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# VINYL TO CD PREAMPLIFIER

TERRY de VAUX-BALBIRNIE

*Clean up those old records, dust down that turntable and let's get burning!*

**D**O YOU have a collection of old vinyl records? If so, you might wish to transfer them to CDs. By doing this, you will preserve their value because you will only need to play them once.

It may even be possible to enhance the sound by removing some of the background noise and clicks which are found on worn recordings. If you have a CD player in your car or own a portable unit, you will also be able to play your work "on the move".

## SYSTEM REQUIREMENTS

To transfer a recording to CD, you need a computer with a Compact Disc writer installed. Many new machines, of course, already have one of these. If yours is not so equipped, you will find that fitting a CD "burner" module is inexpensive and straightforward.

You do not even need a particularly modern machine. A Pentium 133MHz PC may suffice but a new up-to-date machine will be much quicker (that is, produce a CD at the higher speeds allowed by the writer). Before purchasing any hardware, it is important to check compatibility with the supplier/manufacture.

To record sound files on to the hard drive before transferring them to a CD will require quite a lot of spare capacity. If your drive is almost full, you will need to back up files in order to clear sufficient space. To record stereo tracks in 16-bit resolution at 44.1kHz (CD quality) you will need some 600MB for one hour of work and you could run into trouble if you do not have at least 800MB available.

## METHODOLOGY

It is not a good idea to link the record deck to the computer sound card *direct* by plugging it into the microphone input. Some people have done this thinking, quite correctly, that a magnetic cartridge provides a low-level output comparable with that of a dynamic microphone. Although this may work, the results will be very disappointing. This is because no *equalisation* has been applied to the signal. It will be found that the

copy recording is deficient in bass (low frequencies) but have excessive treble (high frequency content). In other words, it will sound very "tinny". More will be said about equalisation presently.

A better method would be to use an existing hi-fi amplifier. The record deck would be plugged into its "Phono" input and a Line (high level) output obtained at the back (the one used for tape recording). This would be connected to the line input on the sound card using a piece of twin-screened wire fitted with the appropriate connectors. The phono connection would provide the necessary equalisation.

Unfortunately, many modern amplifiers make no provision for playing "old fashioned" vinyl discs. You may therefore find that it has no phono input. Even if you do have a suitable amplifier, it may need a long connecting lead to reach the computer station and this could result in hum pick-up and degraded performance.

## OVERVIEW

The circuit described here is a small battery-operated stereo preamplifier which provides equalisation and boosts the output

of a magnetic cartridge to line-level. There are also Scratch and Rumble filter push-button switches. These may be used to reduce the effects of surface clicks and low-frequency motor or turntable noise respectively.

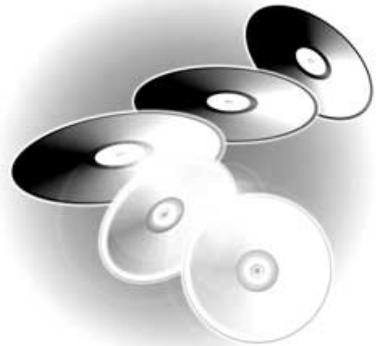
As well as being useful for making CDs, the preamplifier will be found handy by enthusiasts who simply wish to play their vinyl records using a hi-fi amplifier that does not have a phono input. Some readers may even use it for tape or Mini Disc work or for making MP3 files to be sent over the Internet.

In operation, the circuit requires some 40mA and the four AA size cells housed internally will provide up to fifty hours of service. A front panel mounted i.e.d. indicator requires some 15mA so, if the user can be trusted to switch the unit off after use, the i.e.d. may be omitted. This would give a significant increase in battery life. For extended periods of use, a larger battery could be placed externally.

***This unit must not be powered using a mains-derived low-voltage supply (such as a plug-in adaptor).***

## MORE EQUAL THAN OTHERS

Returning to the topic of equalisation, this must be applied if analogue recordings are to be reproduced with any degree of



fidelity. To understand why this is necessary, you need to know something about the recording process.

Imagine the sound has three "bands" comprising the *low*, *intermediate* and *high* frequency content. When the groove was cut in the master disc, the low frequency part was reduced in level (volume) while the high frequencies were increased. Only the intermediate band was left unchanged.

Leaving the low frequencies as they were in the original sound would have required more violent movements of the groove cutter (that is, heavier modulation). This would have produced a wider groove and a consequent reduction in available playing time. Also, the playing stylus might have difficulty following such a groove and it may tend to jump out. By reducing the level of the low-frequency sound, it is possible to obtain a uniform groove width and a longer playing time.

Equalisation is the process by which the high and low frequency content from the cartridge are restored to their original state and, in theory, should be an exact mirror of that used during recording. Note that by restoring the high frequencies, the surface noise present during playback (which is made up chiefly of high frequencies) is reduced. It thus provides a simple means of noise reduction.

## MAINTAINING STANDARDS

Unfortunately, different equalisation standards have existed regarding the values of the cut-off frequencies defining the low, intermediate and high bands and also the degree of "cut" or "boost". The same circuit will therefore not provide perfect results with all records.

However, most vinyl discs produced since the 60s have followed the RIAA (*Recording Industry Association of America*) standard. In practice, an equaliser designed for this standard will also provide good results when applied to recordings using a different one (*American Standard Record* and *British Micro-groove* format). It should also be suitable for 78s.

Practical equalisation circuits can range from the simple (which provide only a coarse correction) to the very complex. This circuit lies somewhere near the middle of the range and provides good results without special adjustment.

The graph shown in Fig.1 illustrates the ideal (theoretical) RIAA equalisation compared with that provided by this circuit. Note that this is for illustration only and is not drawn to scale.

The section to the left-hand side labelled "A" provides a "roll-off" of frequencies below some 10Hz. This reduces the "rumble" that is transmitted from the motor or turntable bearing to the cartridge through the turntable. This is much more pronounced

with a cheap unit and without such a "cut" would be accentuated due to the low-frequency boost made during equalisation.

Before proceeding to construct this circuit, check that you have a good quality record deck available. This must be fitted with a *magnetic* cartridge (not a ceramic one). If you wish to transfer 78 r.p.m. records, make sure your turntable will operate at this speed (many are designed for 33/45 only) also that it is fitted with the correct type of stylus.

## CIRCUIT DETAILS

The full circuit diagram for the Vinyl To CD Preamplifier is shown in Fig.2. This is built around three identical dual low-noise operational amplifiers (op.amps) – IC1a/IC1b, IC2a/IC2b and IC3a/IC3b.

Equalisation of left and right channels is centred around IC1 and IC2 respectively, while IC3 is a "straight" amplifier which boosts both channels to line level.

It is only necessary to describe the action of one channel (the left-hand one) since the other is the same. Note that the component numbering for the right-hand channel is prefixed with a "one hundred". Thus, R2 (left) corresponds with "R102" (right). Components which are common to both channels, the i.c.s, switches and input/output sockets are numbered as if they belonged to the left channel.

## NON-INVERTING AMPLIFIER

The first section of the circuit is a non-inverting amplifier IC1a. The signal obtained from the input cartridge (left-hand channel) at SK1 is applied to the non-inverting input, pin 3, via capacitor C2 (or C1 and C2 in parallel if Rumble switch S1a contacts are closed).

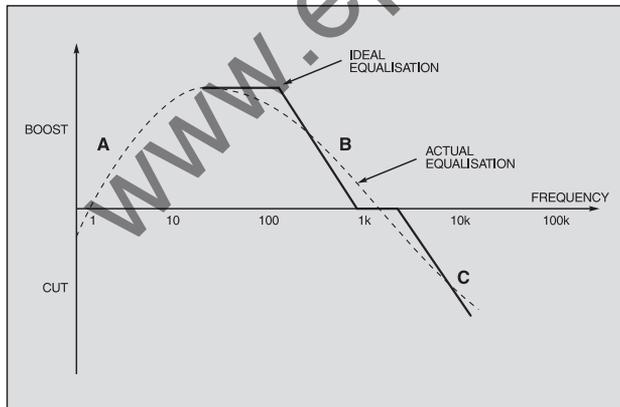


Fig.1. Equalisation graph (not to scale): a) roll-off; b) fall-off and c) high frequency filtering.

This, in conjunction with fixed resistor R3, determine the anti-rumble characteristics of the circuit (the roll-off below 10Hz labelled "A" in Fig. 1). Resistor R3 also sets the input impedance making it suitable for a standard magnetic cartridge.

Anti-rumble processing comes about because the impedance of capacitor C2 rises as the frequency falls. High frequency signals will then flow more easily through resistor R3 and hence through capacitor C3 (which has a relatively high value and therefore negligible impedance at these frequencies) to OV.

It is, therefore, the higher-frequency signals which develop a greater voltage at IC1a pin 3. In other words, the low frequencies tend to be filtered out.

With the Rumble switch contacts closed, the pair of capacitors C1 and C2 give the same effect as a single unit having a larger value. This decreases the overall impedance and the circuit rolls off at a lower frequency.

## OPERATING CHARACTERISTICS

The output of IC1a at pin 1 is connected to its inverting input (pin 2) through the parallel arrangement of resistor R5 and capacitor C4. This works in conjunction with resistor R4 to set the gain.

The other end of R4 is connected to the mid-point of a potential divider consisting of equal-value resistors R1 and R2. This sets a d.c. voltage nominally equal to one-half that of the supply – that is, 3V. This provides a "zero" reference so that the a.c. input signal will rise and fall with respect to it.

If the reference was a true 0V (the voltage of the 0V supply line), the negative half-cycles of the wave would not be amplified. This is because the output voltage cannot fall below 0V. As it is, the output signal will swing above and below the 3V level.

Ignoring the effect of capacitor C4 for the moment, the gain of this section is approximately eight times. However, with C4 in place, the impedance of the feedback loop will fall as the frequency rises. This reduces the gain at higher frequencies and provides the "fall-off" characteristic shown by Fig.1 section "B".

Section IC1b of the circuit is configured as a unity-gain amplifier (buffer). The signal from IC1a output, at pin 1, passes through resistor R7 (or R6 connected in parallel with it when Scratch switch contacts S2a are closed) to IC1b's non-inverting input at pin 5.

High frequency signals now flow more easily through capacitor C5 (due to its reduced impedance) and hence to a further "false zero" derived from the potential divider made up of resistors R8 and R9. The voltage appearing at IC1b pin 5 will therefore be less than with higher frequencies. The higher frequencies therefore tend to be filtered out (shown by section "C" in Fig.1).

## SCRATCH MY BACK

With Scratch switch S2a contacts closed, resistors R6 and R7 are placed in parallel and provide near-RIAA high-frequency attenuation. With the switch contacts open, resistor R7 alone provides a more dramatic cut-off and provides the "scratch reduction" effect. These values may be experimented with or a "tone control" could be fitted to give a continuously variable effect. More will be said about this later.

The output from IC1b, pin 7, is now equalised but still at a low level. The next section, centred around IC3a, is an amplifier used in inverting mode. This boosts the signal by a large factor making it suitable to drive the line input of a sound card or external power amplifier.

Capacitor C7 allows the output signal from IC1b pin 7 to pass with little loss (due to its relatively low impedance at

## COMPONENTS

### Resistors

R1, R101, R2, R102, R8, R108, R9, R109 2k2 (8 off)  
R3, R103, R4, R104, R10, R110, R11, R111 47k (8 off)

R5, R105, R6, R106 330k (4 off)  
R7, R107 120k (2 off)  
R12, R112 15k (2 off)  
R13, R113 1M5 (2 off)  
R14 270Ω

All resistors 0.6W 1% metal film.

### Potentiometers

VR1, VR101 1M min. enclosed carbon preset, vert. (2 off).

### Capacitors

C1, C101 470n polyester film (2 off)  
C2, C102 330n polyester film (2 off)  
C3, C103, C6, C106 22μ min. radial elect. 16V  
C8, C108 (6 off)  
C4, C104 10n polyester film (2 off)  
C5, C105 2n2 polyester film (2 off)  
C7, C107 1μ polyester film (2 off)  
C9, C109 10pF ceramic (2 off)  
C10, C110 10μ min. radial elect. 16V (2 off)  
C11 220μ min. radial elect. 16V

### Semiconductors

D1 3mm red l.e.d.  
IC1 to IC3 NE5532AN dual low-noise op.amp (3 off)

### Miscellaneous

S1 to S3 d.p.d.t. interlocking push-button switch – see text (3 off)  
B1 6V battery pack (4 x AA alkaline cells)  
SK1 to SK4 phono socket, single hole, panel mounting (see text) (4 off)

Printed circuit board available from the *EPE PCB Service*, code 366; 8-pin d.i.l. i.c. socket (3 off); aluminium instrument case, size 150mm x 100mm x 75mm; battery holder and connector; 3mm l.e.d. clip; screened cable; multistrand connecting wire; solder, etc.

See **SHOP TALK** page



Approx. Cost  
Guidance Only

**£24**

excl. batts. & case

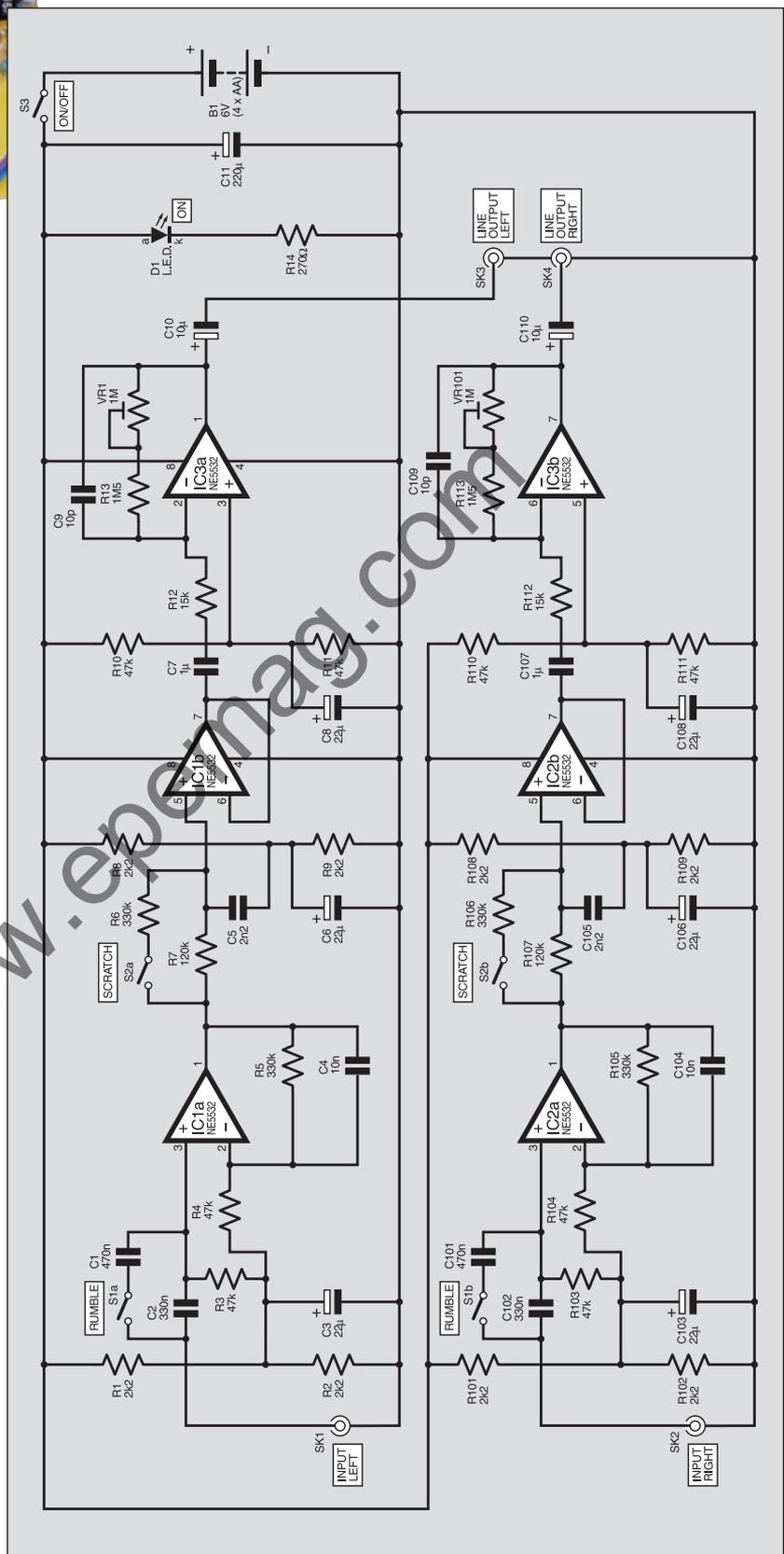


Fig. 1. Complete circuit diagram for the Vinyl To CD Preamplifier.

audio frequencies) through resistor R12 and hence to IC3a inverting input at pin 2. Ignoring capacitor C9 for the moment, fixed resistor R13 connected in series with preset potentiometer VR1 provides negative feedback and, in conjunction with R12, sets the gain.

This will be some 170 times with VR1 set to its maximum value and 100 times at minimum. Preset VR1 will be adjusted at the end to provide a suitable output for the particular cartridge being used.

The value of resistor R13 could be increased to provide a greater gain if this is shown to be necessary at the testing stage. By adjusting preset VR1 in conjunction with its opposite number in the other channel (VR101), the circuit will also be "balanced" to provide equal outputs for both channels.

### PROMOTING STABILITY

Returning to capacitor C9 which appears in IC3a feedback loop, its small value provides an extremely high impedance at audio frequencies. It therefore normally has negligible effect.

However, if radio-frequency signals happen to be picked up by the circuit, the impedance of C9 will be low. This will lower the impedance of the feedback loop and reduce the gain at these frequencies. This prevents instability.

The output signal finally passes from IC3a pin 1, via capacitor C10, to Line Output socket, SK3 (Left channel).

### CONSTRUCTION

Construction of the Vinyl To CD Preamplifier is based on a single-sided printed circuit board. This board is available from the *EPE PCB Service*, code 366. The topside component layout and actual size underside copper foil master pattern are shown in Fig.3.

Commence construction by drilling the three mounting holes as indicated. Solder the spring-loaded, pushbutton switches in position. If the specified type is not available, use toggle or slide units and hard-wire these to the appropriate points on the p.c.b. at the end of construction. Next, solder in position the three i.c. sockets.

Follow with all resistors, preset potentiometers and capacitors – taking particular care over the polarity of the electrolytics. Solder the battery connector to the +6V and 0V points on the p.c.b., again, taking care over their polarity. Adjust presets VR1 and VR101 to approximately mid-track position to provide a medium degree of gain for each channel.

### BOXING UP

*Note that this circuit must be housed in a METAL box to provide adequate screening against hum pick-up.*

Decide on a suitable layout for the internal components. Measure the positions of the switches and l.e.d. on the p.c.b. Mark these on the front panel of the box at the half-height level and drill them through. Mark and drill the p.c.b. mounting holes also those for the battery holder and the input and output sockets.

Cut plastic stand-off insulators to the correct length so that, when the p.c.b. is in position, the switch buttons will pass through their holes with a little clearance.

Secure the p.c.b. and make sure the switches operate freely.

Attach the battery holder and the input and output sockets. If these are of the specified type, you will need to scrape away the paint on the inside surface of the box to allow the outer ("sleeve") connections to make good metallic contact with the case.

Attach one of the solder tags supplied with the sockets under the fixing nut of one of them. This will be used to "earth" the "0V" wire leading from the circuit board.

If you are using sockets of the fully-insulated type rather than the specified pattern, the sleeve connection of *each* must be connected to the case (0V) using a separate solder tag.

Referring to Fig.4 and photographs, complete the internal wiring. Take care that left and right inputs and outputs maintain their identity during the wiring process (that is, they do not become interchanged). Set all switches to the "out" position, insert the batteries and attach the lid of the case.

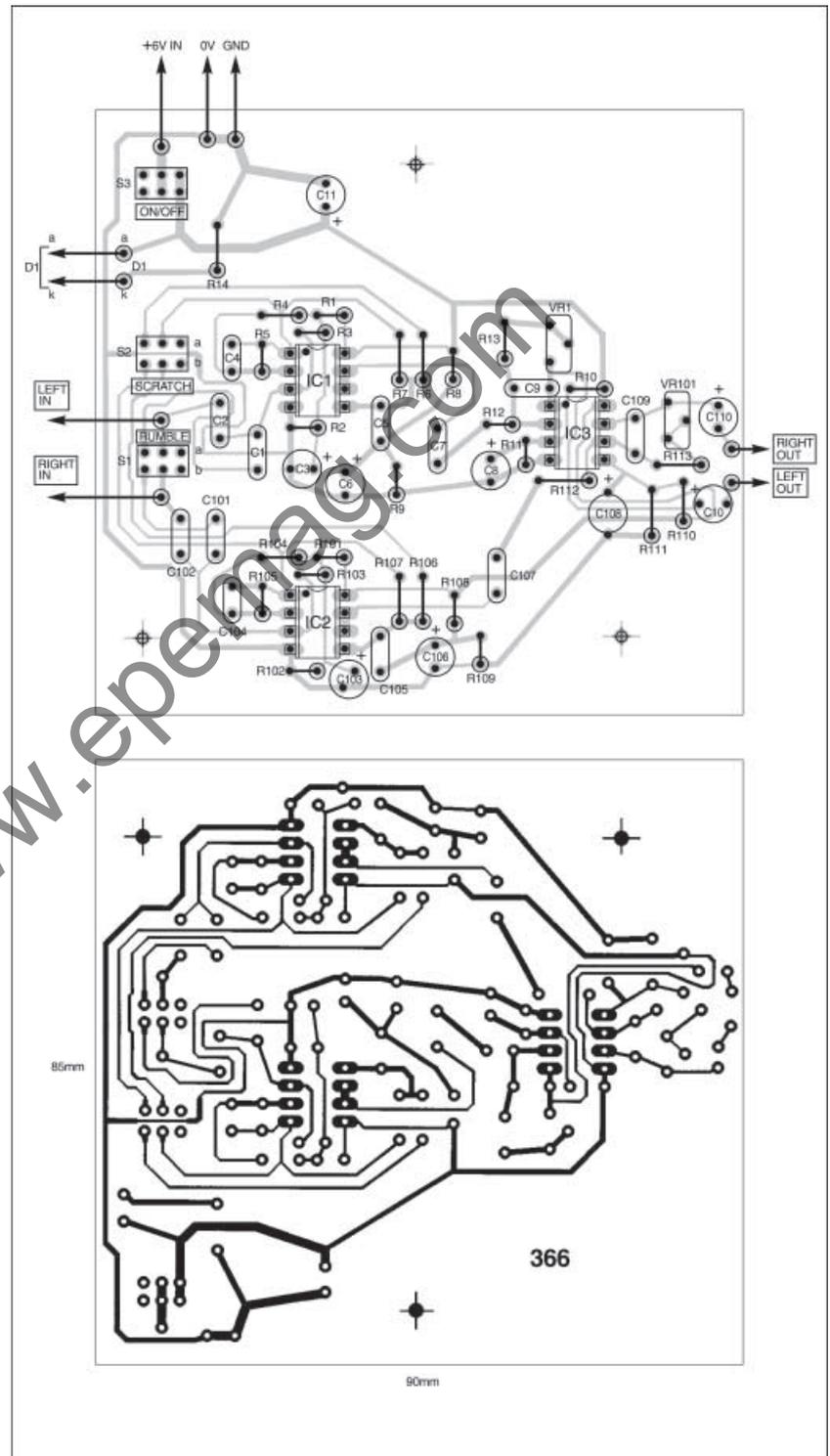


Fig.3. Printed circuit board component layout and full-size underside copper track master pattern for the Vinyl To CD Preamplifier.

## TESTING

Unless the stylus on the record deck is known to have given very little service, renew it. Styli cost very little compared with that of your record collection. Also, a new stylus will give better results. If you are going to transfer 78s you *must* have the correct stylus fitted – *do not use one made for 33s/45s*.

It would be useful to have the turntable manual available to help make optimum stylus pressure and anti-skid adjustments. Sometimes a slightly greater pressure than normal will give better results. Although this wears the record more quickly it may be worthwhile since the record need only be played once.

For initial testing, connect the output of the preamplifier to the line input of a hi-fi amplifier using twin-screened cable fitted with the appropriate connectors. Do *not* connect it to the computer sound card at this stage.

Connect the turntable to the preamplifier input sockets. If possible, use a valueless record to make initial tests. Turn the Volume control on the amplifier to minimum and switch on both units. Check that the front panel l.e.d. operates.

It may be found convenient to use headphones to monitor the sound. Start playing the record and gradually increase the amplifier's volume control. The music should be clearly heard. Compare the volume with that playing similar music from a commercial CD.

If the levels are not similar, adjust VR1 and VR101 so that they are. If one channel is quieter than the other, adjust presets VR1 or VR101 as appropriate to bring the weaker channel to the level of the stronger one. This procedure ensures that the output is at line level and balanced between the channels.

Check the effects of the Scratch and Rumble switches. The rumble effect is very subtle and may not be noticed. Note that, as described, pressing the switches *in* provides the anti-scratch and anti-rumble effects.

## SUBJECT FOR EXPERIMENT

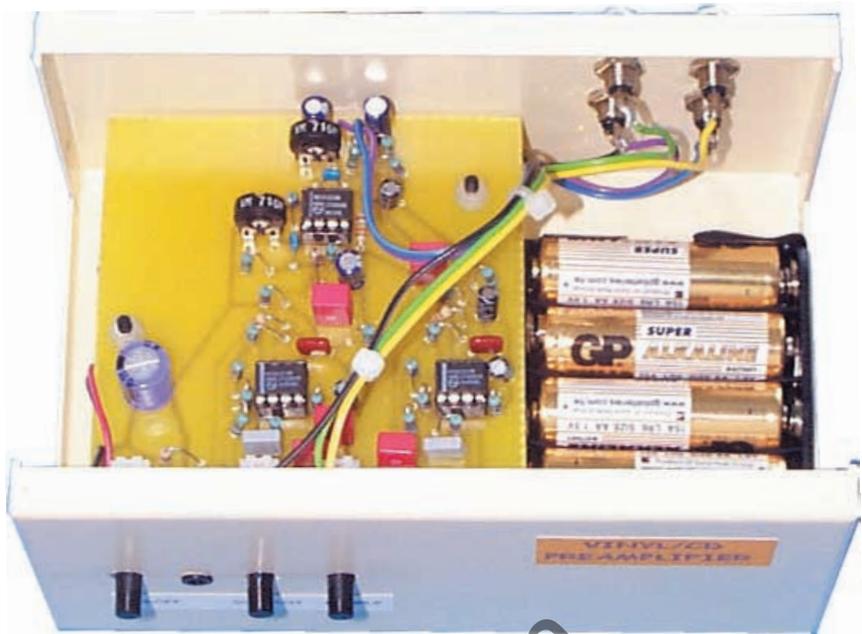
The frequency balance and anti-scratch effects could be altered by changing the value of resistors R6/R7 and R106/R107. By increasing the appropriate resistor values slightly, the high-frequency response will be "cut" and vice versa. Beware – small changes make a lot of difference!

An alternative method would be to replace resistors R7/R107 with a dual-ganged, panel-mounted, potentiometer (stereo). This would allow for continuous variation and switch S2 could then be ignored.

## MAKING TRACKS

When setting up the equipment to make CDs, the turntable should not be placed on the same surface as the computer (otherwise you could introduce hum due to vibration being transferred to the cartridge from the computer). Check that the turntable is "true" using a spirit level.

Connect the preamplifier output to the line input of the PC sound card using twin-screened wire. Check that Left and Right channels are connected correctly.



Layout of components inside the metal case.

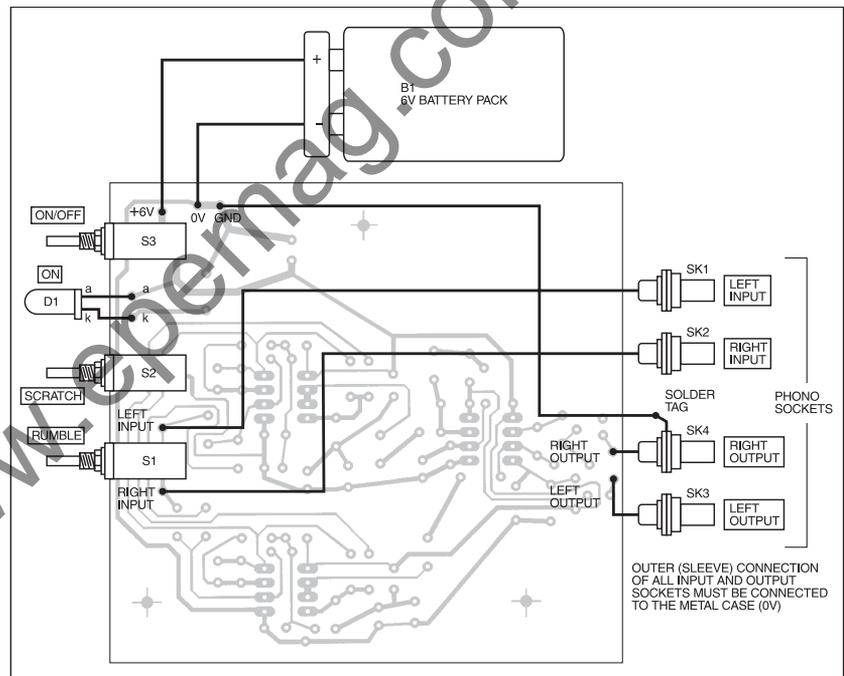


Fig.4. Interwiring details from the printed circuit board to the rear panel mounted input and output phono sockets.

Before making a recording, clean the surface of the disc using a proprietary anti-static cleaner. If it is very dirty, it will need special treatment to remove the debris which will have become deeply embedded in the groove. You could try playing it once or twice in an attempt to allow the stylus itself to remove the contamination.

## STYLUS CHECKS

Check the stylus *after every playing* for any build-up of fluff and dirt. Leaving this will spoil the high-frequency response and also tend to cause the stylus to jump out of the groove. Use a proprietary stylus cleaning kit (a fine brush and cleaning fluid). Styluses are easily damaged so follow the instructions and work carefully.

## MAKING A RECORDING

Refer to your CD recording software instructions to make optimum sound level settings and make some tests using the old record. For your final recordings, you will probably be able to observe the file oscilloscope-style. It is then possible to remove the heaviest clicks by highlighting and deleting them.

However, this must be done with great care. Some CD recording software allows for sophisticated restoration work to be undertaken. Automatic click suppression can be a problem because many sections of the intended waveform are click-like.

One final point – do not use the scratch filter unless the result sounds better. This is because it gives a markedly "dull" effect. □

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Coil Voltage	Contacts	Price	Order Ref:
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24V DC	2-pole changeover	£1.50	FR12
24V DC	4-pole changeover	£2.00	FR13

Prices include base

**MINI POWER RELAYS.** For p.c.b. mounting, size 28mm x 25mm x 12mm, all have 16A changeover contacts for up to 250V. Four versions available, they all look the same but have different coils:

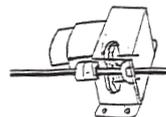
6V – Order Ref: FR17	24V – Order Ref: FR19
12V – Order Ref: FR18	48V – Order Ref: FR20

Price £1 each less 10% if ordered in quantities of 10, same or mixed values.

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## £2 BARGAIN PACKS

**24V STEREO POWER SUPPLY.** Mullard. Order Ref: 2P80.  
**UP TO 90 MIN 25A SWITCH.** Clockwork. Order Ref: 2P90.  
**POWERFUL MAINS MOTOR.** 1½in. stack, double spindle. Order Ref: 2P55.  
**SPEED CONTROL FOR MODELS.** 6V-12V variable p.s.u., also reverse. Order Ref: 2P3.  
**MAINS TIME AND SET SWITCH.** 25A, up to 6 hours delay. Order Ref: 2P9.  
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**TWIN EXTENSION LEAD.** Ideal lead lamp, Black & Decker tools, etc., 20m. Order Ref: 2P20.  
**MAINS COUNTER.** Resettable, 3 digit. Order Ref: 2P26.  
**ILLUMINOUS PANEL,** 16 x 16V bulbs to light coal effect heater, etc. Order Ref: 2P317.  
**TIME AND SET SWITCH.** 15A mains. Order Ref: 2P104.  
**D.C. VOLT REDUCER.** 12V-6V, fits into car lighter socket. Order Ref: 2P318.  
**CAPACITOR, VARIABLE.** For tuning AM/FM with ¼in. spindle. Order Ref: 2P269.  
**CAPACITOR, VARIABLE.** 0.0005 solid dia. ¼in. spindle. Order Ref: 2P268.  
**COPPER CLAD BOARD.** 15 x 10 x ¼in. p.c.b. Order Ref: 2P409.  
**25V-0V-25V MAINS TRANSFORMER.** 1½A. Order Ref: 2P410.  
**20V-0V-20V DITTO.** Order Ref: 2P411.  
**80mm x 46mm x 65mm METAL PROJECT BOX** with rubber feet, supplied as flat pack. Order Ref: 2P412.  
**24V 1A MAINS TRANSFORMER.** Order Ref: 2P413.  
**12V 2A MAINS TRANSFORMER.** Order Ref: 2P414.  
**80 OHM COAX.** Extra thin, 15m. Order Ref: 2P417.

### FOR A LONG LIST OF £1 BARGAIN PACKS SEE AUGUST ISSUE OR RING US FOR THE LIST

**ROTARY SWITCH.** 40A with porcelain pointer control knob. Order Ref: 2P419.  
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**MAINS MOTOR WITH GEARBOX** giving 6 revs per hour. Order Ref: 2P430.  
**CLOCKWORK TIMSWITCH** with scale settable up to 6 hours. Order Ref: 2P432.  
**OLD TIME RADIO CASE** for the Good Companion. Order Ref: 2P436.  
**4 OHM TWEETER.** 20W, by Goodmans. Order Ref: 2P437.  
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**BT ENGINEER'S PHONE.** Unused but missing some parts, ideal for stripping. Order Ref: 2P439.  
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**MINI MOTOR WITH GEARBOX,** giving 16 r.p.m. Order Ref: 2P442.  
**ICESTAT.** Cuts in just above freezing. Order Ref: 2P443.  
**BALANCE KIT** with gram weights for chemical experiments etc. Order Ref: 2P444.  
**Vu METER.** 40mm square. Order Ref: 2P445.  
**SLYDLOK FUSE.** 30A. Order Ref: 2P447.  
**KV CAP.** 1µF 1500V. Order Ref: 2P448.  
**9V P.S.U.** 1A D.C., plugs into 13A socket. Order Ref: 2P450.  
**6-CORE 3A FLEX.** 15m. Order Ref: 2P451.

**TERMS**  
 Send cash, uncrossed PO, cheque or quote credit card number. If order is £25 or over deduct 10% but add postage, £3.50 if under 2 kilo, £6 if under 4 kilo.

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 Telephone: 01444 881965  
 E-mail: Jnfactors@aol.com

# READOUT

E-mail: [editorial@epemag.wimborne.co.uk](mailto:editorial@epemag.wimborne.co.uk)

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

## WIN A DIGITAL MULTIMETER

A 3½ digit pocket-sized I.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 Digital Multimeter to the author of the best Readout letter.



## ★ LETTER OF THE MONTH ★

### SHOCK HORROR TALE!

Dear EPE,

I was re-reading some old *EPE* issues while waiting for the latest to turn up here in New Zealand (I don't suppose you could print *EPE* every week, could you?), and something Alan Winstanley wrote in *Circuit Surgery* of Sept '00 made me laugh out loud. I hasten to say I have the greatest respect for Alan's intellect which shines through everything he does, but I was reminded that there is sometimes a second, more amusing explanation for a set of symptoms.

A reader had queried Alan about "worrying" electric shocks from his dishwasher, and yet his RCD (residual current device) had not tripped the power off, and the RCD "checked out OK". Alan theorized a possible insulation fault but gave the excellent advice to get the dishwasher looked at by a professional.

The following story from my time as an electronic repairman shows how a working RCD might not trip even though the machine it is attached to is giving you electric shocks.

Some years ago I quickly attended a similar "fault" in an old, all-metal franking machine (stamps postage on envelopes) which had been relocated in an old office building and, while it was running well, had been giving electric shocks to everybody since the relocation "even when it was switched off". I believe the NZ power distribution system is the same as UK, 230V a.c., 50Hz, multiple earthed neutral, so on the way to the fault I was mentally going over things like earth wire broken off in the old machine, wiring faults and errors in the building, etc.

The ladies who used the machine were in some fear of their lives, and I had firmly advised them over the phone that this fear was well-grounded (is that a pun?). When I arrived onsite they were at first rather put out when they saw me dash in, wave my meter about the machine, glance around the room and burst out laughing.

What I really did was to check the machine competently, and drew the conclusion that

when they walked over the nice new carpet in their nice refurbished office in their pretty feminine artificial "leather" shoes to the machine, all those thousands of volts of static electricity they had built up found a ready path to ground through the well-earthed machine! And that was it.

After my careful and sympathetic explanation to the ladies about how to minimise static buildup, and how it wasn't endangering their lives anyway, they ruefully saw the reason for my amusement, but still didn't want to touch the machine. In the end I suggested they leave the office scissors (metal) near the machine, they could pick up the scissors and, holding them firmly, touch the machine with the scissors first, thereby discharging themselves with a mighty *crack!* of spark and not feel a thing.

And that would be one way that *EPE* readers could get even severely-felt electric shocks "from" a machine and yet the machine's fully operational RCD wouldn't trip. Having said that, I very strongly advise people not to assume that electric shocks from machinery are just harmless "static". Get it checked or plan your funeral, electricity is a good servant but a bad master!

**Stan Hood,  
Christchurch, New Zealand**

*Reminds me of a situation in my late school years. While showering in the sports changing room, I frequently felt tingles in my hand when lightly coming into contact with the metal shower tap. For weeks the school authorities would not believe me when I said that the tingling was due to electricity being present on the water piping.*

*Eventually the Electricity Board was called in – yes indeed, there was an electrical problem, affecting the adequate earthing of that part of the building. A lot of digging in the road outside was required before the fault was found and cured! I would not be telling the tale had the current flow been more severe.*

*but in practice I have never encountered a situation where entering the main door zone could require a choice between normally-open and normally-closed contacts.*

### HOME SECURITY

Dear EPE,

I am currently doing my final year project on a home security system which involves a 4 x 3 matrix keypad, PIR sensor, magnetic switch and glass break detector. I'm using a PIC16F84 and PICBasic to write the software. Can you please give me some advice?

**Brendon, Malaysia, by email**

*Sorry to disappoint you Brendon, but we cannot give specific advice for reader's own designs, but you might find my PIC Controlled Intruder Alarm of April '02 of interest. That uses a matrix keypad.*

### 8051 FREWARE

Dear EPE,

I know that most of your projects that use microcontrollers are based around PIC devices, but I just want to let any of your readers who use the 8051 microcontroller, or its many derivatives, know about a very good freeware open source ANSI compliant optimising C compiler which I have been using for a few months, now called SDCC. It's available for download from [sdcc.sourceforge.net](http://sdcc.sourceforge.net).

There are several discussion forums for its users also on the same site. It can also be targeted at Z80, Gameboy Z80, AVR and PIC14x microcontrollers, and comes with a freeware 8051 software simulator.

Keep up the good work on your magazine, I have been a reader since I was a schoolboy hobbyist.

**Jez Smith, by email**

*Thanks Jez, undoubtedly we have some readers who are 8051 users as well as PIC addicts. And thanks too for your continued interest in EPE!*

### BASIC STAMP

I have taught myself PICBasic and have a great interest in microcontrollers. What I would like to know is what industries use Basic Controllers and is it hard to start a career using and programming them? Any advice would be greatly appreciated.

**Alex, via email**

*I suspect that in general industry does not use PICBasic types of program, preferring the more universally used assembler codings in various forms. Readers – what are your opinions?*

### SMOKE DETECTION

Dear EPE,

I am from Les Quennevais school in Jersey. For my business GCSE project I am going to make a photoelectric smoke detector, carbon monoxide detector and heat detector for the deaf. I am wondering if you could send me some circuit diagrams or tell me your suppliers as it would largely help me in my project. Any information that you could give would be very helpful

**Alan Morris,  
via email**

*Our Teach In 2002 series looked at smoke detection in the June '02 issue, back issues can be ordered via our Online site, or according to the information published in each EPE issue. We have not done other smoke detectors in recent years.*

### STYLOPIC OP.AMP

Dear EPE

I am having problems finding the LM13600 transconductance op.amp for the *StyloPIC* of July 2002, the RS 304-453 is now listed as "no longer stocked". Do you know what other device could be used as an alternative please?

**Mike Mackellow,  
via email**

*You can use the LM13700 instead as a direct replacement – no mods needed.*

### PIC ALARM

Dear EPE,

I've been building your *PIC Controlled Intruder Alarm* (Apr '02) – great application! It seems, though, that you can only arm the alarm when the entry zone is set-up to be normally-open, is this so?

In your article you suggest feedback would be welcome on the use of the RB4 interrupt for the panic switch. I have linked pins of the S3 connector but can still trigger the panic event by generating mains noise, even pulling the plug out and switching to battery power sometimes generates the event. I'm planning to add mains suppression etc.

**Mark Jones,  
via email**

*Feedback is always welcome Mark, thanks. The entry zone restriction was not intentional,*

## STYLOPIC

Dear EPE,

Following on from your *StyloPIC* in July '02, you might be interested in some info on the original. There were three variations of the pocket model – standard, treble and bass. The treble and bass models being respectively an octave higher or lower (mine is the standard model). Its big brother, the 350S, had many extra features such as short or long envelope, staccato, two speed vibrato, wah-wah, and eight voices.

An innovative feature is a light sensor (l.d.r.) for hand control of vibrato or wah-wah. It also has two styluses (for playing “chopsticks”?). An external amplifier was also available for either instrument, with tone and tremolo controls. On the technical side, the circuit diagram for the pocket version is in the back of the instruction book.

Tone generation is by a programmable unijunction transistor so the waveform would be pulsed, however it is modified by what looks like a diode pump monostable so the mark-space ratio would vary depending on the note frequency (and presumably the harmonics generated). So the output waveform would be something like a square wave with slow rise and fall times. Vibrato is generated by a low frequency phase shift oscillator to vary the programming voltage of the unijunction transistor.

I know John Becker likes to recycle his software so here is something to consider in a future incarnation. It gives greater flexibility of the output waveform. And, of course, you can have multiple waveform tables. This is only an example, other changes may be needed for it to work correctly.

```
OUTTT: call WAVFORM
movwf PORTA
goto MAIN
WAVFORM: andlw $7F ; Sinewave + 2nd harmonic
movwf PCL; 128 entries, amplitude
0 to 63
```

```
DT 00,00,00,00,00,01,02,04,06,08,11,13,16,19,22,26
DT 29,32,35,39,42,44,47,49,52,54,55,57,58,59,59,59
DT 60,60,60,60,60,59,59,59,58,59,59,57,57,57,57,57
DT 58,58,59,59,60,60,61,61,62,62,63,63,63,63,63,63
DT 62,61,60,59,58,56,55,53,51,49,47,45,43,41,39,37
DT 35,33,32,31,30,29,28,28,29,29,30,31,32,33,34
DT 35,36,38,39,40,41,42,43,43,43,43,42,42,41,39,38
DT 36,34,32,29,27,24,21,19,16,13,11,08,06,04,03,01
; (DT is “Define Table of retlw’s” in MPASM)
```

Peter Hemsley,  
via email

Thanks Peter. The technical stuff I did not find on the web. The table concept looks interesting. I don't know that I'll ever upgrade StyloPIC – but who knows?!

## FLOW CHARTS

Dear EPE,

PICs are not my strong point! However, I've started to look at the code for your *PIC Controlled Intruder Alarm* (Apr '02) with a view to modifying it to suit my own purposes. Do you have a flow chart that you could send me?

Trevor Brearley,  
via email

No, sorry Trevor, I don't do flow charts for my software – I keep concepts in my head and work to those!

Readers who do like to work with flow charts will probably be interested in the Flow Code for PICmicro CD-ROM that's available via our CD-ROM pages in this issue, and in Terry de Vaux Balbirnie's review of it, also in this issue.

## BIOPIC LEADS

Dear EPE,

I am building the *BioPIC Heartbeat Monitor* (Jun '02) and need to know the order code for Boots' lead pack, together with the information

where to order from abroad. The TENS replacement electrode pads you specify are easy to find at almost any Boots shop, but the staff there know nothing about leads, nor how to order. I've tried at several Boots shops on my last trip to London.

Cristian, via email

Mine came from Boots in Wimborne. I don't know the order code, they were being supplied as normal stock items. If you can't get any, use flexible wire with crocodile clips to clip onto the chest pads. They don't need screening. You could try asking Boots HQ via email ([www.google.com](http://www.google.com) will provide a web address).

## SERIAL ADC PIC TRICK

Dear EPE,

Readers might be interested in my PIC program for use with the TLC549/8 8-bit serial analogue-to-digital converter. I use file registers COUNT and TEMP as sort of “standard” registers, COUNT for timing etc and TEMP as a sort of second W. It helps me get a mental view of my progs.

In the program this routine comes from, COUNT has previously been reset through DECFSZ, so I can get away with BSF COUNT,3. I have run this at 6MHz without problem, and it should go faster. The A-D value is stored in file UNIT.

```
A2DIN: BCF PORTB,7 ; clear CS line to
; hold value to
; send
BSF COUNT,3 ; set count to shift
; 8 bits (make
; sure that
; COUNT cleared
; before this section
; or use
; MOVVLW etc)
FETCH: RLF UNIT,F ; move bits one
; place left &
; store new value
; in UNIT
BCF UNIT,0 ; set 0 value
; before PORT,0
; bit test
BSF PORTB,6 ; set A2D clock
; pin high, release
; bit for transfer
BTFSF PORTB,5 ; is bit 0 (DOUT)
; set?
GOTO NEXT1 ; no, then leave
; UNIT bit 0 value
; as is
BSF UNIT,0 ; yes, set bit 0 of
; UNIT
NEXT1: BCF PORTB,6 ; clear clock pin
DECFSZ COUNT,F ; is COUNT zero?
GOTO FETCH ; no, get another
; bit!
BSF PORTB,7 ; yes, 8 bits
; clocked out &
; held in UNIT,
; set CS line to
; get new value
RETURN
```

Graham Card,  
via email

Useful, Graham, thank you – I've put it in the *PIC Tricks* folder on our ftp site.

## FREEZER ALARM

Dear EPE,

I've been reading Humphrey Berridge's *Freezer Alarm* in the May '02 issue, and I'm extremely impressed with the low component count for the functionality achieved, but I'd like to make a suggestion:

The piezo sounder needs to be as loud as possible, but it's only being fed with 5V pk-pk from pin GP4 to ground. If you connect the sounder between GP4 and GP5, and feed GP5 with an inverted signal, you will get 10V p-p drive in a bridge configuration – twice the voltage, at no extra cost!

The only changes required are to the sweep2 and sweep3 routines:

```
sweep2 bsf output ; output high
; bcf output2 ; output2 low – added
decfsz freq,f
goto sweep2
movfw nfreq
movwf freq
sweep3 bcf output ; output low
; bsf output2 ; output2 high – added
decfsz freq,f
goto sweep3
```

Plus an extra define line:

```
#define output2 gpio_5 ; inverted o/p to piezo
sounder
```

Nigel Goodwin, via email

Thanks Nigel!

## LOTTERY PREDICTOR

Dear EPE,

I am studying GCSE Electronics. My father has been purchasing *EPE* since 1994 and is still enjoying each new edition. In the April '95 issue I came across the *National Lottery Predictor* project and am wondering if you could please send me as much information on that topic as possible to further my knowledge and passion.

Gopyr, via email

So sorry, but we cannot provide additional material for any published design. Regarding building a circuit from 1995, we normally advise against attempting to build a design that is over five years old since parts could well have become obsolete during that time.

In this particular case, the p.c.b. is no longer available, nor will you be able to obtain the programmed PIC as we are no longer in touch with the authors, and they did not let us the copyright to their software (that was before we began to insist that all project software must be made freely available to readers).

## EARTH RESISTIVITY LOGGER

I am designing an “Earth Resistivity Logger” for archeological use, inspired by Robert Beck's Earth Resistivity Meter of Jan/Feb '97. Mine is PIC controlled and will have its own non-volatile memory (data stays held even after switch off); possibly a graphics l.c.d. may show rough details of reading values as grey scale; serial interface for connection to PC for deeper analysis.

I am not an archeologist and am approaching the design purely as an electronic problem to be solved – send an output signal, retrieve it from a distance and store the value. I am in communication with a local archeological society, but I would be pleased to hear from any EPE readers involved in this field, with special regard to the following:

- How many reading samples do you normally take on a site in one main session?
- How many samples would you like the logger to store before download to PC?
- Is powering it from a 12V car battery adequate, or do I need  $\pm 18V$  as Robert had?
- What probing techniques do you use? I'm assuming the twin-probe technique is best, as described by Robert.
- What maximum probe separation distance do you use?
- How deep do you insert the probes?
- Is a signal frequency of 137Hz as used by Robert the best to use?
- In your experience, how likely is it that 50Hz mains frequency is likely to occur on a site being surveyed, and would thus need to be filtered out in some way?
- Do you always plot the site squares in the same regular order, or would you prefer to sample in random order, telling the logger the square number being sampled?

Any answers would be appreciated, my email is [john.becker@wimborne.co.uk](mailto:john.becker@wimborne.co.uk).

# PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

**C**ONCERNS about finished projects failing to work are probably the main reason for would-be constructors failing to "take the plunge". It is not a major concern for those with years of project building experience because they have the technical knowledge, equipment, and know-how to deal with practically any problem. The opposite is true for beginners who, on the face of it, have little chance of dealing with projects that refuse to work.

## Keep it Simple

In reality the situation for beginners is better than it might seem. Provided you start with something reasonably simple and follow the instructions carefully there is a good chance of success. Pre-publication checking for both books and articles containing electronic projects has increased over the years, and this has greatly reduced the chances of being led astray by printing errors. On the rare occasions that an error does creep in to an *EPE* article it is usually spotted quite early and corrected one or two issues later.

In general, the complexity of modern projects is greater, but your chances of failure if the instructions are followed "to the letter" are much less than they were. Like any creative skill, electronic project construction would not be a worthwhile hobby if perfect results were guaranteed every time with no skills required. You have to be prepared to put in some effort and try to go about things the right way.

It is worth repeating the importance of choosing a project that is within your capabilities. It is tempting to dive straight in with a project that will impress your friends, but the more complex the project the greater the risk that you will make a mistake. In the past it was not unusual to receive letters from readers having problems with projects that they clearly did not understand at all.

You do not need to know how a project works in order to build it successfully, but you do need to have a proper understanding of what it is supposed to do and how it is used. Something like a household gadget is a more appropriate starting point than an advanced piece of test equipment where you need a degree in physics in order to switch it on!

Fortunately, letters from readers who have "bitten off more than they can chew" are relatively rare these days, but it is still a problem to take seriously.

## Mains Point

The mains supply is *potentially lethal*, as are projects that connect to it. Mains power projects are only suitable for those with a reasonable amount of experience at project construction. Even if a project is very

simple, if it connects to the mains supply it is certainly not suitable for a beginner.

Start with projects that are battery powered. If you should make a serious blunder it is possible that one or two of the components will be damaged, but *you* should be perfectly safe. In most cases all the components will survive the experience as well.

The two main construction methods used in modern projects are stripboard and custom printed circuit boards (p.c.b.s). While both types of board are pretty straightforward to use, custom printed circuit boards represent the more foolproof option. Stripboard is a multi-purpose circuit board that has a regular matrix of holes, and in most projects only a few percent of these are actually used.

As its name suggests, a custom printed circuit board is specifically designed for a particular circuit and normally has just one hole per leadout wire or pin. With a custom board there is relatively little risk of making a mistake in the first place, and any errors that should creep in are likely to be spotted almost immediately. With stripboard there are hundreds of unused holes that are good at disguising mistakes, and some very careful checking is needed to detect them.

## Bridging the Gap

Having chosen a suitable project and put it together with due diligence, what do you do if the finished unit fails to work? When a newly constructed project is clearly failing to work properly it is not a good idea to leave it switched on.

Leaving a faulty project switched on could result in damage to some of the components, and the semiconductors are particularly vulnerable. Always switch off faulty projects immediately and then recheck the component layout, wiring, etc.

The prudent project builder checks all this sort of thing very carefully during construction, and spotting errors early can save a lot of hassle later. In order to properly check the unit you may have to partially dismantle it in order to get proper access to the circuit board.

Years of practical experience suggest that the vast majority of problems are due to "short-circuits" between copper tracks on the underside of the circuit board. This is not exactly a new problem, but the intricacies of modern boards make it even more problematic than in the past.

Unless the board is coated with a solder resist that is designed to discourage solder bridges, it is likely that several will be produced per circuit board. Most of these bridges will be spotted while you are constructing the

board, and in most cases they are easily removed using the bit of the soldering iron. If there is a lot of excess solder it is better to use a desoldering tool, and an inexpensive desoldering pump is ideal for this application. It is advisable to remove as much solder as possible and then redo any joints that have been desoldered.

## Hidden from View

The more difficult problem is minute trails of solder that are often difficult or impossible to see with the naked eye. The situation can be made more difficult by the trails being hidden under excess flux from the solder. This tends to get liberally splattered across the underside of circuit boards during construction. There are various products that can be used to thoroughly clean the flux from boards, but vigorous brushing with a small brush such as an old toothbrush seems to do the job well enough.



A "dry" joint. Solder failed to flow.



A good joint, nice and shiny.

Photos courtesy Alan Winstanley's *Basic Soldering Guide*

Good eyesight is not sufficient to guarantee that any solder bridges will be spotted. Some form of magnifier now has to be considered part of the standard toolkit for electronic project construction, and even a small magnifying glass will greatly increase the chances of detection.

An 8x or 10x loupe (also sold as lopes) is better though. The inexpensive types sold as photographic accessories for viewing slides and negatives are perfectly adequate for the present application.

Provided the board is thoroughly cleaned first, a careful visual check using a magnifier should reveal any solder bridges. As solder bridges occur so often it is a good idea to clean and visually inspect all completed circuit boards prior to installing them in the case.

## Hot Spots

Dubious soldering is a common cause of problems, particularly amongst beginners. Soldering is like any skill, and it is a case of "practice makes perfect". The more projects you build the more proficient you will become at completing soldered connections. There is insufficient space here for a "soldering tutorial", but a

good one is available at the *EPE* web site. Some soldering irons and soldering kits are supplied with detailed instructions, and it is well worthwhile studying these.

Probably the most common cause of so-called "dry" joints is the soldering iron being left unused for a few minutes before starting a new batch of connections. If there is a substantial amount of solder left on the bit, any flux in it will burn away and it will probably start to oxidise. If you produce the next joint without cleaning the end of the bit first, the joint will contain a significant proportion of old solder, which may not flow over the joint properly.

The resultant joint might look plausible and could seem to have good mechanical strength as well. However, joints of this type usually provide only intermittent electrical contact or no contact at all, and are relatively weak mechanically.

### Shining Example

Always make sure that the bit is tinned with fresh solder prior to making joints. Practice soldering with some bits of wire, a few resistors, and a scrap of stripboard before you start building projects. This will cost very little and will greatly enhance your chances of success.

Checks with a continuity tester or the continuity function of a multimeter should locate dry joints, but thoroughly checking even a small circuit board can be quite time consuming. Large amounts of excess flux are sometimes indicative of a bad joint, but this is of no help once the board has been cleaned.

Good joints normally have a characteristic mountain shape and the surface of the solder is very shiny. "Dry" joints are often more spherical in shape and the solder tends to have a relatively dull surface, possibly with some crazing.

### Clean Break

If any joints look suspicious it is probably worthwhile desoldering them and then re-soldering them. Before trying again it is a good idea to have a close look at the two surfaces. These days it is unusual for dirt or corrosion on one of the surfaces to cause problems. Modern components are less vulnerable to corrosion on the leadout wires and tags, and the flux in electrical solders is very efficient at dealing with contaminants.

However, there can still be occasional problems though, and if there is any sign of contamination it is a good idea to clean both surfaces before redoing the joint. The best way to clean the surfaces is to gently scrape them with the small blade or a penknife, a miniature file, or something of this type.

The driest joint of all is the one you forget to do! Missing joints are usually fairly obvious with custom printed circuit boards, but can be difficult to see with stripboard where there are numerous unused holes and no pads as such. Firmly pulling on resistors, capacitors, diodes, etc., will reveal any missing joints, or ineffective joints that look plausible.

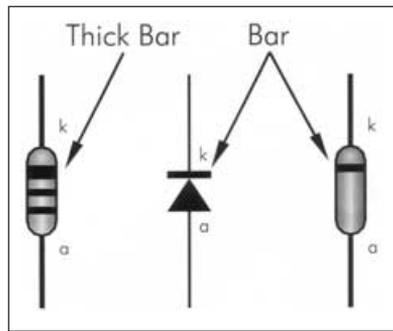


Fig.1. The wide band indicates the cathode (k) leadout of multi-band diodes.

### Heat of the Moment

Apart from semiconductors, modern components are reasonably tolerant of heat. However, it is still possible that damage will occur if you take too long to complete joints. Heat damaged components usually show some obvious signs of damage, such as a darkening in colour or being slightly misshapen. Always replace any "off colour" or deformed components, or any components that show significant signs of physical damage.

Integrated circuits (i.c.s) are mostly fitted in holders, but transistors and diodes are often connected directly to the circuit board. Always take extra care when fitting these in place. As pointed out previously it is a matter of "practice makes perfect", and you can avoid a lot of problems by learning to solder quickly and neatly before dealing with transistors and diodes.

### Try and Try Again

Having thoroughly checked both sides of the board and made any necessary repairs it is time to reassemble the project and test it again. Thoroughly check the hard wiring against the wiring diagram, as it is relatively easy to make mistakes here. If the project still does not work, the most likely explanation is that you have missed an error in the wiring or on the circuit board.

With this type of thing there is a tendency to blame others and not accept that you could have made a mistake. In reality it is easy to make the odd mistake here and there, and even "old hands" make the occasional error.

Start by checking that every component on the circuit board is in the right place and has the correct value. Work through the components methodically making sure that none of them are overlooked. If you have managed to miss out a component, this error should then come to light. With stripboard construction make sure that any link wires are present and correct.

Ideally you should get someone else to check the unit against the construction diagrams. A fresh pair of eyes might spot something that you have consistently overlooked.

### Wrong Connection

The components that must be fitted the right way round are the most likely to give problems. Layout diagrams and

the markings on components such as diodes and electrolytic capacitors are usually quite explicit, so any errors should be easily spotted.

One exception is the type of diode that has several bands rather than one at the cathode ("k" or "+") end of the component. These have had something of a renaissance in recent times, so you may well encounter them. The bands indicate the type number using a variation on the resistor colour code. A wider band at that end of the body (Fig.1) indicates the cathode (k) lead.

Light emitting diodes (l.e.d.s) can also be problematic. If a project works apart from a l.e.d. indicator, it is odd that the l.e.d. is simply connected the wrong way round.

### A Pressing Connection

Before too long practically everyone makes the classic mistake of forgetting to switch on the project or omitting that all-important component – the battery. Battery connectors have always been notoriously unreliable. Try pressing the connector firmly onto the battery to see if it makes the project burst into action. Slightly compressing the female connectors with pliers usually gets a loose clip to work reliably.

Battery holders for 1.5V cells are also something less than totally reliable. Ensure that the terminals of the batteries and the holder are clean by gently removing any contamination with fine sandpaper.

### Multi-checks

A cheap multimeter is useful for checking that the battery voltage is actually getting through to the circuit board. It can also be used to check that the battery is in a usable state.

Even if you do not have much technical knowledge, a multimeter can still be useful for numerous basic checks. For example, it can be used for making continuity checks on switches, which may not operate in quite the way you think they do?

Have you confused the "on" and "off" settings? Often when a project seems to be working irrationally it is just that one of the switches does not function as expected. The high and low ranges are transposed, or something of this type.

A multimeter is also useful for checking cables for short-circuits or broken leads, checking that that plugs and sockets connect together properly, etc. Even some of the cheaper digital types now have the ability to check resistors, transistors, diodes, and capacitors, which is clearly more than a little useful. *A multimeter is a piece of equipment that no project builder should be without.*

Because modern components are very reliable you are unlikely to have a failure caused by a dud component. If you get everything connected together properly your projects will work, and it helps to keep this in mind. Of course, the projects will never work if you do not pluck up the courage to "take the plunge" and actually build them.