion of a gain control was considered in order to reduce this possibility, but it was concluded that having both a mask and a gain control might be confusing to use in practice, and the idea was dropped. If you would like an external sensitivity control, replace VR1 with a case mounted potentiometer of the same value (you may need a bit bigger case, though).

The software is written so that the masking distance progressively increases while Mask is pressed, ranging (in steps of one) from zero to nine with the Standard program and one to nine with the Extended program, rolling over to zero again following nine. The mask value is displayed at the bottom right of the screen, prefixed by the word Mask. It represents an approximate (but not precise) distance in metres. If the value shown is above zero, it is followed by the letter "m", for metres.

Switch S4 increments the mask value at about two digits per second, The rate may be slower when the value is greater than zero and the Send button is pressed at the same time. In this situation, if an echo is not being received the software waits until a time-out occurs before it again examines the switch. It is normally better to press Mask when Send is not pressed.

MASQUERADE

Screen photo 1 illustrates why a mask is useful. The final pulse of the transmission signal is seen top left, and centrally five echo signals are seen at different amplitudes.

The first echo is (normally) too small to be accepted as a valid echo. The second echo, though, is large enough for the software to accept it as the trigger signal, reacting to it about half way above its central (d.c.) position, and it will do so if no response delay is included.

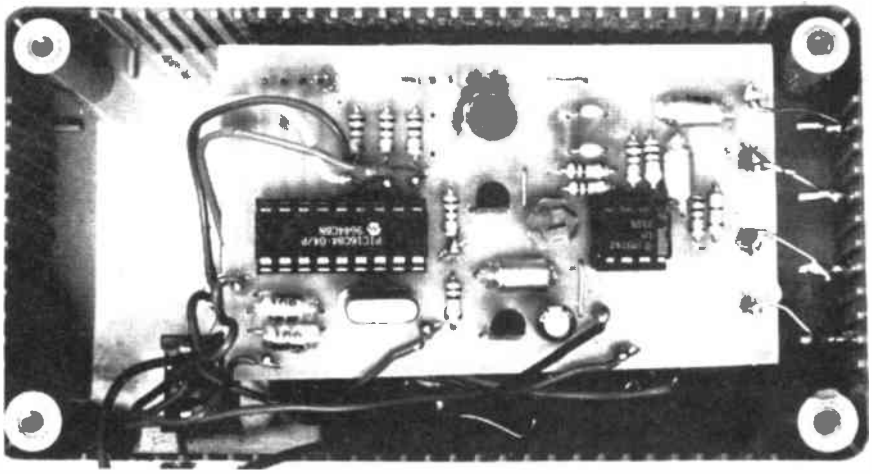
By inserting a suitable delay in the software before it starts looking for echoes, the second echo can be ignored, with the third echo being the one that is accepted. Extending the delay a bit further, the response can be timed to only accept the fifth echo.

As illustrated, the fourth echo is too small to be recognised. However, if the bias level on transistor TR1 were to be suitably increased, effectively increasing the gain, both the first and fourth echoes could be responded to if the delay was set appropriately.

Note, though, that the first echo is probably the residual ringing of the receiving transducer rather than a true echo. Without any response delay, this undesirable signal would trigger the unit, preventing it from responding to any of the subsequent pulses. This is why a minimum masking value of one (about one metre) is necessary with higher bias settings.

The display seen in Photo 1 was created by coupling the *EPE Virtual Scope* (*Jan/Sept '98*) to the transmitting transducer and the output of op.amp IC1b. For the sake of illustration, the conditions were set up slightly unnaturally in that the echoes are those from small items deliberately placed only a few inches in front of the transducers. The data was recorded on disk some months before being recalled to the screen for photography.

Although the pulses have a 40kHz content, the frequency shown at the bottom right of the screen (2979·27Hz) has resulted because the transmission and return pulses are not continuous, the *V-Scope* assessing frequency from the number of pulses occurring in one second.



Prototype p.c.b. mounted "below" the display module.

POWER SUPPLY

The PIC Tape Measure runs from a 9V PP3 battery. Current drawn is normally about 6mA, rising to about 7mA (average) during transmission.

Regulator IC3 drops the 9V supply down to 5V to suit the PIC and the l.c.d.

CONSTRUCTION

Details of the printed circuit board (p.c.b.) component layout and tracking are shown in Fig.2. The board is available from the *EPE PCB Service*, code 207.

It is *essential* to use a socket for IC2, and recommended for IC1. Fit the on-board link wires first, then assemble the board in any order you find convenient.

The l.c.d. module may be connected to the p.c.b. by rigid wires (20 s.w.g. tinned copper wire – although resistor offcuts might be suitable), or short lengths of flexible insulated connecting wire may be used.

Using rigid wires, the l.c.d. can be mounted above the *rear* of the p.c.b. at a height of about 7mm, i.e. clear of any danger of the soldered joints and trimmed component leads touching any part of the l.c.d. To ensure this could not happen if the two units were squeezed, two rubber spacers (self-adhesive case feet) were inserted between them.

The viewing window slot for the l.c.d. is in the *base* of the plastic case. It can be cut in the time-honoured method of drilling a series of holes and then filing down to the correct size to accept the friction-fitting of the l.c.d.'s metal frame.

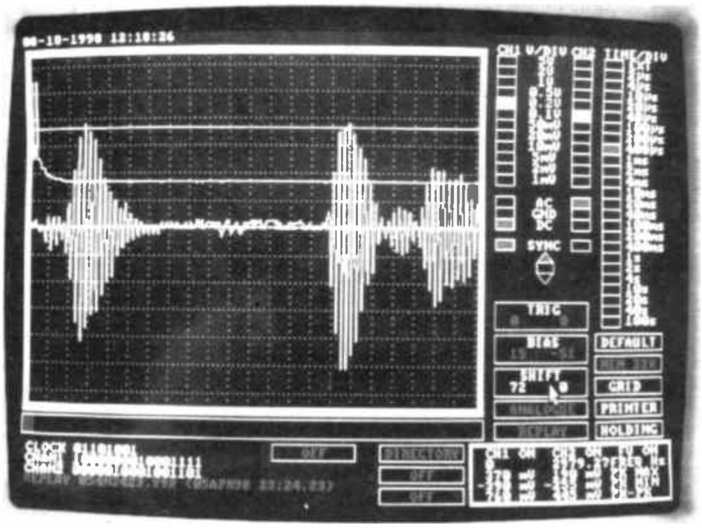
Ensure that the positioning of the l.c.d. and p.c.b. allows room for the battery at one end, yet does not allow the corner pillars in the case to interfere with the mounting of the assembly.

Drill two holes in the case to allow the l.c.d. to be secured with two nuts and bolts via its own mounting holes (those furthest away from the l.c.d./p.c.b. connections).

It is preferable to insert thin spacers between the case and l.c.d. (another nut on each bolt), so that the ends of the soldered connecting wires do not prevent the l.c.d. from sitting comfortably against the case. Any distortion of the l.c.d. module could prevent it from working.

Once the display slot has been completed, and before the l.c.d. is mounted in the case, drill holes alongside and above the slot for the five switches. Also drill holes in the end of the case for the ultrasonic transducer pins. Use a drill bit of about the same size as the transducer pins so that a friction fit occurs.

Wire-up the switches as shown in Fig.2, and in the order seen in the photographs, using ordinary multistrand connecting wire. The transducers should be connected with solid wire, to secure them rigidly in the



Screen photo 1. Without masking, the centre line "echoes" could be interpreted as measurement signals.

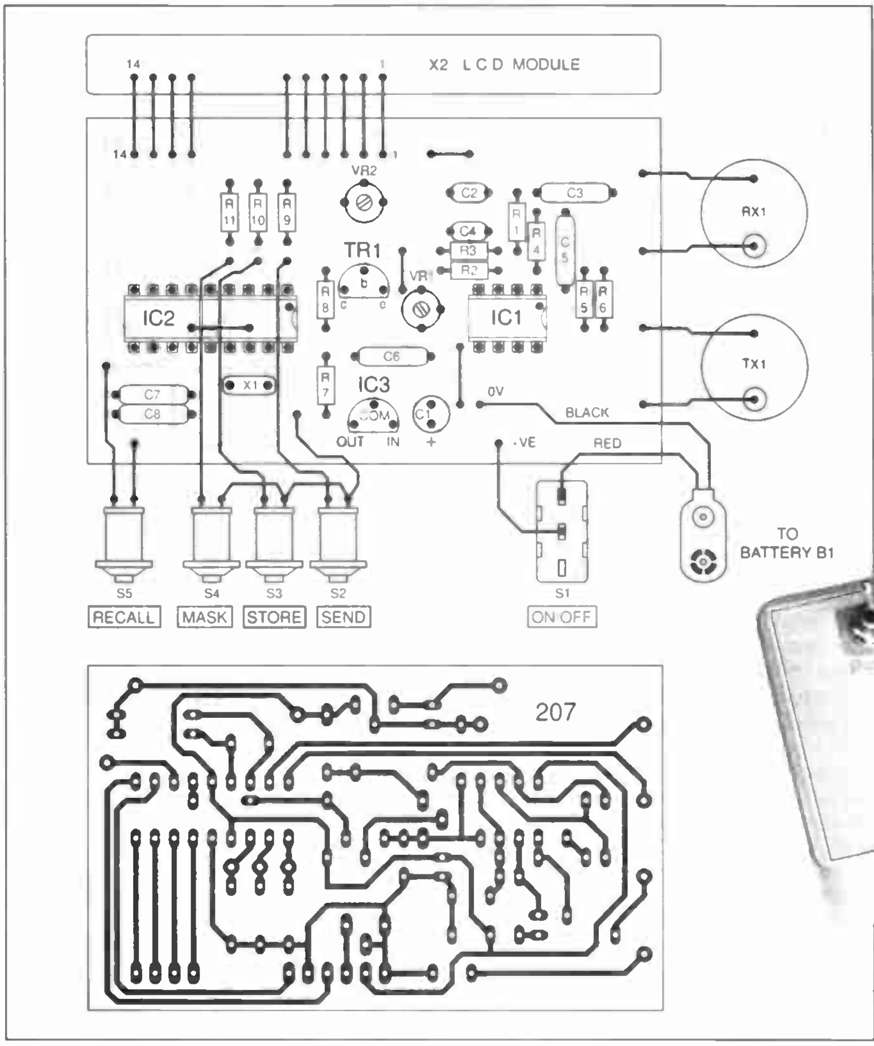


Fig.2. PIC Tape Measure printed circuit board topside component layout, interwiring and full size copper foil master pattern.

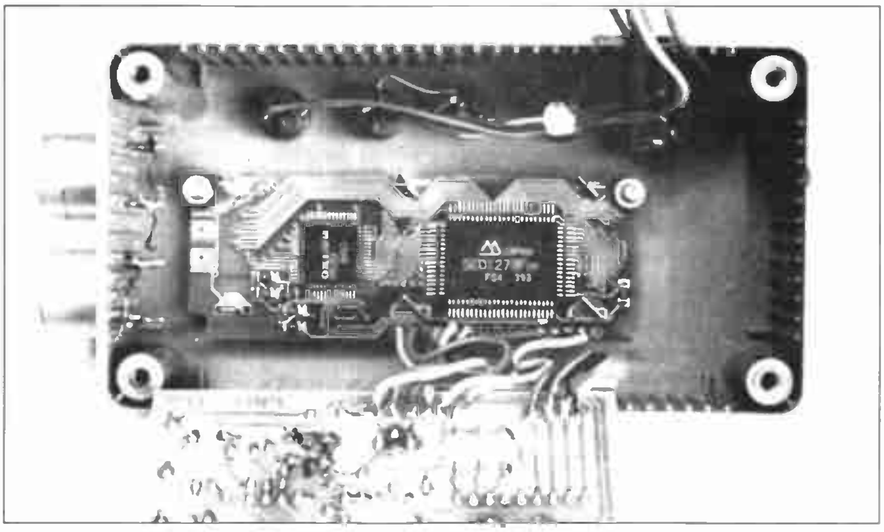
case. Ensure that the transducers are in good alignment with each other, to optimise the signal transmission and return paths.

It is imperative to ensure that there is no chance of the 9V power connection on the p.c.b. (or the 9V track underneath) coming into contact with the tags of the switches. Such an occurrence could kill the PIC and the l.c.d. Use two or three layers of insulating tape on the switch tags and rear of the p.c.b.

Another self-adhesive rubber spacer may be attached to the inside of the lid to prevent the battery from rattling when the unit is fully enclosed.

FIRST TESTS

Having thoroughly checked the completed assembly for shorts etc., plug in op.amp IC1, but not microcontroller IC2. Switch on the battery supply and check that the output from regulator IC3 is at 5V.



Printed circuit board folded back to reveal the l.c.d. module bolted behind the display window in the base of the case (which now becomes the front panel). The function switches are aligned above the module.

COMPONENTS

Resistors — See **SHOP TALK** Page

R1, R5, R8 to R11	10k (6 off)	
R2, R3, R7	100k (3 off)	
R4	1M	
R6	470k	

All 0·25W 5% carbon film or better.

Potentiometers

VR1	20k min. round preset
VR2	10k min. round preset

Capacitors

C1	22µ radial elect., 16V
C2, C4	100n ceramic disc, 0·2in spacing (2 off)
C3, C5, C6	22n polystyrene (3 off)
C7, C8	10p polystyrene (2 off)

Switch-on l.c.d. screen display.

Semiconductors

TR1	BC549 *npn* transistor
IC1	LM358 dual op.amp
IC2	PIC16C84 (or PIC16F84) pre-programmed microcontroller – see text
IC3	78L05 +5V 100mA voltage regulator

Miscellaneous

S1	min. s.p.s.t. toggle switch
S2 to S5	min. push-to-make switch (4 off)
RX1	min. 40kHz ultrasonic receiver
TX1	min. 40kHz ultrasonic transmitter
X1	4MHz crystal
X2	16-character 2-line alphanumeric l.c.d.
B1	9V PP3 battery and clip

Printed circuit board, available from the *EPE PCB Service*, code 207; plastic case, 120mm × 64mm × 40mm; 8-pin d.i.l. socket; 18-pin d.i.l. socket; self-adhesive rubber feet (3 off) (see text); nuts and bolts, M3 × 12mm (2 off) (see text); connecting wire; solder, etc.

***Approx Cost Guidance Only* £33**

Adjust preset VR1 so that the bias on the base of transistor TR1 is about 0·3V.

If all is well, switch off and plug in the PIC16C84 (or PIC16F84), which must be pre-programmed (see later).

Switching on again (without any of switches S2 to S5 being pressed), the PIC will start running. The first thing it does is to initialise the l.c.d., setting it to 4-bit control mode and then, on two lines, displays the opening message:

EPE PIC TAPE BOX
PRESS SEND KEY

You may need to adjust the Contrast preset VR2 to make the message visible.

ALIGNMENT ROUTINES

At this point with the Extended program version, there are some alignment routines to be performed via the switches. These will be discussed later, at the section headed "Extended Program Version". Until then, the following paragraphs refer to both versions.

In normal use, when the unit is first switched on the opening message is displayed and the software goes into a loop in which it waits for any of the function switches S2 to S5 to be pressed.

Point the PIC Tape Measure at a nearby wall, without any other object in the signal path. Press the Send switch S2. The distance that the wall is away from the front of the unit should be displayed on the l.c.d. in metres and feet plus inches.

The words LIVE and Mask, plus the mask value will also be shown.

Keep Send pressed and move backwards and forwards with respect to the wall, observing the change in distance readings.

Ensure that the signal is not reflected off the hand pressing the switch.

DISTANCE EXTREMES

The minimum distance readable with a mask value of zero and transistor TR1's bias at 0·3V, is about 55mm (2in). The maximum depends on a number of factors.

The transmission power of transducer TX1 is one factor. This is likely to vary between different units of the same type, due to manufacturing tolerances. Similarly, the sensitivity of the receiving transducer (RX1) is equally likely to vary between units. The relative alignment accuracy of the two transducers also plays a part.

Another factor is the nature of the surface from which the ultrasonic beam is being reflected. Hard surfaces will provide stronger echoes than soft ones.

Additionally, if the unit is being used outside (don't let it get wet) the wind may deflect or impede the transmitted and reflected signals, reducing the echo signal amplitude received by the unit.

BIAS LEVEL

The most crucial factor, though, is the bias level on TR1. With bias set at 0·3V, a maximum measuring distance of about six metres is a reasonable expectation. Increasing the bias to about 5·5V (using preset VR1), distances in excess of 10 metres should be achievable.

The bias could, perhaps, be raised to about 0·6V, allowing really low amplitude echo signals to trigger transistor TR1. The danger of making it too sensitive, though, is that multiple echoes from around the room will be picked up, resulting in false readings.

Also, increased sensitivity makes the system susceptible to being triggered by the "ringing" of the receiving transducer, caused by its proximity to the transmitter. The mask facility, though, will usually allow this effect to be ignored, except at excessively sensitive settings of VR1/TR1.

Use discretion and ensure that the triggering is always reliable in normal measuring

Typical screen display in the Mask set-up mode.

situations, at the expense of its long distance abilities.

MASK TESTING

To test the masking facility (initially with a bias of about 0·3V), place the unit on the edge of a table facing a wall and place a dining chair (with a normally-high back) slightly in the signal path. With the Send button pressed, position the chair until its distance is displayed rather than the wall's. Now press Mask while still holding Send pressed.

When the masking distance is equivalent to that just beyond the chair back, the chair echo should cease and the wall value become that displayed. The mask can be used on any occasion that foreground items interfere with the desired target reading, as long as a good strength of signal still reaches the target.

In normal use, without foreground echoes and with the bias below about 0·4V, keep the mask value at zero. With higher bias levels on transitor TR1, it is likely to be preferable to normally use the mask value set to one. (In normal use of the Extended version, the minimum mask value is automatically set to one.)

It is suggested that you experiment to find the best bias level that suits your own assembly.

DATA RECORDING

To record a displayed reading, press Store switch S3. Note that the reading displayed must be one that has just been acquired by taking a measurement. A reading which has been recalled for display will not be re-recorded over itself.

So that you know whether you are looking at a real or recalled reading, the messages "LIVE" and "SHOW=" are displayed accordingly. You can only record if "LIVE" is showing.

The record number of the newly stored measurement is displayed on the top right of the l.c.d. Separate EEPROM address pairs are used in ascending order each time Store is pressed. When roll-over beyond the maximum count permissible occurs, the counter is reset and recorded data now overwrites that previously recorded at the same ensuing addresses.

DATA RECALL

Data recall occurs when the Recall button is pressed. A separate counter is used for this routine, incrementing each time Recall is pressed. Again, when roll-over beyond the maximum count occurs, the counter is reset. Note that the record displayed is not normally that which has just been recorded. To view the latest record, the recall counter number has to match the stored counter number.

In a practical situation both counters should be set to zero prior to taking a series of measurements (see earlier – "EEPROM Reset").

PERMANENCE

Recorded data remains in the PIC's EEPROM data memory even when the power is switched off, remaining there until overwritten (be aware of this in other situations if you use a previously programmed PIC '84 for another program).

As stated earlier, the data can be overwritten by zeros when the Store switch is held down while switching on.

With the *Standard* software program, note that each time you switch on the unit, the Store (Record) counter is reset to one, consequently you should *not* switch off during a sequence of measurements.

However, the Extended program records both the measurement data and the counter value in the EEPROM, and with this version you may switch off between readings.

COMMENTS

Of likely interest to PIC programming readers is the way in which the ultrasonic transmitter (TX1) is driven in push-pull mode by Port A pins RA0 and RA1.

In the general initialisation routine at the start of the program, Port A is set with these two pins as outputs, and with RA2 to RA4 as inputs. Port A is then cleared.

On entry into the transmission routine (at label TXIT), a loop value is set at ten, a 2-byte counter is cleared and RA0 is set high, so setting one side of TX1 high. There is then a pause as set by eight NOP (no operation) commands.

Then the command COMF PORTA,F is given. This inverts (*complements*) the value on Port A from binary 00001 to binary 11110 (Port A only has five usable pins). Pin RA0 is thus set low and RA1 set high, an action which reverses the current flow through TX1. The other three pins (RA2 to RA4) are of no interest since they are set as inputs.

A further delay now occurs, of 12 NOP commands, after which COMF PORTA,F is again given, returning Port A to the first value, 00001. The loop value is decremented and if it is not yet zero, the routine jumps back to the first of the eight NOPs (at label BEAMIT) and the process is repeated.

At the end of the loop, transmission ceases and Port A is cleared. Consequently, 10 pulses are transmitted and the time taken to transmit them is equivalent to a frequency of 40kHz.

The transmission routine is shown in abridged form in Listing 1 (the BSF SAVE,0 command seen sets a flag which allows the measurement to be recorded if required).

Listing 1

```
TXIT:     MOVLW 10
          MOVWF LOOPB
          CLRF COUNT0
          CLRF COUNT1
          BSF PORTA,0
          BSF SAVE,0
BEAMIT:   NOP (by 8)
          COMF PORTA,F
          NOP (by 12)
          COMF PORTA,F
          DECFSZ LOOPB,F
          GOTO BEAMIT
          CLRF PORTA
          CALL RECEIVE
```

Whilst there may appear to be a significant imbalance in the mark-space ratio of the output pulses, the presence of other commands in the loop evens out the timing. *Do not change the commands in this loop – to do so would upset the 40kHz frequency and the duration of transmission.*

The RECEIVE routine is too lengthy to reproduce here, but in it the 2-byte timing counter is repeatedly incremented until a change in the status of Port B pin RB7 is detected (from high to low), at which point the count stops.

DISTANCE CALCULATION

Sound travels through air at a rate of 331·4 metres per second (at standard temperature and pressure – s.t.p.), so say the text books. In other conditions its velocity varies accordingly. Over short distances, though, such changes are negligible as far as this unit is concerned. Consequently, they are ignored (making this a far simpler and cheaper device to design and build).

The speed of sound is thus taken as a constant – that encountered in the author's workshop during prototyping! Tests and measurements revealed that a reception count value of 618 represented a target distance of 1000mm i.e. one metre (the value is adjustable in the Extended version). Dividing 1000 by 618 equals 1·6181229, and so it seemed reasonable to multiply the count value by 1·618 to convert it into a metres value.

Two bytes are used to represent 1·618 as a binary value, the MSB holds the value of 1 and the LSB holds a value of 158 (256 × 0·618 = integer 158). An additive technique is then used to divide the count by this binary value.

The answer is decimalised and output to the l.c.d. as a metres reading. (Although the answer is to three decimal places, the accuracy is realistically only within a centimetre or so.)

The binary metres value is also divided by the binary representation of 25·4 (MSB 25, LSB 102 – because 256 × 0·4 = integer 102) to obtain an inches value. This, in turn, is converted to feet with the remainder in inches. Both are decimalised and displayed on the l.c.d.

EXTENDED PROGRAM VERSION

Several months elapsed between designing the PIC Tape Measure and writing this text. In this time, the original software had already been incorporated on the CD-ROM accompanying this *EPE* issue, as program TAPE99.

During the writing of this article, however, the author decided that the addition of "fine tuning" options would be beneficial, allowing minor corrections to be made to the values used for calculating distance and the masking offset.

The following paragraphs discuss how these adjustments are made. The software program to which they refer is coded TAPE100. How to obtain it is detailed later.

TIMING ADJUSTMENTS

In most instances, it is unlikely that any further adjustment to the default timing values will be necessary, and will only be minor if they are needed. The first stage of alignment, though, must always be carried out on a newly assembled unit.

Stage 1

When l.c.d. contrast has been set and the opening message is clearly seen (as described in "First Tests" earlier), switch off.

With Recall pressed, switch on again and then release Recall. At the top right of the opening message, "BOX" will be replaced by "CLR". This action clears the entire contents of the EEPROM data memory and places the timing default LSB values into the final two bytes.

The default values are 158 for Basic timing at EEPROM byte 62, and 234 for Mask timing at EEPROM byte 63.

Stage 2

The bias on TR1 must be about 0·3V for the second stage of alignment, to minimise the echo sensitivity.

Switch off, and with the Send button pressed, switch on again and release Send. The screen will change from the opening message to the distance display with the top line showing "TEST158" preceded by a flashing "S". In this mode the ultrasonic pulses are repeatedly transmitted and the target distance displayed. Mask is automatically set to a value of zero.

The value of 158 can now be changed upwards or downwards by pressing the Store or Recall buttons respectively. The rate of change is about one digit per second.

Place the unit facing a wall at *exactly* one metre distance from the front of the transducers. Press Store or Recall until the displayed metres reading shows 1000 metres. Store increases the LSB value and the distance shown; Recall decreases them. The change of the distance value is much slower than that of the LSB.

The Basic timing is now set. Switch off.

Stage 3

With Mask pressed, switch on again and release Mask. The l.c.d. screen will change from the opening message to the distance display with the top line showing "TEST234" preceded by a flashing "M". In this mode the ultrasonic pulses are again repeatedly transmitted and the target distance displayed. The Mask value, though, is automatically set to one.

Typical screen display during normal measurement mode.

Adjust the bias on transistor TR1 to about 5·5V, giving greater echo sensitivity.

The value of 234 can now be changed upwards or downwards by pressing the Store or Recall buttons, respectively. The rate of change is still about one digit per second.

Place the unit a few metres away from a wall, without intervening furniture in the way. Note the distance reading. Now repeatedly press Mask and note the reading at each mask setting. If the Mask alignment value is correct, the readings should be just about identical. If necessary, use Store or Recall to change the value accordingly.

That completes the alignment. The new values are automatically stored in the EEPROM during the process and will be those used for future measurements. You may change them at a later date if you wish to, using the same techniques.

SWITCHES SUMMARY

In summary, during the alignment procedures the switches have the following roles:

Switch pressed while switching on:

- Send – Basic correction mode
- Store – EEPROM measurement clear (timing factors untouched)
- Mask – Mask correction mode
- Recall – Clear entire EEPROM data and set default timing factors

While in Basic and Mask correction modes:

- Store increases displayed timing value
- Recall decreases displayed timing value

SOFTWARE SOURCING

The source code text files (.ASM) show all the routines, with comments where appropriate. They were written in TASM.

Files for TAPE99 (Standard program) are included on the CD-ROM given away *FREE* with this issue of *EPE*.

Files for TAPE99 and TAPE100 (Extended program) are available from the Editorial office on 3·5 inch disk, as stated on the *EPE PCB Service* page, a nominal post and handling charge applies. Additionally, they are downloadable *free* from the *EPE* FTP site at:

ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PICtapemeasure.

Note that two values in TAPE99.ASM on the CD-ROM should be changed – at lines 428 and 443 (when viewed through DOS EDIT) the code MOVLW 200 should be changed to MOVLW 158 and the source code reassembled to an object file (TAPE99.OBJ) through TASM. The source and object code files on the web site and the normal (3.5 inch) *EPE* software disk have been amended.

The pre-programmed PIC, available from Magenta Electronics, contains the TAPE100 program.

For more information about obtaining the software and pre-programmed chip, also see the *Shop Talk* page in this issue.

New Technology Update

Ian Poole reports on a new device that provides both current and voltage control.

WHILST there are many new developments taking place in the field of device technology, there are also many new and ingenious developments that are making use of them. Even now different types of circuit are being devised to enable the new forms of device technology to be used to the full in novel and exciting ways.

Benistor

In one new development new ideas are being used for power control circuitry. Using active circuits it is normally possible to control either the voltage or current to the output, but not both at the same time. However, an interesting new device called a Benistor enables independent control of voltage and current in electronic circuits whilst still obeying Ohm's Law. The name is derived from the words Blockade of Electric Network and transISTOR.

The development has been undertaken by the Bensys Corporation, a private Californian semiconductor company founded in 1997. The company was set up specifically to pursue the development and commercialisation of the new idea. It is anticipated that it will find widespread use in a number of areas of electronics.

However, it is likely to find particular use in a variety of applications including switching power supplies, power controller applications, and many other areas of electronics at a variety of power levels. The aim is that the device will enable designers to devise power control circuits that are lower in cost and simpler than those used at the moment whilst they are still able to perform their function more efficiently.

First Devices

The company has released the first realisation of the idea. Given the part number BEN35100, it uses bipolar technology. The specifications reveal that the device has a maximum input voltage of 36V, a supply current of 3mA, a bias current of 500nA and a typical threshold voltage of only 0·54V. Switching times are fast for a device of this nature with a rise time of 650ns. Another feature of the design is that the device is protected against conditions of reverse current or voltage.

At the moment the device has been realised as a hybrid, but development is under way to implement it as a fully integrated circuit. This will have increased performance with greater variety of supply and input ratings as well as greater current capabilities.

Inside

The Benistor consists of four major circuit blocks. These are a power controller, a current separator (c.s.), a voltage threshold controller (v.t.c.), and a current controller (c.c.). There are eight connections that define the output, as shown in Fig. 1.

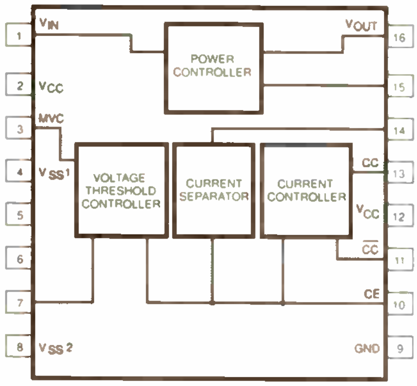


Fig.1. Block diagram of the BEN35100 Benistor.

The power controller block is relatively simple and consists of power *pnp* transistor that acts either as a switch or a variable resistor between the power source and the load. It takes its inputs from the other blocks within the Benistor.

The current separator uses three *npn* transistors that enable the voltage controller and the current controller to operate either together or separately. It is connected to the common electrode or CE connection along with the v.t.c. and current controller.

The current controller utilises two open collector operational amplifiers that enable the circuit to act as a voltage to current converter. This block of the circuit has two control inputs: the first detailed CC in the diagram enables the block to give a current output proportional to the input voltage. The second is via an inverting input $\overline{CC}$ to give a current inversely proportional to the input voltage.

Voltage Threshold Converter

The voltage threshold converter controls the base current for the output buffer. It achieves this using either a switching or self-switching mode. The two inputs to this section of the circuit are the effective voltage control, EVC, and maximum voltage control, MVC.

The two inputs accomplish different functions. The voltage present at the EVC control input establishes the threshold voltage for switching the output from off to on, whilst the MVC affects the on to off transition. Essentially, these two input voltages set the output voltage band.

One final input called the switching select or SS connection selects the initial state of the Benistor. It can be either on or off at the beginning of the waveform requiring control. It can be either at ground or a floating (higher than ground) level.

In operation the CE input provides the reference voltage for the device whilst the CC inputs set the range of the output current. The v.t.c pre-establishes the window in which the output voltage can fall.

Based on these input conditions the device will deliver the required part of the input waveform to enable the voltage and current to fall within the two preset ranges. In other words, the device enables the designer to define a virtually unlimited variation of output conditions.

Applications

A further advantage is that the device can accept a wide variety of waveforms; a.c., d.c., and pulse waveforms are all acceptable. As a result the designer is given tremendous flexibility enabling far more efficient control of power circuits.

The Benistor is targetted particularly at applications including switching power supplies, battery chargers and fluorescent light ballasts. However, its new design concept means that it can be used in a wide variety of different applications in the power control field.

The feedback mechanism will prevent voltage and current overload, enabling the device to provide a very safe charging solution. It can also change the frequency of the charging pulses thereby providing the optimum charging time. A further advantage is that the same basic design can be altered to suit a variety of different battery chemistries.

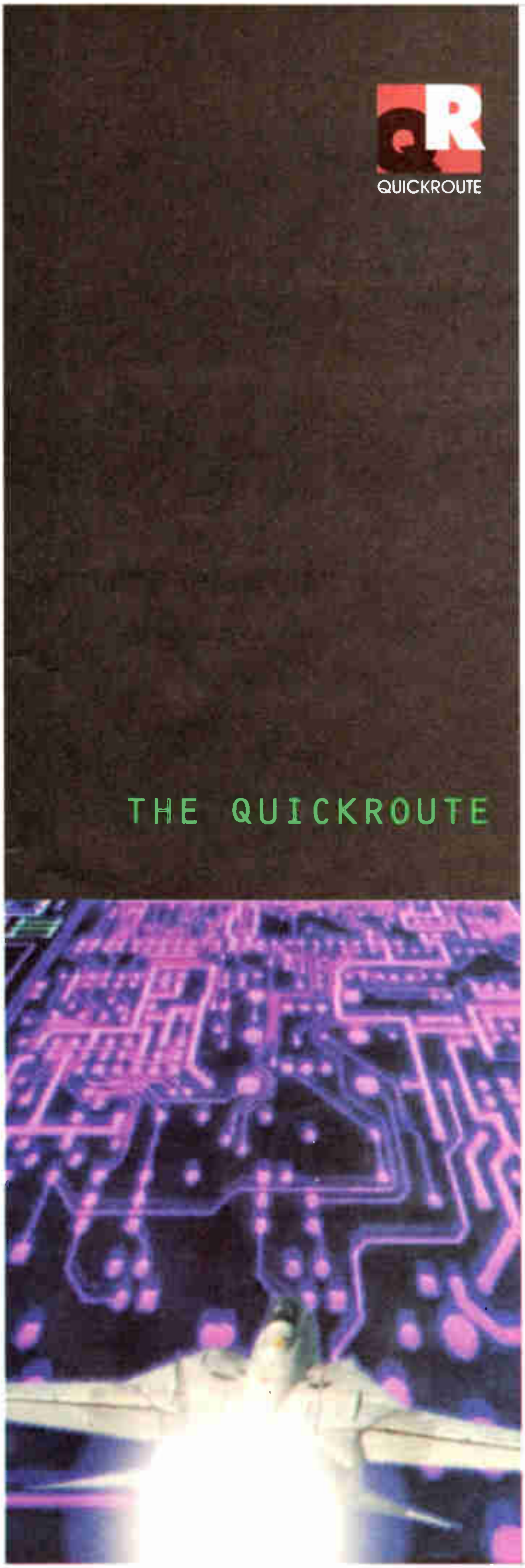
In a further demonstration of the Benistor the Bensys Corporation compared a circuit using the new Benistor with another using traditional techniques. It was found that the Benistor approach gave significant improvements in efficiency.

Not only did this save in terms of the overall power consumption but it meant that cost savings could be made in the production of the unit. This is because smaller components could be used as lower levels of power dissipation were experienced, and heatsinks were much smaller or not required.

Practical Use

Despite the fact that the Benistor represents a new development, the cost is surprisingly low. Currently the BEN35100 is available at a cost of $2.75 in large quantities, making it particularly attractive for many volume production items. Even for small quantity production it will prove to be an attractive solution.

In view of the benefits provided by the Benistor, it will be a powerful tool in the hands of the power control designer.


QUICKROUTE
THE QUICKROUTE

DIGITALLY RECORDING CRIME SCENES

Barry Fox asks if the Law will regard digital cameras as "safe" in the pursuit of justice.

POLICE forces round the country want to start using digital cameras to collect evidence of crime. But they know their evidence will be torn to shreds if defence lawyers can argue that digital images are easily manipulated. British company Signum Technologies of Cheltenham is now offering the police the chance to test a system which encodes an image at the moment of capture and flags a warning if any part of it is altered or cropped.

Currently the police use conventional photographic film to shoot at the scene of a crime, take surveillance pictures or snap the number plates of cars that race past radar speed checks. Using digital cameras would let scene-of-crime photographers check their shots on the spot by viewing on an l.c.d. screen.

Using digital cameras in speed traps would free the police from the labour-intensive job of replacing empty film cassettes and processing the exposed rolls. Digital images can be stored on disc and relayed by phone line to the Vehicle Licensing Authority in Swansea for automated checking.

Although digital cameras are already being tested in Leicester and Devon, and on the M25 motorway, the Crown Prosecution Service recently warned the House of Lords Science and Technology Committee that "some form of data protection and encryption is needed to exclude external interference and rebut claims that images have been tampered."

JIGSAW

All digital images are built from a mosaic of several hundred thousand individual picture points or pixels, each represented by a coded value. If the camera uses 8-bit code, each pixel can have any one of 255 different values.

Signum's VeriData system breaks the picture down into an unpredictable jigsaw of small rectangular blocks, polygons or curved shapes of various sizes. Each block contains around a thousand pixels, and the value of selected points is slightly altered, usually by plus or minus one value. The pattern of these changes is dictated by a mathematical key, specific to the user.

The changes are too small to be noticeable to the human eye, but analysis software uses the key to check the pattern in each block, and between blocks. If all the check sums in all the blocks add up, the picture is validated. If the sums in any block come out wrong, that block is highlighted with cross hatching to warn of tampering. If the picture has been cropped, to remove an object or person from the scene of a crime, the picture shows hatching round the altered edges.

The analysis is currently done with a PC and VeriData software "plugged into" Adobe Photoshop. Processing is virtually instant. But Signum recognises that for the system to be of real value to the police, coding must be carried out inside a camera, as the image is stored. The company is working with Agfa on real-time coding. Agfa currently provides much of the film used in speed trap cameras and recognises that its market will dry up as soon as electronic imaging is approved.

Signum is also working with Hammersmith Hospital on a similar system to encode medical images, such as X-rays, as they are created.

"The medical area is now full of litigation" says Signum's Alan Bartlett. "Validating a patient's records lets a doctor prove what records were created and when."

David Hilton, who invented the system, is now hoping to use it for validating digital sound recordings of police interviews.

DIGITAL RADIO TUNER

THE BBC is already broadcasting digital radio across the UK, and Arcam have introduced what they describe as the world's first digital radio tuner for the home. The Alpha 10 DRT is a stand-alone component which will connect easily and simply to existing hi-fi systems. The advantages of digital radio are that it sounds better, is totally consistent, and most broadcasts will be in hi-fi stereo at near CD quality. It also gets rid of the annoying flutter or multi-path distortion common in built-up areas, and is virtually immune from interference and fading.

Arcom are a well established company who started making amplifiers in 1976. They say that they are the UK's largest manufacturer of hi-fi electronics. The Alpha 10 DRT has been styled to match the appearance of other products in Arcom's Alpha range.

Full volume production starts in January '99. The expected selling price is £799.90.

For more information, contact A & R Cambridge Ltd., Pembroke Avenue, Denny Industrial Centre, Waterbeach, Cambs CB5 9PB. Tel: 01223 203200. Fax: 01223 863384. E-mail: custserv@arcam.co.uk. Web: http://www.arcam.co.uk.

MICROCHIP EDUCATION PROGRAM

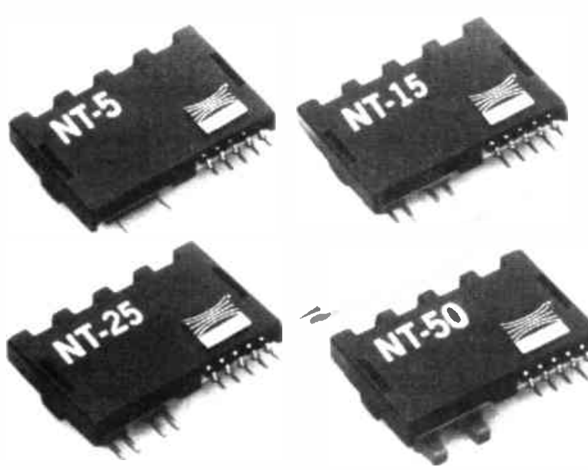
Microchip, the manufacturers of PIC chips, have launched an innovative program to educate mechanical and electromechanical engineers in using intelligent electronic components in their mechanical design.

By providing a wide range of sample designs, the Mechatronics PowerPak shows how mechanical applications can take advantage of microcontrollers to reduce cost and increase functionality. It provides a microcontroller primer, reference designs and other support materials.

For a free copy of Mechatronics PowerPak, visit Microchip's web site at ***www.microchip.com/mechatronics****.*

If you are without Net access, more information can be obtained from Arizona Microchip Technology Ltd., Microchip House, 505 Eskdale Road, Winnersh Triangle, Wokingham, Berks RG41 5TU. Tel: 0118 921 5858. Fax 0118 921 5835.

MAGNETIC SENSORS



MOST of you will have heard of Hall Effect devices, those extremely useful components that sense magnetic fields. We used one, for example, in the *PIC Electric Meter* mains current monitor of Feb/Mar '96. Well, we have been interested to learn that Magnetic Consultants have introduced some new sensors which they claim offer a considerable price advantage over conventional Hall Effect products – £9.50 plus VAT, or less, depending on quantity and current rating.

Described as Magnetoresistance Current Sensors, they use a feedback technique which cancels out errors caused by temperature drifts. They can be used for d.c. and for frequencies up to 50kHz, and have very good linearity, typically less than ±0·5%.

There are four devices, suited to monitoring r.m.s. currents of up to 5A, 15A, 25A and 50A, respectively. Their peak current capabilities are three times these values. As you will see from the photo, they have a very small "footprint".

For more information, contact Magnetic Consultants, Dept EPE, 21 Humbledon Park, Sunderland, Tyne and Wear SR3 4AA. Tel: 0191 528 4408. Fax: 0191 515 2837. Web: http://www.belltechinc.com.

DIGITAL SKY

By Barry Fox

SKY was due to launch its digital satellite service on 1st October to try and get in ahead of terrestrial rival British Digital Broadcasting, now called ONdigital. To pre-empt ONdigital's marketing campaign, which will remind that no dish is necessary for terrestrial reception, Sky will install dishes free, regardless of where the receiver was bought.

If existing subscribers buy their set-top box direct from Sky, the price will be cut to £160, from the already subsidised £200. Sky says the £40 difference will be saved by cutting out dealers' profits.

Sky will have 0·2 million boxes ready for sale by Christmas, initially from Pace, and soon after from Amstrad, Grundig and Panasonic. The true price of these boxes would be around £400.

The Sky box must be connected to a phone line and few people have a socket by their TV set. A Sky spokesman says there will be no need to fit an extra socket because the aerial engineer can run an extension wire.

Integrated TV sets, from Toshiba, Panasonic, LG, Grundig, Amstrad, Sharp and Samsung, will follow the set top boxes. These too will be subsidised, but there is no agreement yet on the rate.

Under pressure from the EU, Sky will give the subsidy as soon as the viewer has connected the receiver to a phone line, even if they use their dish only to receive free-to-air programmes like the BBC's. Sky has also pledged to provide the necessary free-to-air smart cards free.

PATENT IT CHEAPER!

YOU enterprising lot can now patent your ideas more cheaply! A reduction in fees for the Patent Office has been announced and applies not only to patents, but also to trade marks and registered designs; a number of fees are being abolished altogether.

The principal changes proposed are:

* Patent filing fee (currently £25) to be abolished
* Trade mark application fee reduced from £225 to £200
* Renewal of a trade mark registration to be reduced from £250 to £200
* Patent renewal fees to be reduced on average by 18 per cent.

For more information phone the Department of Trade and Industry (DTI) on 0171 215 5000.

MAPLIN'S NEW CAT

MAPLIN have released the latest version of their renowned catalogue, and provides its users with a number of new features.

Available in the traditional printed version (order code CA18U), this new issue launches a semiconductors guide. This lists an additional 17,000 new products, making Maplin the largest source of semiconductors from a single catalogue in the UK.

It also shows price reductions on over 2000 products and includes range extensions of an additional 1000 new lines across the 42 product range.

The catalogue is also available on CD-ROM (order code CQ02C) that features all the above plus a number of other new features. The companion CD includes a *free* copy of MacAfee anti-virus software, a *free* 30 Internet trial with Demon including software, and over 1000 data sheets.

The catalogues are available mail order from Maplin Electronics, Dept EPE, PO Box 777, Rayleigh, Essex SS6 8LU and from the chain's 48 stores nationwide. Tel (HQ): 01702 554000. Web: http://www.maplin.co.uk.

RADIO METERING

GAS, electricity and water meters are to be read remotely by radio, the Government has announced. The Radio Communications Agency has allocated space on the airwaves which will allow low-powered radio equipment to tune in and read your meter – all without the need for home visits.

It is expected that the remote reading technology will be available within the next two years.

EG3 CHIP SEARCH SITE

IN *Network* August '98, we mentioned a web site that provides the world's largest on-line semiconductor search resource. We have now had a press release from the organisers of that site, announcing a major upgrade.

Site www.eg3.com (previously incorrectly reported as e3g – which turns out to be an employment agency!) provides a meta-search service for electronic design engineers in the embedded, realtime, DSP, and board level computing area. The newly upgraded search feature offers an *almost realtime* index to actual documents hosted on the vendor web sites themselves, around 3000 of them. The search engine also includes Adobe Acrobat .pdf documents which comprise the majority of product data sheets and information from chip companies. The site is updated daily.

If you are searching for semiconductor information, drop in on www.eg3.com and have good browse – it's an amazing site!

EG3 Communications Inc are based at 12 South First Street, Suite 702, San Jose, CA95113, USA. Tel: 408 938 9150. Fax: 408 938 9155. E-mail: inquiry@eg3.com.

£1 BARGAIN PACKS – List 1

1,000 items appear in our Bargain Packs List – request one of these when you next order.

2 LITHIUM COIN CELLS, 3V p.c.b. mounting. Order Ref: 1078.
2 × 5A BRIDGE RECTIFIERS with heatsink couplers for 12V charger. Order Ref: 1070.
1 × 12V STEPPER MOTOR, 7·5 degrees. Order Ref: 910.
1 × 10 PACK SCREWDRIVERS. Order Ref: 909.
2 × AMP PULL CORD CEILING SWITCHES, brown. Order Ref: 921.
5 × REELS INSULATION TAPE. Order Ref: 911.
2 × CORD GRIP SWITCH LAMP HOLDERS. Order Ref: 913.
1 × DC VOLTAGE REDUCER, 12V-6V. Order Ref: 916.
LIGHTWEIGHT STEREO HEADPHONES, moving coil so superior sound. Order Ref: 896.
2 × 25W CROSSOVERS for 4ohm loudspeakers. Order Ref: 22.
2 × Nicad CONSTANT CURRENT CHARGERS, easily adaptable to charge almost any NiCad Battery. Order Ref: 30.
18V-0-18V 10VA mains transformer. Order Ref: 813.
2 × WHITE PLASTIC BOXES with lids, approx. 3in. cube. Lid has square hole through the centre so these are ideal for light-operated switch. Order Ref: 132.
2 × REED RELAY KITS, you get 8 reed switches and 2 coil sets. Order Ref: 148.
12V-0-12V 6VA mains transformer, p.c.b. mounting. Order Ref: 938.
1 × BIG-PULL SOLENOID, mains operated, has ½in. pull. Order Ref: 871.
1 × BIG-PUSH SOLENOID, mains operated, has ½in. push. Order Ref: 872.
1 × MINI MONO AMP. 3W into 4 ohm speaker or 1W into 8 ohm. Order Ref: 495.
1 × MINI STEREO 1W AMP. Order Ref: 870.
15V DC 150mA P.S.U., nicely cased. Order Ref: 942.
1 × IN-FLIGHT STEREO UNIT is a stereo amp. Has two most useful mini moving coil speakers. Made for BOAC pasengers. Order Ref: 29.
1 × 0-1mA PANEL METER. Full vision face 70mm square. Scaled 0-100. Order Ref: 756.
2 × LITHIUM BATTERIES. 2·5V penlight size. Order Ref: 874.
2x3m TELEPHONE LEADS. With BT flat plug. Ideal for 'phone extensions, fax, etc. Order Ref: 552.
1 × 12V SOLENOID. Has good ½in. pull or could push if modified. Order Ref: 232.
3 × IN-FLEX SWITCHES. With neon on/off lights, saves leaving things switched on. Order Ref: 7.
2 × 6V 1A MAINS TRANSFORMERS. Upright mounting with fixing clamps. Order Ref: 9.
1 × HUMIDITY SWITCHES. As the air becomes damper, the membrane stretches and operates a microswitch. Order Ref: 32.
4 × 13A ROCKER SWITCH. Three tags so on/off, or changeover with centre off. Order Ref: 42.
1 × SUCK OR BLOW-OPERATED PRESSURE SWITCH. Or it can be operated by any low pressure variation, such as water level in tanks. Order Ref: 67.
1 × 6V 750mA POWER SUPPLY. Nicely cased with mains input and 6V output lead. Order Ref: 103A.
2 × STRIPPER BOARDS. Each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of capacitors, etc. Order Ref: 120.
12 VERY FINE DRILLS. For p.c.b. boards etc. Normal cost about 80p each. Order Ref: 128.
5 × MOTORS FOR MODEL AEROPLANES. Spin to start so needs no switch. Order Ref: 134.
6 × MICROPHONE INSERTS. Magnetic 400 ohm, also act as speakers. Order Ref: 139.
6 × NEON INDICATORS. In panel mounting holders with lens. Order Ref: 180.
1 × IN-FLEX SIMMERSTAT. Keeps your soldering iron etc. always at the ready. Order Ref: 196.
1 × ELECTRIC CLOCK. Mains operated. Put this in a box and you need never be late. Order Ref: 211.
4 × 12V ALARMS. Makes a noise about as loud as a car horn. All brand new. Order Ref: 221.
2 × (6in. × 4in.) SPEAKERS. 16 ohm 5 watts, so can be joined in parallel to make a high wattage column. Order Ref: 243.
1 × PANOSTAT. Controls output of boiling ring from simmer up to boil. Order Ref: 252.
2 × OBLONG PUSHSWITCHES. For bell or chimes, these can switch mains up to 5A so could be footswitch if fitted in pattress. Order Ref: 263.
50 × MIXED SILICON DIODES. Order Ref: 293.
1 × 6 DIGIT MAINS OPERATED COUNTER. Standard size but counts in even numbers. Order Ref: 28.
2 × 6V OPERATED REED RELAYS. One normally on, other normally closed. Order Ref: 48.
1 × CABINET LOCK. With two keys. Order Ref: 55.
6½ 8Ω 5 WATT SPEAKER. Order Ref: 824.
1 × SHADED POLE MAINS MOTOR. ¾in. stack, so quite powerful. Order Ref: 85.
1 × CASE, 3½ × 2¼ × 1¾ with 13A socket pins. Order Ref: 845.
2 × CASES. 2½ × 2¼ × 1¾ with 13A pins. Order Ref: 565.
4 × LUMINOUS ROCKER SWITCHES. 10A mains. Order Ref: 793.

BATTERY MOTOR WITH GEARBOX. Will operate on any DC voltage between 6V and 24V, price £3 Order Ref: 3P108. A speed controller is available for this, £12 in kit form or £20 made up, but if you intend to operate it from the mains, then our power supply 2P3 will give you 3 speeds and will also reverse. Price of power supply is £2
ANOTHER PROJECT CASE. Should be very suitable for a non-recognisable bug or similar hand-held device It is 150mm long, 36mm wide and 15mm thick. Originally these were TV remote controls, price 2 for £1. Order Ref: 1068.
A MUCH LARGER PROJECT BOX. Size 216mm × 130mm × 85mm with lid and 4 screws. This is an ABS box which normally retails at around £6 All brand new, price £2 50. Order Ref: 2.5P28.
BT TELEPHONE EXTENSION WIRE. This is proper heavy duty cable for running around the skirting board when you want to make a permanent extension. Four cores properly colour coded, 25m length only £1. Order Ref: 1067.
LARGE TYPE MICROSWITCH. With 2in. lever, changeover contacts rated at 15A at 250V, 2 for £1. Order Ref 1/21R7.
MINI MICROSWITCH. Only approximately 15mm long with a 20mm lever which could quite easily be removed, changeover contacts rated at 5A AC, 50p each. Order Ref: 1/21R8.
FLEX PROTECTORS. Rubber, 30mm long, 8mm diameter with a 12mm shoulder. Ideal for protecting flex passing through a metal panel, 5 for £1. Order Ref: 1/21R10.
10K POT. With double-pole mains on/off switch, good length of ¼in. spindle and hex fixing nut, 50p each. Order Ref: 1/22R6.
DITTO but 5K. Order Ref: 1/11R24.
AMSTRAD POWER SUPPLY/AMPLIFIER. This is quite a big unit, measures approximately 8in long and 3½in. wide and has a heatsink approximately 3in. high. At one end is the mains transformer which looks to be about 40VA. Then there is an assortment of i.c.s, power transistors and the lead coming out terminates on a panel with twin speaker sockets and miscellaneous input sockets. Price £5 Order Ref: 1/1R2
BALANCE ASSEMBLY KITS. Japanese made, when assembled ideal for chemical experiments, complete with tweezers and 6 weights 0·5 to 5 grams. Price £2. Order Ref: 2P444.
SUPER CROMPTON PARKINSON MAINS MOTOR. Really well made, totally enclosed by ventilated framework. Size approximately 4in. diameter, 4in. high and with 2in. of a ⅜in. spindle. Speed is 750rpm. hp is not quoted but we estimate this to be around 1/6hp Price £10. Order Ref: 10P149.
EQUIPMENT COOLING BLOWER. Near enough 5in. square and 1½in. thick but a really good air mover. Mains operated, price £4. Order Ref: 715L.
SCALE TO GO UNDER A CONTROL KNOB. Approximately 2in. diameter and engraved 1 to 10 on a black base, price 50p Order Ref: 1/3L16.
DITTO but white. Order Ref: 1/5R10
OVEN THERMOSTAT with knob calibrated so you can set it to cut out at any temperature up to 600°F, £3. Order Ref: 3P229
SPEAKER IN CABINET. Just right if you want music in the garden. Cabinet size approximately 8in. × 5in. × 4in. thick, speaker is 6½in. 8 ohm. These are ex-equipment but in tip top condition, price £4 each or 2 for £7. Order Ref: 812L
PURE SINE WAVE GENERATOR. All parts to make this, £3. Order Ref: 1/10R14.
MAINS ADAPTOR. Plugs into 13A socket and will take 3 more 13A plugs, price £1.50 each. Order Ref: GR28.
DOORBELL PSU. This has A.C. voltage output so is ideal for operating most doorbells. The unit is totally enclosed so perfectly safe and it plugs into a 13A socket. Price only £1 Order Ref: 1/30R1.
GEAR WHEELS. Set of 5, quite small, should enable you to get a variety of speeds, mounted in a metal case but easy to remove and use separately. Price £1 the set Order Ref. D409.
WIND GENERATORS. The ex-GPO alternator, our ref 5P249, has been used to generate from the wind. We understand it will light a 100W bulb or through rectifiers would charge batteries. These are ex-GPO equipment but fully guaranteed, price £5 each.
CYCLE LAMP BARGAIN. You can have 100 6V MES bulbs for just £2.50 or 1,000 for £20. They are beautifully made, slightly larger than the standard 6·3V pilot bulb so they would be ideal for making displays for night lights and similar applications. 50 joined in series can be connected to the mains and would make a very attractive window display. 100 for £2.50 Order Ref: 2.5P29.
12 RELAY. Miniature, clear platic enclosed, has one set changeover contacts, one set that breaks contact and 3 sets that make contact. Price £1 each. Order Ref: GR30.
SCREW TERMINAL. Can also take 4mm plug, with panel insulators and 2 quite hefty nuts for securing the cable Price 3 for £1. Order Ref: GR42. Only red ones available.
BLACK POINTER KNOB. 2in. diameter, push on to ¼in spindle, 3 for £1. Order Ref: 1/7RC17.
COMPONENT MOUNTING PANEL. Heavy Paxolin, size approximately 10in. × 2in. with 32 pairs of brass pillars for soldering or binding on components, £1. Order Ref. 1/7RC26.
AIR-SPACED TUNING CAPACITOR. Twin 100pF with trimmers, extra small. Fixed from the front by 3 screws, £2 each. Order Ref: 1/7RC29.
PEA LAMPS. Very tiny, only 4mm, but 14V at 0·04A, wire-ended, 25p each. Order Ref: 1/7RC28.
HIGH AMP THYRISTOR. Normal two contacts from the top and heavy threaded fixing underneath We don't know the amperage of this but think it to be at least 25A. Price 50p each. Order Ref: 1/7RC43.
THREE LEVEL PRESSURE SWITCH. All 3 are low pressures and the switch could be blow-operated With a suitable tubing these switches could control the level of liquid, etc., price £1 Order Ref: 67.
BREAKDOWN UNIT, Order Ref: BM41001. This is probably the most valuable breakdown unit that you have ever been offered. It contains the items specified below, just 2 of which are currently selling at £3 50 each. Other contents are.
Computer grade electrolytics. 330µF 250V DC, you get 4 of these. 4,700µF at 50V DC, you get 2 of these. 1,000µF at 16V DC, you get one of these, and 16A 250V double rocker switch. 115V to 250V selector switch You also get a standard flat pin instrument socket, a 250V 5A bridge rectifier, 2 × 25A bridge rectifiers mounted on an aluminium heatsink but very easy to remove.
2 *NPN* powered transistors ref. BUV47, currently listed by Maplins at £3.50 each, a power thyristor, Mullard ref. BTW69 or equivalent, listed at £3.
All the above parts are very easy to remove, 100s of other parts not so easy to remove, all this is yours for £5. Order Ref. 1/11R8

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READOUT

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

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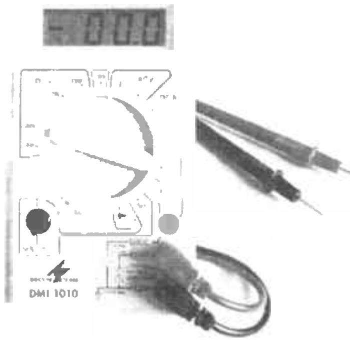
The DMT-1010 is a 3½ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a DMT-1010 Digital Multimeter to the author of the best *Readout* letter.



★ LETTER OF THE MONTH ★

AMIGA AMIGO!

Dear EPE,

Regarding John Gray's letter (Why a PC? – Sept '98), I have a few points to make that will clarify the position with regard to PCs and Amigas etc.

Firstly, I wonder why you think that the author of the letter has no access to the Internet? Most Amiga users have access to it – in fact if it were not for the Net, the Amiga would be struggling even more than it is at present.

Since the Amiga's disappearance from the mainstream stores, it is largely through the Net that it has survived. There is a large site in America, known as Aminet, which has a huge, some say the biggest, collection of software archives devoted solely to the Amiga. There are even some electronics programs!

Any Amiga user can visit the web site, just like the PC user can. There are some really good programs for utilising PIC chips. There are also hardware and software solutions for emulating a PC on an Amiga if you must, though admittedly they are slow.

Try telling Graphics studios that the Amiga is dead – not so! The great thing about the Amiga is that it has become a sort of hobbyist's computer, so it's almost back to the days of scores of magazines covering all sorts of computers.

As for the future of the Amiga, since being bought up by Gateway 2000, things have been very quiet. That is, until the last few months. Plans are underway for new hardware and software that will blow the socks off any Pentium based PC. The phoenix will rise from the grave ... you have been warned!

Great magazine (by the way), and pass on my regards to all fellow Amiga users that read your mag.

P.S. I've just accessed your web site – on an Amiga!

Terry Blay, via the Net

Do I gather you might be a fan of the Amiga?! More power to you, and indeed your enthusiasm proves again that we often learn from readers as well as they learning from us. I was unaware (as I have said before) of the Amiga's current status and abilities.

However, on a shear practical and common sense level, I must continue to caution against buying any computer that does not conform to the abilities that the main-stream computers, such as PC-compatibles (in whatever guise), offer to their users on an international scale.

Your comments about the Amiga's position in the marketplace does not, I have to say, fill me with great confidence, even though you place a positive emphasis on its potential. When choosing any computer, it seems valid to consider what the situation would be if the computer develops problems and the manufacturer has ceased trading.

Such concerns, though, are academic if you already own a computer with which you are satisfied. In that case, there is obviously merit in sticking with that machine as long as you can until you wish to move ahead, or are forced to.

TOOLKIT PROBLEM

Dear EPE,

It suggests in *Shop Talk* Sept '98 that the *PIC16x84 Toolkit* of July '98 will allow the *PIC Altimeter* source code to be converted from TASM to MPASM. I tried, having taken out a lot of comments as suggested, but the result was still a "string handling error" in Basic.

Would it be possible, that in future two versions of source code for PIC projects could be provided, since then those of us happy with MPASM could assemble the code as is?

Chris Neale, via the Net

So sorry, Chris, but supplying two versions of software would not be a practical proposition.

The reason for the "string error" is that QBasic and QuickBASIC have a limit on the amount of memory available for string handling and too many "comments" in the program being converted can cause that limit to be exceeded. The only direct solution, as stated on the screen when the error occurs, is to delete comments until the total string byte count is less than the maximum permitted.

One way round it, however, is to program the PIC via Toolkit *using the TASM object code (.OBJ). Then, in order to obtain an MPASM source code file, disassemble the PIC in that* Toolkit *mode. You would, though, have to key in the comments separately, and to give names to the jump addresses and labels.*

PICS AND LAPTOPS

Dear EPE,

Firstly, can I say the *PIC Tutorial* series (March to May '98) has been absolutely brilliant! I now have so many projects I want to build I don't know where to start. The combination of the hardware, software and superbly structured tutorial has allowed me to develop my knowledge and skills at my own pace.

For reasons I won't go into, I must now do all my tutorial programming on a Compaq Concerto laptop. I have been trying to get all three Send programs to work with the printer port (&H3BC normally) but can get no output.

Can you suggest where I can get any software, and WWW sites or other sources of help that might fix this problem? My tutorial board was working well on a desktop machine I was able to use before, but I don't seem to be able to get an output from the laptop. There is no conflict listed under Win95.

Guy Robinson, via the Net

Two or three people have told me by phone of difficulties with laptops and PIC programming. Regrettably we don't know the answer, and none of the callers has yet told us of any solution they have found.

The advice I offered them is to run the Basic port test program to really make sure that the correct Send program is being used for the correct port register address. In doing so, to also check the clock and data voltages from the port that are actually reaching PIC pins 12 and 13 (i.e. after the protective resistors R3 and R4) – the PIC Data Book *quotes an input low voltage range of V_{SS} to 0·8V, and an input high voltage range of $0{\cdot}36V_{DD}$ to V_{DD}.*

Is it possible, perhaps, that some laptops have parallel printer ports that require pull-up (or pull-down) resistors when coupled to the PIC, in order to get a satisfactory logic swing?

Could it also be that the rate at which some laptops output the Send data is not at the correct speed? I would be pleased to be told how long it takes you to send a specific quantity of bytes to the PIC. A full 1024 block takes about one minute 20 seconds on all the desktops I've used with Send. It should take the same time on other machines since the rate is independent of the crystal frequency. (Incidentally, my PIC16x84 Toolkit *of July '98 uses a different algorithm to the Send program and is much faster.) Information on clock pulse widths provided to PIC pin 12 would be useful to know.*

Additionally, I would like to know the programming voltage reaching the PIC's MCLR pin 4. Curiously, I've inadvertently but successfully programmed a 'C84 with only 9V on pin 4, instead of the recommended 12V to 14V, but this latitude might not be found on all 'C84s. Furthermore, I want to know whether it is 'C84s or 'F84s that are being used. Whilst in the majority of applications they can be regarded as totally interchangeable (and I too use them interchangeably), are readers finding them totally compatible?

We would like to receive feedback from anyone on these points.

I should point out, perhaps, that in making the above comments I am assuming that such troubled readers have done all the usual physical checks for incorrectly placed components and solder shorts.

In this context, check that the oscillator is working and, if not, that the thin tracks passing between the legs of the PIC in that region are intact and cleanly separated from the adjacent pins. Check their integrity with an ohmmeter.

SOFT SOLDERING

Dear EPE,

I enjoyed reading Alan Winstanley's soldering guide on your web site. Can you send me some information specifying the melting and remelting temperatures or various types of soft solder and silver solder. I need to solder some critical parts on an electron beam accelerator that will operate at elevated temperatures and I do not want the solder to melt.

Ken Williams, via the Net

Alan replied to Ken via the Net, saying that:

Silver solder has a higher melting point, e.g. Multicore Solders in the UK advertise a high melting point solder for use at high operating temperatures – 5% tin, 93·5% lead, 2% silver. It melts at 301°C. A bit temperature of 421°C is recommended.

Ordinary 40/60 solder melts at about 234°C, soldering bit temperature 335°C.

It is worth looking at the web site of Metcal Inc. **(http://www.metcal.com/home.html)** *where there is a considerable amount of material related to reworking etc.*

ARCHIVES

Dear EPE,

Many thanks for kindly elevating my observations to "Letter of the Month" for *EPE* September '98. The arrival of a new DVM through the door was a welcome surprise.

In response to a couple of "points arising" in your reply:

I have managed to track down early *EE* (1972-83) to the British Library document supply centre in Wetherby. In a strangely inconsistent manner, old *PE* and *PW* are stored in London, but *EE* has been sent to Yorkshire for storage, and has only recently been entered onto the on-line catalogue. Mystery solved. *EE/EPE* from 1983 remain stored in London!

Secondly, I would certainly recommend a visit to the Amberley Chalk Pits Museum to anyone with an interest in electronics or electricity generally – apart from a Southern Electricity display centre (reached by vintage buses or steam train!) they also have a nice display of "vintage" kits, including an AVO Multiminor identical to the one owned and still regularly used by me!

Philip Miller Tate,
Walton-on-Thames, Surrey
(not Sussex, as previously published!)

Thanks Philip for the "archive info" – useful for us all to know.

MANUAL SKILLS

Dear EPE,

I am writing in response to Philip Miller Tate's letter in Sept '98. He is absolutely correct on all counts, as also is your Tech Ed, John B.

In fact, Philip, I did include information in my unedited letter that I sent to *EPE*, but I also acknowledged the fact that *EPE* would have to edit out any references to other publications, and that the Inductance Tester would be copyright even if not patented.

All I can say is that you will find a circuit in a publication, printed over the last two or three years as a Manual and by a Radio Ham organisation in a large Country across the Pond. The test instrument under discussion is actually a mixture of standard (old) technology, and latter day logic chip technology.

Incidentally, regarding JB's reply and comments about a Sci-Fi story regarding the loss of handwriting skills by society, a true story comes to mind:

A certain large Super Power leading the Space Race to the Moon invented a ball-point pen that could write under any conditions of extreme pressure or in a vacuum or upside-down. Its research and development cost millions of dollars. The reply from the other Super Power was that they already had such a writing instrument that cost absolutely nothing at all in research and development – they said that it was called a *Pencil!*

Bill Jackson,
G7VPL, Blackburn, Lancs.

Hello again Bill. On your first point – oh, all right, I'll spill the chips (publish or be damned?), you referred to the design having been published in the ARRL Manual, *the ARRL being the American Radio Relay League. I'll also point out that our erst-while sister magazine* Practical Wireless *imports and sells them through its books pages!*

On your second point – nice one!

OFF-THE-SHELF TAYLORING

Dear EPE,

A.A. King, in his letter to *Circuit Surgery* August '98 admits to not even having resistors in stock. As he says he is enjoying the hobby, can I suggest he buys a pack of resistors as soon as possible. A regular *EPE* advertiser lists 730 0.25W resistors for £4 and a glance down the rest of the advert shows that for about £20 you could get a very good starter kit of components at a much lower price than buying each component as required.

In fact the savings can be such that even if you never use half of what you've bought, you are still ahead. Does anyone pay more that 1p each for 1N4148s, for example? I don't because I always buy 100 at a time, knowing that even if I only use 25 of them I've broken even!

B.J. Taylor,
Rickmansworth, Herts

Absolutely right and, indeed, the technique of "buying-in" at the right price to suit expected future use can be developed to quite a fine art. Even ignoring "bumper bundles", there is ALWAYS a quantity level to be found at which components can be bought at a price lower than single-unit cost. Generally known as "price-breaks" the quantities at which the reductions occur depends on the goods in question, and there are usually several levels of further-reducing prices per quantity; for example, quantities of 10, 50, 100, 500, 1000 and so on might each qualify for better discounts.

This is where shopping-around can often reap rewards, even taking post and handling costs into account. If you think you deserve a discount for what you consider to be significant quantities, negotiate with your dealer. If he won't budge on price, try someone else.

It has to be admitted, of course, that sometimes it may be more convenient to simply accept the price asked, irrespective of potential savings elsewhere. Sometimes, "convenience" is worth paying for (and I am not punning on the word!).

Nonetheless, dedicated hobbyists should keep a good stock of regularly called-for items whose restocking can be predicted and good prices found before urgent more-costly purchasing is necessary. As I said, it's an art (if you want it to be)!

PIC POINT

Dear EPE,

I would like to disagree with you on the last paragraph or two of your *PIC Altimeter* article, which suggests the PIC16x84s are the only PICs with EEPROM. This is not the case. Microchip have recently announced OTP PICS with an E infix which have EEPROM. Of course it takes a good while for such to become available here in the UK.

For example, I am interested in trying out the 8-pin PIC with ADC, from the PIC12C67x family, but have yet to find anyone supplying it.

Chris Neale, via the Net

What I should have said is that I chose the '84 because of its EEPROM program memory and EEPROM data storage, but would have preferred to use one having 2K of the former instead of just 1K, had it been available.

With your "E" infix comment, I assume you refer to the PIC16CE62X family. Pulling in some info from the web, I see this features 512 to 2048 words of one-time programmable (OTP) programmable memory, 128 bytes of secure EEPROM data memory and 96 bytes of SRAM data memory. Although its maximum capacity is enticing, its OTP nature is not likely to be so to many hobbyist constructors, who prefer the flexibility of being able to reprogram a chip like '84.

To find out who might stock less-common PICs, readers should ask Arizona Microchip Technology Ltd., 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel: 0118 921 5800. Their web site is at **http://www.microchip.com.**

For a bit more info on PIC16CE62X family, key in the above web address and add the extension: **/10/Company/Edit/pRelease/PR70/index.htm.**

At the time (28 Aug), I did not try to locate a data sheet, but one should be there, somewhere. The whole Microchip site is worth exploring anyway.

It calls itself "Planet Microchip" and has a great deal of useful info.

TASM vs MPASM

Dear EPE,

I have been reading the *PIC Altimeter* project (Sept. '98) which mentions that the source code is written in TASM assembler. I have not done anything with PICs now for about three years and have not heard of TASM.

Could you give me a brief overview of the differences between MPASM and TASM. Which one is best for me to use if I wish to begin building PIC projects again?

Richard Hughes, via the Net

Neither is "best", but for my own purposes I find that TASM is easier and faster to use.

In a nutshell, MPASM is the program supplied by Arizona Microchip, the PIC manufacturers. The full version includes an on-screen simulator as well as programming facilities, and caters for the entire PIC family.

TASM is a shareware product that is supplied by us on our software disks with a purpose-designed PIC16C84 programming facility. It does not allow other PICs (apart from the PIC16F84) to be programmed.

To learn more about the coding differences, read our PIC16x84 Toolkit *constructional article of July '98. The* Simple PIC Programmer *of Feb '96 gives more information about TASM itself.*

To know more about MPASM as a complete package contact Arizona Microchip Technology Ltd., 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel 0118 921 5800. Or browse their web site at **http://www.microchip.com**, *from where all their data is downloadable free.*

MAINS SAFETY

Dear EPE,

I would like to express my concern over the *Mains Socket Tester* featured in the September '98 issue. In the past I too have used stripboard for mains powered projects, but I feel that its use should not be encouraged.

Genuine Veroboard appears to work well, but the cheaper varieties from some other manufacturers seem to absorb water and become conductive.

Over a period of time, such boards can become charred and brittle, leaving mains wiring prone to breaking free. Spraying the board with a conformal coating reduces the problem, as does ensuring that adjacent tracks do not have high potentials between them.

Matters are made worse if high frequency, high voltages are used – though this clearly is not the case with this circuit.

I think you should consider only using fibreglass p.c.b.s for mains projects

Matt Waite, via the Net

We thank you for your cautionary advice and are pleased to pass it on to other readers. Whilst we would not agree that stripboard should never be used for mains projects, it obviously makes sense to use a top quality variety.

We would also add the caution that no electrical circuit (whatever the voltage) should be subjected to wetness, even if it's only condensation. If water ingress (in whatever form) is likely to occur, it should be housed in suitably approved waterproof case.

BASIC TOOLKIT

Dear EPE,

I have been trying to run your *PIC Toolkit* with GW-BASIC, but have had no success. What interpreter did you use for development?

Anon, via the net

Toolkit *will only run on QBasic or QuickBASIC. Whilst GW-BASIC can be used instead of these two interpreters in many instances where "normal" BASIC listings are concerned, there are significant differences in the way machine code is handled – which* Toolkit *relies on for much of its operation. Also, GW requires line numbers whereas the QBs do not.*

VIDEOS ON ELECTRONICS

A range of videos (selected by EPE editorial staff) designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes originate from VCR Educational Products Co, an American supplier.
(All videos are to the UK PAL standard on VHS tapes.)

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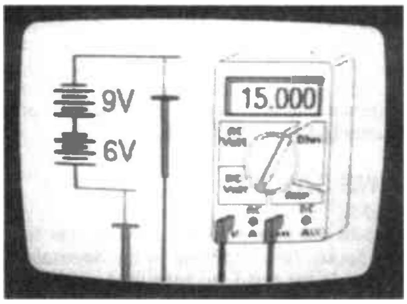

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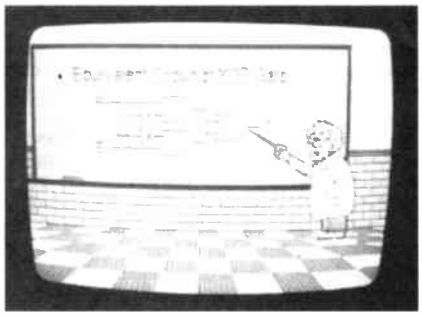

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E22

How To Use Your

EPE CD-ROM No.1

Presented Free with this issue

THERE'S a trial version of the *EPE* world exclusive *PhizzyB Simulator* on the *Free* CD-ROM, plus a wealth of free demonstrations, PIC files and more besides! This CD-ROM runs on an IBM-compatible PC, with Windows 95/98/NT. A web browser is used to view the contents, but the demonstration files can also be accessed manually using Windows Explorer or File Manager.

The CD runs best if Microsoft Internet Explorer is used (note that no Internet connection is needed), as all software demos will then self-install when selected.

If you don't have a browser, we have included a free copy of Netscape Navigator Version 4, but you should then note that the software demos may need to be run manually from the Windows 95 Start/Run line – full instructions on doing this are provided on-screen, please follow them closely.

Start Here!

Use Windows Explorer to view the contents of your free CD ROM. Netscape Navigator users, double-click on the file **welcome.txt** to view instructions on using the CD contents with your browser. Or, click on **default.htm** to launch it in your browser straight away.

> **IMPORTANT: when running demos, if you are offered an option by your browser, you should choose "Open" or "Run this program from its current location" (depending on version) in order to start the set-up procedure. Please do not choose "Save this program to disk" which only copies the setup routine itself, and does not start the installation.**

EPE CD ROM No.1 Welcome Page

PhizzyB Computer Simulator Introduction – specially recorded for EPE by Clive "call me Max" Maxfield, co-author of the Bebop books. Click the Bee to launch a two minute movie presentation! Note: if using Microsoft Internet Explorer, choose "Open this file from its current location" to run the movie directly from CD. If using Navigator 4, wait for the AVI to load up, then right mouse-click and choose "Play," to run. Click your browser's "Back" button to return to the Welcome page, if necessary.

Also on the free EPE CD ROM No.1, we've included these fabulous demonstrations and previews:

PhizzyB Simulator – introducing the new PhizzyB (Physical Bebopuler) simulator. Follow the on-screen instructions, click the link and choose (Explorer) "Open" or "Run this program from its current location" depending on your browser version.

A group called PhizzyBD will be created ("D" for "Demo") - click the icon to run the special *EPE* Edition PhizzyB Simulator! Click the on-screen "Power" button to start the demo unit. *Please note this demonstration version will* **not** *communicate with an actual hardware PhizzyB connected to a serial port. The full version of PhizzyB Simulator on CD is required to download programs.*

EPE PIC Tutor – we've included a special pre-release demo edition of our brand new CD-ROM tutorial package. Follow the instructions on screen. This will also install the Toolbook II Runtime engine in a Windows sub-directory (**windows\asym**) which is needed for several other demos. Please ignore any start-up error message, and run the pre-release version by clicking the newly created PICTutor icon. Some of the PIC tutorials are enabled in this preview edition: run them and also remember to try the PIC button to see a fantastic display of PIC processor operation in action, in our unique new Virtual PIC environment.

EPE PIC Files & Projects

- Also squeezed onto the disk is the entire *EPE* software library of available PIC, 8051 and other project files! Simply open the appropriate folder to access the files, or navigate to the PICS directory using Explorer/Windows File Manager. Please see the **readme** text files in each folder for a description of file contents.
- Reprint of the article *Using Intelligent LCDs* by Julyan Ilett, in Adobe Acrobat format. A 32-bit Acrobat reader is included on the CD-ROM. Note that a 16-bit version reader is also included in the Proteus sub-directory on the CD.

Please note that some files may be "zipped" so a file unzipping utility (e.g. PKWARE or WinZip) is needed to open them. Some files (e.g. the *Mind PICkler*) relate to future *EPE* projects yet to be published (see **EPEwelcome.txt**)! Special instructions are given separately for users of the *EPE PIC Tutorial* - see box.

Electronic Software Demos

Click the "other demos" option on the Welcome page to explore the software demonstrations included on your free-CD ROM.

- **Digital Electronics** by Mike Tooley takes users through the subject right up to the operation of microprocessors. The virtual labs allow users to operate many circuits on-screen.
- **Electronic Circuits and Components & The Parts Gallery** by Mike Tooley – two applications in one package! Provides an introduction to the principles behind the most common electronic components, plus a Parts Gallery to help students recognise actual components.

Follow the on-screen instructions to run the demos directly from the CD – the Toolbook Runtime engine will be installed, see the installation information provided on-screen. An order form in Adobe Acrobat format is included on disk for purchasing the full versions of these programs from the *EPE Direct Book Service*.

- **Quickroute Systems: The Idea Factory** – a demo version of their virtual laboratory and modelling tool, combining graphs, maths, sound and animations to form a captivating, fun-packed circuit simulator for all ages. **Quickroute 4.0** – demo of Quickroute's powerful integrated schematic capture, p.c.b. autorouting and CADCAM package. **MExpress** – "BASIC for engineers", a highly versatile 2D/3D modelling tool. (Limited demo version.) Follow the on-screen instructions to install these trial versions onto your hard disk.
- **PICO Technology** – trial versions of PICO's test and measurement software suite: **PicoScope** – converts your PC to an oscilloscope using a PICO ADC. **PicoLog** – data logging software for Windows. **EnviroMon** – measures a range of environmental parameters, with set-point alarms and other features. **osziFOX** – this probe-style mini l.c.d. oscilloscope can store and print via PC link software. Instructions are given for Microsoft Explorer and Netscape Navigator users to install onto their PC.
- **Electronic Principles 5.0:** A rolling demonstration of the many hundreds of screens available in the very latest version of this popular electronics educational package. Follow the on-screen installation notes to install it to your hard disk.
- **Labcenter Proteus IV:** Trial version, which includes **full working versions of ARES Lite**, a freeware/shareware p.c.b. design package, plus **ISIS** Lite freeware schematic capture programs. Install by following the on-screen instructions.
- **Number One Systems Easy-PC:** This demonstration version of Easy-PC offers users a sophisticated Windows package for advanced p.c.b. design. Features include a high-speed, gridless, shape-based autorouter, and Number One Systems offers free technical support for full version users. Installation instructions provided on-screen.

PIC TUTORIAL

Special instructions for using the files provided for the *PIC Tutorial* series (*EPE* March, April, May 98):

Open the folder PICTutor in the CD path "EPE\EPE_Files\PICS". Extract (unzip) the file **pictutor.zip** on the CD to a new directory on your hard disk called C:\PICTUTOR and also copy the file **tut.bat** to the same place.

Open the TASM sub-directory in the same PICTutor directory on the CD. Then extract **tasm30.zip** to directory C:\PICTUTOR on your hard disk.

On the CD, open the PICS sub-directory called PIC.programmer and extract **picprog.zip** to C:\PICTUTOR. Also copy **send2.exe** and **send3.exe** to directory C:\PICTUTOR if necessary (see readme2.txt).

Now switch to the directory C:\PICTUTOR on your hard disk. Run the DOS-based batch program **tut.bat** to compile all the .ASM files to .OBJ files. Now exit to DOS and switch to C:\PICTUTOR from where the files can be used.

Setting up the PICS directory on your hard disk: Open the folder PIC.programmer in the PICS directory of your free CD-ROM. Unzip **picprog.zip** to a new directory on your hard disk called C:\PICS, then copy **send2.exe** and **send3.exe** to C:\PICS as well, if necessary.

Open the TASM directory in the PICS directory on the CD-ROM and extract **tasm30.zip** to C:\PICS. At this point, you'll find it convenient to open and copy the contents of any other PIC project directories that you want to use, to C:\PICS on your hard disk. Close all windows and exit to the DOS prompt.

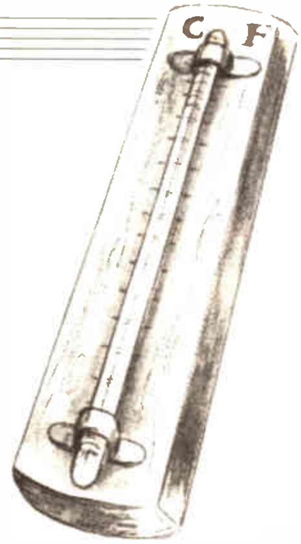
You can now enter the directory C:\PICS from where these files can be used in preparation for programming your own microcontrollers with the relevant codes.

Note, TASM shareware is duplicated on this CD-ROM, to mirror the way our FTP site is organised for the benefit of Internet users.

In case of problems E-mail:
techdept@epemag.wimborne.co.uk

You can also post feedback and general enquiries in the *EPE Chat Zone* on our web site or write to the editorial address.

Please note the legal disclaimer and copyright notice on the CD-ROM.



T-STAT ELECTRONIC THERMOSTAT

ANDY FLIND

Part One

A precision electronic thermostat for control of room heaters up to 3kW.

ONE might ask "Why bother to construct an electronic thermostat when it costs less to buy a heater already fitted with one?" The answer is accuracy and convenience. A heater thermostat is usually a bi-metallic device fitted into the heater itself, usually near the bottom to minimise the effects of proximity to the heating elements.

Generally this places it close to the floor which is just about the worst place for a room heating control's sensor. Being mechanical, it can operate at any point in the mains a.c. cycle, resulting in frequent arcing which burns contacts and generates mains-borne electrical noise.

From this point of view the less often it operates the better but the feedback effect of heat reaching it from the element tends to increase operating frequency. Consequently, most thermostats of this type have a large differential between the "on" and "off" points so users usually complain of being too hot or too cold most of the time! Of course, frequent thermostat adjustments can be made but to make them the user must bend down, often in an awkward place, to reach the control and this can become a pain in every sense of the word!

STRESSFUL POINT

By contrast an electronic thermostat can have its sensor and control placed anywhere the user prefers. Usually this will be around chest height on a wall, well away from direct heat rising from the heater.

Switching takes place at the "zero-crossing" points of the a.c. mains voltage, so that there is less stress on the heater element and very little mains-borne noise. As the "switch" is an electronic device with no contacts to burn the heater can be turned on and off as often as is necessary for precise control, although a small differential is normally used to ensure positive switching and reasonable heater efficiency.

For the user's point of view an electronic thermostat is usually a great improvement. Once the desired temperature is set the room temperature simply rises to it and remains there.

A thermometer will often show it remaining constant within a degree, affording comfort unknown with conventional thermostats. Another advantage is that more sophisticated electronics can be incorporated to provide extra functions, such as damp reduction by tracking just above the external temperature.

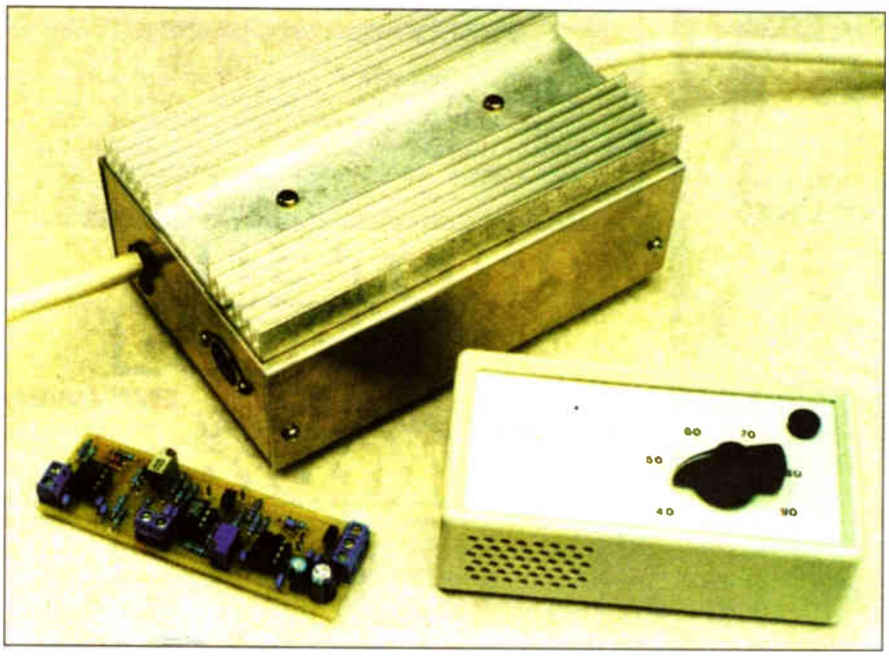
SAFE POWER

At the design stage of this project it was decided to construct it as two separate sections. A "Power Controller" unit handles the 230V a.c. mains power and provides a safe, low-voltage interface for controlling the electronics. This section has an opto-isolated input for the control signal and contains the zero-crossing detection, and provides a low-voltage d.c. supply.

Using this unit the constructor can construct and experiment with control circuits in complete safety even whilst it is switched on and operating. This will be particularly useful for experimenters wishing to use it with other primarily resistive loads.

For instance, it could control up to 3kW of lighting. Three of these units could control up to ninety 100W light bulbs using a simple three-channel sequencer or a sound-to-light circuit for a really stunning home disco display. ***Care would be needed to ensure the mains supply could handle the combined load of course, but the controlling circuitry could be handled with complete safety.***

Two versions of the power controller were built and both are described here.



T-Stat modules (left to right): Power Controller, Damp Stat (next month) and Room Stat.

The first uses a 16A triac controlled by an opto-triac with a built-in zero-crossing detector. The second, for constructors attracted to this project but unhappy about constructing 230V a.c. mains circuits, uses a "solid-state relay" which costs more but greatly simplifies construction.

Both units have to be capable of dissipating some heat. Both the "relay" and the triac develop about 1·6V across their power terminals when supplying a load. At full power, about 13A, this corresponds to about 20 watts so consideration must be given to the safe dispersal of the heat generated and to the resulting temperature rise.

Both versions of the controller use an inexpensive aluminium box with a large heatsink bolted to the top, resulting in a case with an attractive and compact appearance and a thermal resistance of about 1·5°C per watt. At full power the greatest expected temperature rise is about 30°C, though in practice neither unit has become more than very slightly warm to the touch. Better safe than sorry, though! The all-metal housing allows "***secure earthing***" of all accessible parts of the unit both for safety and for effective screening against radiation of any interference that may be present despite the zero-crossing feature.

TRIAC POWER CONTROL

The circuit diagram for the Triac version of the Power Controller is shown in Fig.1. A conventional power supply using a 12V-0V-12V transformer provides a nominal 12V d.c. output from socket SK1. In fact, the unloaded output is about 17V and it can provide up to 25mA before the voltage dips below 15V. This is sufficient to supply a thermostat circuit using a 12V regulator i.c., but where a higher current is required a 250mA transformer or a 15V-0V-15V type can be used instead.

A positive voltage applied to the input pin of SK1 causes current to flow through limiting resistor R1 and the l.e.d. in opto-triac IC1 to turn on the internal triac. Also, IC1 contains a zero-crossing detector so it only turns on when the next mains zero-crossing point is reached.

As it does so, current is supplied to the gate (g) of the power triac CSR1 which then supplies current to the main load through SK2. On removal of the input voltage both triacs will turn off at the next zero-crossing, cutting off the output.

A voltage dependent resistor, VDR1, is included in the circuit as a transient suppressor. Normally this does nothing, but if a high voltage "spike" occurs in the mains supply it conducts briefly to clamp it to a safe value. Triacs are sensitive to over-voltage so the inclusion of an inexpensive suppressor is a worthwhile precaution.

CONSTRUCTION

Construction and wiring of the Triac unit, with the main components in approximately the positions they occupy in the prototype, is shown in Fig.2. There seemed little point in producing a p.c.b. design for this simple circuit so most of the electronic components are soldered to a short tagstrip. The tagstrip is mounted so as to clear the metal chassis of the case, using screws and nuts as shown.

The opto-triac, IC1, is inserted into a d.i.l. socket soldered into a small piece of 0·1in. matrix stripboard which is then connected to the tagstrip as shown in Fig.2. If a 6-pin d.i.l. socket is not obtainable an 8-pin type can be used, but it would

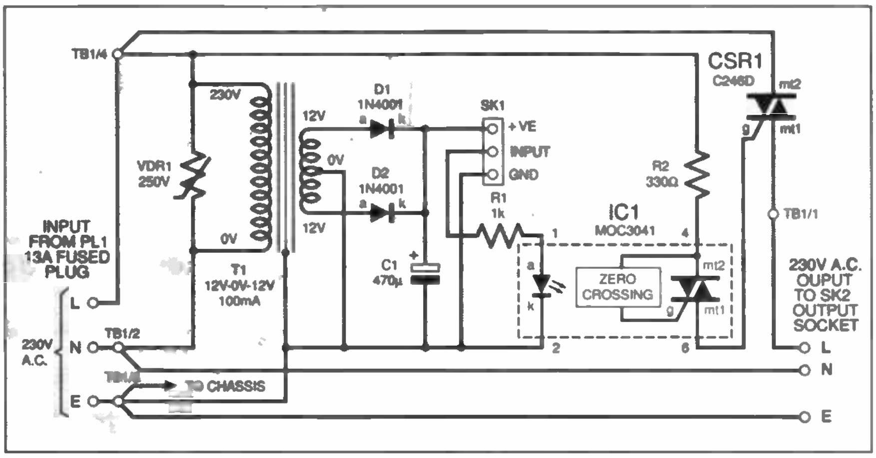


Fig.1. Circuit diagram for the Triac Power Controller.

COMPONENTS

TRIAC POWER CONTROLLER

See SHOP TALK Page

Resistors

R1	1k
R2	330Ω

All 0·6W 1% metal film

Capacitors

C1	470µ radial elect. 35V

Semiconductors

D1, D2	1N4001 50V 1A rec. diode (2 off)
CSR1	C246D 400V 16A triac
IC1	MOC3041 zero crossing, opto-triac isolator

Miscellaneous

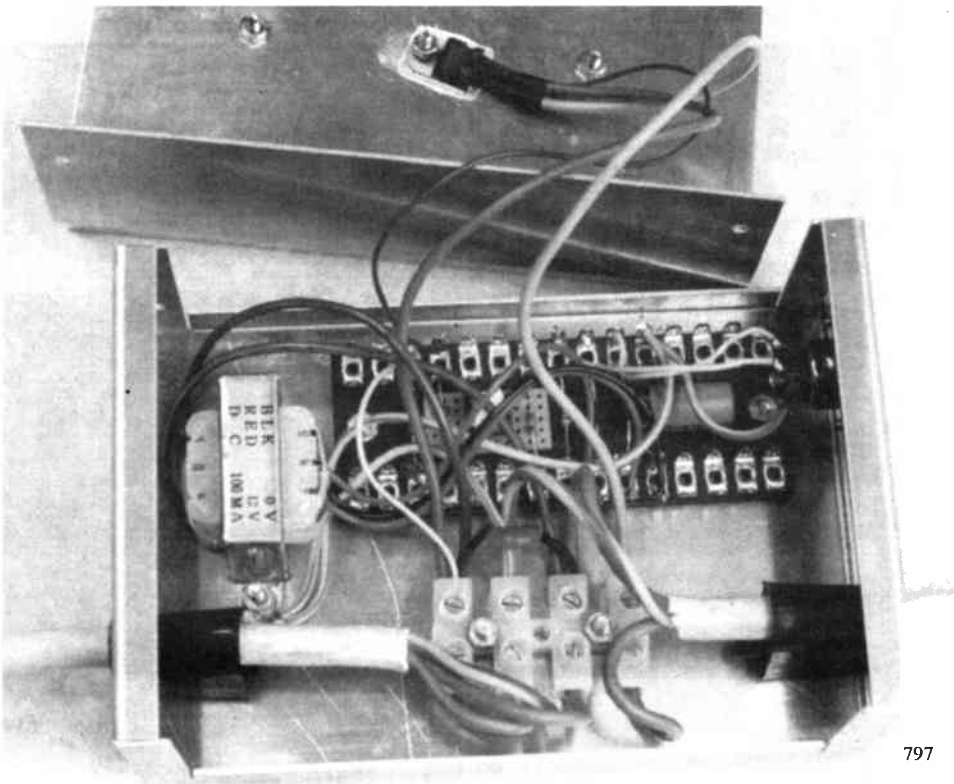
T1	min. mains transformer: 230V a.c. primary; 12V-0V-12V 100mA secondary
VDR1	250V a.c. transient suppressor
SK1	3-pin 180° DIN chassis socket
TB1	4-way screw terminal block, 16A rating

Aluminium box (AB13), size 152mm × 102mm × 51mm; min. tagboard, 38mm wide cut to 15 pairs of tags; stripboard 0·1in. matrix, size 5 copper strips × 10 holes; flat, undrilled, plain aluminium heatsink, size 152mm × 94mm × 14mm; 6-pin d.i.l. socket; TO220 mounting kit; 13A fused mains plug; 13A mains trailing socket; 13A mains cable; heatsink compound; heatshrink sleeving for CSR1 (see text); multistrand connecting wire; solder etc.

Approx Cost Guidance Only £22

excl. 13A mains plug & socket

The power triac bolted to the metal case cover, using a mounting kit, and positioning of components on the base of the case.



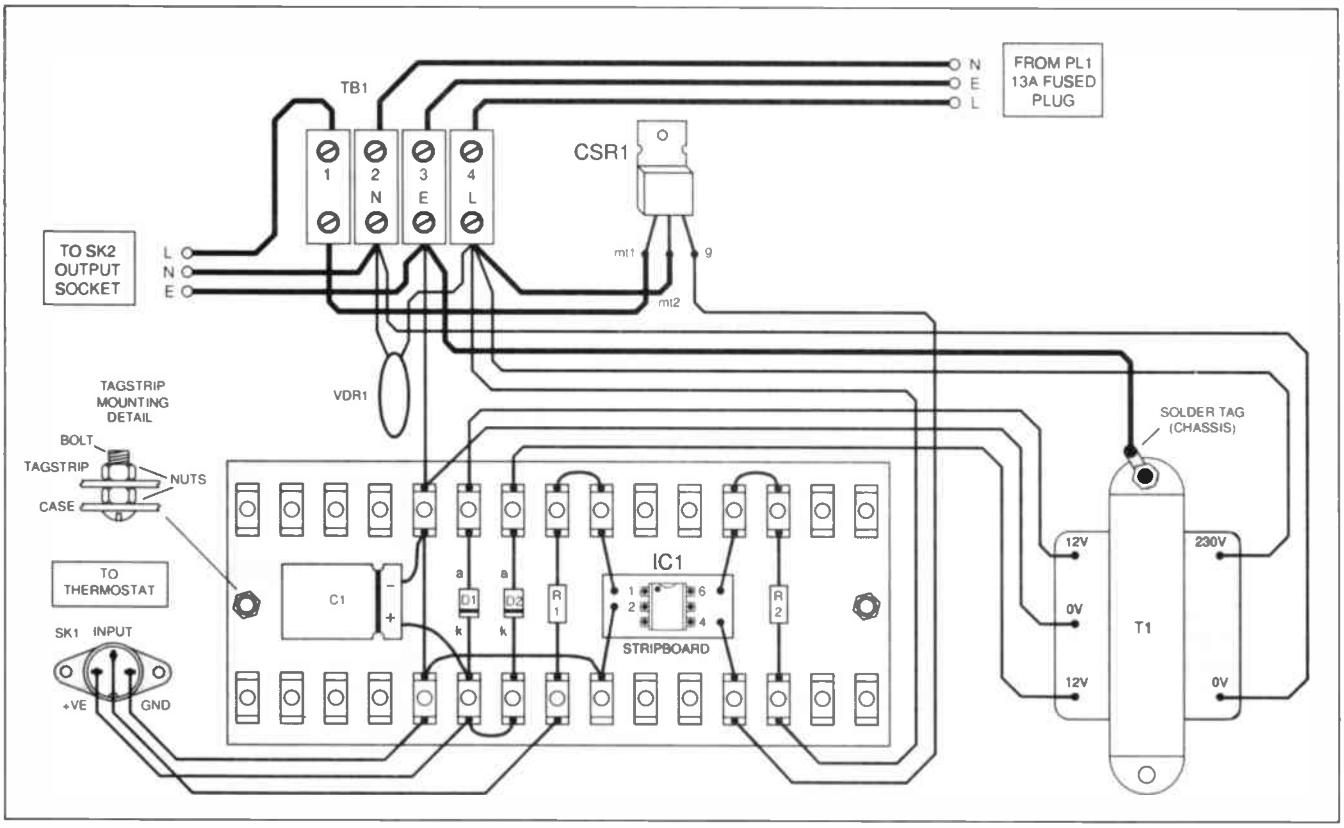


Fig.2. Tagboard component layout and interwiring for the Triac Power Controller version. The heavy duty wiring is indicated by the thick leads.

be worth blanking off the unused holes in some way to prevent incorrect insertion.

Stripboard is not intended for 230V a.c. use, so to increase the clearance between tracks unused sections should be carefully removed with a sharp knife as shown in Fig.3.

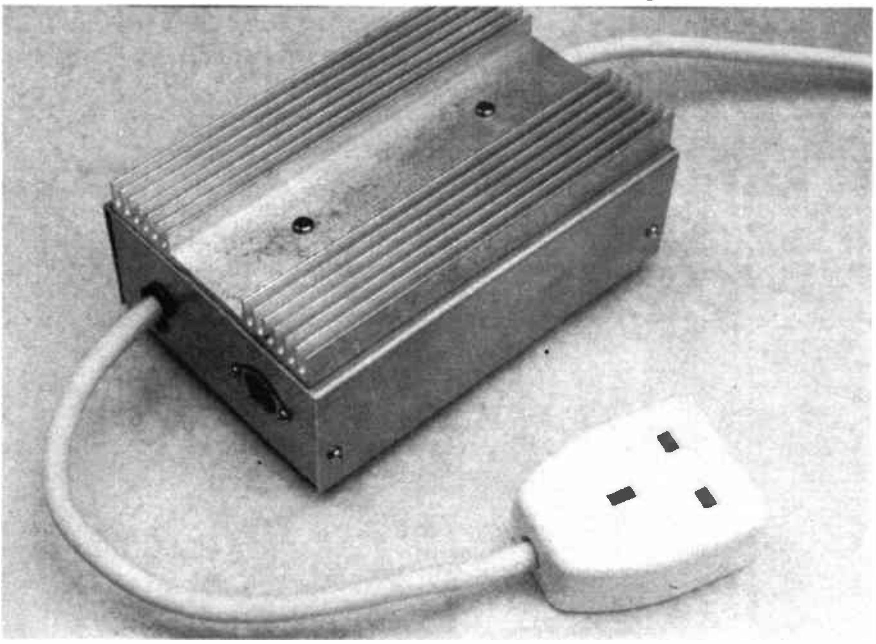
WIRING

Socket SK1 is a 3-pin 180° DIN chassis type. Wiring to this and other low-power parts of the circuit can be carried out with ordinary thin insulated hook-up wire, but the ***high-current mains wiring*** through terminal block TB1 consists mainly of the cores of the incoming and outgoing cables, which are ***13A 3-core mains flex.***

Connections to the triac CSR1 are made with short lengths of insulated wire taken from ***10A mains flex.*** Heavier wire than this would put undue stress on the triac leads, which are, in any case, thinner. The connections of these leads to the triac are soldered and then insulated and strengthened with heatshrink sleeving.

Thick wire should also be used to make the "earth" connection from terminal block TB1 to the metal case. This is soldered to a tag secured under one of the mounting screws for transformer T1. These small transformers are often thickly coated with varnish and paint which should be scraped off the mounting lugs before fitting to ensure good contact.

Completed Triac Power Controller with its trailing socket.



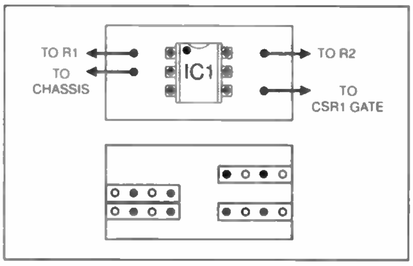


Fig.3. Once the opto-isolator has been mounted, remove all unwanted copper tracks from the piece of stripboard.

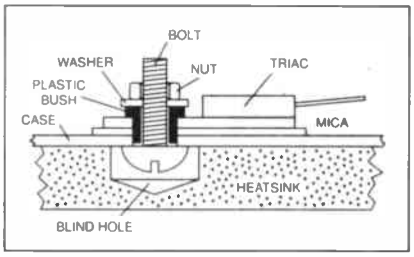


Fig.4. Mounting the power triac on the metal case using a TO220 mounting kit.

ASSEMBLY

The method of mounting the power triac CSR1 is shown in Fig.4, see also photographs. The mounting tab of this device is internally connected to MT2 and so becomes "*live*" during operation, and it must also be able to transfer up to 20W of heat to the case.

It is bolted to the centre of the top section of the case, beneath the centre of the heatsink, using a TO220 mounting kit. This consists of a plastic insulating bush and a mica washer which are assembled as shown in Fig.4, using a small quantity of silicone heat transfer compound to obtain good thermal contact. Any burrs around the mounting hole should be removed carefully and there should be no dirt or other material between the mica and adjacent surfaces which might cause impaired heat transfer.

The heatsink is secured to the case with a bolt at either end, again with plenty of heat transfer compound to ensure good thermal contact. The centre section of this is about 6·5mm (¼in.) thick, so a small blind hole drilled in it can neatly conceal the head of the triac mounting screw.

The output flex from the unit is fitted with a trailing 13A socket SK2 whilst the input has a fused plug, PL1. The fuse can be a 13A type, or a lower value if the full 13A output is not required. Use of a smaller fuse is also recommended whilst testing.

TESTING

Before testing it is advisable to check the insulation between mains "Live" and the metal case, using a meter with a high-resistance range or a "Megger" if one is available to ensure the integrity of the triac mounting insulation. Testing involves simply powering the unit and ensuring that about 17V d.c. is available from the appropriate pins of socket SK1, then connecting a load, such as a 100W light bulb, to the trailing output socket SK2 and shorting SK1 +VE and Input connections which should turn on the load.

Whilst testing this part of the project it is essential to take great care to avoid touching any "live" parts. When testing is complete the case can be screwed together and this part of the project completed with some self-adhesive rubber feet.

RELAY CONTROLLER

Using a solid-state relay cuts down on mains wiring

As PROMISED, for those wishing to avoid the construction of mains powered circuitry an alternative version using a "solid-state relay" can be built. This device consists of a plastic block with two large screw terminals at one end for connection into the mains circuit and two smaller ones at the other for the low-voltage d.c. control input. Its metal underside provides a much larger contact area for heat dissipation than that of a triac mounting tab and is internally isolated so there are none of the insulation problems associated with the triac.

Internally it contains two back-to-back thyristors for power switching and an opto-isolated control circuit with zero-crossing detection. Suppression components are also built-in. It even contains a current limiting resistor for the opto input device.

Although much easier to use the cost is higher, approaching £20 in small quantities. It is still necessary to dissipate heat at full power too, so the same case and heatsink are used as for the Triac version.

CIRCUIT

The circuit diagram for the Solid-State Relay Power Controller version is shown in Fig.5. As before it has a simple low voltage d.c. supply with a transformer T1, and diodes D1/D2 to supply an external control circuit through socket SK1.

The Input connection of DIN socket SK1 goes straight to the relay RLA input and the mains Live passes through the relay to the load, at SK2. Although suppression is built into the relay an external suppressor VDR1 is also provided for additional protection as these are very cheap compared to the relay.

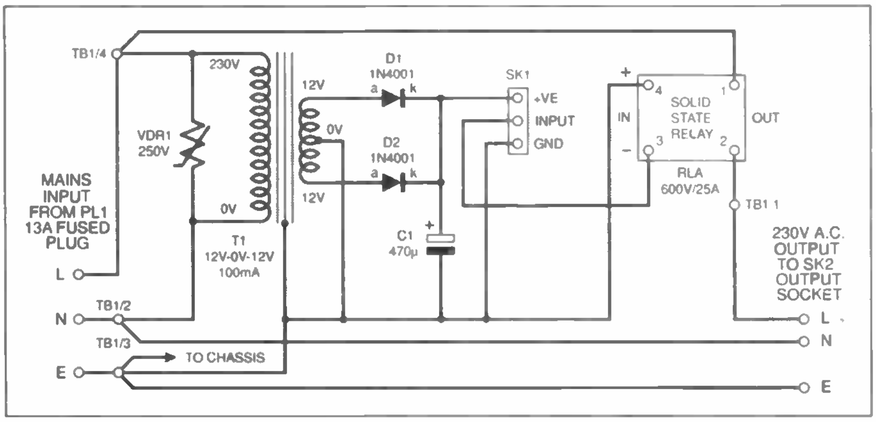


Fig.5. Circuit diagram for the Solid-State Relay Power Controller.

COMPONENTS

SOLID-STATE RELAY POWER CONTROLLER

See SHOP TALK Page

Capacitors

C1 470µ radial elect. 35V

Semiconductors

D1, D2 1N4001 50V 1A rec. diode (2 off)

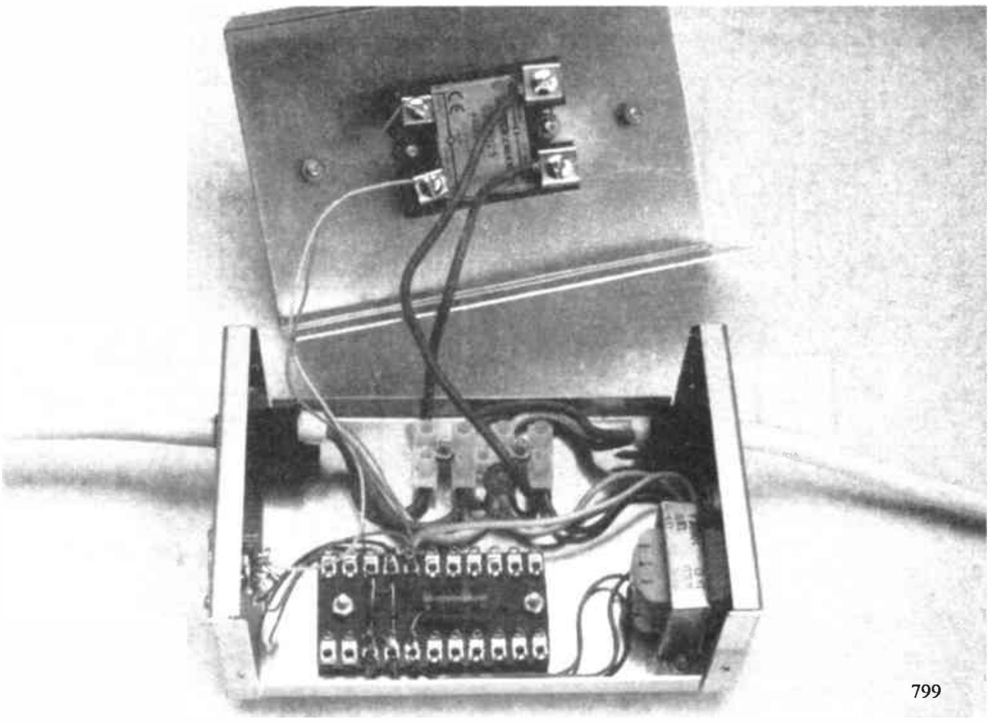
Miscellaneous

RLA 600V 25A solid-state relay
T1 min. mains transformer: 230V a.c. primary; 12V-0V-12V 100mA secondary
VDR1 250V a.c. transient suppressor
SK1 3-pin 180° DIN chassis socket
TB1 4-way screw terminal block, 16A rating

Aluminium box (AB13), size 152mm × 102mm × 51mm; min. tag-board, 38mm wide cut to 11 pairs of tags; flat, undrilled, plain aluminium heatsink, size 152mm × 94mm × 14mm; heatsink compound; 13A fused mains plug; 13A mains trailing socket; 13A mains cable; multistrand connecting wire; solder etc.

Approx Cost Guidance Only £25
excl. 13A mains plug & socket

The solid-state relay bolted directly on the case cover of the relay version.



CONSTRUCTION

Construction and wiring of the Solid-State Relay Power Controller version is shown in Fig.6. The two diodes D1 and D2 and capacitor C1 are again mounted on a small piece of tagstrip and external 230V a.c. connections are made though a terminal block TB1. The two leads from TB1 to the relay RLA are made using insulated core wire taken from *13A mains flex*.

The relay is fixed to the upper part of the metal case with a single bolt passing through relay, case and the heatsink, with liberal applications of heatsink compound to ensure good heat transfer. A special mounting washer is available for the relay, consisting of a very thin plate with a special coating, but this didn't look ideally suited to this application and the use of compound was preferred instead.

When siting the tagstrip, terminal block and transformer in the case it is necessary to ensure that they will not come into contact with the relay since this projects further into the internal space than does the triac. Testing of this unit is carried out in the same way as for the triac version.

Both of these controllers are intended to operate with primarily resistive loads such as convector heaters or incandescent light bulbs. However, two ancient fan heaters, containing at least some inductance because of their motors, were tried with both versions and worked without any problems arising.

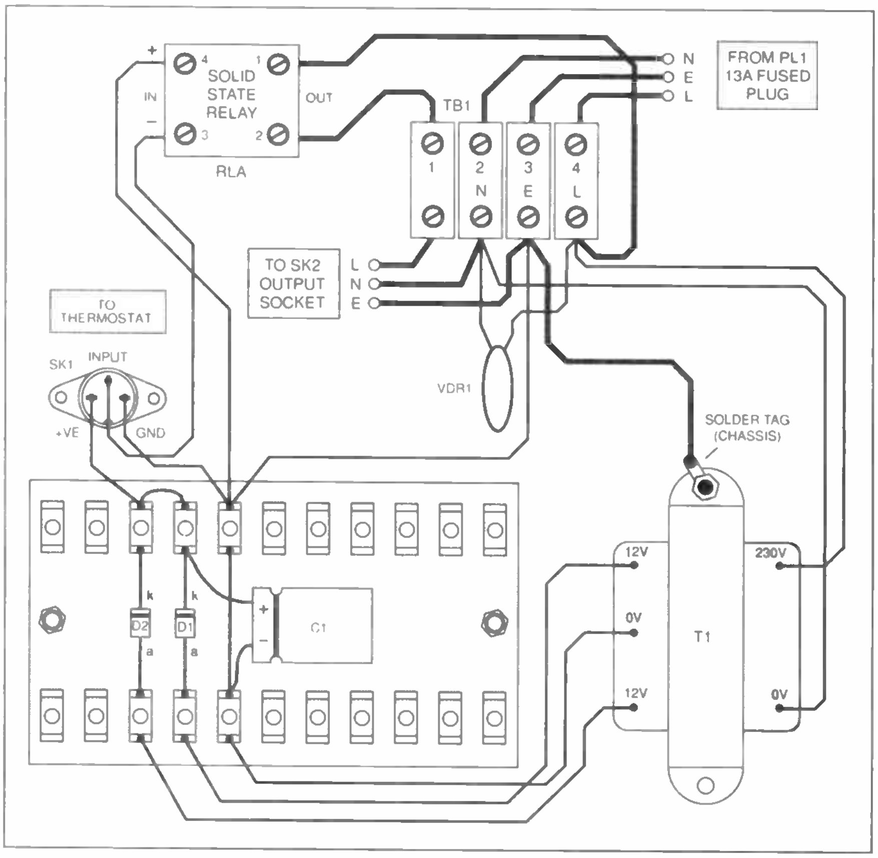


Fig.6. Interwiring between components for the Solid-State Relay Power Controller.

ROOM TEMPERATURE THERMOSTAT

Temperature sensing using the LM335Z chip

HAVING built one of these power controllers it is necessary to construct a suitable circuit to operate with it. The circuit of a simple but very accurate and effective Room Temperature Thermostat is shown in Fig.7.

The sensor IC1 is an LM335Z temperature sensor i.c. This is supplied with a current of about 1mA by resistor R1, and a temperature-sensitive output voltage is developed across it. This has a positive coefficient of 10mV per degree C but, as it starts from absolute zero (−273·15°C), at room temperature it has an output of about 3V. For improved accuracy the LM335Z has an adjustment terminal but this is not used in this circuit as error compensation is made elsewhere.

An adjustable reference voltage is provided by resistors R3, R4 and preset VR2, with a small amount of user-adjustable variation from VR1 and R2 for the users' control. This voltage is buffered by op.amp IC2a, and compared with the output of IC1 by IC2b. Resistors R7 and R8 provide positive feedback equivalent, to about one degree Fahrenheit (sorry, but the author prefers the old units! Calibration can be in Centigrade or Fahrenheit).

Output current to operate the Power Controller is provided by transistor TR1. This current also passes through l.e.d. D1 to indicate when the output is "on". When it is off, resistor R9 ensures a low impedance path to negative for the control line. Power for the circuit is provided

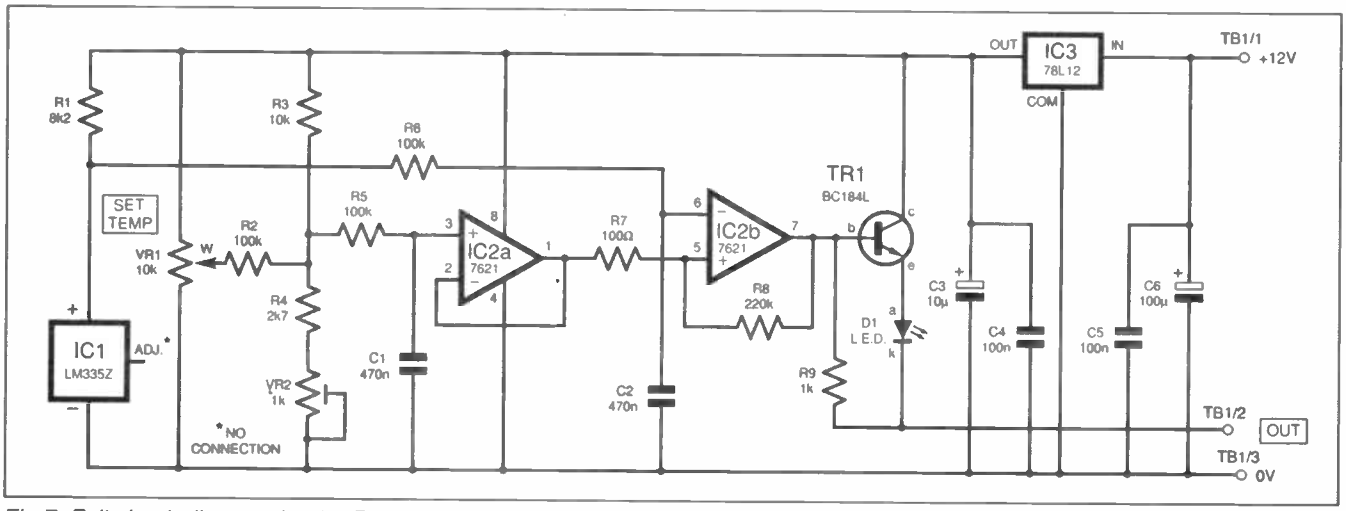


Fig.7. Full circuit diagram for the Room Temperature Thermostat. The TB points, on the right, link to the Power Controller via a DIN plug and socket SK1.

by regulator IC3, which converts the unregulated supply from the controller to 12V with the usual decoupling capacitors C4 to C6.

CONSTRUCTION

The components for the Room Temperature Thermostat are all mounted on a small printed circuit board (p.c.b.) as shown in Fig.8. This board is available from the *EPE PCB Service*, code 208.

Photograph below shows foil glued to the sensor, IC1, to improve thermal coupling.

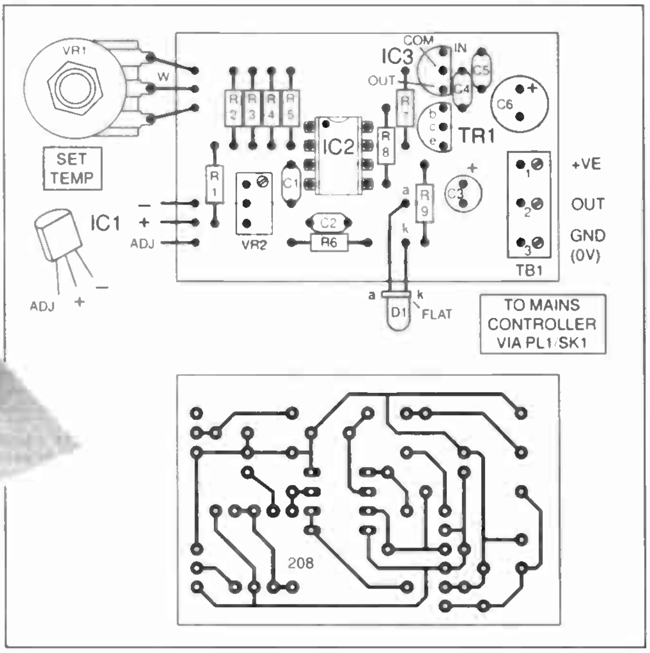


Fig.8. Component layout, interwiring and full size copper foil master for the Room Temperature Thermostat.

Construction should present no special problems. It is best to fit the resistors first, then the small ceramic capacitors, then larger components. A d.i.l. socket should be used for IC2.

For testing, the unit should be powered without IC2, using a supply of about 15V either from a bench power supply or from the controller unit. Presence of the 12V regulated supply should be checked, following which IC2 can be inserted.

COMPONENTS

ROOM THERMOSTAT

Resistors

R1	8k2
R2, R5, R6	100k (3 off)
R3	10k
R4	2k7
R7	100Ω
R8	220k
R9	1k

All 0·6W 1% metal film

See **TALK** Page

Potentiometers

VR1	10k rotary carbon, lin.
VR2	1k 22-turn square cermet preset

Capacitors

C1, C2	470n resin-dipped ceramic (2 off)
C3	10µ radial elect. 63V
C4, C5	100n resin-dipped ceramic (2 off)
C6	100µ radial elect. 35V

Semiconductors

D1	5mm red l.e.d., 10mA type
TR1	BC184L *npn* silicon transistor
IC1	LM335Z precision temperature sensor
IC2	7621 dual CMOS op.amp, rail-to-rail outputs
IC3	78L12 12V 100mA positive voltage regulator

Miscellaneous

TB1	3-way 5mm, low-profile, p.c.b. mounting, screw terminal block

Printed circuit board available from *EPE PCB Service*, code 208; 8-pin d.i.l. socket; case, size and type to choice; plastic knob; multistrand connecting wire; solder pins; solder etc.

Approx Cost Guidance Only £15 *excluding case*

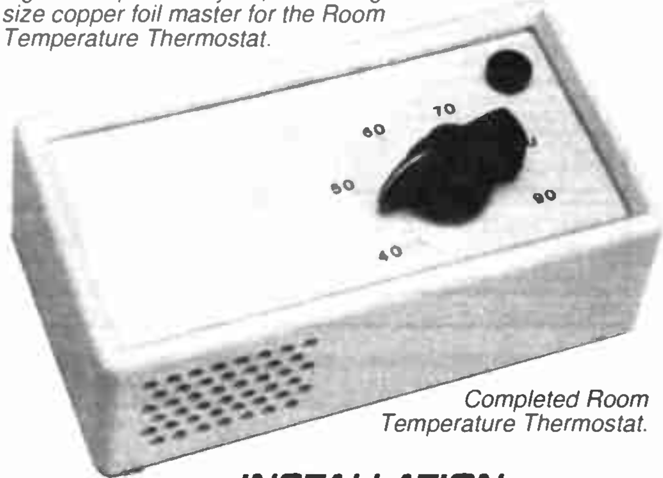
CALIBRATION

For calibration, the sensor IC1 should be connected to the board with a short length of two-core cable so that it can be immersed in water at various temperatures. It will need waterproofing for this, the easiest way is to place a finger cut from a thin rubber or plastic glove over it. Suitable plastic gloves are available free from many petrol stations, where they are to be found next to the diesel pump!

A 1k resistor connected across Output (TB1/1) and 0V (TB1/3) connections will cause the l.e.d. D1 to illuminate when the output is in the On state.

A container should be filled with water, using a thermometer to adjust the temperature to the intended mid-scale value of control VR1, probably 65°F or about 17°C. Temperature control VR1 should be adjusted to mid-point, and with the sensor immersed in the water as described the preset VR2 should be adjusted so that the output is at it's switching point, i.e. tiny movements of VR1 should turn it on and off.

Following this it is a simple matter to adjust the temperature of the water to some scale values, find the corresponding settings of VR1 and mark them. The prototype covers a range of 40°F to 90°F, marked every 10 degrees.



Completed Room Temperature Thermostat.

INSTALLATION

The completed board can be fitted into a case for mounting in a suitable position as described earlier. The sensor IC1 can be sited externally or internally in the case as desired.

Internal fitting will require a few holes to be drilled to allow air to flow through the case to ensure a reasonably rapid response to temperature changes. The prototype also has a small piece of aluminium cooking foil glued to the sensor to improve thermal coupling to the surrounding air. Connection of the unit to the Power Controller can be made using thin, unobtrusive wiring since no high voltages or currents are involved.

Initially the controlled temperature may differ slightly from the setting of control VR1 due to the small self-heating effect of the current flowing through IC1. If a thermometer is placed close to the unit preset VR2 can be tweaked until the indicated and actual temperatures agree, following which acceptable accuracy should be obtained across the full range.

Next Month: The construction of a special thermostat designed to minimise the problem of dampness in outbuildings, such as garages or sheds used as workshops, will be described. This should be of particular interest to readers with outside "shacks", where damp can cause havoc with modern circuits and components.

WORLD EXCLUSIVE

PhizzyB COMPUTERS

Introduction – Getting it off the ground!

Alan Winstanley

"PRACTICAL ELECTRONICS! Sheesh! I remember that from years ago!" Such was an unsolicited E-mail I received from somewhere in America about four years ago, which in the event was to be the genesis of Something Pretty Big.

Much electronic mail has flowed between Clive "Hi! Call me Max" Maxfield and myself since then, mostly jokes and wise-cracks (as you will discover, readers, Max is a wit and a half [1]), which garnish Max's incredible knowledge of anything to do with computing systems, digital electronics and present and future electronic technology.

When I finally set eyes upon Max, I was greeted by the sight of a tall bespectacled person cutting a dash in American blue denims and exquisitely-crafted American leather cowboy boots. Quite remarkable, that, because we were in the middle of Sheffield at the time – a bright November morning several years ago; a meeting from which great things lay ahead for the readers of *EPE* and the world at large!

Max introduces himself to you in a specially-made AVI multi-media movie clip included on your free demo CD-ROM, which runs in Microsoft Windows. Simply run the CD-ROM and click the Bee to witness (and hear) Max orating at his best.

WORLD EXCLUSIVE

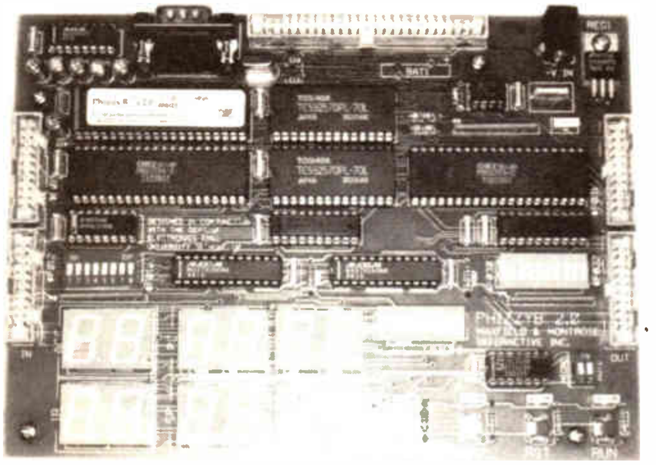
What you are reading now, though, is an introduction to the first instalment of an *EPE* world exclusive series in association with Maxfield & Montrose Interactive, Inc., featuring the *PhizzyB* – the Physical Beboputer – the latest in a sprightly series of highly entertaining, educational and original works from the creative minds of Max and co-author Alvin Brown.

Although British born and bred, Max departed this country to go and work in the United States, and Alvin too picked up certain transient Sheffield mannerisms *en route* to the USA nearly a decade ago. Both of them live and work in Alabama, USA, for Intergraph Computer Systems (**www.intergraph.com/ics**) a well-known manufacturer of powerful NT-based computer 2D/3D workstations.

Max and Alvin have toiled relentlessly for the past year to create the concept of the PhizzyB, a unique piece of computer hardware which can be made to mimic and execute the actions of its on-screen counterpart, whose "virtual" embodiment takes shape in the PhizzyB Simulator software.

Together, the PhizzyB hardware and the PhizzyB Simulator software form a great-to-build, fun-to-use computer tutorial, demonstration and application system which is, well, rinky-dinky and mega-cool (as Max would doubtless say).

"What", I hear you cry, "is the Beboputer?" Well, that's a computer teaching and demo tool which relates to Max's and Alvin's second book, *Bebop Bytes Back* (the first being Max's unparalleled *Bebop to the Boolean Boogie*, a chapter from which we reproduced in the Dec. '97 and Jan. '98 issues).



The second book is a comprehensive low-down on how computers were created, how they live and breathe and generally strut their stuff. Accompanying *Bebop Bytes Back* is a multimedia CD-ROM featuring *The Beboputer Computer Simulator*, a fully-functional "Virtual Computer" replete with interactive labs – so, you can learn to drive and program the Beboputer using your own personal computer, and by following the book and the on-screen "labs", you will learn more about the fundamentals and operation of computer systems in a month of Sundays than you ever dreamt possible (remembering there are five Sundays in a month, maximum).

Then another idea sprang to mind, as these things do. How about a real, live, pulsing and breathing, hardware version of the Beboputer? A *physical* version of the Beboputer? Thus the Physical Beboputer – dubbed *PhizzyB* – was born.

BIZZY-BEE

Now we could work some real magic – we could learn to program and use a "virtual" computer on a personal computer screen using the PhizzyB Simulator software, and then we could send those programs to the real PhizzyB which connects to your computer's RS232 serial port. PhizzyB can then be made to do some pretty cool and useful stuff in the real world.

Extending the idea further, we could then develop a range of PhizzyB add-on units (such as simple input/output sub-systems) which would allow the outside world to interact with the PhizzyB (and vice versa).

If you want to dig further, or learn more about the *Bebop* books, there is a mass of additional material on the free CD-ROM to entertain and amaze you, and we're sure you'll agree it's all pretty unique.

So, readers, hopefully between the three of us, we'll tantalise you enough for you to want to follow the series, learn how computers think and work, and *most importantly* to build your own PhizzyB to run on your own PC.

Each monthly PhizzyB feature is divided into two distinct sections, a constructional design and a tutorial. Max and Alvin have masterminded and written the entire tutorial series which uses the PhizzyB and PhizzyB Simulator software in conjunction with your personal computer (an IBM-compatible PC running Microsoft Windows 95/98/NT) to form a fully-fledged tutorial and demo system.

You will also need the full working version of the PhizzyB Simulator software, and a spare serial port, which must be either COM1 or COM2. We will tell you about sourcing everything later.

The constructional article each month is a practical one which deals with the aspects of assembling the PhizzyB and a variety of smaller peripheral units.

Max and Alvin tell you more about PhizzyB and what it does in the feature on the next page. Then I'll tell you about assembling its printed circuit board – it's all very straightforward.

[1] The principal reason for the reduction in transatlantic Internet bandwidth is directly attributable to the volume of Max's jokes sent by E-mail every morning. (Max also enjoys using dry humorous footnotes like these, so I thought I would, too – it might be the making of me as a writer.)

PhizzyB COMPUTERS

Part 1: PhizzyB and PhizzyB Simulator

Clive "Max" Maxfield and Alvin Brown

HELLO there, and welcome to the first installment of a really unique and exciting electronics and computing project. This series of articles will be of interest to anyone who wants to know how computers perform their magic, because it uses a unique mix of hardware and software to explain how computers work in a fun and interesting way.

This series doesn't assume any great technical knowledge, although an understanding of fundamental electronic concepts would certainly be an advantage. It would also be helpful to have had some practical experience at assembling components onto a printed circuit board. You should also be moderately familiar with using a PC-compatible computer.

IN OUR book, *Bebop BYTES Back (An Unconventional Guide to Computers)*, we described a simple microcomputer that we named a *Beboputer*. As opposed to building this microcomputer out of physical devices, we implemented the Beboputer as a "virtual machine" – something you could see and play with on your computer screen – that was delivered on an interactive CD-ROM accompanying the book.

Next, we worked in conjunction with the Department of Electronics Engineering at the University of Hull in England to design a physical manifestation of the Beboputer. The result created by student Andrew John Ayre as his final year project we called the *PhizzyB* (which stands for Physical Beboputer), as illustrated by the screen shot shown here (Fig.1).

The accompanying constructional article has been specially written for us by Alan Winstanley, who describes how to assemble the PhizzyB from the ground up.

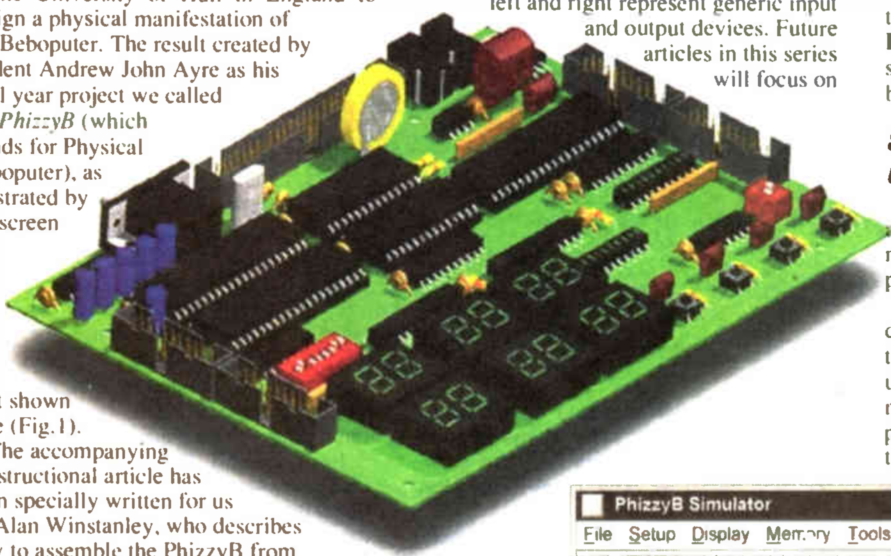


Fig.1 (above). Computer simulation of the assembled PhizzyB printed circuit board.

VIRTUALLY CUNNING

Now comes the cunning part of our tale, because next we created a special *PhizzyB Simulator*, which provides an accurate virtual representation of the real PhizzyB, as shown in Fig.2. Amongst other things, the CD-ROM accompanying this issue of *EPE* contains a *Free* demonstration copy of the PhizzyB Simulator that you can use to emulate the PhizzyB on your PC screen.

In order to run this simulator, you will need an IBM-compatible PC containing an Intel 486 processor or higher and running Windows 95, Windows 98, or Windows NT. Oh, and a CD-ROM drive of course!

Over the coming months, this series of articles will describe how to create programs and run them on the PhizzyB Simulator, and how to then download these programs into the PhizzyB and run them in the real world. Note that in order to transfer your programs into a real PhizzyB, you will need a fully-functional version of the simulator – more details later.

Returning to Fig.2, note that the large circuit board at the bottom of the PhizzyB Simulator Interface corresponds to the PhizzyB itself. The other large board (at the top of the screen) represents an expansion board, whilst the smaller boards to the left and right represent generic input and output devices. Future articles in this series will focus on the construction and use of the expansion board and a variety of input and output devices.

All you have to do to learn how to install your demonstration copy of the PhizzyB Simulator is to put the *EPE* demo CD in your CD drive, invoke your Web browser (Netscape, Microsoft Explorer, or similar), and point the browser at **D:\default.htm** (substitute "D:" for the letter of your CD drive).

If you don't have a Web browser installed, one can be found on the demo CD (just run the program **D:\Plus+\Netscape\cb32e404.exe** to install a 32-bit version of the Netscape browser on your PC).

SIMPLE DIGITAL COMPUTER

Before we leap into the fray, it's probably a good idea to quickly refresh our minds as to what constitutes a simple computer system.

In its broadest sense, a computer is a device that can accept information from the outside world, process that information using logical and mathematical operations, make decisions based on the results of this processing, and ultimately return results to the outside world – see Fig.3.

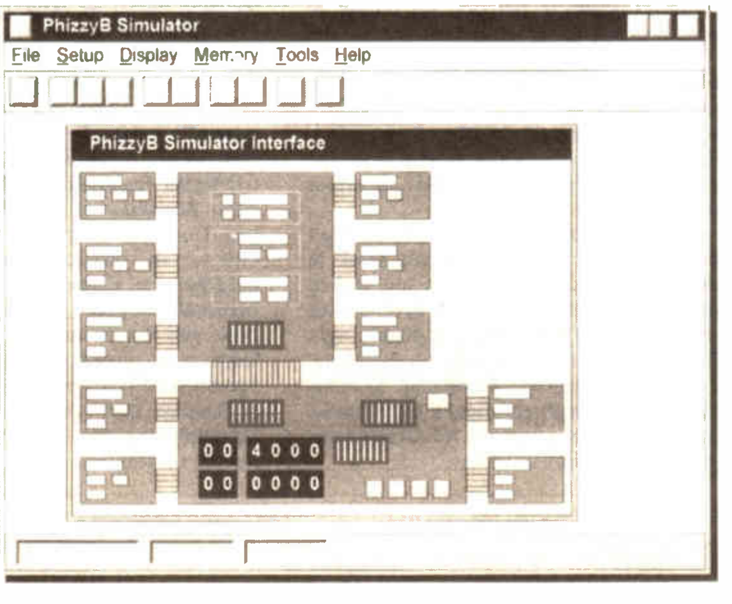


Fig.2 (right). Screen shot of the PhizzyB Simulator.

The "brain" of the computer is its central processing unit (CPU), which is where all of the number crunching and decision making is performed. High-level control of the CPU is provided by two signals called *clock* and *reset*.

The clock input switches back and forth between two voltage levels millions of times a second and is used to synchronize the internal and external actions of the CPU, while the reset input is used to force the CPU into a known, well-behaved state.

The reset signal is automatically activated when power is first applied to the system, and this power-on reset serves to initialize the CPU. Note that there are some other control signals such as the IRQ (*interrupt request*), but we'll leave any discussion of these signals for future articles.

Coming out of the CPU are three buses called the *control bus*, *address bus*, and *data bus* (where the term *bus* is used to refer to a group of signals that carry similar information and perform a common function). The CPU uses its address bus to "point" to other components in the system; it uses the control bus to indicate whether it wishes to "talk" or "listen"; and it uses the data bus to convey information between itself and the other components.

With regard to these "other components," the ones we're interested in here are the *memory* devices (each of which may contain thousands or millions of words of data) and the input and output ports. As their name might suggest, the data contained in *read only memories* (ROMs) is hard-coded during their construction. The CPU can read (extract) data from ROM devices, but it cannot write (insert) new data into them.

By comparison, data can be read out of *random access memories* (RAMs) and new data can be written back into them (the act of reading data from a RAM does not affect the master copy of the data stored inside the device).

When power is first applied to the system, the RAMs *initialize* containing random values, so any meaningful data stored inside a RAM must be written into it by the CPU after the system has powered up.

Last, but not least, the computer uses its input and output ports to communicate with the outside world. (Fig.3 only shows individual input and output ports, but a computer can effectively have as many of each type as its designer wishes.)

By a strange quirk of fate, Fig.3 also reflects the architecture of the PhizzyB (and thus the PhizzyB Simulator). To all intents and purposes, the PhizzyB Simulator is a fully-functional computer, its just that its been implemented as a virtual machine (in the form of a program called a *computer simulator*) as opposed to constructing it from physical devices.

One other point worth knowing is the way in which the PhizzyB's CPU perceives the external world, which is as a series of memory locations. The PhizzyB's 16-bit address bus can be used to point to 2^{16} = 65,536 unique locations numbered from $0000 to $FFFF (where "$" characters are used to indicate hexadecimal values), as represented in Fig.4.

The hexadecimal numbering system is described in the *PhizzyB User Manual Volume 1*, which is provided *free* with your PhizzyB Simulator (check the PhizzyB's online help for more details).

For our purposes here, we need only note that addresses $4000 through $EFFF are occupied by random access memory (RAM), which is used to store any programs you create (addresses $0000 through $3FFF are considered to be occupied by read-only memory (ROM), which is of little interest to us at the moment).

Towards the top of the memory map are the input and output (I/O) ports, which the PhizzyB uses to communicate with the outside world. In fact the PhizzyB regards these I/O port addresses as standard memory locations and doesn't realize that we're using them for other purposes. The PhizzyB has three input ports, at addresses $F010, $F011, and $F012, and three output ports, at addresses $F030, $F031, and $F032.

To refresh your memory about *bits* and *bytes* – a *bit* is a single part of an electronic memory which can be set to one of two states *on* (logic 1) or *off* (logic 0). A *byte* is a group of bits (usually eight) which can be operated on as a single unit.

ACCUMULATOR (ACC)

Before we start to create our first program, you should also be aware that, amongst other things, the PhizzyB's CPU contains an 8-bit register, which is called the *accumulator* (ACC). As its name implies, the accumulator is where the CPU gathers, or accumulates, intermediate results – see Fig.5.

The ways in which you can modify and employ the contents of the accumulator will become apparent as we progress. Suffice it to say that the CPU can be instructed to load a byte of data from a memory location into the accumulator (this involves taking a copy of the data in the memory; the contents of the memory at that location remain undisturbed).

The CPU can also be instructed to perform a variety of arithmetic and logical operations on whatever data is currently inside the accumulator. Last, but not least, the CPU can be instructed to store the contents of the accumulator into a memory location (this overwrites any existing contents in that memory location, but leaves the contents of the accumulator totally undisturbed).

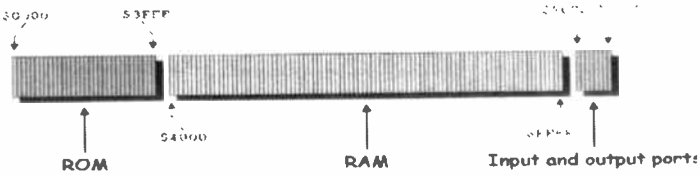


Fig.4. PhizzyB memory map.

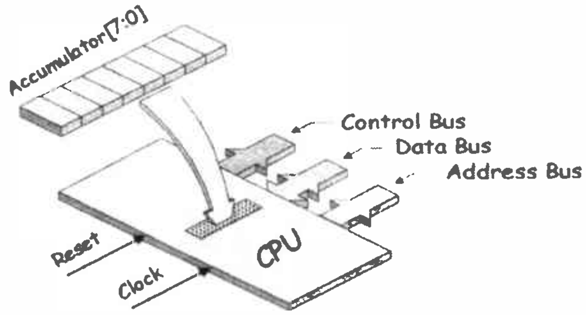


Fig.5. The accumulator (ACC).

INSTALLING PhizzyB

If you haven't already done so, install your demonstration copy of the PhizzyB Simulator as described on the *EPE* CD-ROM, onto your Windows 95/98/NT PC. It's best to ensure that your monitor is set to a screen resolution of 1024 × 768 if possible, to make the most of the displays. You can check this by right-clicking the Microsoft Windows "wallpaper", choose Settings Desktop Area and select the desired screen resolution, which also depends on your video card and monitor size. Now use:

Start -> Programs -> PhizzyBD -> PhizzyBD

to invoke the simulator, as illustrated in Fig.6.

Initially, we are only going to be concerned with the large board at the bottom of the PhizzyB Simulator Interface window, because this is the portion of the interface that represents the main PhizzyB.

As we see, the main PhizzyB has three input ports. The input port at address $F010 is connected to an 8-bit switch device on the board, while the other two input ports at addresses $F011 and $F012 can be used to receive information from the outside world.

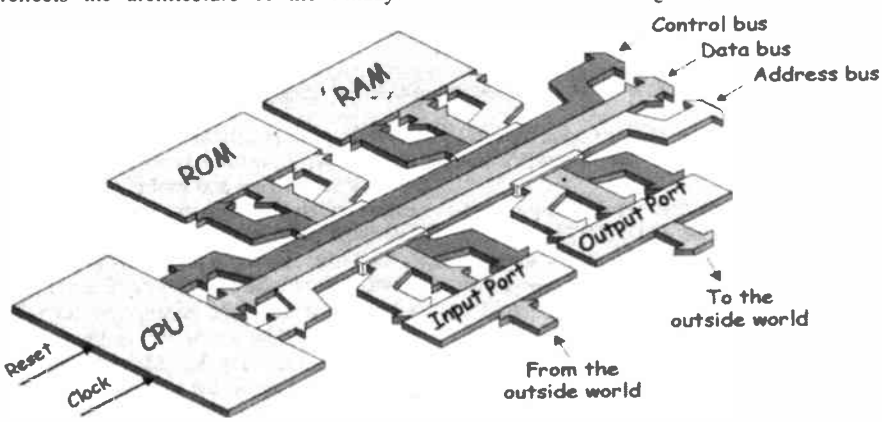
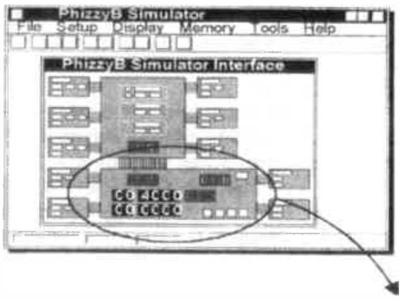


Fig.3. The bowels of a simple digital computer.



a deep breath and proceed to the next section.

PROGRAM CREATION

The program you're about to create is very simple and contains just three instructions (Fig.7). The first instruction loads the accumulator with the contents of address $F010, which is actually connected to one of the PhizzyB's input ports (as we'll see, this port is driven by an 8-bit switch).

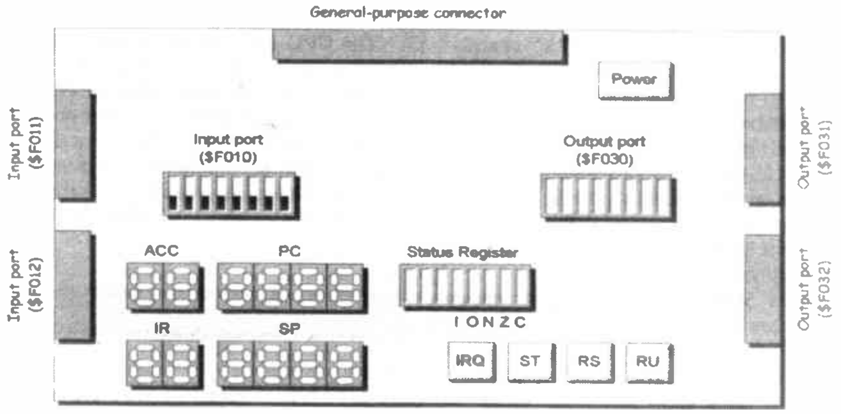


Fig.6. The main PhizzyB interface.

Similarly, the main PhizzyB has three output ports. The output port at address $F030 is connected to an 8-bit l.e.d. bargraph display on the board, while the other two output ports at addresses $F031 and $F032 can be used to send information to the outside world.

First click the Power button. This will cause the Status Register and $F030 output port l.e.d.s to all flash on and then off again. Also, the ACC (Accumulator), PC (Program Counter), IR (Instruction Register), and SP (Stack Pointer) 7-segment displays will all flash number 8s, then the PC will change to display $4000 (the first address in the PhizzyB's RAM), and the other displays will display all zeros.

Note that this power-on reset sequence exactly matches that of the real PhizzyB. We'll explain the roles of the ACC, PC, IR, and SP in the fullness of time.

Exciting isn't it? What, you want more? Well, the reason why nothing appears to be happening is that your PhizzyB Simulator doesn't yet have a program to run. In the not-so-distant future we'll show you how to create your own programs. But for the moment, use the **Memory -> Load RAM** pull-down menu in the main window to invoke a dialog offering a list of the programs that are currently available.

Locate the **test1.ram** file in the scrolling list on the left-hand side of the display and double-click this entry to add it to the right-hand list.

In fact **test1.ram** contains a very simple machine-code program that we delivered with your PhizzyB Simulator. Click the dialog window's Load button to load the contents of **test1.ram** into the PhizzyB Simulator's memory. Now click the PhizzyB's Ru ("Run") button to execute the program and note that the $F030 output port l.e.d.s start to flash a simple pattern. Once your adrenalin rush has run its course, click the Power button to power-down the PhizzyB Simulator, then take

The second instruction writes the contents of the accumulator to address $F030, which just happens to be one of the PhizzyB's output ports (this port drives a set of eight l.e.d.s). The third instruction directs the CPU to jump back to the beginning of the program and do it all again.

To the left of Fig.7 is a flowchart illustrating the sequence of operations. To the right of each action box in the flowchart is the equivalent machine code that must be placed in the PhizzyB's memory. The first instruction is located at address $4000, which is the first location in the PhizzyB's RAM. All of your programs will commence at this location, because this is the address that the PhizzyB will automatically run from when you hit the Run button on the interface.

INDIRECT ADDRESSING

The $91 opcode at address $4000 instructs the CPU to load the accumulator with the data from the location whose address is specified by the following two (*operand*) bytes at addresses $4001 and $4002 ($F0 and $10 = $F010).

This form of instruction is said to use the *absolute addressing mode*, because the two bytes following the instruction contain a specific (absolute) address. What the CPU doesn't know is that address $F010 doesn't actually point to a location in the memory, but instead points to the input port driven by a set of eight switches.

The $99 opcode at address $4003 directs the CPU to save the contents of the accumulator to the location pointed to by the following two bytes at addresses $4004 and $4005 ($F0 and $30 = $F030). Once again, the CPU doesn't know that address $F030 doesn't actually point to a location in the memory, but instead points to the output port that drives a set of eight l.e.d.s.

Finally, the $C1 opcode at address $4006 tells the CPU to perform an unconditional jump to the location pointed to by the following two bytes at addresses $4007 and $4008 ($40 and $00 = $4000), which will cause the program to start all over again. So this program's sole function in life is to loop around reading whatever values it finds on the 8-bit switches and writing these values to the 8-bit l.e.d. bargraph display.

PROGRAM ENTERING AND ASSEMBLING

The program representation shown in Fig.7 is in a form known as *machine code*, so-called because this is the form that is understood and executed by the computer (machine). If you wished, you could write all of your programs directly in machine code and then manually insert them into the PhizzyB's memory, one byte at a time. But this approach would be excruciatingly boring and error-prone, to say the least.

A vastly more preferable technique is to

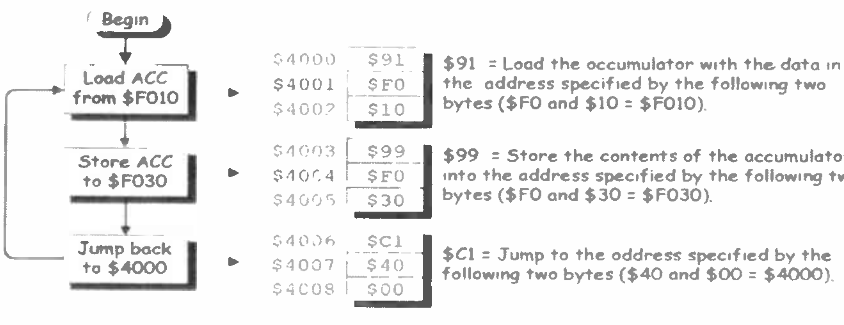


Fig.7. Flow chart and machine code for counting program.

The $91, $99, and $C1 opcodes (*operation codes*) are part of the PhizzyB's instruction set:

(The full instruction set is documented as described in the PhizzyB Simulator's online help. Also, the PhizzyB's instruction set and addressing modes are fully documented in Appendix A of *The Official Bebopuler Microprocessor Databook*; for your further reading pleasure, this Appendix is provided *free* with your PhizzyB Simulator (check the PhizzyB's online help for more details).

describe your programs at a higher level of abstraction – say in a form known as *assembly language* – and to then use a utility called an *assembler* to automatically translate these programs into machine code.

Use the **Tools -> Assembler** pull-down menu in the main PhizzyB Simulator window (or click the appropriate icon on the main window's tool bar) to invoke the assembler (see Fig.8). Make sure the cursor is flashing in the assembler's work-ing area, then enter the following program in the PhizzyB's assembly language:

```
.ORG  $4000   # Set program's origin to
                address $4000
LDA   [$F010]# Load accumulator from
                address $F010
STA   [$F030]# Store accumulator to
                address $F030
JMP   [$4000]# Jump to address $4000
.END           # End of the program
```

Note the **.ORG** and **.END** statements. These are known as *pseudo instructions* or *directives* (because they "direct" the assembler). The **.ORG** is used to specify the start address or origin of the program (address $4000 in this case), while the **.END** informs the assembler when it reaches the end of the program.

Also note that anything to the right of a hash "#" character (also known as a number sign, pound sign, or sharp) is considered to be a comment. Comments may occur anywhere on a source line and are ignored by the assembler.

the assembler has just created a file called **myprog1.ram**, which contains the machine-code equivalent of your program. Once you've successfully assembled your program, dismiss the assembler to make room on your screen.

PROGRAM LOADING AND RUNNING

Click the PhizzyB Simulator's Power button to power up the simulator. Now use the **Memory -> Load RAM** pull-down menu in the main project window to invoke a dialog offering a list of the programs that are currently available.

Locate the **myprog1.ram** file you just created in the scrolling list on the left-hand side of the display, double-click this entry to add it to the right-hand list, and click the dialog window's Load button to load the contents of **myprog1.ram** into the PhizzyB Simulator's memory (see Fig.9).

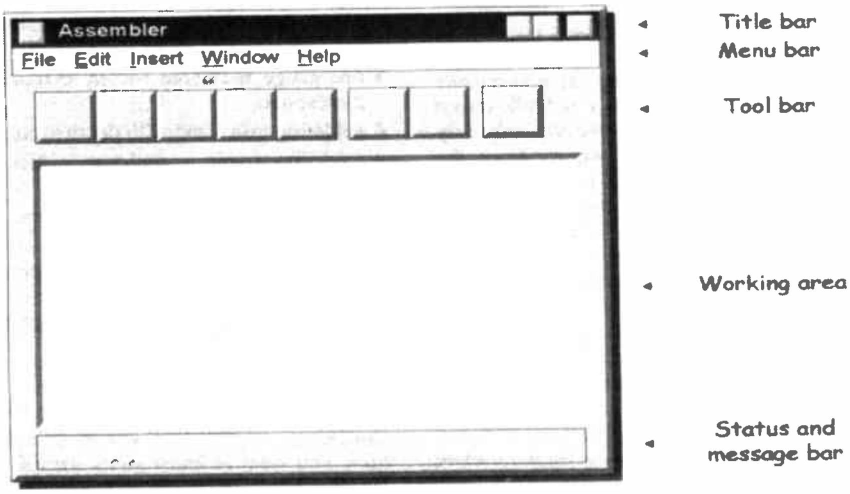


Fig.8. PhizzyB assembler screen.

Now consider the **LDA [$F010]** statement, where **LDA** is a mnemonic meaning "load the accumulator". This statement instructs the CPU to load the contents of address $F010 into the accumulator. As we see, our assembly language uses square brackets [and] to imply that we're talking about the contents of a memory location.

The next instruction, **STA [$F030]**, instructs the CPU to store the contents of the accumulator to the location at address $F030, **STA** being the mnemonic meaning "store the accumulator (at)". Finally, the **JMP [$4000]** instruction uses the absolute addressing mode to instruct the CPU to perform an unconditional jump to address $4000, which returns it to the beginning of the program.

Once you've entered this program, use the assembler's **File -> Save As** command to save it to a file called **myprog1.asm**.

Now comes the exciting part where you assemble your program, which you do by selecting the **File -> Assembler** pull-down menu in the assembler's menu bar (or by clicking the appropriate icon on the assembler's tool bar).

Assuming you haven't made any errors, you'll receive the message "*File assembled successfully*" in the assembler's status bar, otherwise you'll have to debug any mistakes and try again.

In addition to a number of other actions,

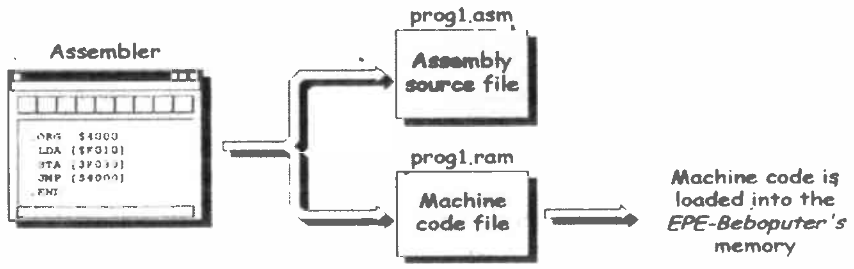


Fig.9. The machine code generated by the assembler is loaded into the PhizzyB Simulator's memory.

Now click the simulator's Ru ("Run") button to execute your program (the CPU automatically starts with whatever instruction it finds at address $4000). As we know, this program loads the accumulator with the contents of the input port connected to the 8-bit switch device, writes this value to the output port driving the 8-bit l.e.d. display, and then jumps back to the start of the program at address $4000 and does the whole thing again.

Test that your program is working by clicking on one or more of the switches on the 8-bit switch device and observe what happens.

Congratulations! You've successfully written, assembled, loaded, and executed your first program. Now that wasn't too bad was it?

FUTURE ACTIONS

In the next part of this series, we'll describe the design and construction of a pair of simple circuit boards that can be used to test the real PhizzyB's external Input/Output ports. Also, we'll create some programs to emulate these boards on the PhizzyB Simulator, and we'll describe how to use the PBLink utility to download these programs to your real PhizzyB. Note that the PBLink utility is not included with the demo copy of the PhizzyB Simulator.

In future issues we'll be designing, building, and simulating a smorgasbord of input and output devices that will enable the PhizzyB to interact with the outside world, cumulating in a project that is so amazing you'll ... But NO! The excitement might be too much for you at the moment, so for your own safety we're going to be forced to hold some of our plans in reserve.

Now that we've whetted your appetite, you'll doubtless want to hasten over to the details for the PhizzyB hardware, in a practical article specially written by Alan Winstanley.

Everything you need to know about the construction is included, and we don't assume any great prior knowledge of electronics.

FURTHER READING

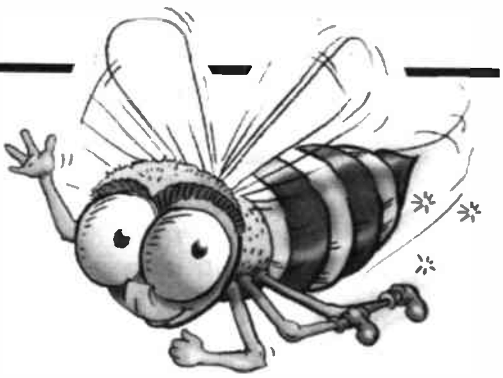
The PhizzyB and the PhizzyB Simulator are so amazingly cunning that we have been moved to create a number of user manuals and other documents for them. The *PhizzyB User Manual Volume 1: PhizzyB Simulator* (on the free CD-ROM) introduces the various components of the main simulator and describes how to use the various tools and utilities to create and run programs.

The second volume in this series, the *PhizzyB User Manual Volume 2: Development System* (on the PhizzyB Simulator CD-ROM), describes how to use the PBLink utility to download programs from the PhizzyB Simulator to the real PhizzyB.

The third volume, the *PhizzyB User Manual Volume 3: Expansion Board* describes both the real and simulated versions of the expansion board.

Also of interest is *The Official Bebopuler Microprocessor Databook*, which, amongst many other things, describes the PhizzyB's assembly language, instruction set, and addressing modes.

More details on these documents can be found on the PhizzyB Simulator's help pages or on our PhizzyB web pages at **http://www.maxmon.com/phizzyb** (details on Volume 3 of the user manual are only available from this web site).



PhizzyB COMPUTERS

Construction – Build your own Bee

Alan Winstanley

Assembling and testing the main PhizzyB computer board.

LET'S get down to the practical aspects of creating your very own PhizzyB computer from the ground up. Straight away, we must say that the PhizzyB is a commercial product and, for the purposes of these articles, we are far more interested in showing you how to build and use it, rather than exploring how PhizzyB works in detail. Such technicalities would be beyond the scope of this series.

The free demo disk provided with this *EPE* issue has Volume 1 of the *PhizzyB User Manual* to get you started.

However, there are several on-line manuals available in Adobe Acrobat PDF format on the full working version of the PhizzyB Simulator.

Further technical data is also available in *The Official Bebopuler Microprocessor Handbook* which can be purchased on-line from Maxfield & Montrose Interactive, Inc. for a very modest price. How to obtain such things (and others) is covered later.

To assemble and enjoy using your PhizzyB, no assumptions are made about your knowledge of electronics. It is necessary, though, for you to have had some experience of using a soldering iron. But it has to be stressed that the success of the electronics side of things rests on the quality of the soldered joints. Presently we shall give some advice on how to ensure you get a good soldering result.

The PhizzyB board is quite densely populated and the soldering, whilst not difficult, is quite intricate: PhizzyB uses a double-sided board with plated-through holes (p.t.h.). It includes an extra "solder resist" too – that's the green layer which helps ensure molten solder only goes where it's supposed to go.

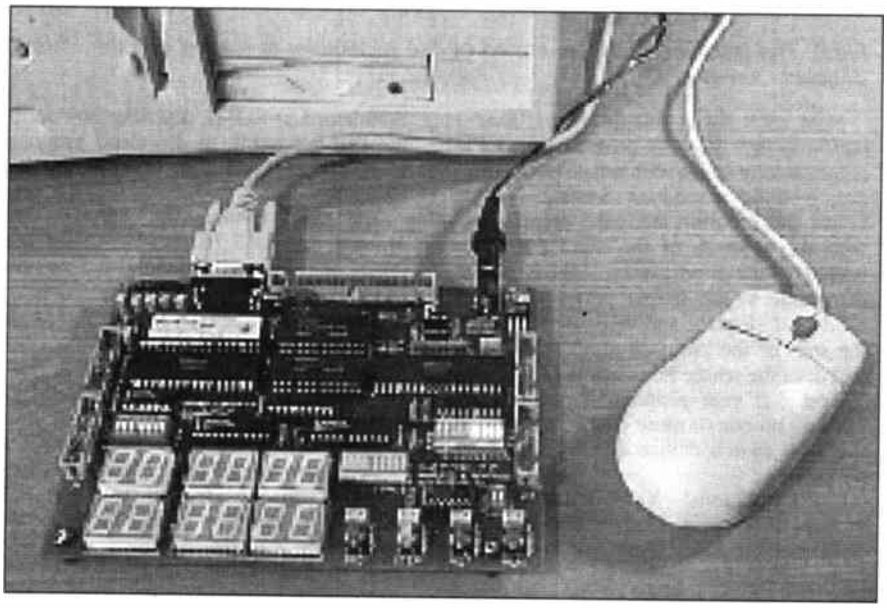
Just to help make construction as reliable as possible, there is also a full silk-screen print on the board, showing you precisely which component goes where. Since the board was designed in the USA, it has been necessary to locate equivalent parts on sale in the UK, and these have been tested and approved during development.

Whilst we have provided a full parts list, readers must be made aware that for a minority of the parts, the manufacturer is critical and alternative brand devices should not be substituted. Furthermore, some parts are obviously critical as far as their dimensions are concerned, so if they are to fit the p.c.b. properly, care must be taken to select appropriate parts.

The pre-programmed microcontroller, printed circuit board and full CD-ROM are available from the *EPE* Editorial office, see later.

HOT TIPS!

We have an excellent resource available on the Internet, in the form of our universally recognised *Basic Soldering Guide* (**www.epemag.wimborne.co.uk/solderfaq.htm**) which tells you virtually everything you need to know about soldering.



You need the following basic tools and equipment:

- hands (two, maximum)
- pencil-type soldering iron, say 15W or so, with a fine tip point
- fine-gauge multicore solder, 0·7mm or thereabouts
- soldering iron stand with damp sponge
- soldering frame – optional – nice to have if you can afford it
- miniature electronics-grade pliers for bending wires
- side-cutters for snipping component leads
- screwdriver for good measure (all kits worth their salt use one).

Because we want PhizzyB to have as wide an appeal as possible, this constructional article will tell you everything you need to know about identifying the electronic components and general methods surrounding its assembly, as we have in mind (say) the PC user who may not be very experienced in electronics assembly but would like to construct a PhizzyB to link to their own computer.

Regular *EPE* readers can skip through some of the detail as you probably know it already (but maybe have a peek just to be sure you're not missing anything important).

If necessary, if you have not used a soldering iron very much before, practice using a soldering iron with some surplus components. Construction of the PhizzyB is best undertaken using a "soldering frame", a gadget which holds various parts *in situ* on the board while you solder the joints on the underside, although many people seem to get by without one.

Be patient during assembly. Don't rush it, and there's an excellent chance that your PhizzyB will work first time!

MODULAR OPTIONS

To help with the construction costs, it is possible to adopt a "modular" approach to assembling the PhizzyB, at least up to a point. You may decide to go the whole hog and assemble the entire product, or you can choose to be more selective and upgrade the board later with extra components, if desired. You can:

- Solder all components into place to produce the coolest computer demo and hardware/software system ever conceived in the history of humankind, or

- omit the battery back-up function (the controller chip IC7 and battery BAT1), and/or
- omit the 7-segment displays (DUAL1 to DUAL6) and their corresponding display driver chips (IC101/IC102). You will still have the ability to monitor the registers (memories) which are "mirrored" on your PC screen, although it's maybe not as neat as watching what the PhizzyB has to say for itself
- Lastly you can omit IC5, one of the two 32K random access memory (RAM) chips used to store data in the PhizzyB. This obviously reduces the data storage capacity of the PhizzyB, but there will still be ample available firepower to follow the series. You can add the second chip later if you like.

The construction follows a logical order, fitting the smallest parts first and progressively building up the board until the tallest and largest parts are inserted last of all. If you use a soldering frame, you might still want to follow this same order and gradually locate the parts rather than insert everything at once.

However, before starting, be sure to check that you have all the parts, and that they all fit the PhizzyB board. Do not remove any integrated circuits (i.c.s – also known as *chips*) from their anti-static packaging until you are ready to fit them to the board. This will be at the *very end* of construction and preliminary testing.

CONSTRUCTION

First, an important note for UK/European readers: at the time of writing, it has not yet been possible to source an equivalent p.c.b. mounting 3V Lithium back-up battery to fit the American-designed board.

This situation may change but, in the shorter term, a small adaptor board has been designed in the UK which is capable of carrying a Lithium battery coin cell holder, so that the battery can be exchanged if necessary without any desoldering being needed.

The adaptor board fits the pinouts of the PhizzyB battery (BAT1). Skilled and experienced readers will be able to improvise. Without the battery, any program and data contents will be lost when power is interrupted, and PhizzyB will have to be reloaded from the PC software, via the PBLink. This only takes a second.

At this point, you may decide to omit the battery altogether for now. That's OK – start assembly by inserting the jump wire JUMP1, and omit IC7. This bypasses the battery controller. (If you decide to insert the battery at a later date, you must desolder or cut the jumper wire and fit IC7 plus the battery.) Otherwise, the battery will be fitted last of all, because it is the tallest component.

A copy of the silk-screen print is shown in Fig.1 for reference. The following suggested order of assembly will help less experienced constructors to gain some revisionary practice of soldering and handling the PhizzyB board.

Insert the six 22k resistors R1 to R4 and R101 to R102 (colour coded red-red-orange-gold) into place, bending the leads with thin-nosed pliers to match the board. Make sure the resistors are reasonably flat against the board. Solder the leads, then snip off any excess wire with miniature side-cutters. Continue with R6 and R7, which are two 4·7 kilohm resistors (yellow-violet-red-gold).

Next, insert the three single-in-line (s.i.l.) resistor packages, labelled on the board as R5, R8 and R9. These packages actually contain nine individual resistors all joined to a "common" pin, making ten pins in all. You can prove this by using an ohmmeter. Hence the s.i.l. resistor must be correctly orientated: a dot printed on the body marks pin 1 (common), which aligns with the square box in the silk-screen print symbol. Note also that if the recommended s.i.l. resistors are used (Bourns 4610X series) then:

- R5 and R8 will be marked as 10X-1-472 (the "472" indicates 4·7k)
- R9 will be marked as 10X-1-151 ("151" indicates 150 ohms)

So far so good! The next stage is more intricate. We strongly recommend protecting your investment in PhizzyB by using dual-in-line (d.i.l.) sockets to carry all of the i.c.s (and one or two other parts). They

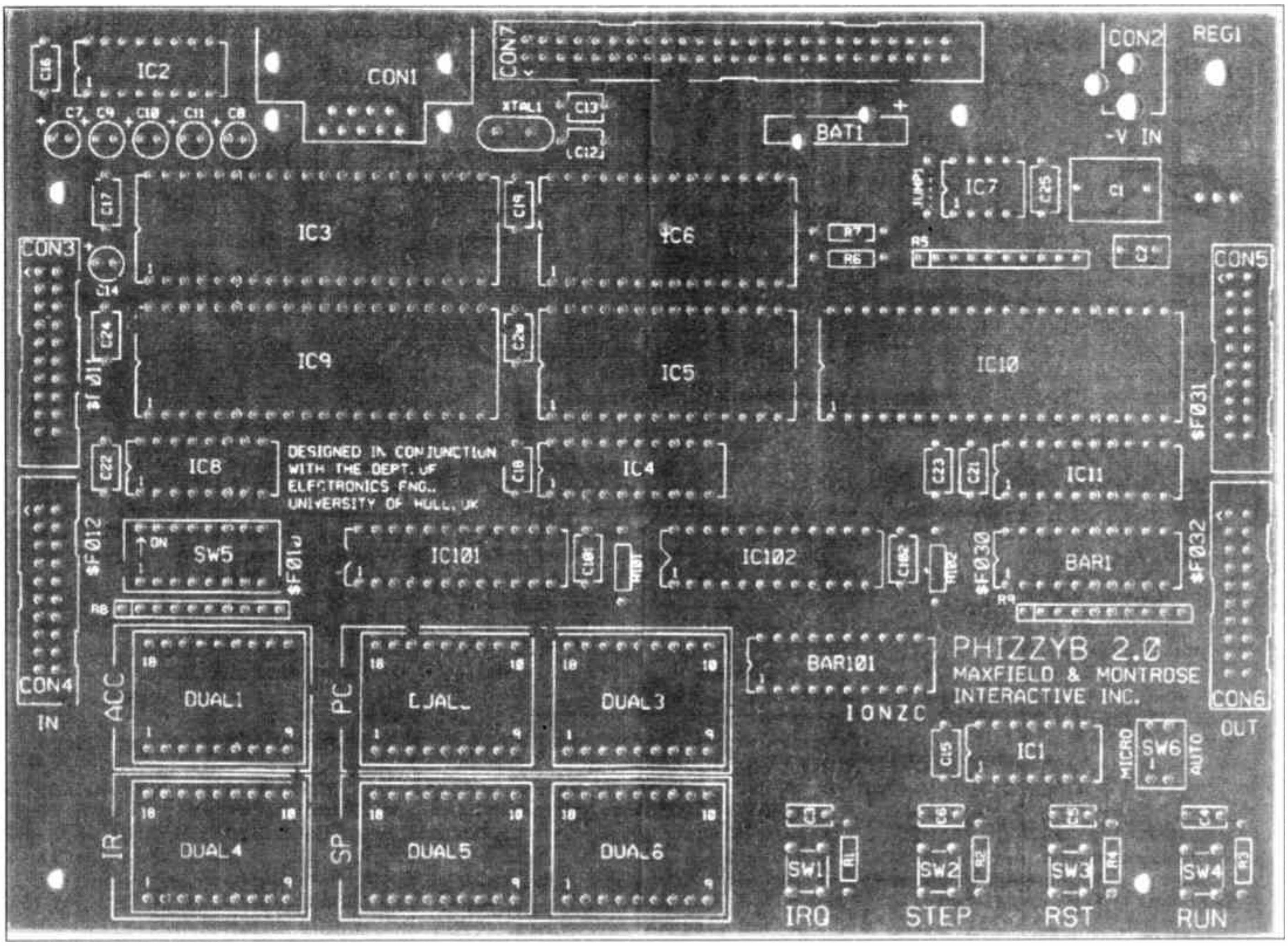


Fig.1. Full size reproduction of the silk-screen print showing component positions on the PhizzyB printed circuit board.

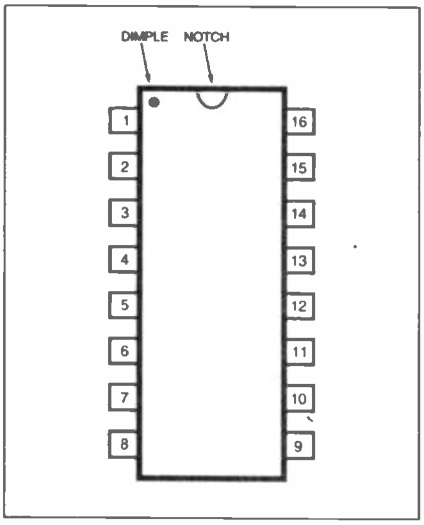


Fig.2. Example of d.i.l. i.c. pinouts. Orientation is denoted by the dimple and/or notch.

enable you to change any faulty chips (unlikely, but you never know) and, more importantly, they help prevent any damage occurring to the semiconductor chips through excessive soldering heat being applied.

ORIENTATION

The orientation of each i.c. is identified by a notch at one end, and/or a dimple (see Fig.2). What you must do is insert the d.i.l. socket for each of these devices the correct way to match the silk screen printing on the PhizzyB board. A notch at one end of the socket must match the same identifier on the silk-screen print. The i.c.s themselves will later be inserted the same way round.

For reliability and strength, it's best to ensure that every socket lies flush against the board. This is easy if a soldering frame is used, but otherwise various tricks include using a length of adhesive tape to hold the socket temporarily during soldering.

As a tip, look closely at the pins when soldering: if all the pins protrude through the board at the same height, then it's safe to say the d.i.l. socket is flush against the PhizzyB board. This is pretty important, because if you are inexperienced in handling and soldering such devices then you would find it somewhat tricky to desolder and correct again. Ultimately, you could accidentally damage the board and the last thing which any of us want you to be is disappointed!

Proceed by soldering in the i.c. sockets. If you are inexperienced at this, practise on IC7 socket first (regardless of whether you choose to fit the battery controller chip). Take your time, working diligently and methodically and you should be fine.

It only takes two or three seconds at most to make such a joint, using a few millimetres of solder. Definitely avoid applying an excess which might bridge and short adjacent contacts, and double-check all the time to ensure the sockets are completely flush against the board. Keep the i.c.s in their packaging for now.

Max and Alvin suggest "socketing" the 7-segment dual light-emitting diode (l.e.d.) displays and bargraph displays should you have any worries about damaging these devices during soldering.

This is an option, and single-in-line socket strips can be used, snapped off to length (two strips of nine sockets for each dual display). However, note that it is worth socketing switch SW5 (16-pin dual-in-line switch) together with BAR1 (20-pin bargraph l.e.d.) using ordinary d.i.l. sockets. This is in order to make these devices removable for future expansion projects, but they are not shown in the photos of the prototype.

CAPACITORS

Once you have all the resistors and i.c. sockets in place, next insert the non-electrolytic capacitors, most of which are used to decouple the power supply by removing noise and spikes near to the i.c.s. All capacitors are vertical ("radial") p.c.b. mounting types.

To make a neat job, a good tip is to solder one pin of a capacitor, turn the board over and straighten the device, then secure it by soldering the other pin. Solder all the polyester and ceramic capacitors into place, paying close attention to their markings. These can confuse beginners and old hands alike:

- Devices marked "10n" are 10nF (ten nanofarads)
- "100n" means 100nF
- Any labelled as "µ1" are 0·1µF, or 100nF
- C1 may be labelled as "µ33" which is 0·33µF (0·33 microfarads).

There are various "pitches" (distance between the pins) used for the capacitors, so be sure to select the right types (see components list). Leave the electrolytic capacitors until later. Follow on with the switches SW1 to SW4, and SW6. (Remember SW5 is best socketed.)

The dual l.e.d.s can be fitted next if you're confident enough about soldering them directly instead of using sockets, again making sure they are flat against the board. Look for the decimal point location to align them correctly – see photos. The bargraph display BAR101 follows next (BAR1 being socketed).

LARGER PARTS

By now your PhizzyB should be really taking shape. Continue construction by soldering into position the quartz crystal XTAL1, then the electrolytic capacitors C7 to C11 and C14. These capacitors are polarity critical, and you will observe a positive sign on the p.c.b., which denotes the positive lead. (Usually, you see a negative sign printed on the capacitor's body which by an uncanny coincidence, signifies the negative wire.) It is very important that these capacitors are soldered in the right way round.

Turning next to the power supply section: PhizzyB's circuit operates at 5V d.c. so an on-board regulator is used (REG1) to provide a constant 5V voltage from the suggested 9V d.c. mains adaptor. The best way of fitting it is to bend its wires to the required shape, then bolt the device through the hole provided in the board using an M3 × 6 nut and bolt. Then solder the regulator's three leads.

Now install CON2, which is the d.c. power inlet socket.

Amongst the very last components to solder are the five "IDC headers" (Insulation Displacement Connector), CON3 to CON7. PhizzyB has a preferred way and a wrong way, and it is indicated on the silk screen print which way the large notches in the sides of the headers should match with the board.

(Experienced users of IDC connectors will see an arrowhead symbol moulded in the plastic body, too, which matches an arrow on the silk-screen print.) Ensure the headers are flush against the board.

The very last item is CON1, the RS232 serial connector which hooks to your PC. There are several holes on the board to accept the commonest styles of right-angle socket, and the connector will drop straight in. Some types use mounting prongs which need no further attention, otherwise consider using small nuts and bolts to firmly secure the connector.

You can now add the four mounting pillars, which act as "feet" for the PhizzyB and which stand the solder side off the tabletop.

After this, your PhizzyB is very nearly complete: there is only the battery (if used) to solder on-board, which can be done after all the testing is complete.

Construction for the battery sub-board is described later. But before we breathe life into PhizzyB, it is necessary to perform some preliminary tests to ensure everything is in order.

INITIAL TESTING

With none of the dual-in-line devices installed – still keep the integrated circuits in their packaging – the next stage is to closely inspect all your soldering. Look especially for:

- Joints you overlooked completely – solder them!
- Badly made or "dry" joints: desolder them with a desoldering pump or braid, and re-apply fresh solder
- Excessive "blobs" of solder bridging adjacent pins – desolder, clean up and rework
- Whiskers of solder shorting neighbouring terminals.
- If you see *any* dubious-looking solder joints, rework them.

If everything looks to be in order, we now move to the testing phase, where we power up the board without any integrated circuits in place. An ordinary 9V 300mA to 500mA regulated mains adaptor is needed, with a standard 2·1mm d.c. plug. The "tip" or inner sleeve is *negative* (see the PhizzyB Manual on the CD-ROM), so go ahead and apply d.c. power to the board.

If regulator REG1 becomes warm after 10 to 15 seconds, switch off immediately and check the polarity of your power supply!

Use a voltmeter set to a 10V d.c. range and proceed to test out the board as follows. The metal tab of REG1 and its mounting bolt are at 0V, which you can use as the common 0V connection for your multimeter.

Test for +5V appearing at the i.c. pin locations in Table 1, using the positive probe of your meter.

Table 1

IC Designation	Pin number
IC1	14
IC2	16
IC3	31, 40
IC4	20
IC5 (if used)	28*
IC6	28*
IC7 (if used)	8
IC8	16
IC9	26
IC10	26
IC11	20
IC101 (if used)	19
IC102 (if used)	19

*IC5/IC6 will only measure +5V if JUMP1 is in place, or if BAT1 is fitted.

If you fail to measure any voltage at all, double-check the polarity of your mains adapter plug (test with a voltmeter), and also check the voltages around REG1 (see Fig.3) to ensure the power supply is reaching the board.

We think, though, that the chances of failure at this point are very remote, and any problems will be due to mechanical defects, including poor soldering, and very unlucky would be the reader whose PhizzyB doesn't measure up correctly at this stage. (See the end of the article for details of where to get more help.)

Next, you should install i.c.s. Disconnect the power supply before inserting them.

All the d.i.l. i.c.s are CMOS devices and are static sensitive, so special precautions are needed to ensure you do not inadvertently "zap" the chip with a discharge of static electricity which may have accumulated on your board, or yourself. (A computer monitor screen is one example of a source of static, nylon carpets and underwear another.)

Most people use an anti-static wrist strap in conjunction with a special mains earthing adapter (and often, an earthed bench mat) to ground their body and work area, thereby eliminating static build-up. Alternatively, you should touch a good earth before handling the chips.

The main problem now is that the

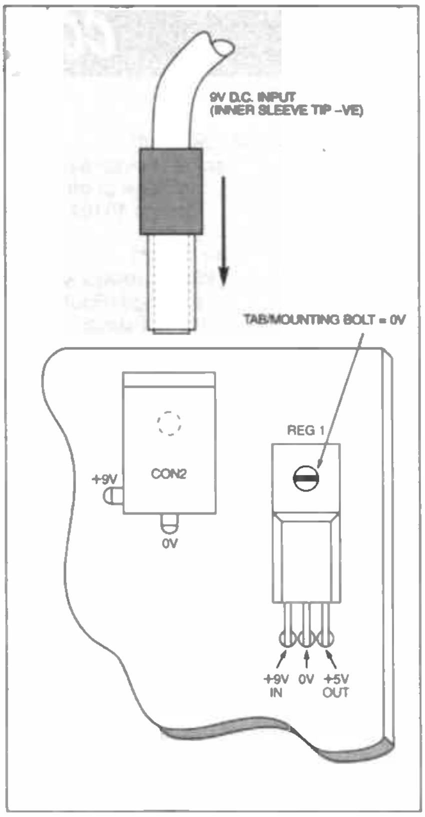


Fig.3. Power supply section of the p.c.b. The mounting bolt of regulator REG1 is at 0V.

pins of the dual-in-line devices must be made to align with their respective sockets: pins tend to arrive ex-factory slightly splayed out, so it is necessary to gently straighten them slightly.

Do this by resting one row of pins on an anti-static surface and bend them by grasping the i.c. moulding and bend the pins simultaneously. The pins are generally "springy", but you should bend the pins evenly and progressively, and repeat until they align with the i.c. sockets.

(Don't worry: chips are remarkably sturdy, but don't overdo it.)

Now comes a critical part of the assembly. You must double-check the polarity of the i.c.s, looking for the notch/dimple on the chip and align it with the notch of its i.c. holder. All the i.c.s face the same way, you'll notice, to make life easier.

Place each i.c. on its socket and push it firmly into place, but do ensure that each pin is properly located. Avoid any pins misaligning with its terminal and possibly bending underneath. (Straighten any bent pins by using fine-nosed pliers, ensuring you briefly earth yourself before touching the chip with metal pliers.)

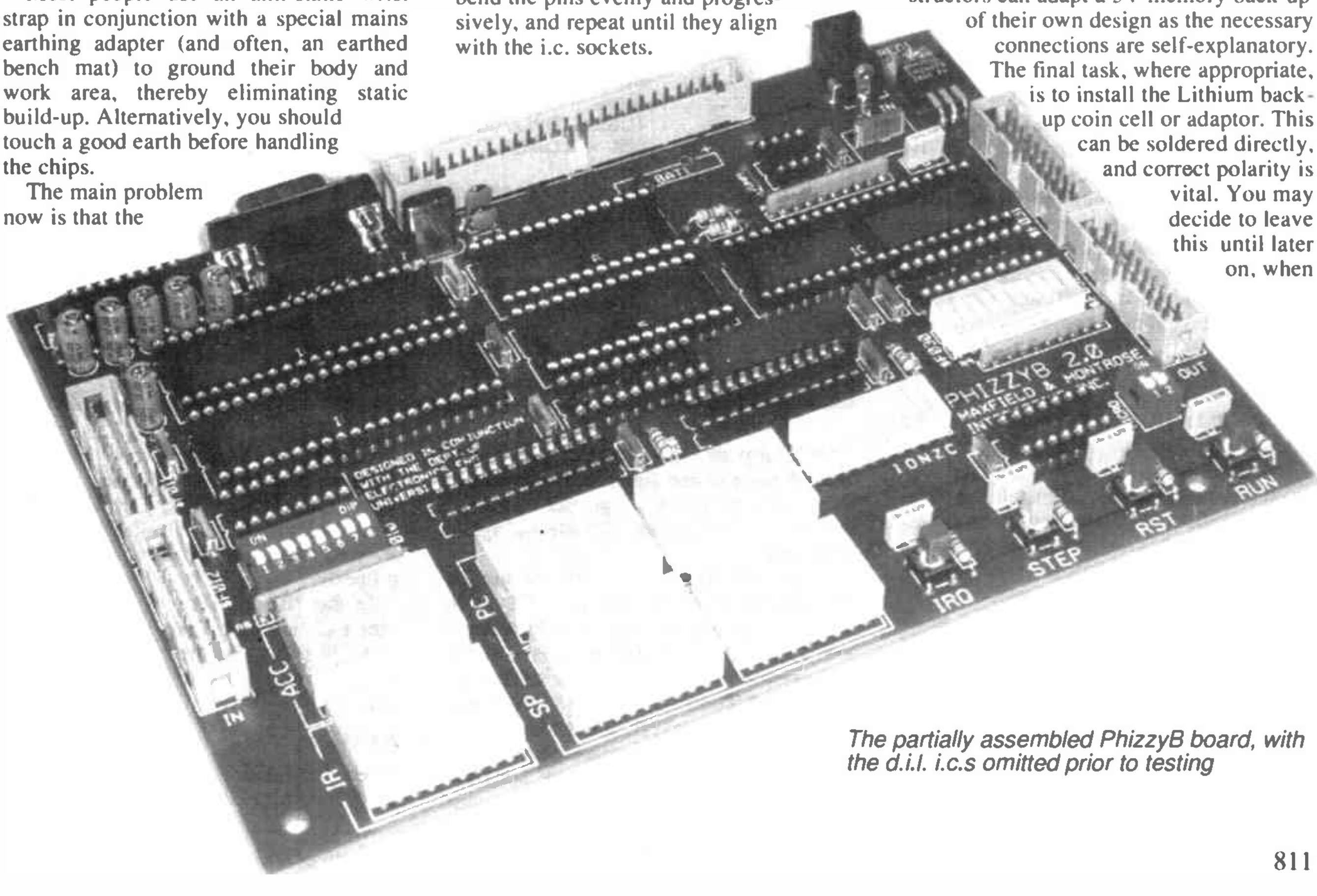
The most important component is IC3, the PhizzyB microcontroller, and you will want to ensure that this particularly is installed correctly into its holder. Also fit the dual displays, SW5 and BAR1 into their holders, if used.

Inspect the board very closely to confirm that each and every pin is correctly in place.

BACK-UP BATTERY

The PhizzyB RAM 3V battery back-up is an optional extra which retains memory data when the main power supply is interrupted. A Lithium coin cell (CR2430) will manage a low current consumption CMOS memory probably for many years. At the time of writing, and in spite of the best endeavours of your scribe, it hasn't proved possible to source a battery which exactly matches the PhizzyB board.

An adaptor board has therefore been designed which is 1·4inch square and carries a coin cell battery clip. This fits vertically into the PhizzyB board. The design is shown in Fig.4. This board is supported using two short thick lengths of solid copper wire (e.g. as used in domestic lighting systems). Experienced constructors can adapt a 3V memory back-up of their own design as the necessary connections are self-explanatory. The final task, where appropriate, is to install the Lithium back-up coin cell or adaptor. This can be soldered directly, and correct polarity is vital. You may decide to leave this until later on, when



The partially assembled PhizzyB board, with the d.i.l. i.c.s omitted prior to testing

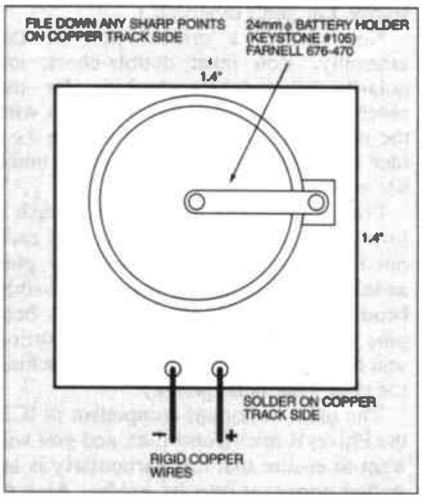


Fig.4. PhizzyB battery connection and mounting.

programs are loaded into the PhizzyB which can be retained by the back-up battery.

When all components are in place, congratulations! Give yourself a slap on the back! You can, incidentally, generally handle the completed PhizzyB board without needing to take any further anti-static precautions, although you must certainly take precautions if you have cause to handle any individual chips.

PhizzyB is not your average everyday object, though, so treat it with some care.

FINAL TESTING AND OPERATION

IMPORTANT: before proceeding to the final test, note that both switches on SW6 must be set to OFF.

The next check is to power up your fully-populated PhizzyB from the mains adaptor. It is not necessary to connect to your PC at this time. (Note that the regulator REG1 will be warm or hot in normal operation.)

The modest display PhizzyB provides when it awakens should gladden the heart and tell you that all is well. All the 7-segment displays will briefly flash 8s (the decimal points aren't used), and both the bargraph displays should flash briefly (the eight right-most l.e.d.s only: the two left l.e.d.s are unused).

After less than half a second or so, the l.e.d.s should all turn off, and the 7-segment displays should show:

(ACC) 00 **(PC) 4000**
(IR) 00 **(SP) 0000**

(A similar start-up routine is displayed by the PhizzyB Simulator when you hit the virtual "power" switch.)

Your PhizzyB is now ready for use. You can then proceed to install the PhizzyB Simulator software from the full version CD-ROM (view the file **default.htm** in your browser, or open **Welcome.txt** for CD installation instructions).

Load the software, connect the PhizzyB to your computer serial port, and then open a demonstration file and send it to your PhizzyB, as follows.

To attach PhizzyB to your PC, you must use a *null modem cable*, i.e. a female-to-female 9-pin serial lead on PhizzyB CON1 and either COM1 or COM2 of your PC. Some leads may have male-female connections, in which case it is possible to attach a "gender changer" to produce the required female fittings at both ends.

After installing the software, ensure the *full version* PhizzyB Simulator CD is in the drive, then click **Start –> Programs –> PhizzyB –> PhizzyB** to launch the full version PhizzyB Simulator software.

Then go **Tools –> PhizzyB Interface** (or use the PhizzyB Interface icon – there's a "flyover" prompt on the icon toolbar) to activate the PBLink software (which is used to load programs to your PhizzyB). In its menu, click **File –> Options** (or use the Options icon) to select the relevant COM port. Come back here and check or change the settings if your PhizzyB doesn't communicate properly.

In the PBLink window, click **File –> Open** (or click the icon, or CTRL + O) and open the filename **Test1.ram**. The first few lines of the PBLink window will read:

RAM file:

Start –>	Finish	Size (bytes)	Downloaded
$4000	$4017	24	No

COMPONENTS

Resistors

R1 to R4, R101, R102	22k (6 off)
R5, R8	4k7 9-resistor s.i.l. package (2 off, Bourns 4610X series)
R6, R7	4k7 (2 off)
R9	150Ω 9-resistor s.i.l. package (Bourns 4610X series)

All 0.25W 5% carbon film unless marked.

Capacitors

C1	0·33µ polyester, 10mm pitch e.g. Siemens B32560 series
C2	100n polyester, 5mm pitch, e.g. Thomson BF series
C3 to C6	10n polyester, 5mm pitch, e.g. Thomson BF series (4 off)
C7 to C11, C14	1µ 63V min. radial elect. 2mm pitch, e.g. Philips 037 range (6 off)
C12, C13	33p min. ceramic disk, 50V, 6mm pitch approx. (2 off)
C15 to C25, C101, C102	100n polyester, 7.5mm pitch, e.g. Siemens B32560 range (13 off)

Semiconductors

IC1	74LS14 hex Schmitt trigger
IC2	MAX232CPE RS232 transmitter/ receiver
IC3	Pre-programmed PhizzyB microcontroller
IC4	74LS373 tri-state octal D-type flip-flop
IC5	Toshiba TC55257DPL-70L 32K × 8 CMOS SRAM *
IC6	Toshiba TC55257DPL-70L 32K × 8 CMOS SRAM
IC7	Harris ICL7673 battery backup controller *
IC8	74LS138 3-to-8 decoder
IC9, IC10	OKI (only) 82C55A2 programmable peripheral interface (2 off)
IC11	74LS540 octal buffer/driver
IC101, IC102	MAX7219CNG display controller (2 off) *
DUAL1 to DUAL6	dual 0·56-inch 7-segment common cathode l.e.d. display, e.g. HDSP 5323 (6 off) *
BAR1, BAR101	10-segment l.e.d. bargraph display, e.g. HDSP 4820 (2 off)
REG1	LM340-T5 5V 1A TO-220 voltage regulator

Miscellaneous

SW1 to SW4	min. push-to-make switch, p.c.b. mounting, 6·5mm × 4.5mm (4 off)
SW5	8-way s.p.s.t. d.i.l. switch
SW6	2-way s.p.s.t. d.i.l. switch
XTAL1	11.0592MHz HC49 quartz crystal
BAT1	3V Lithium CR2430 coin cell *
CON1	9-pin right-angle p.c.b. mounting D-connector (male)
CON2	2·1mm d.c. power inlet socket
CON3 to CON6	shrouded (boxed) 20-pin straight-up IDC header (4 off)
CON7	shrouded (boxed) 50-pin straight-up IDC header

PhizzyB Simulator CD-ROM (full working version)

Printed circuit board, available from the *EPE PCB Service*, (PhizzyB); 8-pin d.i.l. socket; 14-pin d.i.l. socket; 16-pin d.i.l. socket (3 off); 20-pin d.i.l. socket (3 off); *24-pin d.i.l. socket, 0·3-inch wide (2 off); 28-pin d.i.l. socket (2 off); 40-pin d.i.l. socket (3 off); p.c.b. connectors, single-in-line snap off, 12 strips × 9 contacts*; 9-pin to 9-pin null modem serial cable (female-female); mounting pillars, 3mm thread (4 off); M3 × 6mm nut and bolt; 9V 300mA to 500mA regulated d.c. mains adaptor, 2·1mm plug (tip negative); p.c.b. mounting 24mm coin cell holder, 24mm, Farnell 676-470*; solder, etc.

* optional (see text)

Approx Cost Guidance Only £130 including full CD-ROM

Ensure your PhizzyB is connected and powered up. Go **File –> Download**, or click the Download RAM File icon (third one), and this tiny program will instantly (as fast as a mouse click!) be downloaded to the hardware PhizzyB.

Then click **Run** (the **> > icon) or F2**, and your PhizzyB will run the program and display a simple binary count on $F030 output port. You can also press the "Run" and "Step" keys either in the software or on your real PhizzyB and watch the l.e.d. displays react.

Don't forget the on-line help contained in the *PhizzyB User Manual Volume 2* (run the full version PhizzyB CD-ROM). You may wish to print it off for reference. It gives explicit instructions for setting up and installing the hardware, configuring the PBLink software, and loading and testing your PhizzyB, which is now ready for use.

HELP!

What to do if it doesn't work? We really do think that if you have soldered the components with reasonably tidiness, and fitted the integrated circuits correctly, PhizzyB will work first time.

However, rest assured that support is never very far away, and is available by E-mail or post, see the on-line help of the PhizzyB Simulator CD-ROM. Don't forget to check **http://www.maxmon.com**, the web site for Maxfield & Montrose Interactive, Inc. Max and Alvin are always pleased to hear feedback, comments, and (especially) praise.

Alternatively, you can write to the PhizzyB co-authors at the Editorial address and your queries will be relayed to them.

EPE web site users can also check the *EPE Chat Zone*. The Constructional author's E-mail address is: **alan@epemag.demon.co.uk.**

ACKNOWLEDGEMENTS

• The hardware design of the PhizzyB was undertaken in the UK at the Department of Electronic Engineering at the University of Hull, by a gifted young student – Andrew Ayre – who, for his final year University project – and with arms tied behind his back and teeth gnashing – nevertheless successfully engineered the entire circuitry needed to create a real-life PhizzyB. Andrew also developed the PBLink for the PhizzyB Simulator software for Windows. The PhizzyB-loving world owes Andrew a big thank-you.

• PhizzyB wouldn't fly in a straight line unless all its innermost workings talked to each other properly. The printed circuit board required for the PhizzyB was engineered in the USA by David Thompson using the Auto-Active environment provided by the Veribest PCB layout suite, from VeriBest Inc., CO., USA (**http://www.veribest.com**).

• PhizzyB is a Trade Mark of Maxfield & Montrose Interactive, Inc., Alabama, USA. The PhizzyB source code and microcontroller files are commercial items which are fully protected by international copyright.

RESOURCES

The following items are available from the *EPE PCB Service* at the Editorial address (prices include VAT and P&P):

Full working version of the PhizzyB CD-ROM £14.95

Pre-programmed PhizzyB microcontroller £14·95

PhizzyB printed circuit board, £14.95.

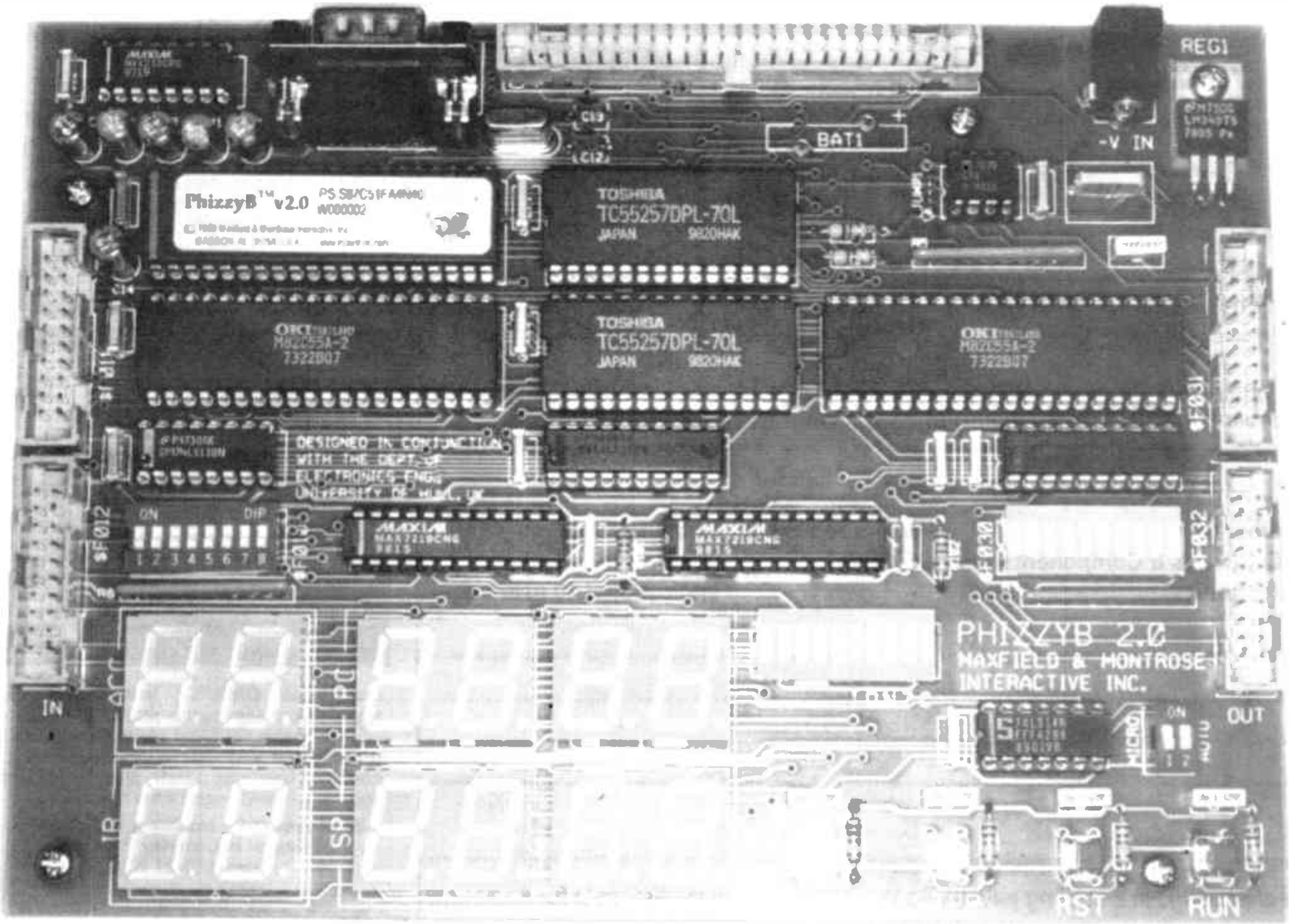
BEBOP-A-LULA!

The two amazing books referred to earlier, *Bebop Bytes Back* and *Bebop to the Boolean Boogie*, are available from the Direct Book Service (see their pages elsewhere in this issue).

NEXT MONTH

Two really simple constructional projects are described next month – an 8-bit Switch on an "input" board, and an 8-bit L.E.D. Display on an "output" board. These are intended to test out the external I/O ports and they let us experiment with the software.

Looking ahead to future instalments, we will be adding a liquid-crystal display and a versatile expansion board to greatly enhance the capabilities of your newly-hatched PhizzyB!



The fully assembled PhizzyB printed circuit board – it is so well designed you should have little difficulty achieving such a professional appearance.

Everyday Practical Electronics are pleased to be able to offer all readers these

ELECTRONICS CD-ROMS

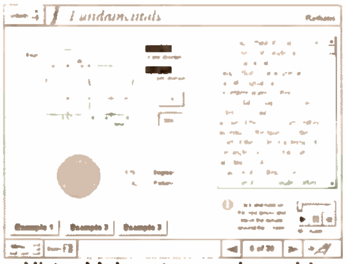
TWO APPLICATIONS ON ONE CD-ROM

ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY
by Mike Tooley

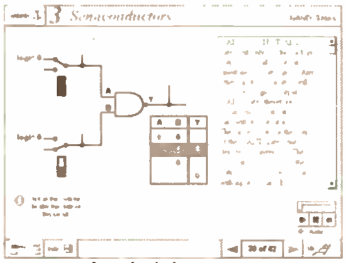
ELECTRONIC CIRCUITS & COMPONENTS

lectronic Circuits & Components rovides an introduction to the rinciples and application of the ıost common types of electronic omponents and shows how they re used to form complete circuits. he virtual laboratories, worked xamples and pre-designed circuits llow students to learn, experiment nd check their understanding as ıey proceed through the sections n the CD-ROM. Sections on the isk include:

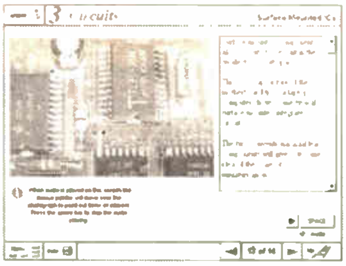
undamentals: units & multiples, lectricity, electric circuits, lternating circuits.
assive Components: resistors, apacitors, inductors, transformers.
emiconductors: diodes, ansistors, op.amps, logic gates.
assive Circuits
ctive Circuits



Virtual laboratory – sinusoids



Logic laboratory



Circuit technology screen

THE PARTS GALLERY

lany students have a good nderstanding of electronic theory ut still have difficulty in recognising ıe vast number of different types of lectronic components and symbols. *he Parts Gallery* helps overcome ıis problem; it will help students to ecognise common electronic omponents and their corresponding ymbols in circuit diagrams. elections on the disk include:

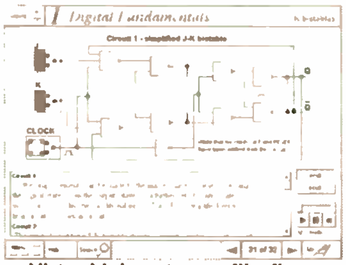
omponents
omponents Quiz
ymbols
ymbols Quiz
ircuit Technology

lobbyist/Student .... £34 inc VAT
ıstitutional (Schools/HE/FE/Industry) ....£89 *plus* VAT
ıstitutional 10 user (Network Licence) .... £169 *plus* VAT

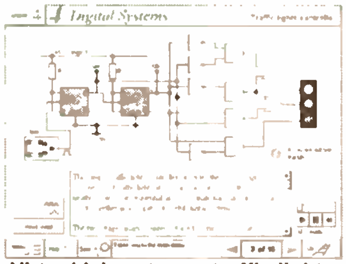
DIGITAL ELECTRONICS
by Mike Tooley

NEW

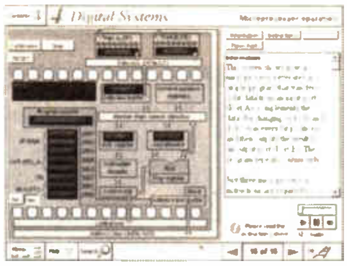
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components*, and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.



Virtual laboratory – flip-flops



Virtual laboratory – traffic lights



Microprocessor

FUNDAMENTALS
Fundamentals introduces the basics of digital electronics including binary and hexadecimal numbering systems, ASCII, basic logic gates and their operation, monostable action and circuits, and bistables – including JK and D-type flip-flops

COMBINATIONAL LOGIC
Multiple gate circuits, equivalent logic functions and specialised logic functions such as majority vote, parity checker, scrambler, half and full adders. Includes fully interactive virtual laboratories for all circuits

SEQUENTIAL LOGIC
Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers.

DIGITAL SYSTEMS
A/D and D/A converters and their parameters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic unit.

GALLERY
A catalogue of commonly used IC schematics taken from the 74xx and 40xx series. Also includes photographs of common digital integrated circuits and circuit technology.

Hobbyist/Student .... £45 inc VAT
Institutional (Schools/HE/FE Industry) ....£99 *plus* VAT
Institutional 10 user (Network Licence) .... £199 *plus* VAT

Minimum system requirements: PC with 486/33MHz, VGA+256 colours, CD-ROM drive, 8MB RAM, 8MB hard disk space. Windows 3.1/95/NT, mouse, sound card. Demo available from Web site **http://www.MatrixMultimedia.co.uk**

CD-ROM ORDER FORM

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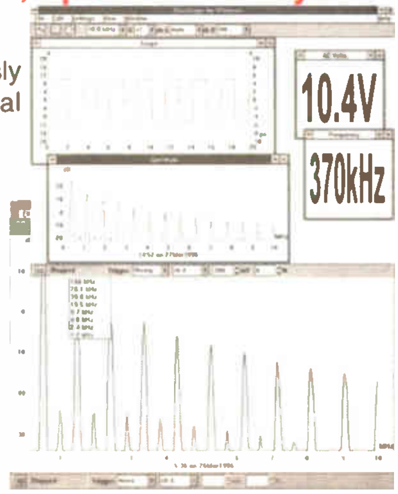
CD-ROMs are normally sent within seven days

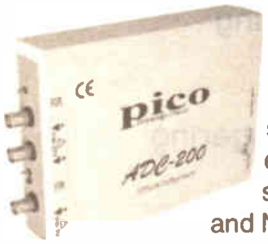
Cover CD and reader offer

Test Equipment has come a long way over the last few years. Traditional `benchtop' instruments such as oscilloscopes are giving way both to smaller hand held units and, more recently, to PC based instruments. Pico Technology are at the forefront of these developments and we are giving you the chance to save 15% off the purchase price of this high quality test equipment. You can order either the ADC200 or OsziFOX oscilloscopes using the order form below. This offer is valid until the 15th Dec 1998.

Transform your PC.... Into an oscilloscope, spectrum analyser and multimeter...



The ADC200 range of PC based oscilloscopes offer performance only previously available on the most expensive `benchtop' scopes. By intergrating several instruments into one unit, the ADC200 is both flexible and cost effective.



Connection to a PC gives the ADC200 the edge over traditional oscilloscopes: the ability to print and save waveforms is just one example. Advanced trigger modes, such as save to disk on trigger, make tracking down those elusive intermittent faults much easier. The ADC200 is supplied with PicoScope software (DOS & Win 3.1, 95/98 and NT) which is powerful, yet simple to use, especially with its comprehensive online help. Installation is easy and no configuration is required; simply plug into the parallel port and it is ready to go.

There are three models in the ADC200 range: the ADC200/20, 200/50 and 200/100 offering a 20, 50 and 100 MS/s scope and a 10, 25 and 50 MHz spectrum analyser respectively. The ADC200 is the ideal solution for applications such as video and automotive testing, electronics design and fault finding.

From £255 + VAT

The ADC200 is also supplied with Picolog software, which enables it to function as an advanced data logger and chart recorder. Don`t take our word for it, see how good the software is for yourself. Take a look at the demo versions of all of Pico`s software on the front cover CD.

A scope at your fingertips.....

Once oscilloscopes were heavy and clumsy to handle, but over the years they have got smaller and smaller. The latest development in this field has just arrived: a digital storage oscilloscope in a handy slim housing, scarcely longer than a pencil and about as thick as your thumb.

Despite its small size, its performance can match that of a service oscilloscope. With a sampling rate of up to 20MS/s, even signals in microprocessor circuits can be recorded. Using its voltmeter function, numeric AC and DC voltages can be easily measured. The low cost of the OsziFOX, together with its small size makes it ideal for any electronics engineer who needs the ultimate in portability.

Only £68 + VAT

Order form

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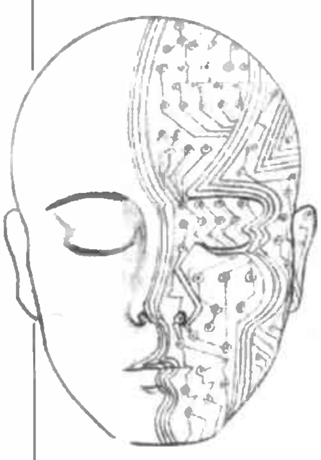
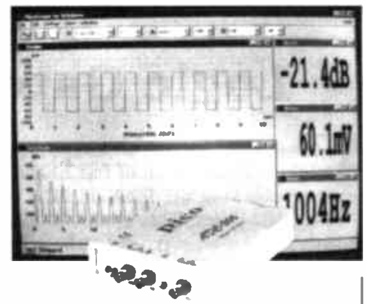


INGENUITY UNLIMITED

Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**

Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF.
They could earn you some real cash **and a prize!**



WIN A PICO PC BASED OSCILLOSCOPE

- 50MSPS Dual Channel Storage Oscilloscope • 25MHz Spectrum Analyser
- Multimeter • Frequency Meter
- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.

Every six months, Pico Technology will be awarding an ADC200-50 digital storage oscilloscope for the best IU submission. In addition, two single channel ADC-40s will be presented to the runners up.

Audio Frequency Doubler – Pitch Effects

Being interested in electronic effects for music, I was quite intrigued by the pitch doublers and changers found on some professional effects units. I quickly realised that the frequency changes were arrived at by digital means and the circuit digram shown in Fig.1 is one way this can be achieved by the hobbyist.

The method used is basically that of a non-linear mixer. Given two sine waves of frequency *f1* and *f2*, then the sum and differences, i.e. f1 + f2 and f1 – f2, may be generated by arranging the circuit to multiply the two sine waves together. As f1 and f2 are actually the same, the result is f1 + f1 or 2f1; f1 – f1 is zero.

The multiplication is accomplished by passing one copy of the input onto the non-inverting input (pin 3) of IC2 which, in conjunction with the junction f.e.t. TR1, forms a variable gain amplifier. Its gain is controlled by the amplitude of a second copy of the input amplified by IC1, and applied to the gate (g) of TR1. The f.e.t. is biased so as to mimic a reasonably linear resistance between its source and drain. This resistance is then modulated by the input sine wave.

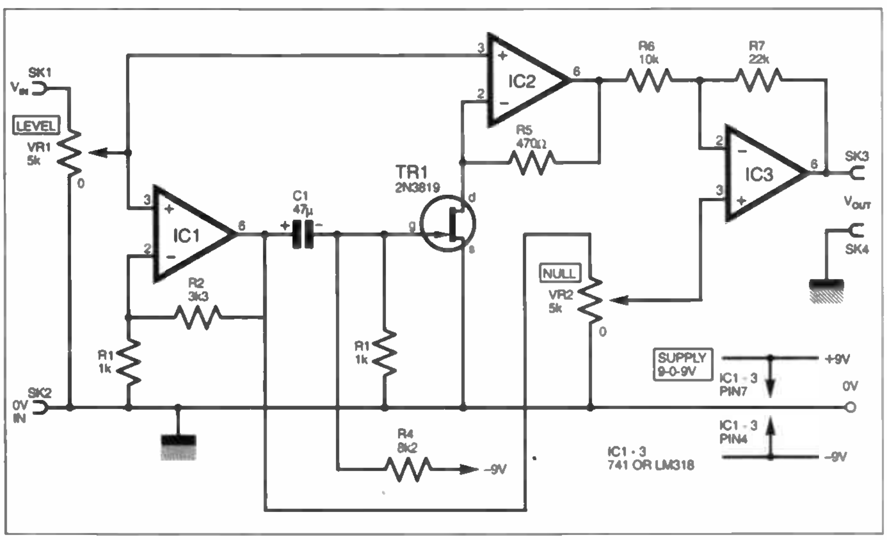


Fig. 1. Circuit diagram for the Audio Frequency Doubler.

The gain of IC2 equals $(R5+R_{ds})/R_{ds}$ where R_{ds} is the f.e.t. drain-source resistance. The change in gain produces the multiplying action.

If V_{out} of IC2 = G × V_{in} where G is the gain and G itself is a function of V_{in}, then $V_{out} = G(V_{in}) \times V_{in}$.

Unfortunately, due to the f.e.t. and op-amp arrangement, $G(V_{in})$ mathematically resembles something like $a + (b \times V_{in})$ where a and b are constants. This gives us:

$V_{out} = (a + (b \times V_{in})) \times V_{in}$, and

$V_{out} = a = V_{in} + b \times V_{in} \times V_{in}$

This means we have an extra term, $a \times V_{in}$ which is of course the original input signal multiplied by some constant. This must be removed, and this is the purpose of IC3, an adder circuit, or rather a subtracter! The mixed output is applied to the inverting input and the original signal is applied to the non-inverting input via potentiometer VR2. By careful adjustment of VR2 the original signal will be nulled out, leaving the doubled frequency at the output of IC3.

In use, set Level control VR1 so as not to overdrive IC1. It is not recommended exceeding 0·4V pk-pk on the input. I originally used 741s for the op.amps which gave good results, but better spec types such as LM318s improved the nulling. The circuit worked well up to 10kHz. Note that a 9V dual split supply is required.

Alan Lippett, Stafford.

PICO PRIZE WINNERS

It's time to judge the *Ingenuity Unlimited* submissions over the last six months. Three lucky entrants each win a fabulous prize of a PICO Technology (**www.picotech.com**) **PC-based Oscilloscope!** *EPE* Editor Mike Kenward and *IU* host Alan Winstanley carefully considered all the published submissions and prizes were finally awarded as follows:

WINNER – receives a superb PICO Technology ADC200-50 PC Digital Storage Oscilloscope
Electronic Dice – Steve Teal, Witney, Oxfordshire (July 1998). Although far from a new application of electronics, in light of our *Teach-In 98* series the judges were pleased to see how the contributor had fulfilled the logic design requirement methodically, meeting the challenge of incorporating specific logic devices to hand.

RUNNERS-UP – each wins a PICO Technology ADC-40 Single-channel PC-based Oscilloscope
L.E.D. Cycle Rear Lamp – Alan Bradley, Belfast, Northern Ireland (October 1998). We were impressed by this simple but effective design which was well researched in relation to component choice and current UK legislation.
Audio Frequency Doubler – Alan Lippett, Stafford (November 1998). A systematically designed effects unit using a small number of active components.

Our thanks to PICO for their on-going sponsorship

Logic Gate Tester – When the chips are down

ANYONE with lots of surplus TTL chips might find the circuit of Fig.2 handy as a means of checking the function of a variety of TTL logic gates. This circuit is ideal for students and enthusiasts who make extensive use of AND, NAND, OR, NOR, XOR and XNOR gates (7408, 7400, 7432, 7402 and 7486 respectively).

IC1 is a clock generator configured in the astable mode, and VR1 allows the user to set the input frequency of the network. IC2 contains a dual J-K flip-flop that is designed to operate as a modulo-4 asynchronous counter. IC2 will generate the codes 00, 01, 10 and 11. These codes will be distributed to the i.c. to be tested in IC Sockets 1 and 2, and the NOR gates of IC3 and IC4 will decode and display the condition of the inputs via a simple l.e.d. display D5 to D8 (*outputting the result similar to a Truth Table – A.R.W.*).

Thus, D1 to D4 display the gate output states and D5 to D8 display the result of their truth tables. The "expected" outputs which are derived from Truth Tables should be compared to the actual outputs displayed by the light-emitting diodes. An error will register as a small leakage current that will turn an l.e.d. slightly on.

Since this circuit contains two i.c. holders (the second one for 7402's only) it is important to know the pinouts of the i.c. that you would like to test. *Two i.c.s should not be inserted at the same time.* Also, the circuit cannot test i.c.s with an open collector output.

Mirza N. Beg,
Lenasia, South Africa.

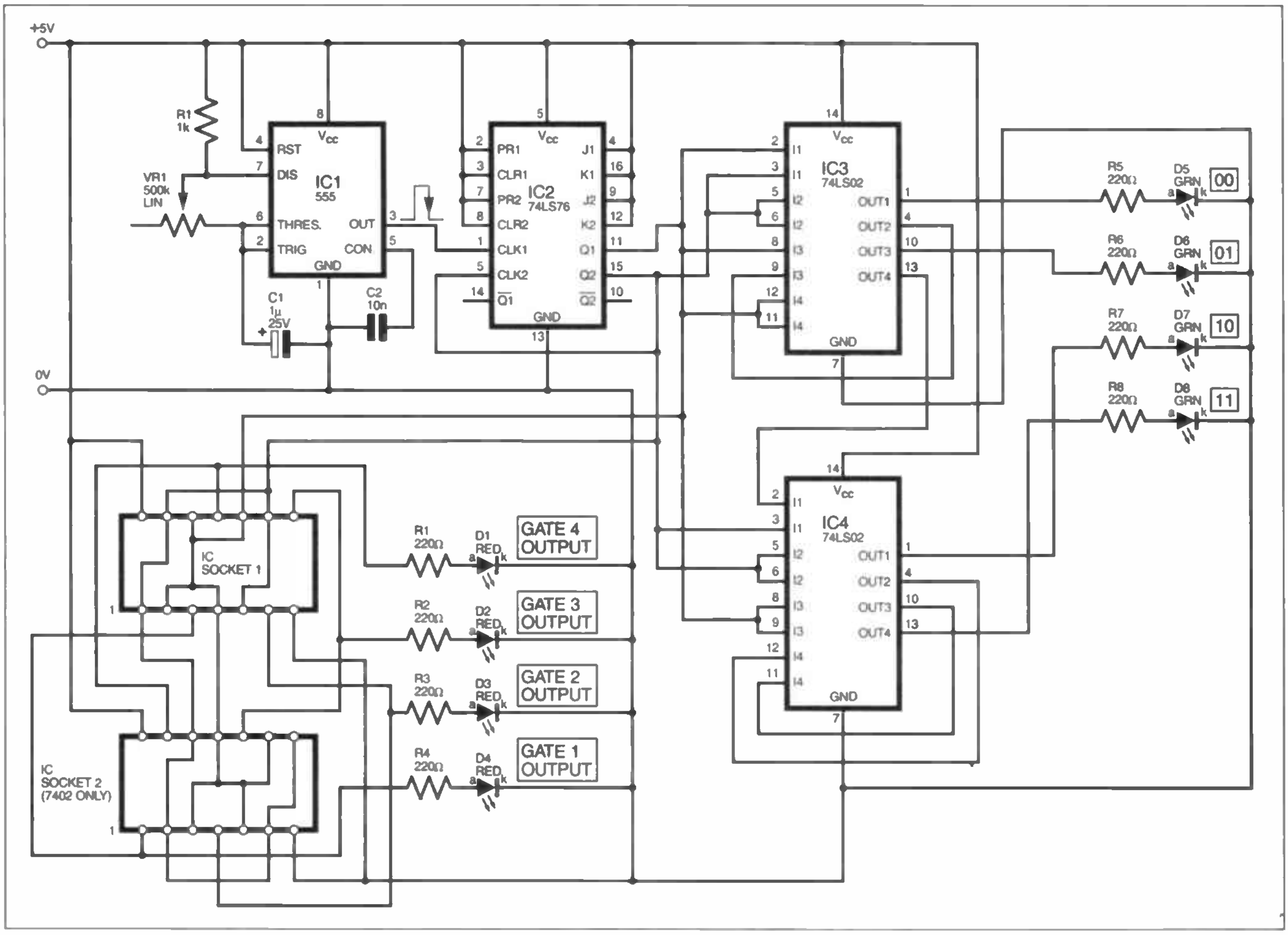


Fig.2. Circuit diagram for the Logic Gate Tester.

Courtesy Light Delay – Down to Earth

THE SIMPLE circuit diagram shown in Fig.3 forms an electronically-controlled time delay for a car's courtesy light ("dome light"). The only connections to the unit are an "earth" (negative chassis), and a lead to the courtesy light switch "live", on the driver's doorswitch, which should be a ground-switching type.

On closing the driver's door, switch S1 will open and capacitor C1 will charge through transistors TR2 and TR3. These are connected as a high-gain Darlington pair. Diode D1 ensures that C1 is discharged quickly when the doorswitch is closed. (i.e. the door is open).

As the collector of TR3 rises, the lamp starts to dim. When it reaches approx. 4·5V, transistor TR1 will turn full on, lowering the base volts of TR2, causing it and TR3 to turn off. The collector of TR3 will rapidly rise, causing the lamp to go out. The speed at which the lamp dims will depend on the value of C1 and the combined gains of TR2/TR3.

Most medium gain, low power *npn* transistors can be used for TR1 and TR2, but TR3 will need to be capable of switching 1A. It should not require a heatsink. The whole unit can be constructed on stripboard, enclosed in a small box, and fixed neatly under the vehicle dashboard.

Peter Exeter,
Dereham, Norfolk.

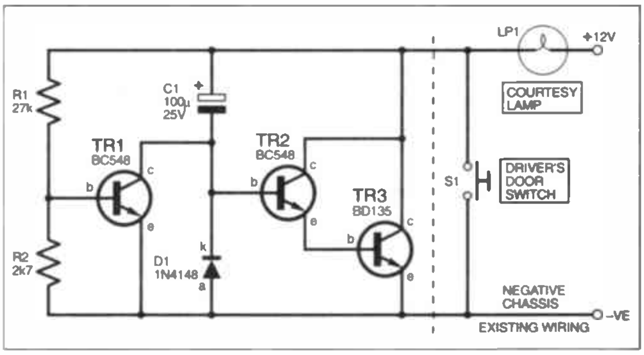


Fig.3. Vehicle Courtesy Light Delay circuit diagram.

INGENUITY UNLIMITED

BE INTERACTIVE

IU is *your* forum where you can offer other readers the benefit of your Ingenuity. Share those ideas and earn some cash and possibly a prize!

EASY-PC FOR WINDOWS 95

ROBERT PENFOLD

We put another p.c.b. design program under the microscope.

OVER the years I suppose that I have tried most of the printed circuit design programs that have come onto the market, from simple shareware offerings to up-market professional packages providing every feature imaginable.

Easy-PC is one of the more successful printed circuit design programs, and this award-winning software has now been available for about ten years.

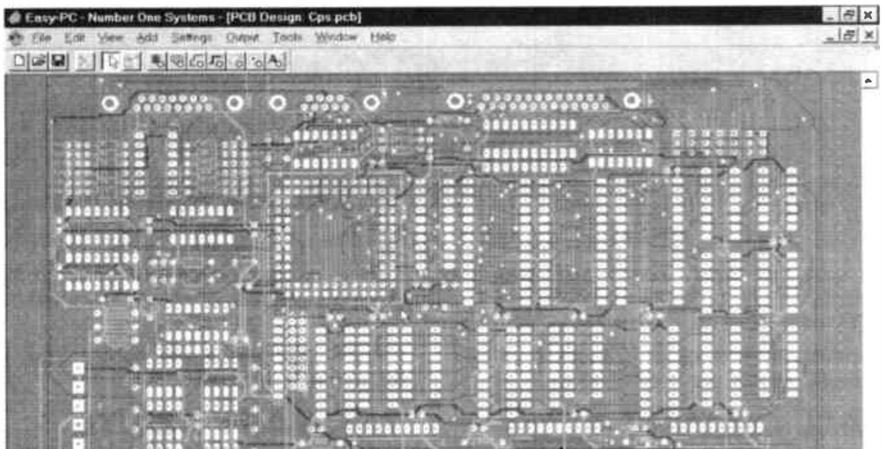
For some reason the original MS-DOS version of Easy-PC eluded me, as did the various upgraded MS-DOS versions. I was therefore more than a little happy to try out the new Windows version of Easy-PC. This runs under the Windows 95/98 or Windows NT operating systems, but not under Windows 3.1 or earlier.

Running modern Windows software and older MS-DOS programs on the same computer can be problematic, and the MS-DOS programs often fail to make full use of the facilities available on a modern PC. For example, you often have to run graphics programs at standard VGA resolution, while Windows programs on the same computer operate in SVGA modes at double or more the normal VGA resolution. The new Windows version of Easy-PC will no doubt be of great interest to users of previous versions, as well as first-time users looking for a modern printed circuit design package.

MINIMUM REQUIREMENTS

In order to run Easy-PC you need a reasonably well-specified PC. The minimum requirements are and 80486 processor with maths co-processor, 8MB of RAM, 20MB of hard disk space, and a SVGA display having a resolution of 800 by 600 or more in 256 colours. However, the minimum recommended system is a 100MHz Pentium, 16MB of RAM, and a display resolution of 1024 by 768. The graphics performance is not quite as fast as some other modern Windows programs, and when designing large boards there is definite advantage in using a very fast PC.

There is no set limit to the number of tracks, pads, etc. that the program can handle, because its capacity is governed by the amount of free memory. Running the program under Windows 95, 16MB of RAM was sufficient to accommodate a large demonstration board, and most users will probably not need to worry about a memory upgrade. The program is supplied on five HD disks, and installation in standard Windows fashion proved to be trouble-free.



The screen has a conventional Windows layout, complete with scrollbars. The graphics are excellent, and with a screen resolution of 800 × 600 or more will clearly show quite large board layouts.

FIRST IMPRESSIONS

On running the program you are greeted with a conventional Windows screen having a menu bar and a toolbar at the top, and a status bar at the bottom. This leaves most of the screen free for drawings, but the toolbar and status bar can be switched off if the largest possible drawing area is required.

Due to the large number of file types and output options, separate File and Output menus are used. Easy-PC is a combined schematic capture and printed circuit design program. Circuit diagrams and boards have their own file types, but there are other types including project files, which are used to group together all the files for a project. This enables circuits split over several pages to be associated with a single printed circuit board.

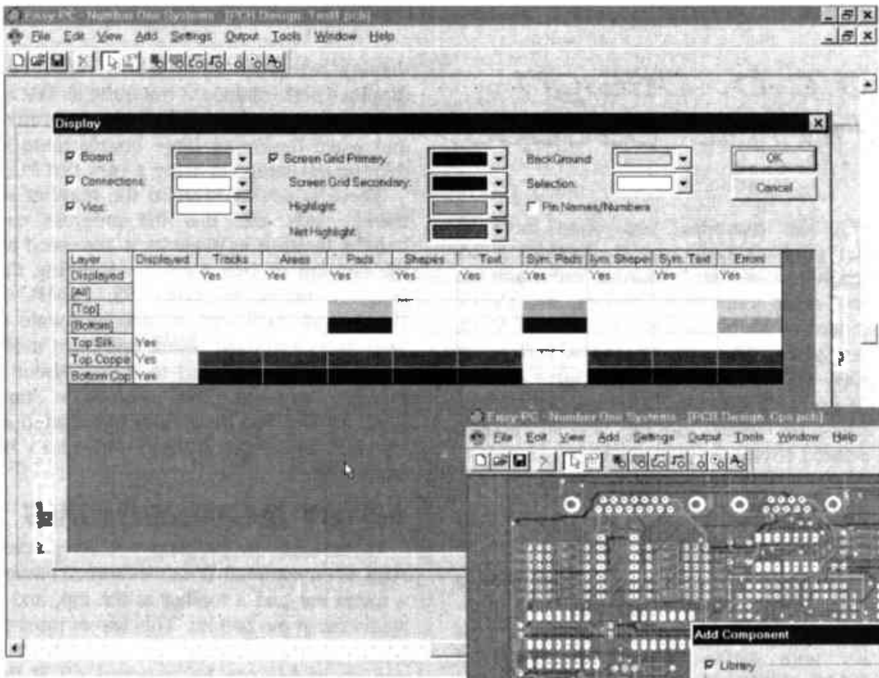
There are also technology files, which act rather like templates in word processors, etc. In other words, a technology file controls layer settings, the screen grid, etc., but does not contain a design. Amongst other things, this enables different sets of starting conditions to be used for different types of project. You simply produce a technology file for each type of project (audio, digital and radio frequency circuits for example). There are further file types to handle symbols, components, and their libraries.

DESIGN PROCESS

The design process starts by selecting "Schematic Design" from the file menu, and then drawing the circuit diagram in the window that this produces. The supplied libraries of components are not quite as comprehensive as those supplied with some other printed circuit design programs, but there is still an excellent selection of analogue and digital components. You can, of course, add your own libraries of components.

Components are selected via either the menu system or one of the buttons on the toolbar. In either case this brings up a window which enables you to scroll through the available components in the current library, and select the one you require. When necessary, a second window can be brought up, and a different library can then be selected. Each component can have more than one physical symbol, and many of the semiconductors are available with both conventional and surface mount encapsulations.

Although the physical attributes are irrelevant to the circuit diagram, it is still important to choose the right one at this stage because the physical outline of the component will be carried forward into the printed circuit design. Selecting the right component and outline is quite straightforward, but no "thumbnail" sketches of components are shown in the selection window. *(We understand there is a component preview window on the new Version 2. Ed.)*



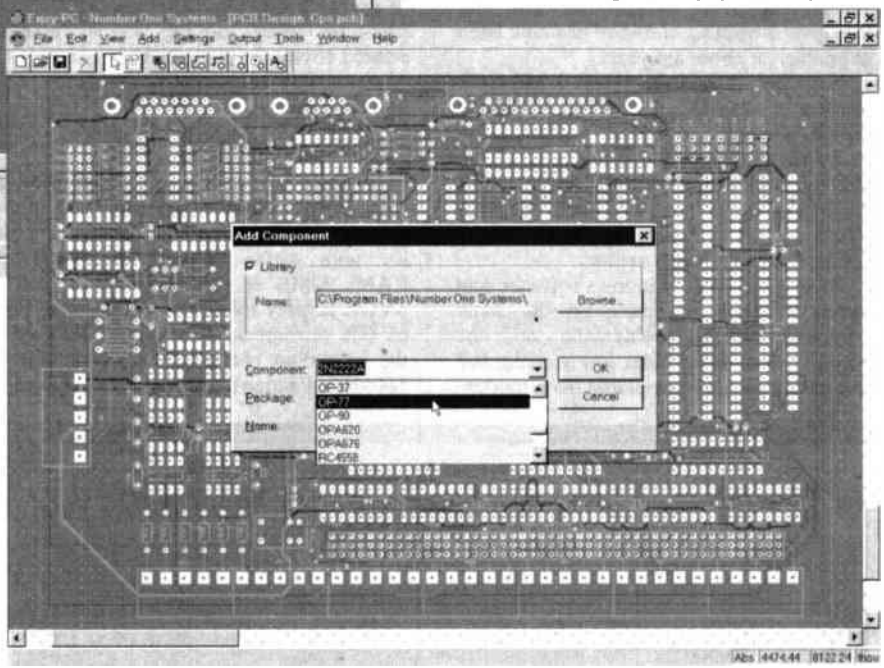
Easy-PC makes widespread use of pop-up control panels. This one controls various aspects of the display, such as the screen colours.

INTERCONNECTIONS

Once the circuit symbols have been placed on the screen the interconnections can be added. There is a "free" mode, which permits lines to be added at any angle, as well as the usual orthogonal mode that only permits horizontal and vertical lines. Each line carrying interconnections is called a net. Each net is automatically numbered, but you can use your own names for supply rails or any net that can be given a useful name.

Symbols, nets, and text are easily edited. Left clicking on an object selects it, and it can then be dragged around the screen. Rubber banding ensures that moving objects does not alter the existing set of interconnections. Simply right clicking on an object brings up a control panel that enables it to be deleted, rotated in 90 degree increments, the line width to be changed, etc. The exact options available depend on the type of object chosen. The "Properties" option brings up a further control panel that provides more precise control, such as rotation in 0·1-degree increments.

Using the schematic editor is generally quite easy and after each net is completed it dumps you back into the editing mode, this makes editing easier, adding new connections can continue simply by double clicking on any device connection. The diagrams produced by the various schematic capture programs tend to be neat if rather basic. Easy-PC is no exception, but it is possible to use various line widths and text styles to produce prettier results, should you need to do so.



Using the "Add Component" button brings up a control panel that enables the required component to be selected. It is possible to switch to another library via the "Browse" button.

ALL CHANGE

P.C.B. CAD programs that use schematic capture can be rather convoluted in use. Easy-PC is very user-friendly, and converting a circuit diagram into a corresponding board design is very straightforward. Selecting "Translate to PCB" from the Tools menu opens a new window into which the basis for the board is placed. At this stage the board design is simply the physical symbols for the components with a "rats nest" of interconnections. A large amount of work is needed in order to turn this into a practical board design.

The normal way of tackling the conversion is to start by drawing a board outline. Connectors and other major components are then moved into the required positions. Once any additional repositioning of components has been completed, the nets (that simply run straight from one pin to the next) must be routed properly, one-by-one. Left clicking on a net converts it to a track, which can then be dragged around the screen and have segments added. Editing in the printed circuit part of the program is broadly the same as when using the schematic capture section.

If you wish to produce a printed circuit design for an existing circuit diagram, it is not necessary to redraw the circuit and then convert it to a p.c.b. If preferred, Easy-PC can be used as a simple electronic drawing board. The physical symbols are placed on the screen and the board outline is added. Then either the nets are added and routed, or the tracks are laid down straight away with no rats-nest being used at all. Producing boards in this fashion is quite straightforward using Easy-PC, and all the usual editing facilities are available.

Components are easily added to a board produced via the schematic capture method. It is again just a matter of adding the physical symbols for the components and then putting in the new nets and (or) tracks.

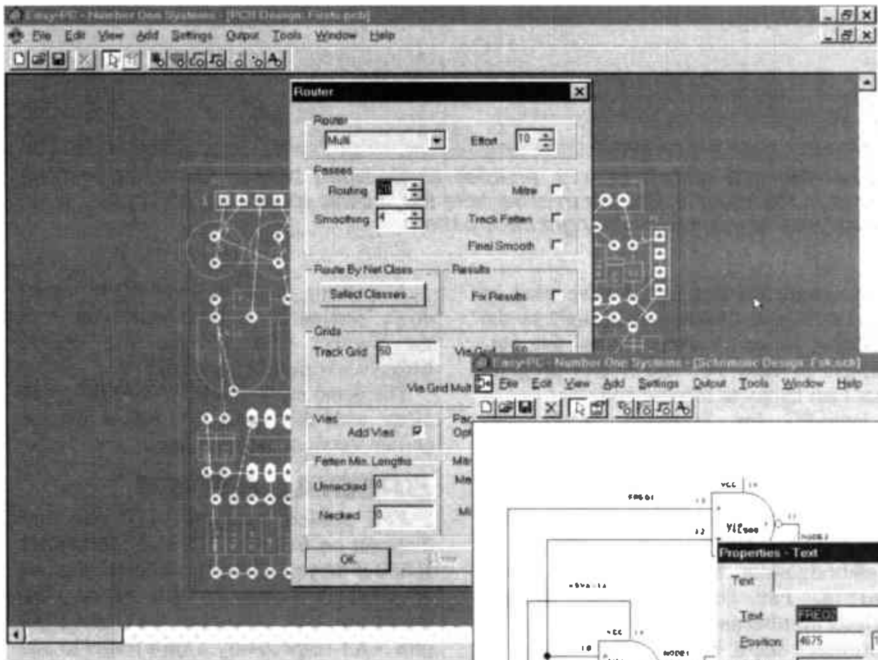
THE EASY ROUTE

Although no autorouter is included as standard with Easy-PC, an add-on autorouter is available in the form of Multirouter II. This can only handle up to two layers, but four and eight layer versions are available at higher cost. Multirouter II is supplied on two HD disks, and is installed separately from Easy-PC. However, once installed it effectively becomes part of Easy-PC, and it is activated by way of the Tools menu.

I think it is fair to say that, in general, autorouters do not live up to expectations.

They are very good at weaving ultra-fine tracks across boards having two layers, operating on the basis of mainly working horizontally on one layer and vertically on the other. This rather simplistic approach does not necessarily produce boards that are reasonably cheap and easy to produce. Also, with some types of circuit, but particularly analogue types, it tends to produce large amounts of stray coupling which could easily prevent the layout from working at all.

What is often needed is a single-sided board, aided by some link-wires or zero ohm resistors where true single-sided routing is not possible. This type of board is easy for do-it-yourself board production, relatively cheap for commercial production, and gives a good chance of the finished board actually working.



Multirouter II provides good control over the routing strategy via this control panel. The layer control panel is used to select the layers on which tracks can be run, and whether each layer has a vertical or horizontal bias.

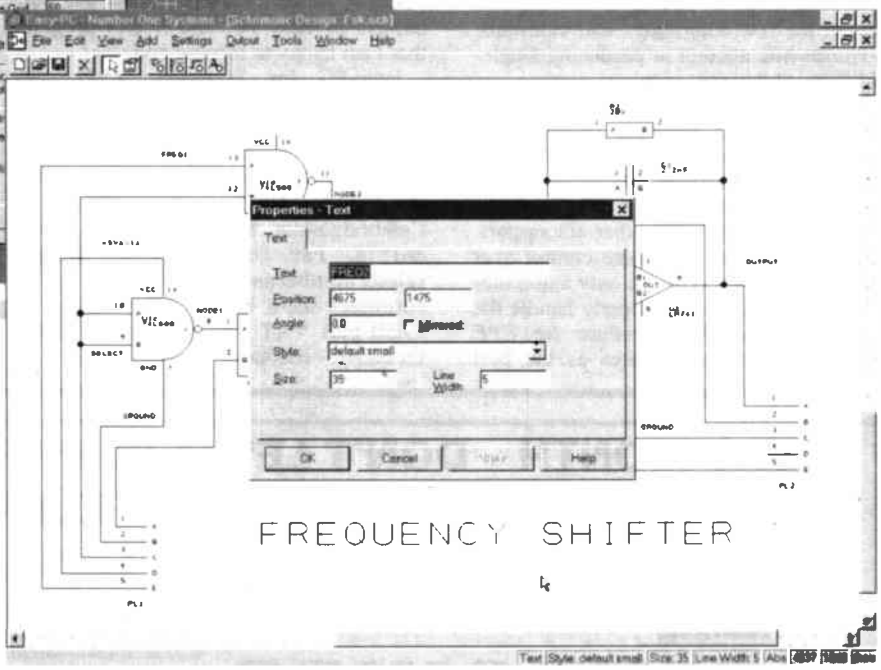
NEW BREED

Multirouter II is one of a new breed of autorouters that tries to do things rather more like a human designer. It has rip up and retry, where a failed attempt to route a track is aborted and a fresh attempt with a different strategy is tried. It also uses shove aside techniques, which can move existing tracks out the way to make room for new ones.

Gridless autorouting enables awkward components having unusual pin spacings to be accommodated. Multi-pass operation enables designs to be refined, with unnecessary track segments being removed, corners being mitred, and where possible, tracks are fattened. Last, and by no means least, it can operate on a single layer with no horizontal or vertical bias on that layer. This permits efficient routing of single-sided boards.

So much for the theory, does it actually produce worthwhile results in practice? As with most autorouters, there are various design rules that can be adjusted in an attempt to get the program to route the board in the desired fashion. Provided the component placement and design rules are sensible, Multirouter II seems to make a good job of things, and avoids excessive use of vias (through-board connections). It is also quite fast, generally taking no more than a few seconds to route simple boards, and a few minutes to route the more complex ones.

As an initial test of the program's single-sided routing capability, I gave it a very simple preamplifier circuit with component placement that made the board very easy to route. With the right design rules Multirouter II produced the intended track pattern, albeit with one or two tracks taking slightly circuitous routes. This may not seem like much of a test, but most autorouters would actually fail to completely route this board, or would go "all round the houses". Trying some more complex circuits produced very good results with both double and single-sided boards.



Right clicking on an object brings up a control panel that provides basic editing facilities such as delete and rotation in 90-degree steps. Selecting "Properties" produces a control panel that permits more precise control. This is the text properties control panel.

MEMORY AND PREVIEW

In addition to the normal router, there are preview and memory autorouters. The memory router is intended for use with boards that have simple repeating track patterns, as found in many memory circuits, and digital circuits in general. In most cases this would only be used to route appropriate sections of a board. It is a rather specialised facility, but one that could be very useful when designing certain types of board.

The preview router is a simple single pass type that can help the user to set up the main router with the optimum design rules. With a fast PC the main router is usually so fast that this facility is not really required, but it could be useful when using an older PC.

MANUALS

Both Easy-PC and Multirouter II are supplied with A5 ring-bound manuals. There are some 290 pages in the Easy-PC manual and 57 pages in the manual for Multirouter II. Both manuals are fairly comprehensive, explaining principles as well as telling you how to operate the program. The Easy-PC manual includes a large section at the back giving details of the component symbols supplied. Both include thorough indexes.

There are also comprehensive on-line help systems included in both programs. Hard copy can be produced via the Windows printer, and users of HPGL compatible plotters will welcome the inclusion of a direct output for plotters of this type. There are also NC drill, Gerber, and DXF outputs, together with parts lists and reports generators. No Windows metafile output facility is available. However, I understand that in the new Version 2 anything added to the clipboard using cut or copy can be pasted into other Windows programs.

TRACK RECORD

Easy-PC is a well-established and much respected program, and for the many existing users who wish to move on to a modern Windows p.c.b. CAD program this new version probably represents the only sensible upgrade path. New users have several other programs in the same price range to consider.

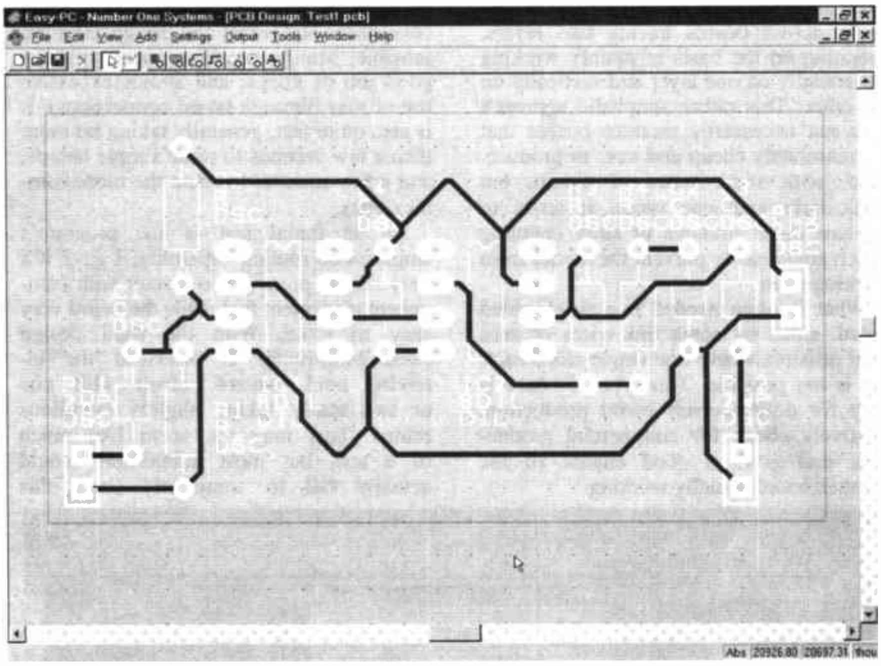
In some minor ways I found Easy-PC a little disappointing. For example, some more buttons on the toolbar could speed up operation of the program. There is plenty of room for them, and plenty of keyboard shortcuts they could replace or augment. *(We understand a ''Zoom All'' button has been included in Version 2. Ed.)*

One of the big selling points of Easy-PC has always been the ease with which new users could learn to use it. I certainly found that it was easier to learn than other p.c.b. CAD programs of similar capabilities, and new users should be able to start using it in earnest almost immediately. It proved to be entirely stable during the test period, with no crashes, Windows error messages, or odd happenings.

Although Easy-PC does not stand out from the crowd, it compares quite well with other p.c.b. CAD programs, and having moved on to Windows 95 software it is the one that I will probably use from now on. Unfortunately, the price tag is probably too high for most home users, but there is now a limited version of the software which can be used for designs containing the equivalent of over thirty 16-pin i.c.s, i.e. 500 pins.

Multirouter II *does* stand out from the crowd. This is a seriously clever piece of software that seems to reach the pads that other autorouters cannot reach! Apart from producing efficient two layer boards, it is one of the few autorouters that can make a worthwhile attempt at producing single-sided board designs.

With most autorouters you have little real control over the way the board is routed, and have to accept things the way the program does them. Multirouter II attempts to route boards in a more sophisticated fashion than most other autorouters, and also gives the user more control over the finished result. It is the only autorouter I have tried that could properly handle the single-sided boards I produce for *EPE* projects, and certainly rates as the best program of this type that I have tried so far. I think that Multirouter II might be the deciding factor for some prospective purchasers of Easy-PC, and it is a program that I am happy to recommend.



Using the right routing options enables single-sided boards to be auto-routed. Some of the tracks in this preamplifier take the "scenic route", but Multirouter II has found what is essentially the right track pattern.

Easy-PC for Windows (£595 plus VAT), Multirouter II for Windows (£295 plus VAT), Easy-PC 500 (£245 plus VAT) and MultiRouter II 500 (£150 plus VAT) are available from Number One Systems Ltd., Harding Way, St. Ives, Cambridgeshire, PE17 4WR (Tel. 01480 461778, Fax 01480 494042, E-mail: **sales@numberone.com.** For mail order customers there is a delivery charge of £7.50 plus VAT. Upgrades are available for earlier versions of both programs.

A working demo of Easy-PC for Windows Version 2 can be downloaded from the Number One Systems web site at **http://www.numberone.com**

The demo on the FREE CD-ROM given away with this issue of *EPE* is for the earlier Version reviewed here.

SPECIAL OFFER

EPE readers can get a 20 per cent discount on Easy-PC 500 and Multirouter II 500 if they purchase them before the end of 1998. Just mention this review, the prices are then £196 plus VAT and £156 plus VAT respectively. Don't forget to add the VAT and £7.50 plus VAT for mail order delivery.

15-WAY INFRA-RED REMOTE CONTROL

MAX HORSEY

PCB DESIGNS BY TOM WEBB

Part Two

Increase your control options with this 15-way coded IR Transmitter and Receiver system.

LAST month we described a unit based around a 38kHz modulated system, which offers the range and reliability associated with commercial infra-red (IR) control systems. Several set-ups were described, amongst them a 4-way latching or momentary system, which makes it possible to transmit two or more "ways" at the same time.

The 15-way system described now employs a multiplexing arrangement. Open collector transistor outputs are provided at the receiver, to enable the user to control whatever is required, either directly, or via relays.

15-WAY TRANSMITTER

The transmitter circuit is the same as that described last month, except that the data inputs are encoded in binary fashion to provide 15 ways, as shown in Fig.1.

The circuit diagram illustrates how 15 push-to-make switches are connected to four points, labelled Data 8 to Data 11. This numbering system conforms with the data inputs (D8 to D11) of the HT12B encoding device shown in Fig.4 (Transmitter system circuit) last month.

Note that the switches labelled S1 to S4 in last month's Fig.4 are not required and should not be confused with the switches in the 15-way circuit.

One side of all the switches in Fig.1 is connected to 0V. Each switch is joined to the appropriate combination of data points via a matrix of diodes. To take one example, if S4 is pressed, then Data 10 goes low, but the diodes prevent any other data points from being affected.

When Data 10 at the Transmitter (HT12B pin D10) goes low, the equivalent data output at the Receiver shown in Fig.2 goes high. We will see later how a high at pin D10 is made to activate Output 4 at the Receiver.

Returning to Fig.1, if S6 is pressed, then Data 10 goes low again, but Data 9 also goes low. Hence pins D10 and D9 both go high at the receiver, and this activates Output 6. We are effectively counting in binary, with receiver pins D8 to D11

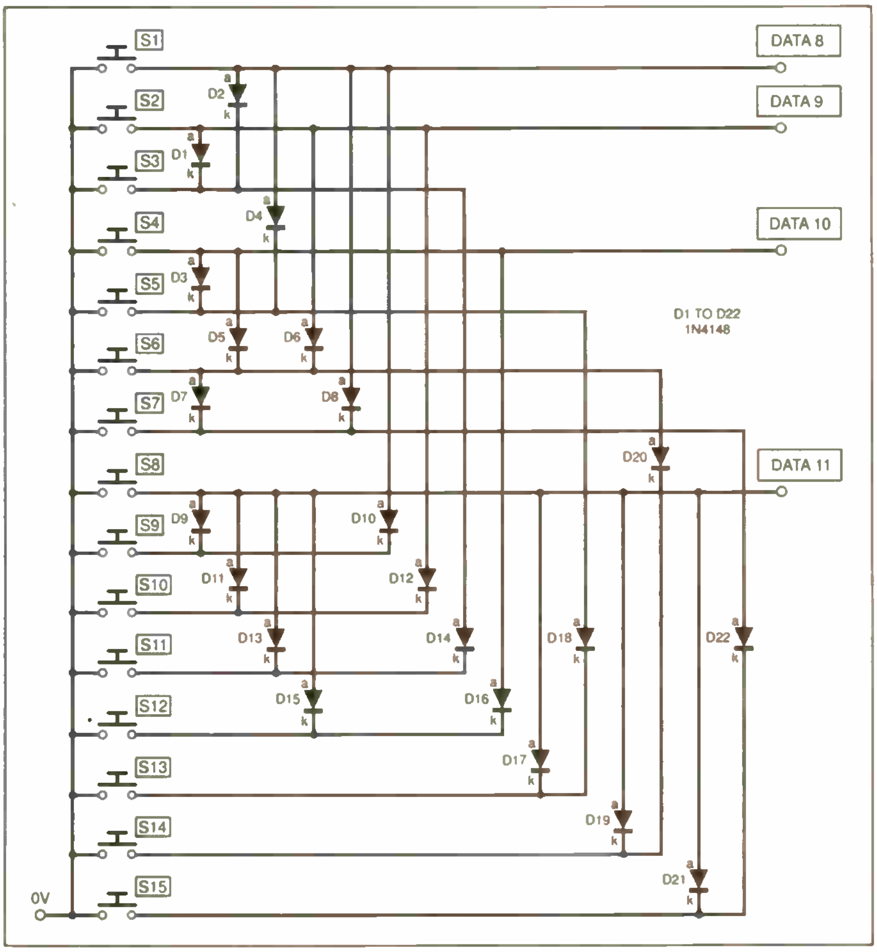


Fig.1. Circuit diagram for 15-way switching matrix. This circuit is incorporated, with some simple amendments, to last month's Transmitter.

representing values of 1, 2, 4 and 8 respectively. Table 1 illustrates the principle, in which logic 0 is represented by 0V and logic 1 is about 5V.

15-WAY RECEIVER

The 15-way Receiver and Decoder circuit diagram is shown in Fig.2. It is similar to the 4-way receiver shown last month, except that the data output pins from IC2 (D8 to D11) are connected to the control inputs A, B, C and D on the multiplexer/demultiplexer IC4.

This device behaves like a rotary switch, the position of the switch being controlled by the logic state of inputs A, B, C and D. For example, if A is at logic 1, and the other inputs at logic 0 then the switch will be set to position 1, shown as output X1 in Fig.2. In other words pin 1, the centre pole (moving contact) of the imaginary switch inside IC4, connects with pin 8.

If the inputs A, B, C and D count up in binary, the pole (pin 1) of the switch "moves" through the various ways shown as X1, X2, X3 etc. Note that when inputs A, B, C and D are all at logic 0, output X0 is active. Hence there are actually 16 outputs if this is included.

The outputs X0 to X15 can be used to drive light emitting diodes (l.e.d.s) directly (via current limiting resistors), or anything requiring a similar current (up to about 15mA). If l.e.d.s are required they can be wired across the pads on the printed circuit board (p.c.b.) intended for the base/emitter connections of the transistors.

Darlington transistors (TR2 to TR17) are shown in the circuit in order to allow switching of an amp or more from each output. Since only one output can be on at any time, a single series resistor (R4) can be used instead of resistors R6 to R21. The latter resistors were included in case some outputs are used for l.e.d.s, and others for buzzers etc. If any resistor is not required, it may be replaced with a wire link.

Table 1: Relationship between Matrix switches, Transmitter and Receiver Outputs.

	TRANSMITTER				RECEIVER				
	D11	D10	D9	D8	D11	D10	D9	D8	
S1	1	1	1	0	0	0	0	1	= 1
S2	1	1	0	1	0	0	1	0	= 2
S3	1	1	0	0	0	0	1	1	= 3
S4	1	0	1	1	0	1	0	0	= 4
S5	1	0	1	0	0	1	0	1	= 5
S6	1	0	0	1	0	1	1	0	= 6
S7	1	0	0	0	0	1	1	1	= 7
S8	0	1	1	1	1	0	0	0	= 8
etc.									etc.

The values of the resistors will depend on the required use. For example, l.e.d. series resistors should be around 220Ω on a 4·5V supply or 680Ω on 12V. If transistors are employed, increase these values by about three to four times.

As in the previous receiver circuits, the regulator IC3 can be omitted if a 4·5V supply is employed. Components R5, TR18, R22 and D1 may all be omitted if a "code detect" indicator is not required.

OPEN COLLECTOR OUTPUTS

Each of the Darlington transistors TR2 to TR17 are *npn* types which turn on when the voltage at the base (b) rises. If ordinary transistors are employed, such as BC108 or BC184L (for small currents) the base voltage required for turn on will be around 0·7V. If Darlingtons such as TIP122 are used, the turn on voltage will be around 1·4V. Darlingtons have the advantage of being able to switch high currents (an amp or more) yet still require only a tiny current at the base.

The collector (c) of each transistor is shown unconnected (open circuit). It is essential to note that any device being powered must be connected between the chosen open collector output and the *positive* supply line. This is because the collector will be "open" when the transistor is turned off, and around 0V when the transistor is turned on.

So, if a relay is required, for example, connect one side of the relay coil to positive and the other side to the appropriate collector. Note that the word "positive" in this instance means the positive supply voltage ***before*** the regulator IC3, i.e. directly to the battery or other power source.

IC1, IC2 and IC4 all operate on a +5V supply from the output of the regulator. Hence the transistors interface the 5V supply with the pre-regulation power supply, enabling 12V relays or solenoids to be employed.

If the regulator IC3 is omitted and replaced with a wire link, the whole circuit may then be operated on a 4·5V supply.

BACK-E.M.F PROTECTION

If relays, motors or similar inductive output devices are used, a diode (such as type 1N4001) should be connected across the output device, with the cathode (k) of the diode on the positive side, to protect against "reverse surges – back e.m.f. (electromotive force) at switch-off. (Note that a band or ring on the diode body indicates the cathode end).

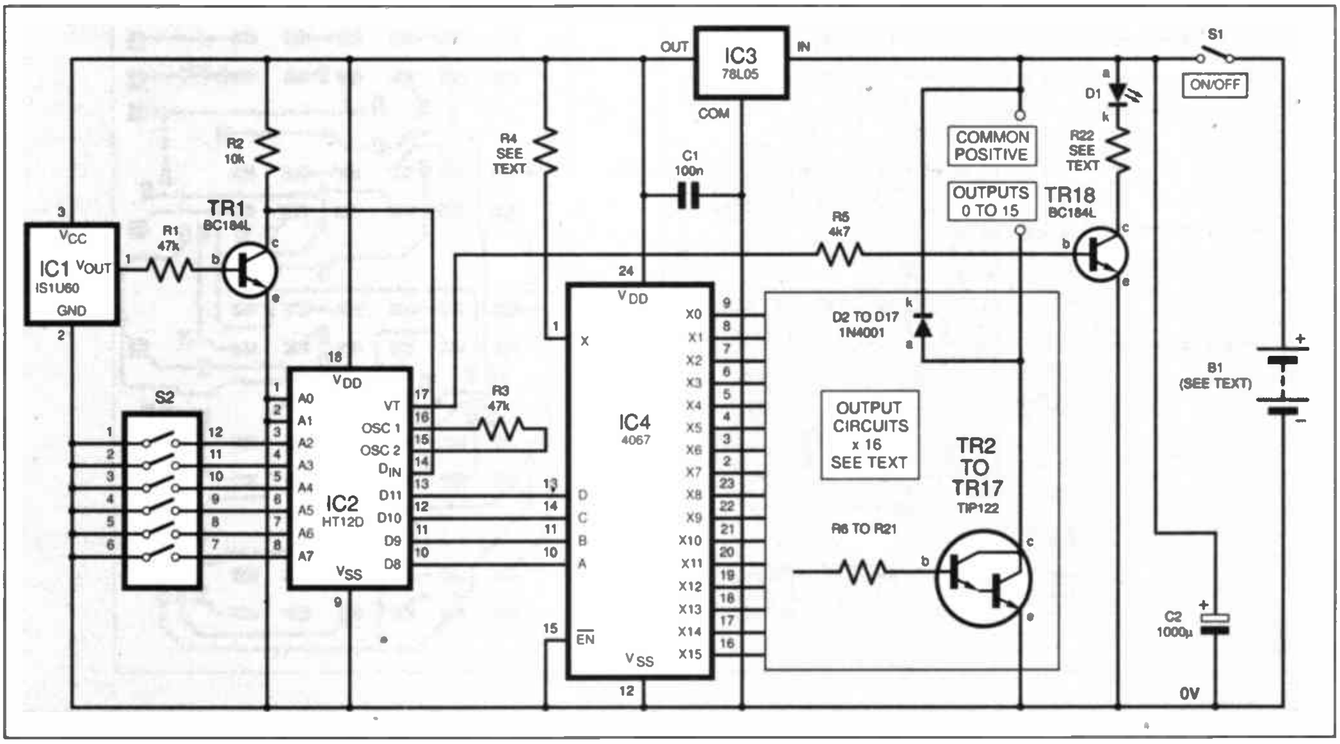
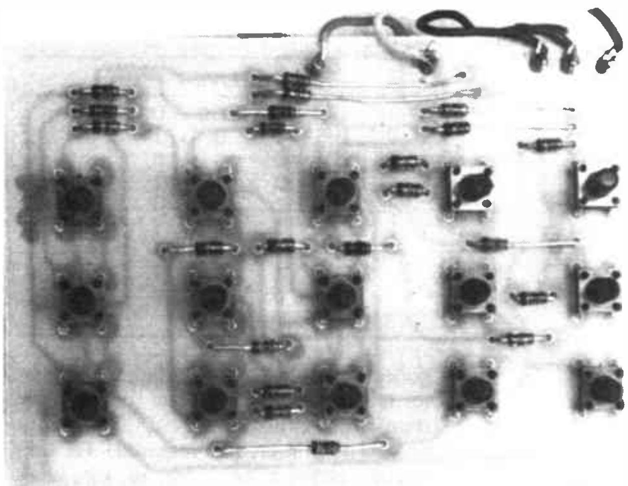


Fig.2. Full circuit diagram for the 15-Way Receiver and Decoder. The inset area (TR2/TR17) is repeated for each output pin of IC4.



Layout of components on the 15-Way Switch Matrix board. The l.e.d.s belong to the Transmitter p.c.b.

TRANSMITTER CONSTRUCTION

Switches S1 to S15 and diodes D1 to D22 are mounted on a separate p.c.b., (the *Matrix* board) as shown in Fig.3. This board is available from the *EPE PCB Service*, code 211(15-Way Matrix).

It may be more convenient to insert the diodes in the p.c.b. before the switches. Ensure that they are fitted the correct way round.

Next, construct the Transmitter p.c.b. as shown last month in Fig.6, but without its switches S1 to S4. Remember to note which options are required regarding supply voltage and whether S5 (on the transmitter p.c.b., not the switches p.c.b.) is required.

As with last month's transmitter, the coding switches (S6) will probably not be required unless you wish to frequently change the code. If you have built more than one infra-red control system, you will need a different code on the second Transmitter/Receiver system. This can be achieved by inserting an extra wire link across a pair of pads intended for S6, or by soldering in S6 and setting one or more ways to *on*.

When the transmitter board is complete, insert connecting wires as shown in Fig.4 so that the matrix switches p.c.b. may be linked with the transmitter p.c.b.. The two p.c.b.s are placed back-to-back, with an insulating piece of plastic or card between them to prevent a short circuit.

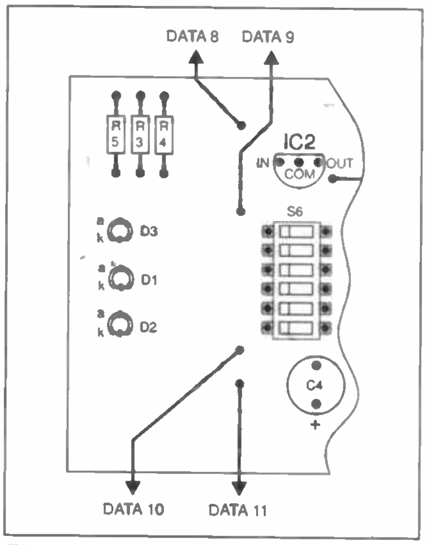


Fig.4. Printed circuit board connections/amendments to last month's Transmitter.

COMPONENTS

TRANSMITTER

See SHOP TALK Page

Resistors

R1	4k7	
R2	10M	
R3 to R5	4Ω7 (3 off) (see text)	

All 0.25W 5% carbon film or better.

Capacitors

C1, C2	100p ceramic disc (2 off)
C3	100n ceramic disc
C4	470μ radial elect. 16V

Semiconductors

D1 to D3	infra-red l.e.d. (3 off)
TR1	TIP122 *npn* Darlington
IC1	HT12B coded IR-transmitter
IC2	78L05 +5V regulator (see text)

Miscellaneous

S5	min. s.p.d.t. toggle switch (see text)
S6	6-way d.i.l. s.p.d.t. slide switch module
X1	455kHz ceramic resonator

Printed circuit board (Transmitter) available from the *EPE PCB Service*, code 205 (trans.); plastic case with battery compartment, 145mm × 78mm × 34mm; 18-pin d.i.l. socket; battery and holder (see texts); connecting wire; solder, etc.

SWITCH MATRIX

Semiconductors

D1 to D22	1N4148 signal diode (22 off)

Miscellaneous

S1 to S15	min. push-to-make switch (15 off)

Printed circuit board (Matrix) available from the *EPE PCB Service*, code 211 (Matrix), insulating card to suit.

Approx Cost Guidance Only £25

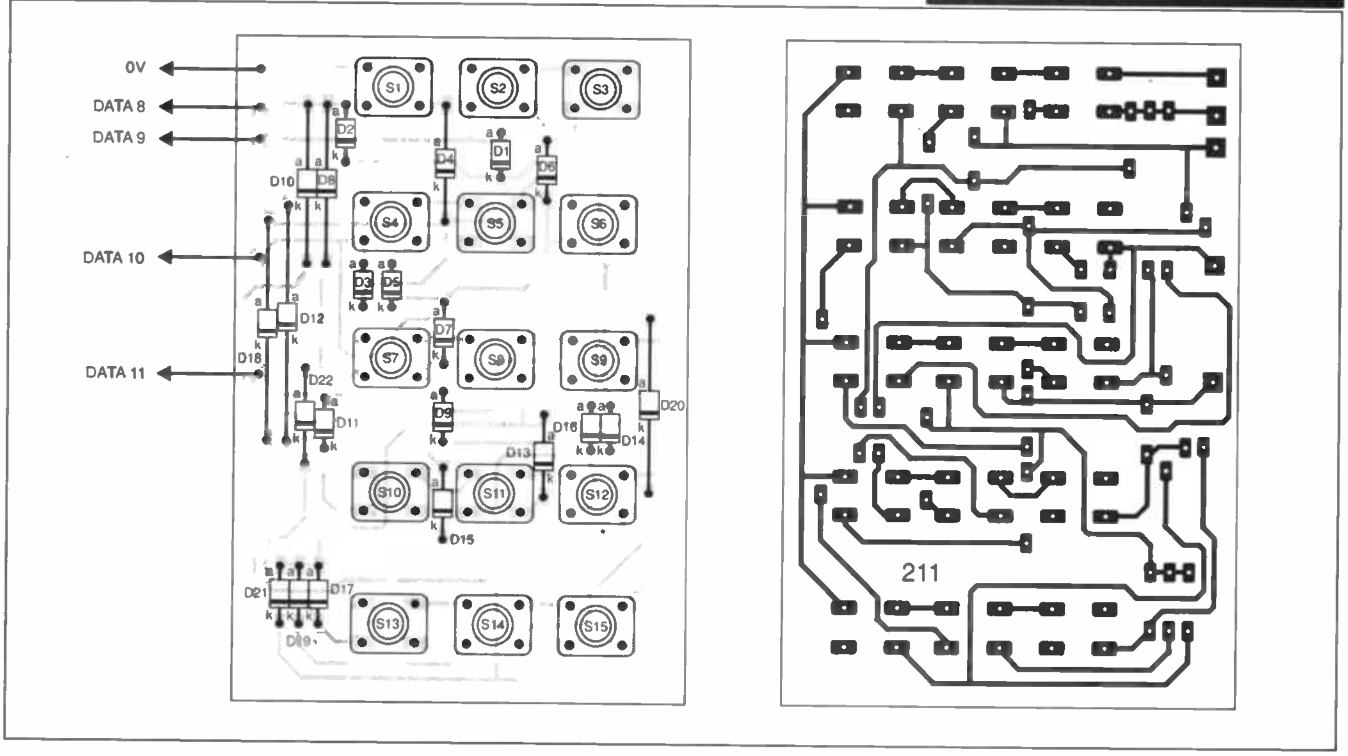
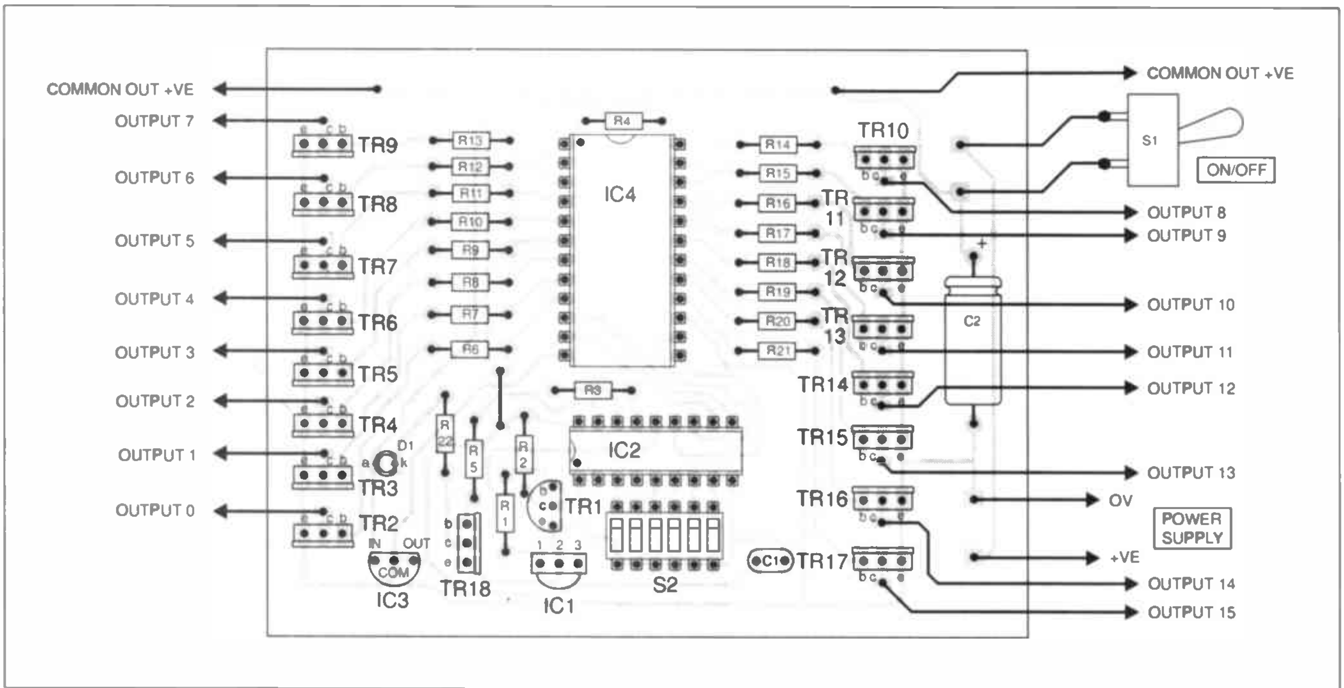


Fig.3. The 15-way Switch Matrix printed circuit board component layout and full size copper foil master. The Data lead-off wires link to the Transmitter board (last month) as indicated in Fig.4.



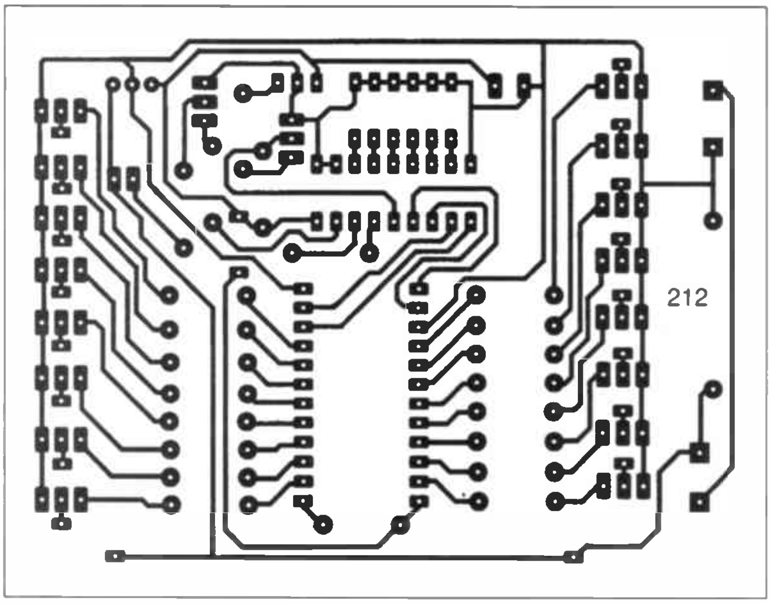


Fig.5. Receiver/Decoder printed circuit board component layout, wiring and full size underside copper foil master pattern.

RECEIVER CONSTRUCTION

Now construct the 15-way Receiver board, as shown in Fig.5. This board is available from the *EPE PCB Service*, code 212 (15-W Rec/Dec).

Ensure that the various options have been considered. For example, if a 12V supply will be used, fit regulator IC3. Omit IC3 and link its In/Out pads on the board if a 4·5V supply is to be employed.

Consider how many outputs are required, and whether an output current of up to about 10mA is sufficient, in which case Darlington transistors TR2 to TR17 are not required.

Resistor R4 is provided in case the current required by all outputs is the same. For example, if only a set of l.e.d.s is required, a single resistor (R4) can be fitted, and resistors R6 to R21 omitted. The current for the l.e.d.s will then be taken directly from the outputs of IC4. The pads which are joined to the outputs from IC4, and intended for R6 to R21, make convenient connecting points.

The cathodes (k) of the l.e.d.s may all be connected to 0V via a single wire. There will be a number of spare 0V points on the p.c.b. if the transistors are not employed.

If a variety of currents is required then fit a wire link in place of R4, and fit resistors R6 to R21 as required. In the prototype, a mixture of l.e.d.s and transistors was used (as seen in the photographs), and so various resistor values were fitted. For example, on a 12V supply a typical resistor value for an l.e.d. is 680Ω, and 2k2Ω for a transistor base. The suggested values for a 4·5V supply are 220Ω for the l.e.d. and 680Ω for the transistor base.

One source of confusion may be the pads labelled "COMMON OUT +VE". These are positive (from the battery or power supply), and are intended for any device which is operated via the transistors. Alternatively, a device which is connected directly from any output of IC4 must be connected to 0V. As stated, a number of pads are available on the p.c.b. which are joined to 0V.

The point made about the code switches in the Transmitter also applies here, and

COMPONENTS

15-WAY RECEIVER

Resistors

R1, R3	47k (2 off)
R2	10k
R4, R6 to R21	see text
R5	4k7
R22	680Ω for 12V, 220Ω for 4·5V

All 0.25W 5% carbon film or better.

See SHOP TALK Page

Capacitors

C1	100n ceramic disc
C2	1000µ axial elect. 16V

Semiconductors

D1	red l.e.d.
D2 to D17	1N4001 rectifier diode (16 off) (see text)
TR1, TR18	BC184L *npn* transistor (2 off)
TR2 to TR17	TIP122 *npn* Darlington transistor (16 off) (see text)
IC1	IS1U60 or PIC12043 sensor/receiver
IC2	HT12D decoder
IC3	78L05 +5V 100mA regulator (see text)
IC4	4067 1-to-16 way analogue multiplexer

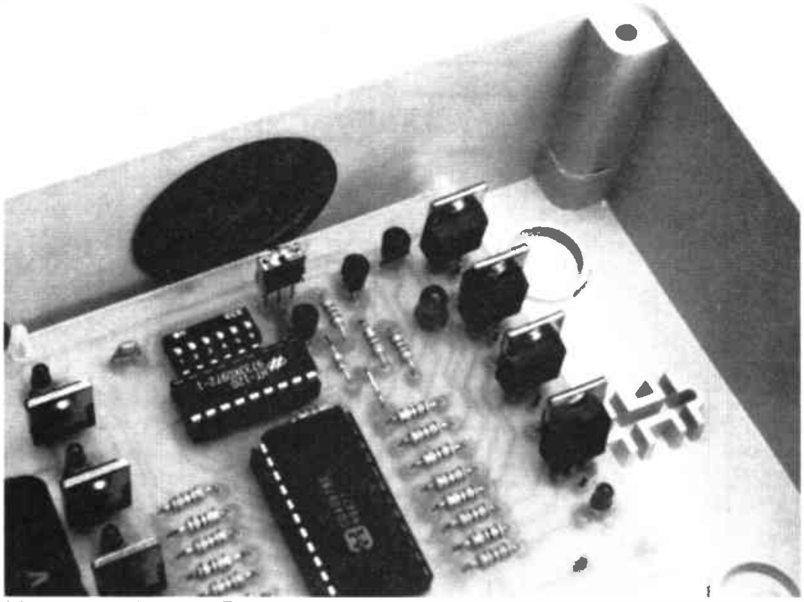
Miscellaneous

S1	min. s.p.s.t. toggle switch
S2	6-way d.i.l. s.p.s.t. slide switch module

Printed circuit board (Receiver), available from the *EPE PCB Service*, code 212 (15-W Rec/Dec); plastic case with clear lid, 152mm × 113mm × 72mm approx; p.c.b. mounting pillar (4 off); connecting wire; solder, etc.

Approx Cost Guidance Only £38 excluding case

The completed Receiver housed in a case with a transparent lid. A larger case may be required if "switching" relays are to occupy the same case.



Make sure that the Receiver infra-red sensor, on the p.c.b., aligns with the IR lens and the "beam entry" hole in the side of the case.

remember to have exactly the same arrangement in the receiver with regard to switch mode S2 so that the circuit looks for the correct code.

Begin assembly by soldering in the i.c. sockets, followed by the wire link and small components. Fit the optional components as required, and take care with the polarity of electrolytic capacitors and transistors. The transistors are unlikely to require heatsinks.

Fit the delicate IR sensor IC1, either directly to the p.c.b., with the bulge facing the outside, or via wires. Remember that the infra-red beam must be able to "see" the sensor when installed in a case.

Fit the necessary connecting leads and insert the i.c.s.

TESTING

When the receiver is turned on, output X0 (pin 9 of IC4) should be at about 3V to 4V. This should make Output 0 active, assuming that no IR signal is being received. If this is not the case, check the power supply connections on IC4 (pins 24 and 12) for a reading of 5V (or 4·5V if battery power is used). A 12V reading suggests a serious problem and the circuit should be switched off immediately before damage to IC1 and IC2 is caused. In this event, check the connections to regulator IC3 carefully.

If all is well so far, aim the transmitter l.e.d.s at the front of the receiver module (there is a small bulge at the front). Place the two units about a metre apart. See if pressing a button on the transmitter causes any reaction at the receiver.

If TR18 and its associated components have been fitted, l.e.d. D1 will indicate the presence of a correctly coded signal. Otherwise, test the voltage on the VT pin (pin 17) on IC2 of the receiver. It should be at 0V but change to about 5V when a signal is received.

Should the VT test fail, check that the receiver (IC1) is fitted the correct way round, with its bulge facing the outside edge of the p.c.b. Now check the voltage on the pins of IC1. Pin 3 should be positive, and pin 2 at 0V.

When a signal is not received, pin 1 (the output pin) should be at just under 4V. When a signal is received this voltage should fall by about 1V. Note that as the signal is oscillating, a voltmeter provides a rather approximate guide to voltage. If an oscilloscope is available, it should be possible to view the encoded signal, in which case the trace will rise and fall between 4V and 0V.

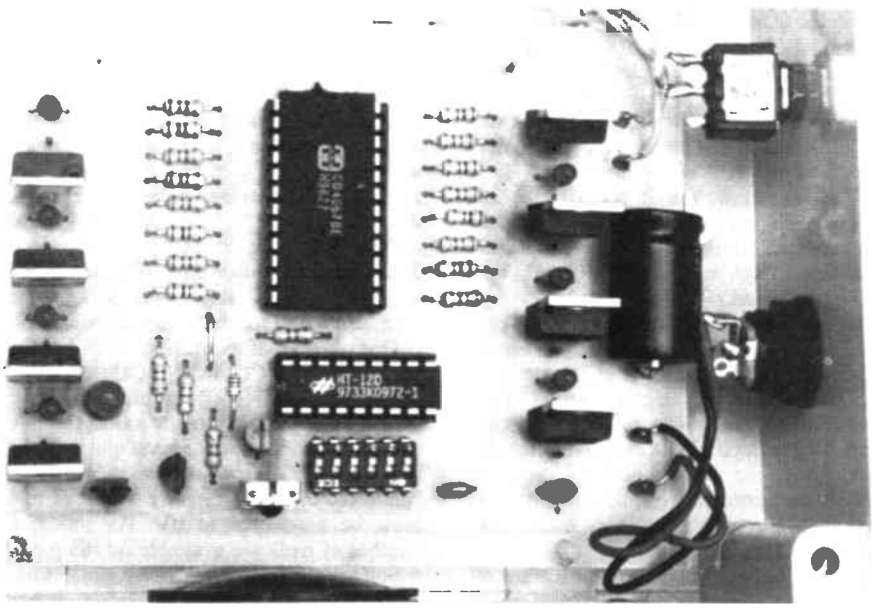
If this test fails, try sending a signal from a remote control unit belonging to a TV or similar. The signal will not be decoded, but you will at least know if IC1 is working and hence determine if the fault lies in the transmitter or receiver assembly.

If the output from IC1 is working, test the signal at the Data In (pin 14) of IC2 on the receiver. It should be at about 0V when no signal is received, rising to about 1·3V on a voltmeter. An oscilloscope will show that the signal actually pulses to about 5V.

Pushing switch S1 on the transmitter should make pin D8 on IC2 of the receiver switch to about 5V, S2 should switch D9, S4 should switch D10, and S8 switch D11. Other switches should cause different combinations of the outputs from IC2. Check that the voltages on these outputs are copied correctly to IC4.

Note that Output 0 on the receiver is only active at switch on, or if the transmitter is in non-latching mode.

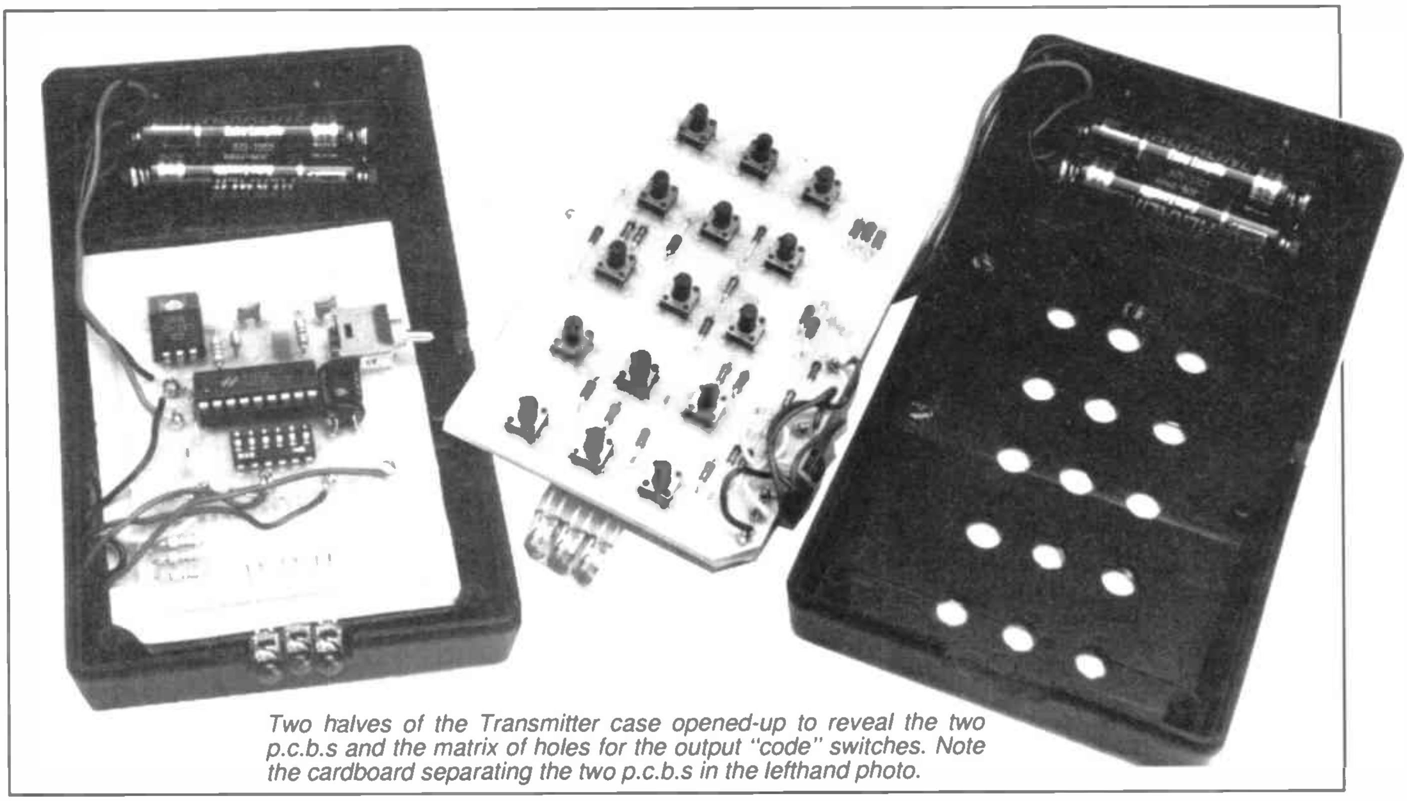
If the outputs from IC4 are working correctly, remember that the outputs from the transistors (if fitted) are either open circuit or at 0V. Normal voltmeter tests are not possible. Instead, connect the positive side of the voltmeter to positive (e.g. the "COMMON OUT +VE" point on the p.c.b.) and use the negative lead of the voltmeter as a probe to test the outputs.



Layout of components on the completed Receiver p.c.b.

TRANSMITTER TESTS

It is difficult to test the transmitter (see last month) fully unless an oscilloscope is available, in which case the code can be checked at the D_{OUT} (pin 17) of IC1. A similar but inverted code should appear at the collector of TR1 and (if the IR l.e.d.s are the correct way round, and the series



Two halves of the Transmitter case opened-up to reveal the two p.c.b.s and the matrix of holes for the output "code" switches. Note the cardboard separating the two p.c.b.s in the lefthand photo.

resistors are of the correct value) a signal will be transmitted.

An oscilloscope will also determine if the resonator (X1) is oscillating.

Voltmeter tests are confined to checking the power supply across IC1 (pins 18 and 9). This should be around 3V to 5V. Data pins D8 to D11 should be high unless an appropriate switch is pressed, in which case the voltage should change to about 0V. Note that the series diodes will cause a voltage drop, sometimes preventing the appropriate data pin falling fully to 0V. This should not present a problem.

COMMON PROBLEMS

Typical mistakes include dry joints and bridged pads – i.e. adjacent pads accidentally joined with solder. Further mishaps include failing to insert wire links. For example, do not forget the wire link bridging IC3 In/Out pads if a regulator i.c. is not used. Also check that all the polarity conscious components are the correct way round.

TRANSMITTER CASE

A number of suitable boxes are available on the market, many with battery compartments and a suggested layout is shown in the photographs. Very careful alignment is necessary for the holes made for the switches to project through the case.

Make a photocopy of the p.c.b. layout diagram, fasten it to the case and drill through the appropriate points.

The IR l.e.d.s should be bent over so that they project the beam through holes made in the end of the case.

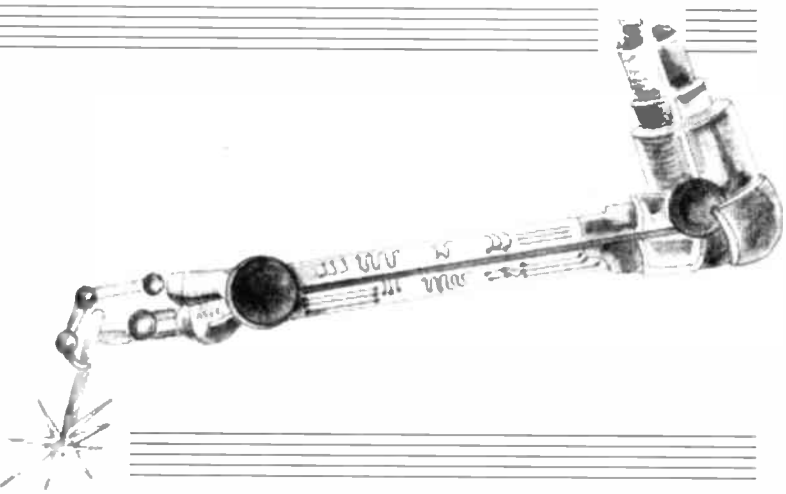
RECEIVER CASE

Any suitable case may be used for the receiver, and a suggested layout is shown in the photographs. However, if 15 relays are required, a much larger case may be necessary!

If the IR sensor is mounted on the p.c.b., take care to position the p.c.b. opposite a suitable hole drilled in the case, for the IR beam to penetrate. A red filter or red lens may be fitted over the hole on the inside of the case; this is for cosmetic rather than performance reasons.

If any relays are required to operate mains equipment, a piece of insulated p.c.b. material or plastic sheet *must* be fixed into the case to make a *separate* compartment for the mains wiring. □

CIRCUIT SURGERY



ALAN WINSTANLEY

This month, our in-house "Surgeon" examines some causes of power supply ripple and checks out the use of buffer circuits.

Ripple of Applause

Here's a query related to power supply ripple, which highlights some issues concerning the layout of power supply circuits. ***Mr. S. Fox*** of Epping writes:

I have been interested in making a variable voltage supply for some time now, and I have been using a circuit with an L200 regulator i.c. However, for one reason or another, I get 30mV of ripple measured on my oscilloscope, which is something I'm trying to sort out. In all the circuits I've seen, whatever method they use to obtain a d.c. voltage from the mains, there is no mention of ripple.

The other point I'd mention, while writing, is that these days it seems one must have some sort of engineering facility since most items are contained in metal containers. This is rather beyond me so I construct most things in wood. I was doing this over 60 years ago when our pocket money was in pence (pre-decimal old money!) rather than in Pounds as would seem today.

Your query on "ripple" first. Ripple is the unwanted a.c. variation superimposed on top of a smooth d.c. voltage. On an oscilloscope, a d.c. voltage will display as a constant straight line over time, but a close look will often reveal alternating peaks and troughs mixed in with it. This can be caused by a number of factors. The ripple content (in millivolts) is one spec. to look for in d.c. power supplies - the lower, the better.

However it's uncommon to see specifications for ripple quoted in regulator data sheets, because ripple can be introduced by a combination of factors which are beyond the control of the regulator manufacturer. It's over to my creaking bookshelves – SGS-Thomson produce the L200 and luckily I have a copy of the "SMART Power" Application Manual, which includes the makers' design notes on this device.

The L200 is a positive variable voltage regulator which includes a current limiter. It provides up to 2A at 2·85V to 36V. The output voltage is fixed with two external resistors and the current with one low-value resistor. Hence, the regulator is housed in a 5-lead Pentawatt package. The operation of the L200 was described in a special feature article by Andy Flind in the July 1998 issue. Also, see Andy's *Float Charger* design in the August 98 issue for a typical application circuit.

Matters of Performance

Like many regulators, the performance of the L200 depends greatly on the design of any printed circuit board or interwiring layout. There are various ways in which ripple can be introduced or affected, including:

1. Insufficient power supply smoothing,
2. Poor regulation of a transformer
3. Poor choice of transformer secondary voltage
4. Layout and wiring considerations
5. I.C. bypassing.

In the case of (1), too small a smoothing capacitor could provide inadequate smoothing and introduce ripple. Provided that the regulator does not "bottom out" this is not a problem, because the regulator will output a d.c. straight-line voltage.

It is possible though for a regulator to come out of regulation if there is insufficient input voltage (to overcome the regulator dropout voltage), so any ripple present on the input will also appear on the output. You should allow sufficient "headroom" on the input side to overcome the drop-out voltage of the device under worst case conditions, to ensure that the device continues to regulate properly.

In (2), a transformer regulation of up to 33 per cent is not uncommon on the smallest sizes, so when the load current increases, the transformer's peak output voltage will fall. Usually the transformer manufacturer ensures the secondary voltage is as specified when running at full load. This means a higher off-load voltage is present across the transformer secondary to compensate.

If the regulation is poor, if you're not careful with your choice of transformer voltage (3) then again there is scope for the regulator to "bottom out" – come out of regulation – and ripple will appear on the output.

Layout considerations (4) are in the constructor's hands, and this is where you can most influence the ripple content of the voltage. If a circuit is being constructed on a p.c.b. then at higher outputs, the layout of the copper track becomes quite critical if ripple and noise are to be minimised.

The L200 is a multi-pin package with separate pins for the reference and current limiting feedback. The manufacturer's data recommends that the track connecting pin 3 (ground) and any resistor on pin 4 (voltage reference) must be kept as short as possible, and should not be crossed by the load current.

Also, there must not be any "impulsive" currents between pin 3 and the negative output terminal of the circuit, because these will increase the ripple. Layout apart, inadequate copper track or wiring thickness could also introduce resistance which adds to the ripple.

For (5), using another device as an example, National Semiconductor warns against introducing resistance between the output and the "adjustment" pin of its LM317K, because this can affect load regulation. *Ripple rejection* is specified in dB, and is often expressed in the form of a series of graphs. National Semiconductor defines load regulation as the line regulation (change in [regulator] output voltage for a change in input voltage) for a.c. signals at a given frequency and a specified value of bypass capacitor on the reference bypass terminal.

In the case of the common LM317, ripple rejection is about 65dB without any bypass capacitor, and improves (85dB) when a 10μF bypass capacitor is fitted between the "adj." pin and 0V. A 10μF tantalum is usually the optimal choice for the bypass capacitor.

Tool Case

Turning to your point about instrument cases, it's true that the cost of plastic moulded boxes can be daunting and also that a bench and a modest number of hand tools are needed to perform some of the mechanical work. (I illustrated the entire prototyping process in my series "*Build Your Own Projects*" in the November 96 to March 97 issues.)

However, it can cost a manufacturer several tens of thousands of pounds in tooling costs to design and mould a complex plastic box, even though the intrinsic value of the plastic itself can be measured in pence and grammes. You're paying for the tooling depreciation and maintenance costs as much as anything, and even I hesitate to purchase nice plastic boxes because of the one-off costs.

I wish you continued success with your wooden boxes!

Buffers for Beginners

My thanks to ***Sivasubramanian Pathmanathan*** in Japan who asked for the low down on "buffers":

"What is a buffer? When are they used? Could I have a brief explanation of the function and use of buffers?" (By E-mail.)

A *buffer* is an amplifier circuit which ideally has an infinite input impedance, and also a low output impedance. They are used in between stages of a circuit, usually acting as a current amplifier to enable a comparatively heavy load to be driven by the preceding stage.

Buffers include ordinary bipolar or MOS transistor switches that you might couple to a logic gate, in order to drive an external load such as a relay, solenoid, loudspeaker, indicator and so on. You could class a MOSFET power transistor, hooked to the output pin of a logic gate or a 555 timer, as a buffer.

Buffers are also produced in dual-in-line packages which contain several Darlington-type transistor drivers that can be used for interfacing a low-power circuit to the outside world. Examples include the ULN2001 range, which contain seven *npn* Darlington transistors (these have a very high gain, which means they require negligible input current to turn each transistor hard on) and can supply roughly 500mA to the load.

You often see Darlington "arrays" like these used for powering external solenoids, indicator lamps and light-emitting diode displays. Some types are classed as TTL/CMOS compatible, which means that they are guaranteed to work with ordinary 5V logic, remembering that a 5V TTL logic "high" can be as low as 2·7V: a logic-compatible device knows how to cope with this.

One in a Million

If you don't actually need seven buffers in one package, then you could use any of a number of MOSFET transistors to interface a low-power circuit to a load. MOSFET transistors are voltage-driven switches which use so little gate current you can ignore it.

However, manufacturers such as Zetex (famed for their small but spirited bipolar E-line ZTX transistors) will argue convincingly that bipolar technology is still an excellent choice over MOS in many applications. Indeed, the ZTX range of transistors combines high capacity with small package size and they make very good buffer/interface devices.

An interesting driver which has been around for over 20 years is the (bipolar) LM395 produced by National Semiconductor. At the time, it was marketed as a power transistor with a gain of a million, and was produced in a TO-3 can as the LM395K. The present version LM395T has a TO-220 package (hence the "T") but still incorporates the protection circuitry which we now all take for granted.

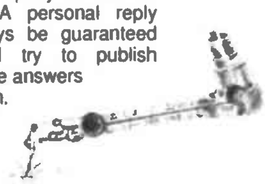
It can be treated like a blow-out proof power transistor – it even looks like one. As always with this type of protected device, you should check any heatsinking arrangements closely to ensure the device doesn't shut down prematurely due to thermal overload.

The National LP395Z is a scaled-down version made in a small plastic transistor package which handles up to 100mA. They are relatively cheap and form ideal buffer transistors especially if a "fail safe" protection is needed to protect the load or the circuit. You can fetch details of these devices from the National web site (**www.national.com**) and the LM395T or LP395Z are listed by Farnell, RS Components, and others.

You can, incidentally, buy a CD ROM directly from National Semiconductor in the USA. It contains tons of data sheets and application notes for National's devices. It costs US$4.00, takes about a week to arrive and is great value. Check their web site.

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.



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

SHOP TALK
with David Barrington

PhizzyB Computers

Great care should be taken when selecting parts for the *PhizzyB Computer* projects. This applies particularly to the capacitors, where lead spacing is critical if they are to fit on the p.c.b., the "null modem" serial cable and the specified semiconductor devices.

It is most important that the OKI 82C55A2 chip and the Toshiba TC55257 SRAM device are used. These were purchased from **Farnell** (☎ *0113 263 6311*) codes 391-207 and 700-939 respectively. They also supplied the null cable, code 976-880.

We have made special arrangements to supply, through our *PCB Service*, a ready-programmed PhizzyB microcontroller, the full working version of the CD-ROM and the screen-printed printed circuit board. These are priced at £14.95 *each*, see page 836.

We have just received the news that **Magenta** (☎ ***01283 565435***) are putting together a full kit of parts for "PhizzyB". We should make it clear that they will *only supply full kits* or ready-built units. The kit is priced at £131.95 including VAT plus £3 for post and packing. A ready-built PhizzyB will cost £149.99 plus £3 p&p. Extras include the lead £3.99 and a plug-top p.s.u. £3.99.

PIC Tape Measure

Not much to report concerning components for the *PIC Tape Measure* as most items should be readily available from your usual local suppliers. One point to note, the 40kHz ultrasonic transducers are normally only sold as pairs and prices do seem to vary, so shop around. The ones in the model came from RS, codes 307-351 (tran.) and 307-367 (rec.). They are also listed by **Maplin** as code HY12N.

For those readers who do not have the facilities to program their own PIC chips, a ready-programmed PIC16C84 microcontroller is available from **Magenta Electronics** (☎ ***01283 565435***) for the sum of £12 all inclusive.

If you do intend to do your own programming, the software listing is available from the Editorial Offices on a 3·5in. PC-compatible disk, see *EPE PCB Service* page 836. There is a nominal admin charge of £2.75 each (UK), the actual software is *Free*. For overseas readers, the charge is £3.35 surface mail and £4.35 airmail. If you are an Internet user, it can be downloaded *Free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/TapeMeasure**. It is also on the *Free* CD-ROM with this issue.

T-Stat Electronic Thermostat

Most items needed for the various options of the *T-Stat Electronic Thermostat* should be stocked by most of our component advertisers. The exceptions could be the relay and the zero-crossing triac opto-isolator.

The 25A relay is an expensive item, around £18, and was purchased from **Maplin**, code MG36P. (On checking their supply, we were informed they had three left but more were due soon.) They also supplied the heatsink (code FL42V), opto-isolator (code RA56L) and the transient suppressor (code HW13P).

The Room Stat printed circuit board is available from the *EPE PCB Service*, code 208 (see page 836).

15-Way Infra-Red Remote Control

The main components for the *Transmitter* were covered in last month's issue, which just leaves us with the *15-way Switch Matrix*. Suitable "tactile" pushswitches for the transmitter's add-on matrix p.c.b. are available from **Maplin**, code KR90X and **Rapid Electronics** (☎ ***01206 751166***), code 78-0610. Most of our component advertisers should be able to offer suitable alternatives.

When ordering parts for the *15-Way Receiver*, it might be worthwhile asking for a discount on the TIP122 power Darlington – you might be lucky, try **Greenweld**. As mentioned last month, the semiconductors came from: ISU60 – **Electromail** (☎ ***01536 204555***), code 577-897; PIC12043S – **Farnell**, code 491-380; HT12D – **Maplin**, code AE18U. Both printed circuit boards are available from the *EPE PCB Service*, codes 211 (Matrix) and 212 (15-W Rec.).

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128 pages Order code EP1 £2.45

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF EPE.

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Deals with the simple methods of copying printed circuit board designs from magazines and books, and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.
66 pages **Temporarily out of print**

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The preamplifier circuits include low noise microphone and RIAA types, a tape head preamplifier, a guitar preamplifier and various tone controls. The power amplifier designs range from low power battery operation to 100W MOSFET types and also include a 12 volt bridge amplifier capable of giving up to 18W output.
All the circuits are relatively easy to construct using the p.c.b. or stripboard designs given. Where necessary any setting-up procedures are described, but in most cases no setting-up or test gear is required in order to successfully complete the project.
100 pages **Temporarily out of print**

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H. C. Wright
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The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.
Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.
72 pages Order code BP278 £3.50

25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll
Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.
This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.
Much information is also given on shortwave bands, aerial directivity, time zones, dimensions etc.
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TWO EXCITING NEW BOOKS

Specially imported by *EPE*

Bebop To The Boolean Boogie

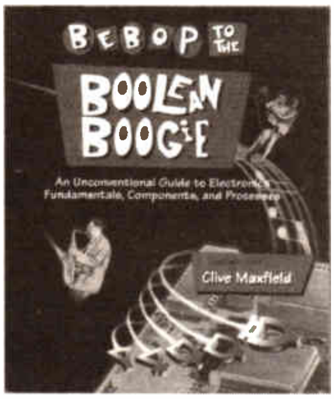
By Clive (call me Max) Maxfield

ORDER CODE BEB1 **£24.95**

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 forewamed, 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: re-reading 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 Kamaugh 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

ORDER CODE BEB2 **£29.95**

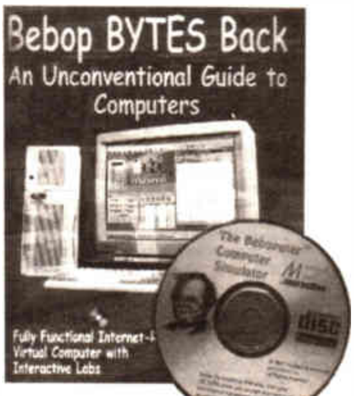
An Unconventional Guide To Computers

Plus **FREE CD-ROM** which includes: Fully Functional Internet-Ready Virtual Computer with Interactive Labs

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!

Audio and Music

VALVE & TRANSISTOR AUDIO AMPLIFIERS NEW
John Linsley Hood

This is John Linsley Hood's greatest work yet, describing the milestones that have marked the development of audio amplifiers since the earliest days to the latest systems. Including classic amps with valves at their heart and exciting new designs using the latest components, this book is the complete world guide to audio amp design.

Contents: Active components; Valves or vacuum tubes; Solid-state devices; Passive components; Inductors and transformers; Capacitors, Resistors, Switches and electrical contacts; Voltage amplifier stages using valves; Valve audio amplifier layouts; Negative feedback; Valve operated power amplifiers; Solid state voltage amplifiers; Early solid-state audio amplifiers; Contemporary power amplifier designs; Preamplifiers; Power supplies (PSUs); Index.

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A must for audio enthusiasts with more sense than money!

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Ian Waugh

In this practical and clearly-written book, Ian Waugh explains all aspects of the subject from digital audio basics to putting together a system to suit your own music requirements. Using the minimum of technical language, the book explains exactly what you need to know about: Sound and digital audio, Basic digital recording principles, Sample rates and resolutions, Consumer sound cards and dedicated digital audio cards.

On a practical level you will learn about: sample editing, digital multi-tracking, digital FX processing, integrating MIDI and digital audio, using sample CDs, mastering to DAT and direct to CD, digital audio and Multimedia.

This book is for every musician who wants to be a part of the most important development in music since the invention of the gramophone. It's affordable, it's flexible, it's powerful and it's here now! It's digital and it's the future of music making.

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AN INTRODUCTION TO PIC MICROCONTROLLERS
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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A. Flind
Extensive coverage is given to circuits using capacitors and resistors to control frequency. Designs using CMOS, timer i.c.s and op.amps are all described in detail, with a special chapter on "waveform generator" i.c.s. Reliable "white" and "pink" noise generator circuits are also included.
Various circuits using inductors and capacitors are covered, with emphasis on stable low frequency generation. Some of these are amazingly simple, but are still very useful signal sources.
Crystal oscillators have their own chapter. Many of the circuits shown are readily available special i.c.s for simplicity and reliability, and offer several output frequencies. Finally, complete constructional details are given for an audio sinewave generator.
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Explains electronic control theory in simple, non-mathematical terms and is illustrated by 30 practical designs suitable for the student or hobbyist to build. Shows how to use sensors as input to the control system, and how to provide output to lamps, heaters, solenoids, relays and motors.
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B. B. Babani
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R. M. Marston
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R. A. Penfold
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A BEGINNERS GUIDE TO CMOS DIGITAL ICs
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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All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.
This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.
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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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Vivan Capel
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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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SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY

WELCOME to the November issue of *Net Work*, our monthly column written especially for Internet users. Phew, what a month! It's a very exciting time for us all at *EPE*, as we present our first ever *free* CD-ROM which contains a range of electronics software, the entire *EPE* project software library, plus of course a trial version of the exclusive PhizzyB Simulator.

The Internet and Bees

The Internet played a major role in the production process of our free CD-ROM No.1. This has been jointly mastered in the UK and the USA, with E-mails flying fast and furiously between the two countries during the design process of the CD. In fact, if you read my introduction to the PhizzyB series, you will see how the Internet was actually responsible for bringing the creators of the PhizzyB and ourselves together: events date back to the days of a 14.4 internal fax/modem running on a (then) state of the art 486 PC with DOS-based Internet E-mail software, when Demon Internet had under 20,000 users – which is one tenth of their current customer base. The world wide web barely existed at user level at that time, nor did CD writers or even a humble Zip disk. How things have moved on.

An Internet web browser also plays a pivotal role in running the free CD-ROM on readers' personal computers. A browser is used to display the contents of the disk, and most experienced users will not have any difficulties running the CD. Note that at no time do you need an Internet connection to enjoy the material included on the CD though, and just in case if you don't have a browser installed on your Windows PC, we've included a free version of Navigator 4, courtesy of Netscape Communications. Regular FTP site users will immediately recognise the layout of the *EPE* PIC files, which we've reproduced on the CD, and we've even included some future project source codes too!

In Series

In order to run a real hardware PhizzyB on your personal computer, you must have an available serial port, which must either be COM1 or COM2, so check your serial port settings (in W95 – right mouse-click on My Computer, then go Properties/ Device Manager/Ports to check your COM port setup). Most importantly, you must have a null modem cable to interconnect your PC and PhizzyB. Such cables have pins 2 and 3 (Tx/ Rx) crossed over internally. Be sure to check the special new PhizzyB pages on our web site, and hop over to Maxfield & Montrose Interactive Inc. in the USA at **www.maxmon.com**.

New this month on the FTP site are the source codes for the *PIC Tape Measure* project, available from **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/TapeMeasure**. It is also on the CD-ROM in the PICS folder, along with several files relating to future projects – including the forthcoming *Mind PICkler* and *Midi Pedal* constructional projects, which will be published on the FTP site when the projects are launched.

FTP Confusion

This month's message is: try not to confuse our FTP site with our web site! Looking closely at our web statistics, these tell me not only the number of "hits" – averaging nearly a million a year – but also the "misses" – files which have not been found. There are a remarkable number of attempts to search for (e.g.) "PIC" files on the web site. Users enter the URL as pub/PICS/<whatever> in search of elusive source codes, but this is unfortunately a waste of time; you need the full FTP site address, which is a completely different URL from the web server. Previous *Net Work* columns have covered how to use FTP in great detail, either from the DOS prompt or by using FTP clients, although one or two frustrated users still berated me for making the process of FTP "unnecessarily difficult".

I must say that by using decent software such as WS_FTP Pro for Windows, or Fetch for Macintosh, the process of FTPing a file is as easy as using File Manager in Windows 3.1, dragging files from one drive to another. The fact that the drives could each be 12,500 miles apart and connected by a phone line, becomes irrelevant! Once again – the address for the FTP server is:

ftp://ftp.epemag.wimborne.co.uk

You can type this – the entire URL (Uniform Resource Locator) – into your web browser. Then click on the folder icons etc. to navigate to **pub/PICS** to access our microcontroller files. You could actually practice this using this month's free CD-ROM: insert it into your CD drive, then open your web browser. Do not connect to the Internet, instead simply type a URL like:

D:\Html\infoepe.htm

into your browser, where "D" is your CD-ROM drive letter.

Some users may not know that they can use their browser as a file viewer to access local files on their hard drive, merely by typing the drive letter as a URL. You can now practice opening folders and navigating around the disk to your heart's content, before connecting to the Internet and going for the real thing on our FTP site!

Drop in for a Chat!

The rest of this month's *Net Work* is devoted to the latest updates on our web site (**http://www.epemag.wimborne.co.uk**). By the time you read this, the *EPE Chat Zone* will have been in operation for several weeks. It's a popular type of interactive bulletin-board messaging system which enables you to post messages as new subjects, or to follow up any messages already there.

The messaging system is refreshed in virtually real-time, although if you post into the *Chat Zone* and then fail to see your new message appearing in the message board, please remember to hit the refresh button of your browser. The *Chat Zone* will then be updated in your window, displaying your message.

Aye-UP

We want everyone to enjoy using the *EPE Chat Zone*, which is devoted to electronics-related material including views, comments and queries about general electronics matters and the magazine itself. A common-sense Acceptable Use Policy or "AUP" is available on-line and it is preferred that users are familiar with its contents before posting into the *Chat Zone*. (As the current office joke goes: Why was Alan's Acceptable Use Policy written in Yorkshire? Because it's an Aye-UP. Thanks Ed.)

The AUP also permits readers to post "small ads." in the form of Want to Buy (WTB) or For Sale (FS) messages in relation to electronic equipment or components, although such transactions are conducted entirely at the users' own risk (the AUP offers further guidance). **Commercial advertising is not permitted, nor is any form of spam-like unsolicited mailing.** There are further specific rules regarding language and abuse, all of which is regulated by the AUP. The *EPE* staff cannot necessarily guarantee to reply to individual queries in the *Chat Zone* but we do drop in from time to time so you never know! So be sure to check into the *EPE Chat Zone* next time you're surfing the net over in our direction.

Electronic Links

My word count having defeated me, I have again included a selection of interesting electronics links on this month's on-line version of *Net Work*. I will be pleased to receive any suggestions – you'll be credited on the *Net Work* page and links are also indexed in the *Net Work* A-Z Best of the Net. E-mail **alan@epemag.demon.co.uk**. My own Home Page is **http://homepages.tcp.co.uk/~alanwin**.

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exists to help electronics enthusiasts by personal contact and through a quarterly Newsletter.
For membership details, write to the Secretary:
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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

On-line readers! Try the new EPE *Chat Zone* – a virtually real-time Internet "discussion board" in a simple to use web-based forum!

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