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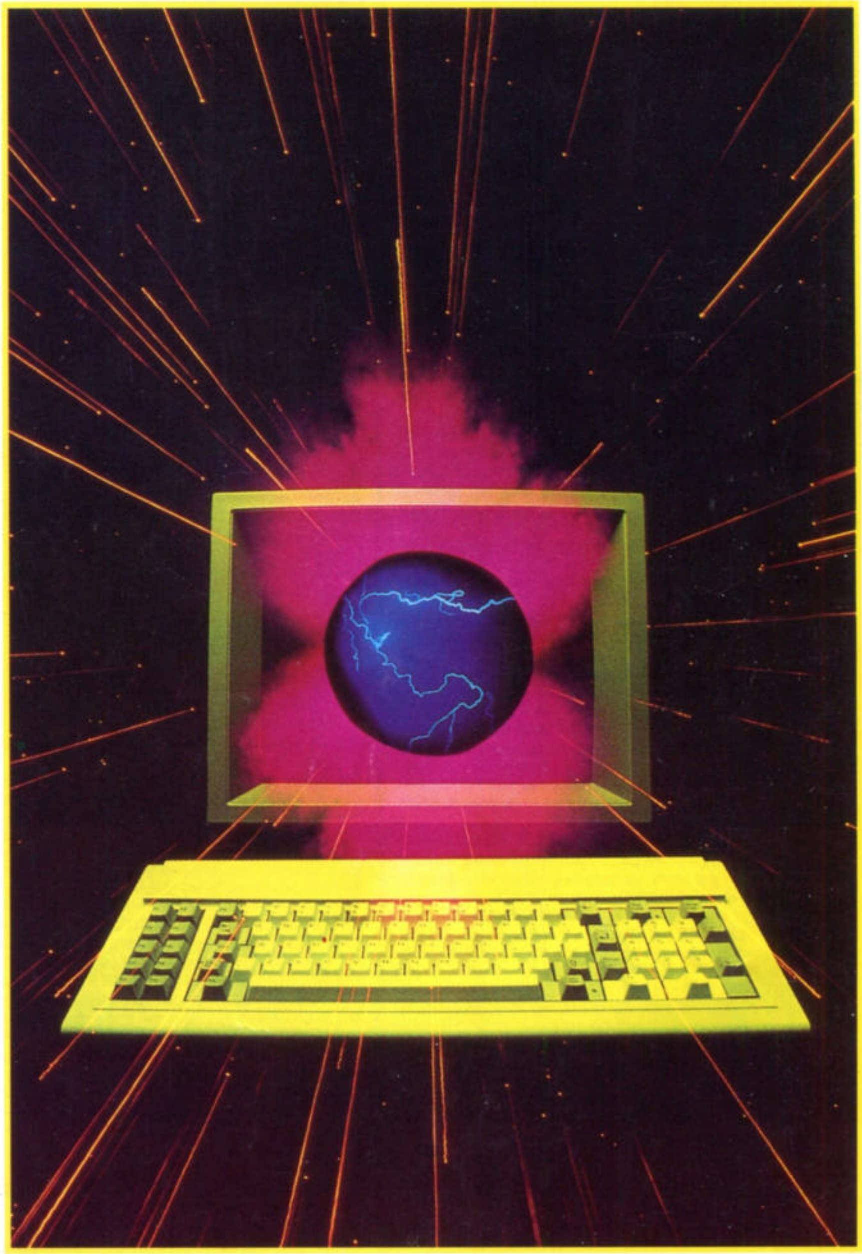

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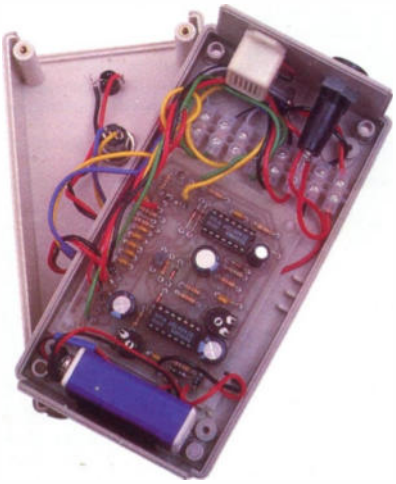

THE NO. 1 INDEPENDENT MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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ISSN 0262 3617
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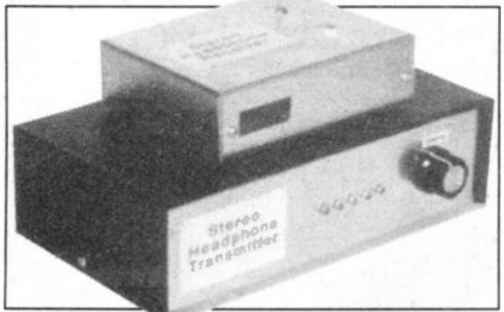
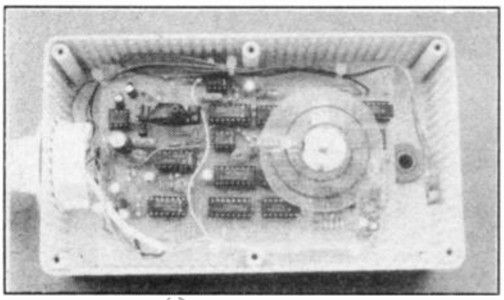
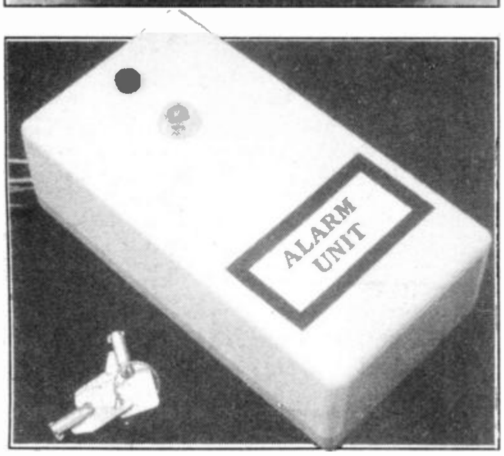
VOL. 24 No. 12 DECEMBER 1995

EVERYDAY PRACTICAL ELECTRONICS

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects







Projects

Series

Features

Our January '96 issue will be published on Friday, 1 December 1995. See page 919 for details.

NEXT MONTH

MAINS SIGNALLING UNIT

A simple and relatively inexpensive unit that will provide through-the-mains control of a remote unit or appliance. Use it to extend the doorbell or turn on the electric blanket etc., without the need to run wires around the house, or to move from in front of the TV!

PRINTER SHARER

Designed to overcome many of the shortcomings of commercial printer sharers this project will allow two PCs to share one parallel (Centronics) printer without user intervention. Users simply print from their software applications as usual, and the Printer Sharer lets the data through on a first-come first-served basis.

AUTOMATIC CAMERA PANNING SYSTEM

Motivate a defensive outlook and keep a roving eye on your property. Using selected modules from Teach-In '96 Part 3, construction of an automatic panning mount for a security camera is clearly explained.

EVERYDAY PRACTICAL ELECTRONICS

JANUARY '96 ISSUE ON SALE FRIDAY, DECEMBER 1

EVERYDAY PRACTICAL ELECTRONICS

VOL. 24 No. 12 DECEMBER '95

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RECOMMENDED

As I have often said on this page, your letters, queries, praise and criticisms are always welcome. However, there are one or two types of query that give us problems and that, as a general rule, we are unable to reply to. The first of these is the letter that asks us to recommend, say, a specific oscilloscope, multimeter, computer or soldering iron.

As regular readers will know we do not indulge in test reports on a wide range of tools and equipment so we have to decline such recommendation. Very often the specific requirements of individual readers will have a strong bearing on the choice of suitable equipment and it is simply impossible for us to research the range, specifications and various other factors to even come up with a short list of suitable items.

MODIFIED

The second type of problem comes when readers request information on how to modify a project to meet their specific needs or to interface it with other equipment. This is simply too time consuming and problematic for us to be able to offer advice.

Sometimes readers or electronics companies are trying to use parts of published designs in circuitry of their own to achieve designs that are far removed from the published project. It is simply not possible to be able to instantly decide how a section of a circuit from one project will work when used in something entirely different. However, our new *Teach-In '96* series does go some way to helping in this area. The various modules described can, generally, be used in a very wide range of different circuits so that, by following simple rules, readers can use any collection of modules to come up with a project design to meet their individual needs.

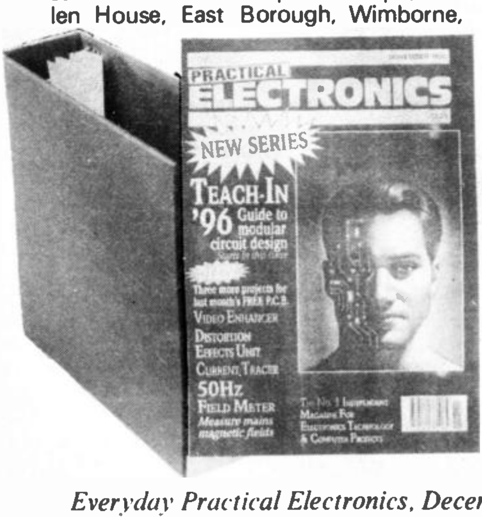
REPAIRED

The third type of query that we are unable to assist with is that which asks how to repair a particular piece of equipment, i.e., a TV, video, hi-fi or computer. Fault finding and repair of electronic equipment is a skill in its own right. We can, however, recommend readers to our *Electronics Service Manual* which provides extensive information on how to set about servicing and repairing a vast range of electronic equipment.

At the present time there is a special offer on this Manual; *EPE* readers can get £10 off the price by using the voucher in this issue (see page 983). Our advertisement for the *Electronics Service Manual* appears on Page 980. The Manual is edited by Mike Tooley (who also wrote the entire base work) and we have no hesitation in recommending it to everyone interested in this fascinating area of electronics.

SUBSCRIPTIONS

Annual Subscriptions for delivery direct to any address in the UK: £24. Overseas: £30 (£47.50 airmail). Cheques or bank drafts (**in £ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subscriptions Dept., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Subscriptions start with the next available issue. We accept Access (MasterCard) or Visa. (For past issues see the *Back Issues* page).



BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £5.95 plus £3.50 post and packing (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas orders.*

Payment in £ sterling only please. Visa and Access (MasterCard) accepted, minimum credit card order £5. Send or phone your card number and card expiry date with your name, address etc.

READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by **a stamped self-addressed envelope or a self-addressed envelope and international reply coupons. Due to the cost we cannot reply to queries by Fax.**

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.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

We regret that **we cannot provide data, or answer queries, on projects that are more than five years old.**

ADVERTISEMENTS

Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.

The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture. Legal remedies are available in respect of some of these circumstances, and readers who have complaints should first address them to the advertiser.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; overseas readers should check local laws.

Constructional Project

LIGHT-OPERATED SWITCH

PAUL STENNING

Let dusk and dawn control your spruced-up Santa lights, or anything else that needs nocturnal enlightenment.

LIGHT operated switches are not new ideas, but neither are they the easiest items to purchase ready-made. Originally, this unit was built to switch on the author's outside Christmas lights when it became dark. No doubt readers will have other uses in mind. One such might be as a security porch light controller.

Up to 500W of lighting can be controlled by this Light-Operated Switch. However, the load must be resistive, i.e. normal lamps. Lights containing transformers are not suitable. The load is switched at the mains zero-crossing point, to minimize radio interference.

The light level required for the unit to switch on or off is fixed, but since the trigger point is set by a single resistor value it can easily be altered. A degree of hysteresis is included to reduce the chance of the unit being affected by the light it is controlling. Reasonably careful siting, though, will still be necessary to prevent the controlled light from directly illuminating the sensor.

The printed circuit board (p.c.b.) is designed to fit behind a single electrical blanking plate, with a hole to allow light to reach the photocell. This plate can be fitted to a single 25mm surface box, giving a cheap and tidy wall mounting case.

For the original purpose, the unit was placed on a window sill with the photocell facing outwards. If the unit is to be used outdoors or exposed to moisture, a sealed waterproof case will be needed.

WARNING

This circuit operates at potentially lethal mains voltages. If you are in any doubt about your ability to construct it safely, obtain advice from a suitably qualified or experienced person. Although the construction is straightforward, THIS PROJECT IS NOT SUITABLE FOR BEGINNERS.

CIRCUIT OPERATION

The complete circuit diagram for the Light-Operated Switch is shown in Fig. 1. Low voltage power is derived from the mains supply without isolation. The a.c. input is clamped to −15V and +0·6V relative to Neutral by Zener diode D1. The remaining voltage is dropped by capacitor C1. A capacitor is used because it dissipates virtually no power (unlike a resistor) due to the 90 degree phase shift between voltage and current. The negative-going cycles are rectified by diode D2 and smoothed by capacitor C2 to give a steady −15V supply rail.

Capacitor C1 must be a Class X component rated for continuous connection directly across the mains. These devices are normally sold as suppression components. A normal high voltage capacitor is NOT suitable and MUST NOT BE USED.

Resistor R1 is a surge limiting component which reduces the in-rush current if the unit is powered up when the mains cycle is near a peak. A wirewound resistor should be used as it has better surge handling than carbon or metal film.

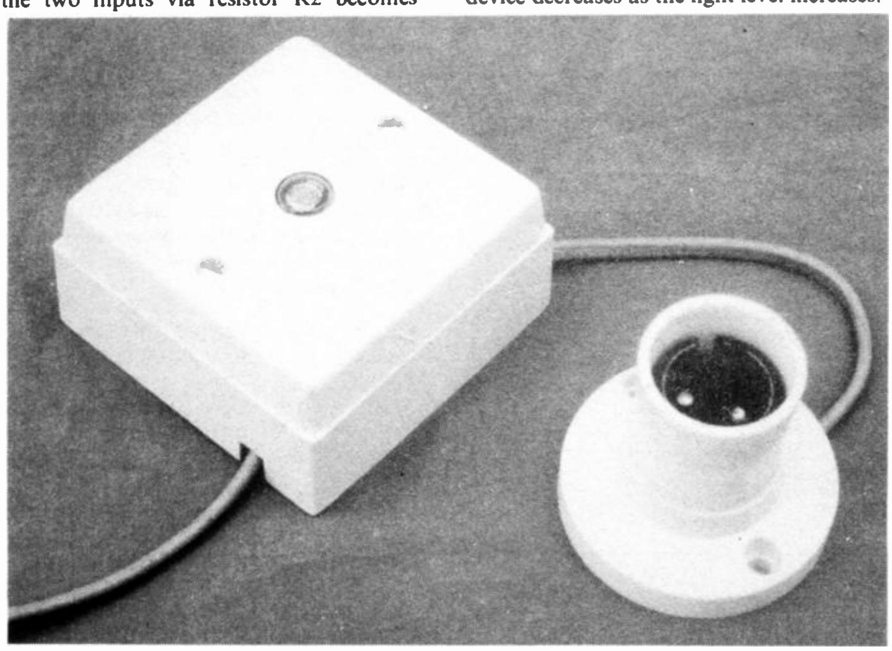
Schmitt NAND-gates. IC1a, IC1b and their associated components produce the zero-crossing pulses, waveforms for which are shown in Fig. 2. The inputs of IC1a, pins 1 and 2, are normally held low by resistor R3, causing a high output at pin 3. When the mains cycle (waveform A) rises above about +40V, the voltage fed to the two inputs via resistor R2 becomes sufficient for the gate to be triggered and its output go low. When the mains voltage falls below +40V near the end of the positive half cycle, the output of IC1a goes high again (waveform B). Diodes D3 and D4 clamp the waveform to the d.c. supply rail, protecting IC1 from excessive input voltages. The Schmitt trigger inputs of IC1 ensure reliable switching.

Input pin 6 of IC1b is connected similarly, but is normally held high by resistor R5. The gate therefore operates on the negative half cycles. The differing values of R3 and R5 are due to the fact that one gate is biased to Neutral and the other is biased to 15V below Neutral. The other input of IC1b, pin 5, is connected to the output of IC1a, so that this second gate sums the two half cycles, outputting from its pin 4 the zero crossing waveform shown in Fig. 2c. This is inverted by transistor TR1, giving a signal which pulses high around the zero crossing points.

A two input AND gate is formed by IC1c and IC1d. One input (pin 9) is driven by the previously mentioned zero-crossing pulses. The output (pin 11) will follow this only if the level on the other input (pin 8) is above 50 per cent of the supply voltage. The voltage here is determined by the light level reaching the light sensor R13.

LIGHT LEVEL

Light is sensed by the light dependent resistor (l.d.r.) R13. The resistance of this device decreases as the light level increases.



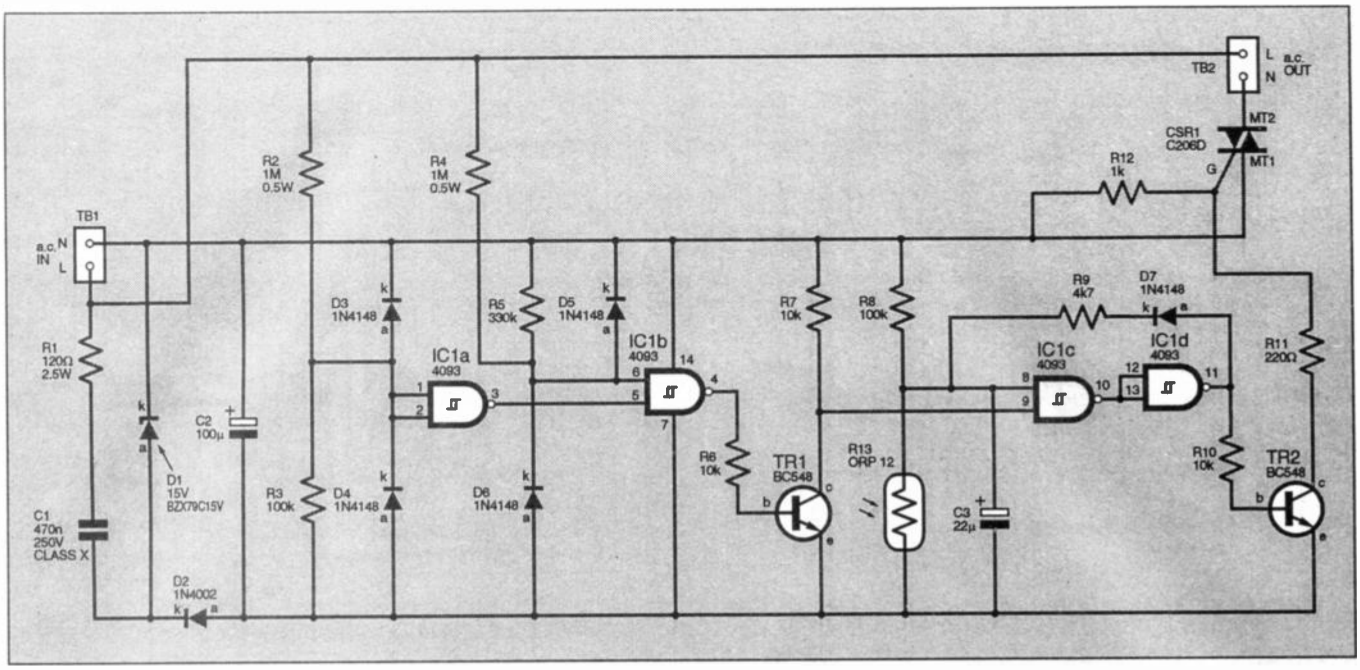


Fig. 1. Complete circuit diagram for the Light Operated Switch.

In bright light the resistance can be as low as 100 ohms, while in darkness it may exceed 10 megohms. In this circuit R13 is half of a potential divider, the other half being resistor R8. The switching point occurs when the resistance of l.d.r. R13 is about equal to R8.

The value of R8 can be varied to change the threshold level if preferred. A preset could be fitted, but this must **NEVER** be adjusted with the power on.

The voltage from the potential divider is damped by C3, to reduce the chances of the unit being triggered by rapid fluctuations in the light level, such as shadows caused by people or animals passing.

When the light level is low enough to cause the unit to switch on, positive-going pulses at the output of IC1d are coupled back to the potential divider by diode D7 and resistor R9. These are smoothed by capacitor C3, causing a voltage increase on IC1c pin 8. This gives the circuit hysteresis: the light level required for the unit to switch off again is now set higher than the level that caused it to switch on.

Thus, if some light from the lamp being controlled reaches the l.d.r., the unit will hopefully not switch off again. There is a limit to this effect, however, for if the controlled light shines directly onto the l.d.r., the lamp will probably start flashing.

The positive pulses on the output of IC1d switch on transistor TR2, which in turn triggers the triac CSR1. The triac is therefore driven only briefly at around the zero crossing points of the mains supply voltage.

Once the triac is triggered it will remain on until the current passing through it drops below a minimum value. This will occur as the mains cycle reaches the next zero crossing point. If the lamp still needs to be lit, as sensed by the l.d.r. (R13), the triac will be triggered again at this point.

The synchronised pulsing arrangement used ensures that the lamp is not switched on near the peak of a mains cycle. If this were to happen the surge could cause momentary radio interference, although this would not be a major problem with a unit that switches so infrequently.

Another advantage of applying only brief drive pulses to the triac is that the average current consumption from the low voltage supply is much lower. This enables the simple power supply arrangement described earlier to be used.

However, this zero-crossing arrangement will not work correctly with inductive loads as the current passing will be out of phase with the voltage.

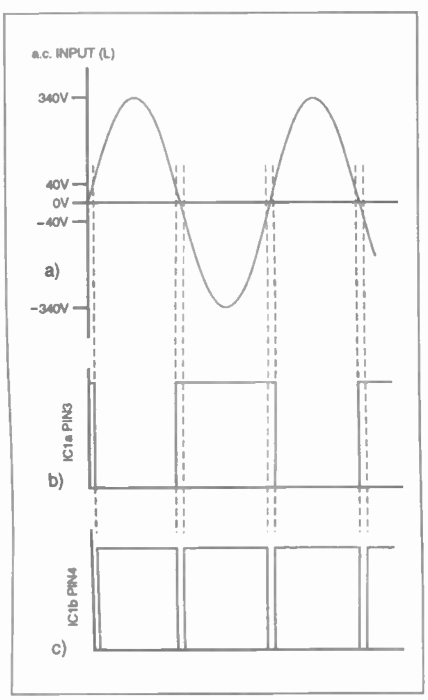


Fig. 2. Waveforms associated with IC1a and IC1b.

CONSTRUCTION

Construction is very straight-forward if the recommended printed circuit board (p.c.b.) is used. The component overlay and track layout for this board are shown in Fig. 3. The board is available form the *EPE PCB Service* code 966.

Assemble the components in any order with which you feel comfortable. It is preferable to use a socket for IC1, fitting the i.c. only after everything has been checked. Discharge static electricity from yourself as usual before handling CMOS devices.

COMPONENTS

Resistors

R1	120Ω 2·5W wirewound
R2, R4	1M 0·5W (2 off)
R3, R8	100k (2 off)
R5	330k
R6, R7, R10	10k (3 off)
R9	4k7
R11	220Ω
R12	1k
R13	ORP12 light dependent resistor

All 0·25W 5% or better unless stated.

See SHOP TALK Page

Capacitors

C1	470n 250V a.c. Class X
C2	100µ axial elect., 25V
C3	22µ axial elect., 25V

Semiconductors

D1	BZX79C15 15V Zener diode
D2	1N4002 rectifier diode
D3 to D7	1N4148 signal diode (5 off)
TR1, TR2	BC548 *npn* transistor (2 off)
CSR1	C206D triac
IC1	4093 CMOS quad 2-input Schmitt NAND Gate

Miscellaneous

TB1, TB2 2-way p.c.b. mounting mains rated terminal block (2 off); printed circuit board, available from the *EPE PCB Service*, code 966; 14-pin d.i.l. socket; single electrical blanking plate; single 25mm electrical surface box; self-adhesive p.c.b. stand-offs (4 off); 13A plug with 3A fuse; cable etc. as required for installation; solder.

Approx cost guidance only **£15**

Do not forget to insert the single link wire near TR1. A number of holes are provided for capacitors C1 and C2 to enable various sizes to be accommodated. The triac, CSR1, should be bolted to the p.c.b. with an M3 nut and bolt. TB1 and TB2 are p.c.b. mounting terminal blocks and should be fitted with the cable entries facing outwards.

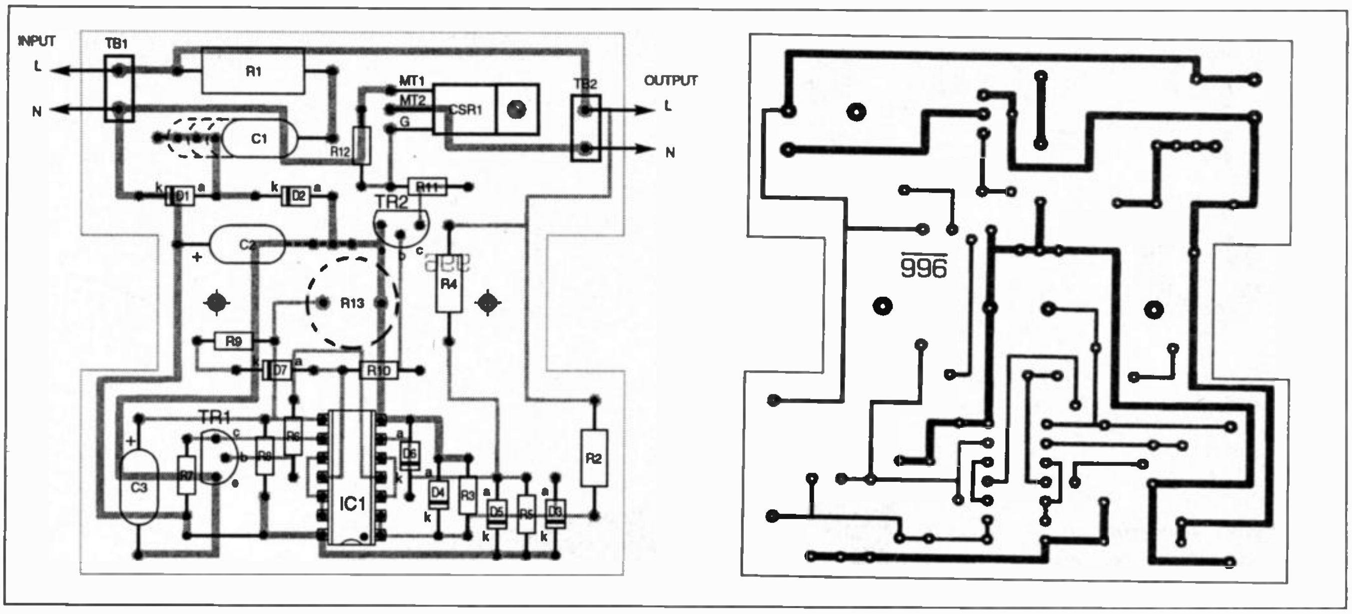


Fig. 3. Printed circuit board component layout and full size copper foil track details. Note the l.d.r. (R13) should be mounted on the track side.

The l.d.r. (R13) should be fitted to the track side of the p.c.b., but do not solder this until you know precisely where in the case the board will be mounted.

Double check the p.c.b. assembly when you have finished, particularly around C1, R1, D1, D2 and TR3. Mistakes on a mains powered circuit like this can cause a horrible mess when the power is applied!

PANEL AND CASE

The front of the case is a single electrical blanking panel. The panel may be carefully drilled using a hand drill or a SLOW electric drill. A normal DIY power drill will be too fast.

Note, though, that the plastic used for the blanking panels is very brittle. Take it VERY gently when you near the point of breaking through. A WorkMate is useful to hold the panel while drilling, as is having a piece of wood firmly in contact with the underside of the panel.

Try to get a panel that is plain on the inside, some have extra moldings and bits which may get in the way.

For safety reasons it is recommended that the p.c.b. is not secured with screws and spacers, unless nylon spacers with a threaded insert at each end are used. A much better method is to use two or more self-adhesive p.c.b. stand-offs to provide steady support.

The rear of the case is a 25mm (socket depth) single electrical surface box. Before buying this, make sure it has only two threaded holes for the front panel screws. Some boxes have four of these, one on each edge – the top and bottom ones will foul on the p.c.b. It will be necessary to remove one or two knock-outs on the side or back for the cables to enter.

TESTING

Since there is nothing to adjust, testing simply involves seeing if the unit works. ***Remember that the whole p.c.b. is at mains voltage and is therefore potentially lethal.***

Fit the p.c.b. into the case before switching on. Connect one end of a length of two-core mains cable to the TB1 terminals (Live nearest to edge of p.c.b.) and connect the other end to a 13A plug fitted with a 3A fuse.

Connect another length (at least one metre) of two-core cable between the TB2 terminals (Live to edge of p.c.b. again) and a lampholder. Fit a 60W lamp into the holder. Position the lamp holder about a metre away from the l.d.r.

Connect the unit to the mains, preferably via an Earth leakage or residual current circuit breaker (the type intended for power tools). Switch on. Hopefully nothing dramatic happened!

Place your hand over the l.d.r. After a couple of seconds the lamp should come on. Move your hand away and it should go off again. That's all there is to it. Hopefully your unit worked fine – there isn't much to go wrong!

INSTALLATION

Installation will depend upon what the unit is to be used for. The prototype was mounted on a piece of wood next to a single 13A socket. Three-core mains cable was used, the Live and Neutral passing through the unit, and the Earth connecting directly to the socket. The other cable end terminates in a 13A plug with a 3A fuse.

It is important to use three-core cable if the unit is being used to control a load via a 13A socket, even if the load does not need an Earth. At some future point someone may plug a load that *does* need an Earth into the unit.

The prototype was sited indoors on a window sill, with the lead to the outside Christmas lights passing through a hole in the window frame. It can be more permanently installed if required. However, it is not suitable for permanent connection to household wiring. This is due to wiring regulations, not a fault with this unit.

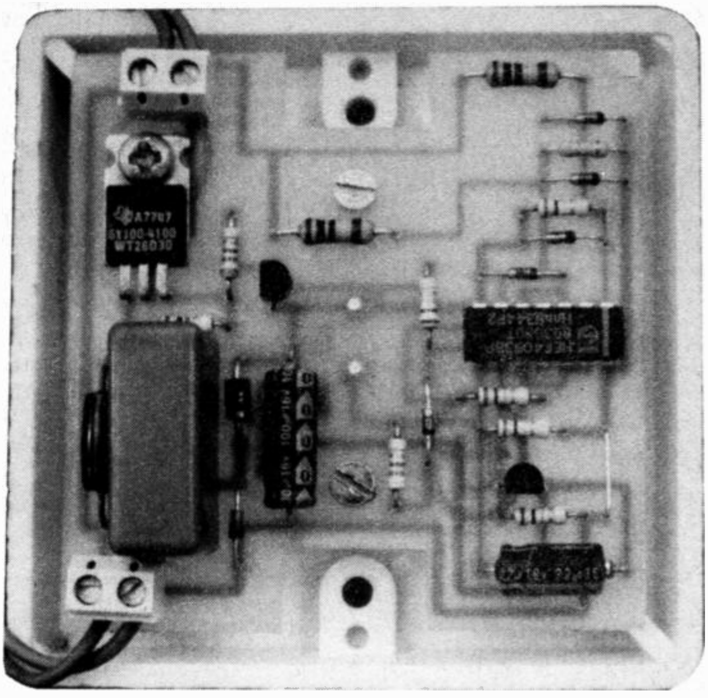
Do not assume that a load is safe if it is switched off by this unit. It is the Neutral line being switched by the unit, not the Live. This reduces the potential difference between the circuit and Earth. Also, there is sufficient leakage through an untriggered triac to give a fatal electric shock.

When working on the unit, or a load connected to it, the power MUST be properly isolated (Live and Neutral disconnected).

Take care to position the unit so that light from the lamp it is controlling does not fall directly on the l.d.r. It may be possible to mount it on a different side of the building to the lamp, for example. Street lamps have the light sensor mounted on the top, above the lamp which shines downwards.

If mounting the unit outdoors it will need a suitably waterproof case. The suggested case is suitable for indoor use only. It is imperative that the circuit cannot get wet. The area where the light gets to the l.d.r. may be difficult to seal effectively. A sealed plastic case (to IP65) with a clear lid would be a satisfactory solution.

Use sealed cable glands for the cable entries. Drill a small (2mm) breather hole at the lowest point in the case, to prevent condensation and let out any moisture which might get in despite your efforts. □



FOX REPORT

by Barry Fox

New Games War

Sony predicts that its PlayStation games system, launched throughout Europe on 29 September, will be the most important product since Walkman. Perhaps; then again, at £300 for the hardware, without even one complete game thrown in, perhaps not.

At that price a lot of people may prefer to put the money towards a Pentium Multimedia PC which can play games as well as a lot of other things, including surfing the Internet. This is especially true now that Sega is competing with Saturn (£400 including one complete game), and Nintendo is promising Ultra 64. There will be winners and losers in this new games format war and no-one wants to be a proud owner of the losing system.

Inventing VCR History

At a press briefing to demonstrate the superior picture and sound quality of the CD PlayStation (sourced from poor quality tape with the worst speaker system Sony could find) an AV (audio video) show from the company's Computer Entertainment division told how "Sony invented the VCR". Later, Head of Product Development Phil Harrison went one better. "Sony invented video tape" he proudly pronounced.

Few people outside Sony will need reminding that it was Ampex who made the first practical video recorders in 1956, with rolls of 2" tape made by 3M. Four heads spun across the tape. In Japan, in 1959, Toshiba showed the first recorder which used helical scan heads.

During the 1960s several companies, including Sony, sold semi-pro open reel recorders which used ½" tape. A new wave of college film-makers used them on student marches and demonstrations. Panasonic adapted the format so that the reel was housed in a cartridge.

Philips showed a prototype of the first consumer Video Cassette Recorder in October 1971. The N1500 went on sale on the Continent in 1972 and reached the UK in mid 1974.

The N1500 VCR used ½" tape and was the first video cassette recorder with built-in tuner to record programmes without a TV set, timer to switch itself on and off, and modulator to feed signals into the aerial socket of a domestic TV set – all of which we take for granted today. It was thus Philips who made VCR time-shifting possible, albeit initially with only one hour per cassette. The N1500 cost £388.62.

Beta Battle

Sony's first consumer VCR, Betamax, was launched (NTSC version) in Japan and the USA in 1975. It too gave only one hour, from the small Beta cassette. In 1977 Sanyo and Toshiba joined forces with Sony and offered a two hour Beta machine. JVC and Panasonic offered two hour VHS. By late 1977 they had doubled the VHS playing time to four hours. Sony did likewise with the Beta system.

European VHS was unveiled in February 1978; Sony first showed Betamax in April 1978. VHS won the standards battle and Beta died.

But Sony did not invent video tape, and the closest they came to inventing the VCR was to launch the professional U-Matic cassette system in 1972. This followed some false starts in 1969 with monster machines which used 1" and ¾" tape and were never seriously marketed.

U-Matic uses ¾" tape and was never intended as a consumer product. It is a one hour system with no built-in timer, tuner and modulator for time shifting. The format quickly became – and still remains – an industrial workhorse.

Literally Daft

Re-writing history with daft claims merely devalues what the company now promises for the future; and Sony does seem to have developed some odd literary habits lately.

The company sent out invitations two weeks ahead of a press conference to annouce its sale of an electronic editing system to TV news provider, ITN. Sony's UK office was immediately flooded with requests from magazines for advance information. Companies routinely release information early under embargo so that weekly and monthly magazines can publish a story at around the same time as the daily newspapers. If journalists do not respect embargos they never get another early release.

But Sony and ITN got a Public Relations company to draft a legally binding document. We had to sign it before we got a few uninteresting pages of text.

Buried in the packed page of small print was the requirement that I would "not disclose, publish or otherwise reveal any of the information to any other party except with specific prior written authority of an officer of Sony UK".

Did anyone at Sony or ITN actually read this text and think what it means?

It means that if I wrote about the electronic news editing system I must ask "an officer of Sony" for fresh written permission every time the words of the story were passed between all the members of office and printing house staff who handle the magazine before publication.

Footnote

Next through the post came another press release from Sony which tells how one of its professional digital video cameras has been used to record another ascent of Mount Everest. So many people now climb the mountain that it no longer makes news. But in this case one of the climbers, Tom Whittaker, was handicapped. He had suffered an accident twelve years ago. According to Sony he got to the top "despite the luxury of only having one foot".

You may have to read that last sentence twice to get the point.

Patently CD Rubbish

John Preston, Director of Technology Development at MIT (the Massachussetts Institute of Technology) flew to Wales recently to tell a technology conference that British businesses "must adapt or die". The Prince of Wales and Welsh Development Agency had encouraged MIT to hold its conference in Wales and tell delegates that "the UK does not have enough entrepreneurial role models and that UK startup companies lack the depth of talent of their US counterparts".

MIT's Director of Technology Development is entitled to his rather patronising views of British industry. But I lost confidence in John Preston when I was on a radio progamme with him the night before his much-publicised speech.

Preston piped up with the bald statement that "CD was invented in the USA and exploited by Japan". This is rubbish.

Philips (Holland) and Sony (Japan) invented, engineered, patented and launched the CD digital audio system. In defence, Preston then threw up the name of US company DiscoVision Associates. DVA (now controlled by Pioneer of Japan) does indeed have valuable patents on optical storage. These were filed on analogue video disc but were sufficiently broadly worded to cover other disc formats.

DVA makes no bones about the fact that it manufactures nothing, and exists solely to earn royalties from paper documents. So most companies which make CDs and Laser Discs now have to pay royalties to DVA, as well as Philips and Sony. But other companies, such as ORC of Canada and Thomson of France, also claim royalites on optical patents which overlap the CD process.

All credit to DVA for its original work on video disc, and clever patent drafting. But I have never before heard anyone, even DVA, claim that DVA invented audio CD.

STEREO "CORDLESS" HEADPHONES

ROBERT PENFOLD

An infra-red "cordless" link that will cut out those family stand-up fights and near destructive accidents, from trailing leads, when you try to use your headphones in the living room. Relax, peace at last!

UNTIL the advent of the personal stereo, headphones were not very popular amongst the general public. Although headphone listening has definite advantages, such as relatively little annoyance to others, there are also some practical drawbacks.

At one time headphones were quite large and cumbersome, and putting them on often felt rather like clamping your head in a vice! Fortunately, most modern headphones are very small and light, and often lack any form of headband.

Probably the main objection to headphones as a general means of listening to televisions, stereo units, etc., is the need for a long connecting cord from the user to the signal source. Someone tripping over a headphone lead can be a painful experience for both parties.

Standing up while standing on the headphone lead is easily done, and can also be a very painful experience if you are wearing headphones that have a headband. The headphones are pulled down hard onto your head.

USER FRIENDLY

Headphones are much more "user friendly" if they are connected to the signal source via some form of "cordless" link. The usual approach to this is to have an infra-red transmitter at the signal source, and a matching receiver connected to the headphones by way of a short cable.

Some infra-red headphone systems are literally cordless at the receiving end, with the receiver built into the headband of the headphones. This approach is not very practical for a home-constructed system, and is not really applicable to most modern headphones anyway. It is better to opt for a personal stereo style receiver, together with lightweight headphones having a short lead.

This "cordless" headphone system provides a stereo link over a range of up to at least four metres. While the audio quality is not in the super-fi category, it is good enough for most purposes, and the signal-to-noise ratio is very good at a range of up to about three metres or so.

There is a slight drop-off in performance at a range of around four metres, but the noise level is still far from excessive at this range. The completed system can be aligned without the need for any test equipment, and it is basically just a matter of adjusting a coupled of presets for optimum results.

MONO LINK

If only a mono link is required it would be perfectly feasible to omit the components that are unique to the left hand channel, and use the right hand channel to handle the mono signal (or vice versa). However, this would still result in a system that was slightly "over the top" for mono use.

A much simpler and cheaper mono system will be featured at a later date, and anyone who only needs a mono system would be well advised to await publication of this follow-up article.

TWO INTO ONE

The linearity through infra-red l.e.d.s and photodiodes is not particularly good, and the audio quality provided by an a.m. (amplitude modulation) link is unlikely to be good enough for use with a music signal. An f.m. (frequency modulation) link is a better choice as the linearity of the system is then determined by the quality of the modulator and demodulator. Amplitude distortion through the photocells does not alter the frequency of the signal, and does not contribute to the distortion on the output signal.

A stereo infra-red system is a bit problematic as it is not possible to simply use two separate but identical links. The receiver circuits would pick up both signals, and would not be able to sort out one signal from the other.

The most practical approach seems to be to use a simple form of multiplexing. The two f.m. carrier waves, operating over different frequency bands, are combined to produce a single signal that is fed to a bank of infra-red l.e.d.s. Filtering at the receiver is used to separate the two carriers, so that each demodulator is fed only with the carrier signal for its own particular stereo channel.

First attempts were tried using squarewave signals at the transmitter. This did not seem to work very well in practice, with the two signals mixing together to produce a vast number of output frequencies. No matter how sophisticated the filtering at the receiver, it proved impossible to obtain really "clean" signals for the demodulators.

Much better results seem to be obtained using reasonably pure sinewave signals. These produce a minimum of interaction, and enable the two carrier signals to be separated at the receiver using relatively simple filtering. The two carrier signals must be reasonably well spaced, and it is important to choose frequencies that avoid audio heterodynes between harmonics of the lower frequency carrier and the fundamental frequency of the higher frequency carrier.

TRANSMITTER

The block diagram for the Transmitter is shown in Fig. 1. The right hand input signal is first fed to a pre-emphasis stage. Pre-emphasis is merely a certain amount of treble boost added to a signal *prior* to transmission or recording.

It is used in practically all analogue radio communications and recording systems. Some complementary treble cut (de-emphasis) is used at the receiving end of the system, so that overall frequency response of the system is unaffected.

The point of all this is that the treble cut at the receiver gives a large subjective increase in the signal-to-noise ratio of the equipment. The perceived improvement can be as much as 20dB, and it was found that this method of noise reduction was essential if a stereo infra-red system was to give good results at anything other than a very short operating range.

Of course, a strong signal at a high audio frequency could be boosted to the point where it overloads the transmitter. This system is reliant on the fact that "real world" input signals do not contain very strong signals at the highest audio frequencies.

After the pre-emphasis has been applied the signal is fed through a lowpass filter. This stage attenuates signals at frequencies above the audio range. In theory there should be no input signals at these frequencies, but in practice there can be slight breakthrough of ultrasonic frequencies at the output of tape recorders, f.m. tuners, etc. These are boosted by the pre-emphasis, and could react with one or other of the carrier signals to produce heterodyne tones at the output of the receiver. The lowpass filtering should reduce any breakthrough of this type to an insignificant level.

The next stage is a v.c.o. (voltage controlled oscillator), and this is the modulator. The normal output frequency of the v.c.o. is about 175kHz, but its frequency is raised when the audio signal is positive going, and reduced when it is negative going.

The higher the audio signal voltage, the greater the increase/decrease in the carrier frequency. A squarewave signal is generated by the v.c.o., but it is fed through a lowpass filter which severely attenuates the harmonic content to leave a reasonably pure sinewave signal.

A virtually identical series of stages are used in the right hand channel. The only difference is that the v.c.o. in the right hand channel has a much lower centre frequency of about 70kHz. Also, the cutoff frequency of the lowpass filter that follows the v.c.o. has a proportionately lower cutoff frequency, so that it also provides a reasonably pure sinewave output signal.

A mixer stage combines the two carrier signals. The composite output of the mixer is then fed to a high current buffer stage which drives a bank of up to five infra-red l.e.d.s.

ONE INTO TWO

The block diagram for the Receiver is given in Fig. 2. The infra-red signal from the Transmitter is picked up by a bank of up to four infra-red photodiodes.

Using four diodes gives a much stronger output than a single diode, and a much improved signal-to-noise ratio and longer operating ranges. Photodiodes offer lower sensitivity than phototransistors, but diodes are more able to handle the relatively high input frequencies involved here.

The output signal from the diodes is fed to a low gain preamplifier stage, and this feeds two virtually identical signal chains, one to handle each stereo channel. The only difference between the two is that the

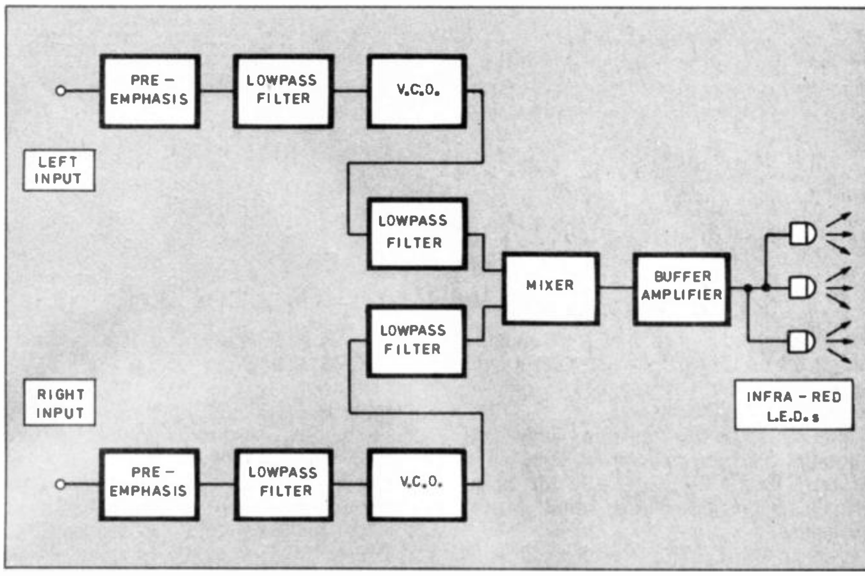


Fig. 1. Block diagram of the Transmitter section of the system.

The two completed Receiver and Transmitter units that make up the Stereo "Cordless" Headphones system.

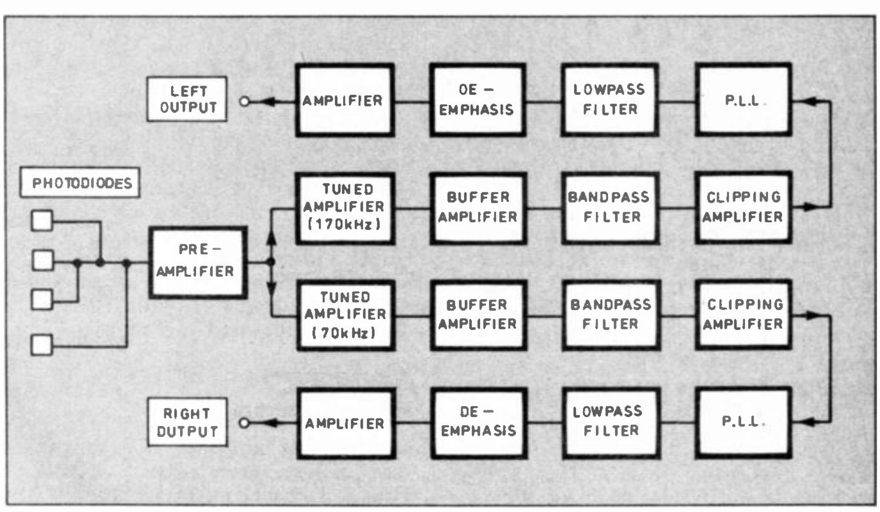
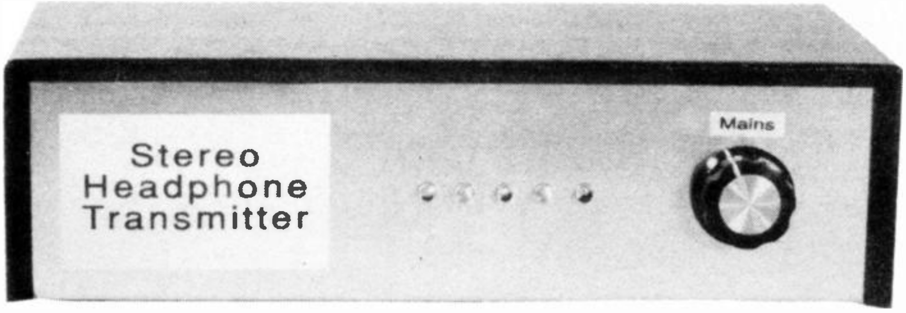


Fig. 2. Block diagram for the Receiver section of the headphone system.



one for the left hand channel is designed to handle a 170kHz carrier, while that for the right hand channel is designed to operate with a 70kHz carrier signal.

The first stage is a tuned amplifier. This amplifies the relevant carrier signal, but produces relatively little gain at other frequencies, including the other carrier frequency.

A single tuned circuit in each signal path gives inadequate separation of the two carrier waves. Therefore, the output from each tuned amplifier is fed to a bandpass filter via a buffer amplifier. This gives sufficient channel separation, and the two filtered carrier waves are fed to clipping amplifiers.

These provide suitable output signals for the f.m. demodulators, which are phased-locked loops (p.l.l.s). The basic action of a phase-locked loop is to maintain a v.c.o. on the same frequency as, and in-phase with, the input signal.

In an application such as this it is not the oscillator signal that is of interest, but the control voltage to the v.c.o. As the v.c.o. tracks the changing carrier frequency its control voltage varies. This voltage constitutes the demodulated audio output signal.

The demodulated audio signals are fed through lowpass filters which attenuate any residual carrier breakthrough. After de-emphasis the audio signals are then fed to output amplifiers which enable any normal headphones to be driven at good volume.

TRANSMITTER CIRCUIT

The full circuit diagram for the Transmitter appears in Fig. 3. As the left and right hand channels are virtually identical we will only consider the operation of the left hand channel here.

A high performance, low noise, j.f.e.t. input op.amp IC1 acts as an input buffer, and it also provides the pre-emphasis. It is basically just an ordinary non-inverting mode circuit having a voltage gain of eleven times, but the value of capacitor C3 is much lower than would normally be the case. Consequently, it only provides a low impedance path to "earth" (0V) at high frequencies, and the full voltage gain of the amplifier is only provided at the highest audio frequencies.

At lower frequencies C3 places a relatively high impedance in series with resistor R4, which gives a lower voltage gain. In fact, the amplifier has virtually 100 per cent negative feedback at low and middle audio frequencies. The circuit therefore provides the required high frequency boost.

PHASED OUT

The output from IC1 feeds into a conventional third order (18dB per octave) lowpass filter based on IC2. The cut-off frequency of this filter is at about 16kHz, and it therefore has a minimal effect on the audio response of the system.

The v.c.o. is based on IC3, which is a CMOS 4046BE "micropower" phase-locked loop. In this case only the v.c.o. section is used, and no connections are made to the phase comparators or other sections of the device.

Capacitor C7 is the timing capacitor, and the timing resistance is provided by resistor R8 and preset VR1. The latter enables the centre frequency of the v.c.o. to be adjusted, and in practice this is set for optimum results from the Receiver (which has fixed tuning).

The lowpass filter at the output of IC3 is a passive type which has two *C/R* networks and an *L/C* type. This gives an attenuation rate of 24dB per octave, which is sufficient to give a reasonably good sinewave output signal.

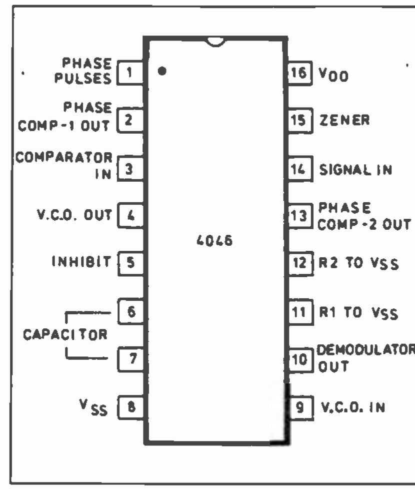
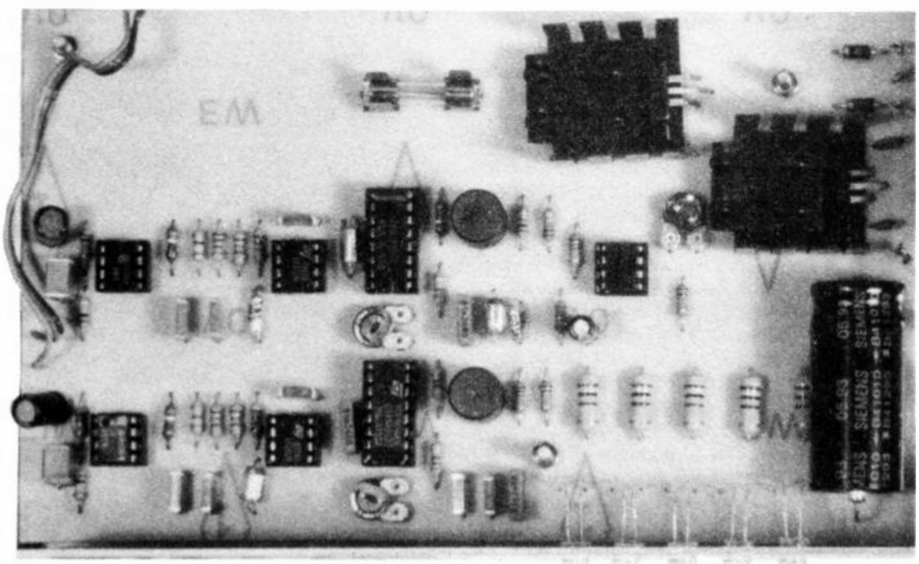


Fig. 5. Pinout details for the 4046 i.c.

circuit works well provided the op.amp used for IC7 is a type which has good high frequency performance.

The 10MHz gain-bandwidth product and high slew rate of the NE5534P (or an NE5534AN) ensure satisfactory results from the mixer. Lower cost operational amplifiers that were tried in the circuit did not function very well.



Completed Transmitter circuit board.

There is no point in trying to generate a really high quality sinewave signal, since the distortion through the photocells makes it impossible to obtain highly pure signals at the receiver. The Receiver must be able to cope with a certain amount of distortion on the carrier waves.

The filtering results in some variation in the amplitude of the output signal as the carrier signals rise and fall in frequency. The variation is not very great though, due to the fairly low modulation level used.

The clipping amplifiers at the receiver remove these variations provided a reasonably strong signal is received. The p.l.l. demodulators are little effected by variations in the input level anyway.

MIXED RESPONSE

Operational amplifier IC7 forms the basis of the mixer stage, which is a standard summing mode circuit of the type often used in audio mixers. In this case the input frequencies are much higher, but the

Preset potentiometer VR3, wired as a variable resistor, controls the voltage gain of the mixer. This is adjusted for the highest output level that gives a "clean" output signal that is free from clipping.

Transistor TR1 is an emitter follower buffer stage that drives the bank of infra-red l.e.d.s (D1 to D5). The TIP122 used for TR1 is actually a Darlington device. Its extremely high current gain ensures that the circuit can easily provide the high drive current required by the l.e.d.s.

The average l.e.d. current is about 50mA per l.e.d., or about 250mA in total. The typical current consumption of the entire Transmitter circuit is about 270mA.

Battery operation is not really a practical proposition with a current consumption as high as this. The unit is therefore powered from a mains power unit, which must provide a stable, low noise, 12V supply.

The circuit diagram for the simple stabilised power supply is shown in Fig. 4. This has full-wave (push-pull) rectification plus a 12V voltage regulator (IC8) to stabilise the output and provide electronic smoothing.

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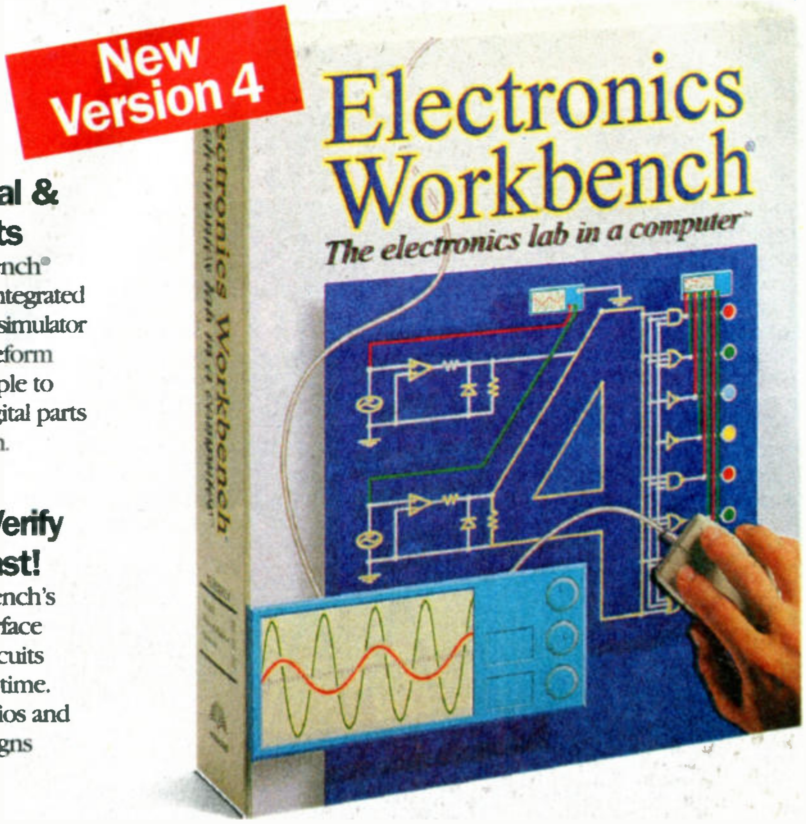

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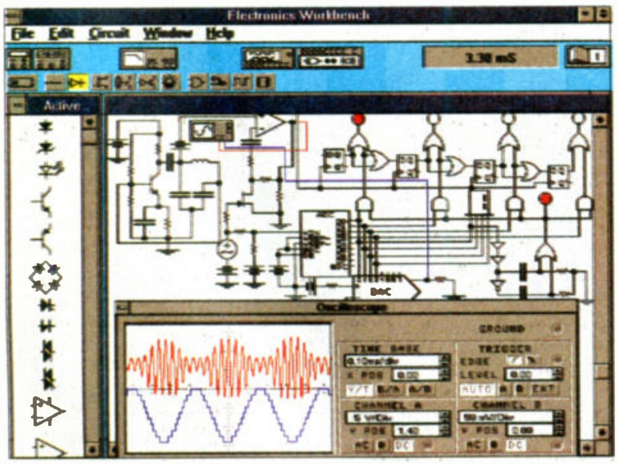

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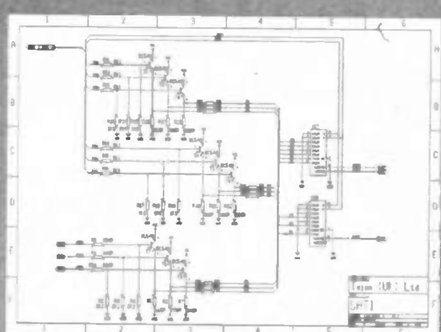

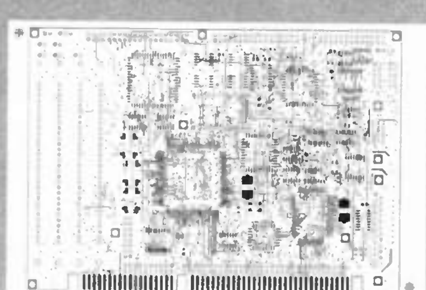

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COMPONENTS

TRANSMITTER

Resistors

R1, R2, R9, R10	100k (4 off)
R3, R11, R17	3k9 (3 off)
R4, R12	390Ω (2 off)
R5, R6, R7, R13, R14, R15	6k8 (6 off)
R8	3k3
R16	8k2
R18	4k7
R19, R20	1k (2 off)
R21, R22, R23, R25	10k (4 off)
R24	11k
R26 to R30	100Ω 1W (5 off)

All 0·25W 5% carbon film, except R26 to R30.

See SHOP TALK Page

Potentiometers

VR1, VR2	10k min. preset, hor. (2 off)
VR3	22k min. preset, hor.

Capacitors

C1, C8	100μ radial elect. 16V (2 off)
C2, C9	470n polyester (2 off)
C3, C10	33n polyester (2 off)
C4, C11	3n3 polyester (2 off)
C5, C12	4n7 polyester (2 off)
C6, C13	330p polystyrene (2 off)
C7	470p polystyrene
C14, C15, C19	1n polyester (3 off)
C16, C18	2n2 polyester (2 off)
C17	680p polystyrene
C20	100p polystyrene
C21	10μ radial elect. 25V
C22	2200μ axial elect. 25V
C23	220n ceramic
C24	100n ceramic

Semiconductors

D1 to D5	5mm infra-red l.e.d. (5 off)
D6, D7	1N4002 100V 1A rectifier (2 off)
TR1	TIP121 or TIP122 *npn* power Darlington
IC1, IC2, IC4, IC5	LF351N bi-f.e.t. op.amp (4 off)
IC3, IC6	4046BE CMOS phase-locked loop (2 off)
IC7	NE5534P or NE5534AN low noise op.amp
IC8	μA7812 12V 1A positive regulator

Miscellaneous

S1	min. mains d.p.s.t. On/Off rotary switch
T1	mains transformer, with twin 12V 500mA sec
FS1	500mA anti-surge fuse, 20mm
JK1	3·5mm stereo, chassis mounting, jack socket
L1	3·3mH inductor/choke type 10RB
L2	6·8mH inductor/choke type 10RB

Printed circuit board available (as a pair) from *EPE PCB Service*, code 961 (Trans.) and 962 (Rec); metal case, size about 230mm x 133mm x 63·5mm (WB4); clip-on TO220 heatsink (2 off); 8-pin d.i.l. i.c. holder (5 off); 16-pin d.i.l. i.c. holder (2 off); mains lead and plug; 20mm fuse-clips; connecting wire; solder, etc.

Approx cost guidance only **£40**

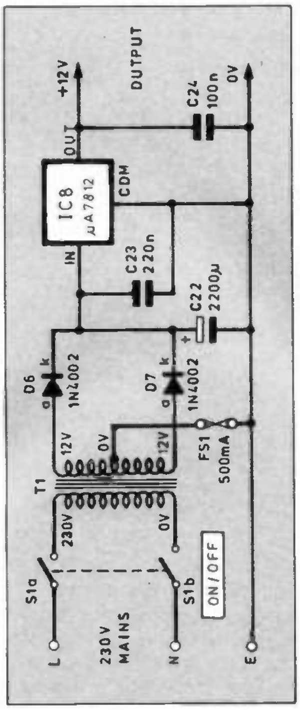


Fig. 4. (right). Circuit diagram for a simple power supply for the Transmitter circuit.

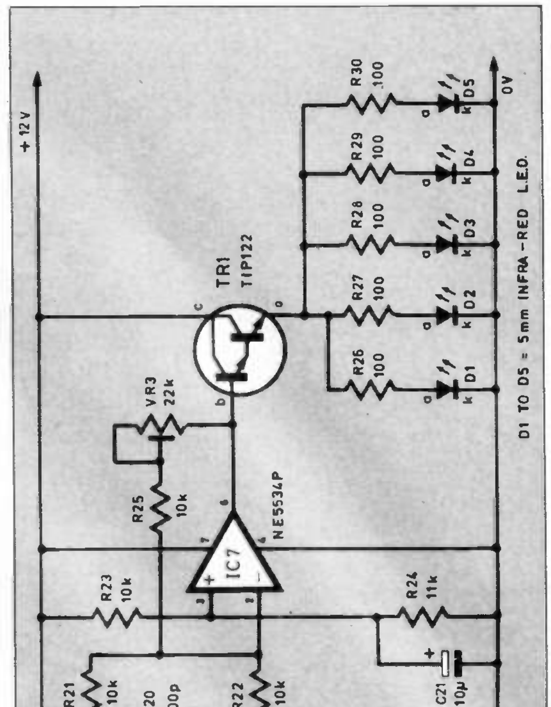
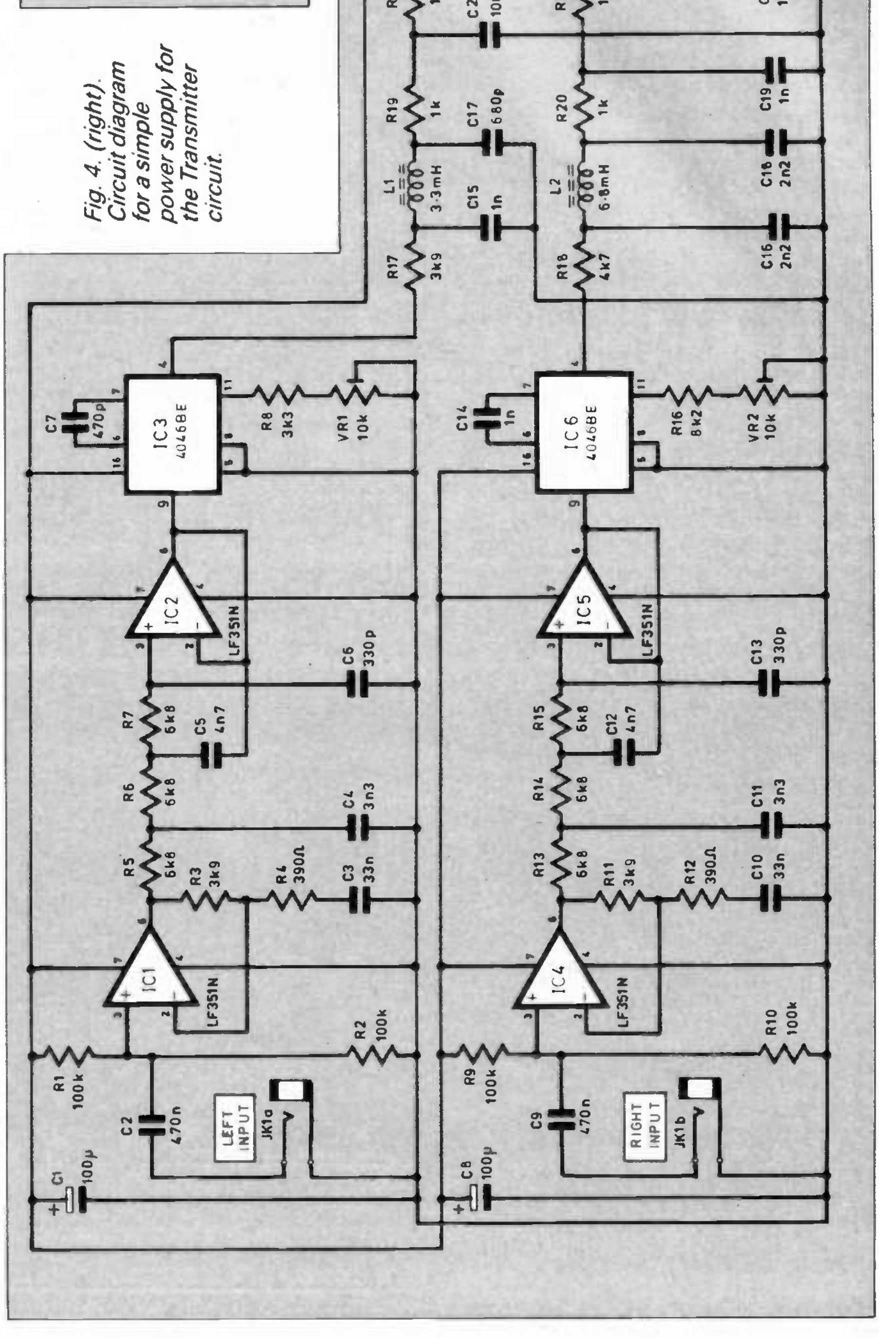
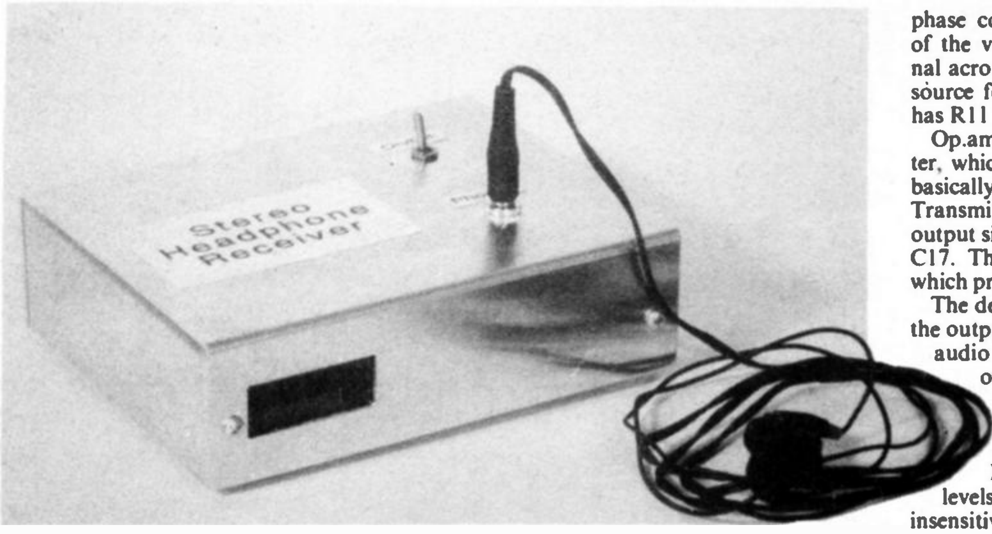



Fig. 3. Complete circuit diagram, less power supply, for the Transmitter section of the Stereo "Cordless" Headphones.



RECEIVER CIRCUIT

The Receiver circuit diagram appears in Fig. 6. The four infra-red diodes (D1 to D4) are connected in parallel and used in the reverse biased mode. Capacitor C4 couples their output signal to a common emitter stage based on transistor TR1.

This has a low voltage gain of only about two times due to the local negative feedback provided by its non-bypassed emitter resistor (R4). The main purpose of this stage is to provide buffering, rather than a large amount of voltage gain.

Transistor TR2 is used as the tuned amplifier in the right hand channel. It is a common emitter stage which has inductor L1 and capacitor C6 as a tuned circuit which act as its collector (c) load. TR3 is an emitter follower stage which provides buffering at the output of TR2, and drives the bandpass filter. This has L2 and C9 as another parallel tuned circuit.

The selectivity provided by the two tuned circuits is not very high, but the response of the filter must be broad enough to accommodate a reasonable amount of carrier deviation. The attenuation of the higher carrier signal is more than sufficient to give good results.

Operating as a high gain common emitter stage, TR4 will be driven into clipping provided a reasonably strong signal is received from the Transmitter. Capacitor C10 rolls-off the high frequency response of TR4. This gives improved attenuation of the higher frequency carrier wave, and also improves the signal-to-noise ratio of the right hand channel.

DEMODULATION

A CMOS 4046BE phase-locked loop is used for IC1, and is actually the same device that is used in each v.c.o. at the Transmitter. In this case it is used as a phase-locked loop rather than just a v.c.o.

Resistor R10 and capacitor C11 are the timing components for the v.c.o. section. The link across pins 3 and 4 connects the output of the v.c.o. to the inputs of IC1's two phase comparators.

The output signals of the phase comparators are available at IC1 pins 13 and 2, and in this case it is the latter that is used. The required f.m. demodulation is produced using either of these outputs, but using pin 2 seems to give much better results, with greater freedom from spurious output signals.

Resistor R12 and capacitor C12 are the lowpass filter between the output of the phase comparator and the control input of the v.c.o. The demodulated audio signal across C12 is extracted via an internal source follower buffer stage of IC1. This has R11 as its discrete load resistor.

Op.amp IC2 is used in the lowpass filter, which is a third order circuit. This is basically the same as the ones used in the Transmitter. Capacitor C16 couples IC2's output signal to resistor R16 and capacitor C17. These form a simple lowpass filter which provides the de-emphasis.

The de-emphasised audio signal is fed to the output amplifier (IC3), which is a small audio power amplifier device. The output from IC3 is actually excessive for most headphones, and resistor R17 is therefore used to attenuate the output signal.

If you require high volume levels, or are using the system with insensitive headphones, the value of R17 can be reduced in order to increase the output power of the circuit. With very low sensitivity headphones it may be necessary to replace R17 with a shorting link.

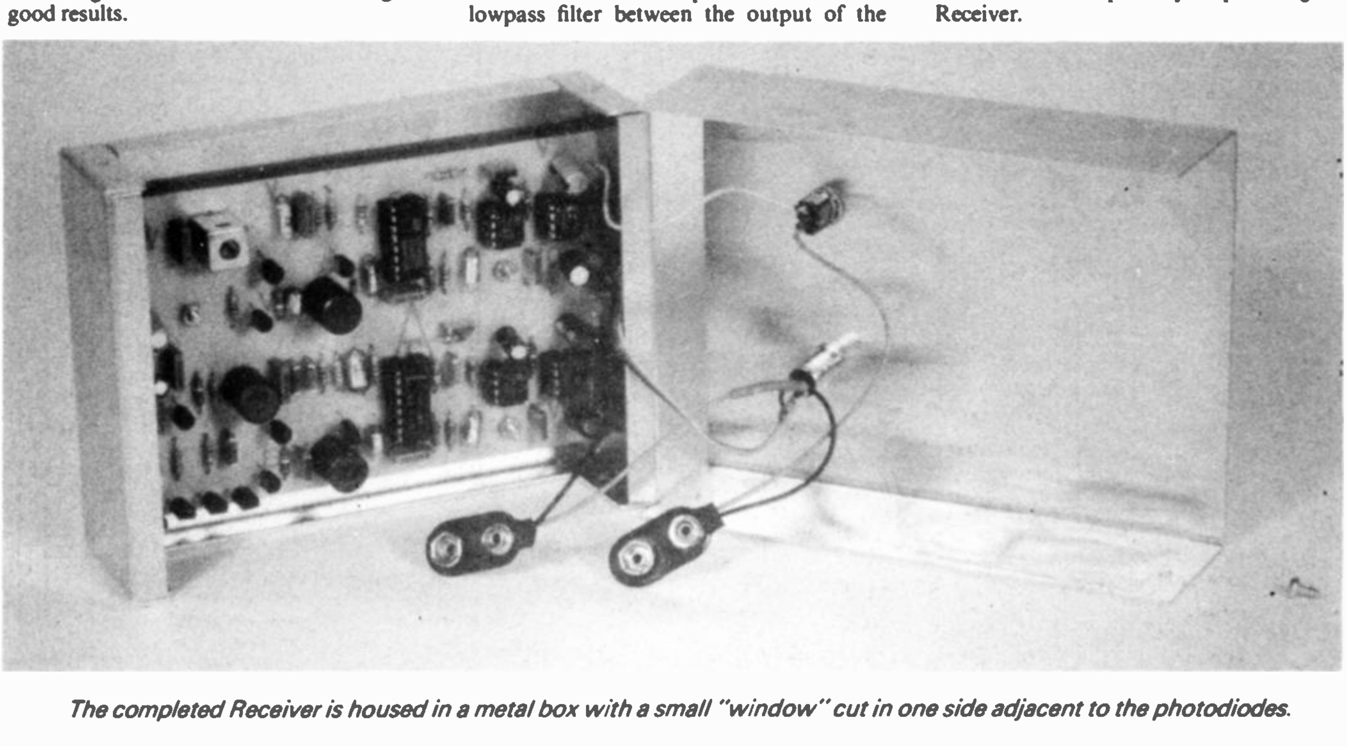
LEFT-HANDED

The additional circuitry for the left hand channel is also shown in Fig. 6, and this is much the same as the right hand channel. Some values have been changed to suit the higher operating frequency of this channel.

Also, the tuned amplifier is based on a transformer (T1) rather than a simple inductor. However, as the secondary winding of T1 is left unused, it really operates here as a tapped inductor rather than as a transformer.

This gives slightly better results than using a non-tapped inductor. T1 is actually an i.f. (intermediate frequency) transformer intended for use at about 455kHz. Capacitor C22 is connected in parallel with its internal tuning capacitor, and this reduces the resonant frequency to around 175kHz.

The current consumption of the Receiver is about 25mA to 30mA. This can be supplied by a "high power" PP3 size battery, but this is likely to be an expensive way of powering the unit if it will receive a lot of use. Six HP7 size cells in a holder represent a much cheaper way of powering the Receiver.



The completed Receiver is housed in a metal box with a small "window" cut in one side adjacent to the photodiodes.

COMPONENTS

RECEIVER

Resistors

R1	22k
R2, R5, R8, R18, R21	1M (5 off)
R3, R7, R13, R16, R20, R26, R29	3k9 (7 off)
R4	1k8
R6	560Ω
R9, R22	2k2 (2 off)
R10, R11, R24	10k (3 off)
R12, R23, R25	5k6 (3 off)
R14, R15, R27, R28	4k7 (4 off)
R17, R30	220Ω (2 off)
R19	1k

All 0·25W 5% carbon film

See SHOP TALK Page

Capacitors

C1, C2, C19, C20	100μ radial elect. 10V (4 off)
C3	10μ radial elect. 25V
C4, C21	10n polyester (2 off)
C5, C7, C8	2n2 polyester (3 off)
C6	1n5 polyester
C9	3n3 polyester
C10, C11	680p polystyrene (2 off)
C12, C22, C24, C27	1n polyester (4 off)
C13, C28	4n7 polyester (2 off)
C14, C29	6n8 polyester (2 off)
C15, C23, C30	470p polystyrene (3 off)
C16, C31	1μ radial elec. 50V (2 off)
C17, C32	33n polyester (2 off)
C18, C33	220μ radial elect. 10V (2 off)
C25	220p polystyrene
C26	330p polystyrene

Semiconductors

D1 to D4	TIL100 or similar infra-red photodiode (4 off)
D5, D6	1N4148 signal diode (2 off)
TR1, TR2, TR5,	BC550C *npn* silicon transistor (3 off)
TR3, TR4, TR6, TR7	BC549 *npn* silicon transistor (4 off)
IC1, IC4	4046BE CMOS phase-locked loop (2 off)
IC2, IC5	CA3140E MOSFET op.amp (2 off)
IC3, IC6	LM386N-1 audio power amp (2 off)

Miscellaneous

JK1	3·5mm stereo, chassis mounting, jack socket
B1	9V battery (high power PP3 – see text)
S1	s.p.s.t. min. toggle switch
T1	i.f. transformer, Toko YRCS11098
L1	2·2mH fixed inductor/choke, type 10RB
L2, L3	1mH fixed inductor/choke, type 10RB (2 off)

Printed circuit board available (as a pair) from *EPE PCB Service*, 962 (Rec.) and 961 (Trans.); metal box, size about 133mm x 102mm x 38mm; battery connector; 8-pin d.i.l. i.c. holder (4 off); 16-pin d.i.l. i.c. holder (2 off); connecting wire; solder, etc.

Approx cost guidance only **£27**

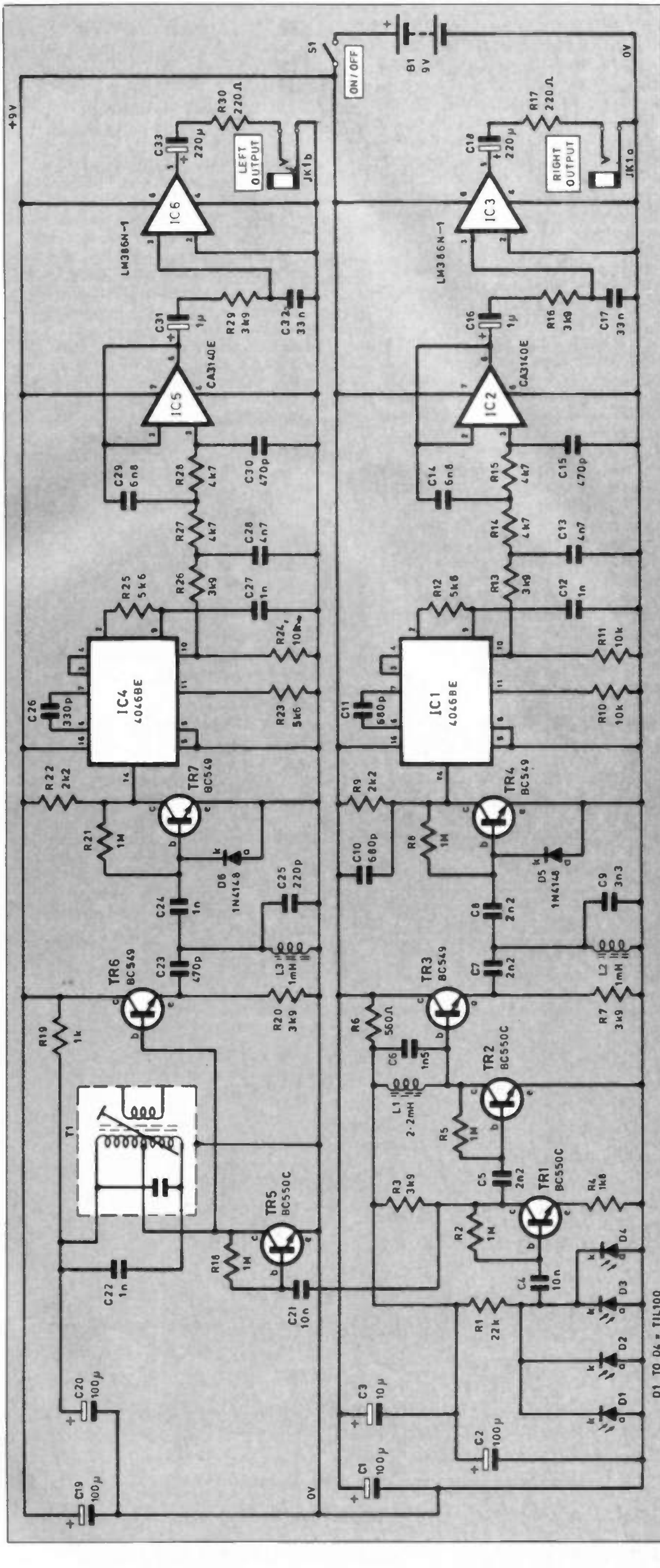


Fig. 6. Full circuit diagram for the Receiver section of the Stereo Cordless Headphones. Note that JK1 is a single stereo jack socket.

CONSTRUCTION - TRANSMITTER

Details of the Transmitter printed circuit board are provided in Fig. 7. This shows the topside component layout and actual size underside view of the board. This board, together with the Receiver board (962), is available (as a pair) from the *EPE PCB Service*, code 961. Construction of this board is reasonably straightforward, but there are several points worthy of note.

Fuse FS1 is mounted on the board via a pair of printed circuit mounting fuse-clips. FS1 should be an "anti-surge" type, or "time delay" fuse as they are also known these days. A normal "quick-blow" fuse is likely to "blow" at switch-on due to the high initial current as capacitor C22 charges up.

Power Darlington TR1 and regulator IC8 do not have to dissipate a great deal of power, but they still require a certain amount of heat-sinking in order to ensure safe operation. Clip-on TO220 type heatsinks having a rating of 13·6 degrees Centigrade per watt are quite adequate.

The polyester capacitors should be printed circuit mounting types having a lead spacing of 7·5 millimetres (0·3 inches) if they are to fit easily into this component layout. The polystyrene capacitors must be reasonably small, modern components, if they are to fit into the available space. The non-electrolytic capacitors should have a tolerance of 10 per cent or better.

INDUCTORS

It is important that the two inductors L1 and L2 are types which will work efficiently at the frequencies involved in this application. Incidentally, the same is true of the three inductors in the receiver circuit. Ordinary r.f. chokes are unlikely to give good results.

It was found that the type 10RB inductors sold by Cirkit give good results. Any similar pot-core based inductors would probably work just as well, but the circuit has only been tested using the type 10RB components.

Note that the ferrite encapsulation of the inductors is extremely hard but quite brittle. Treat them with due care, as they are likely to smash if they are dropped onto a hard surface.

Socket JK1 is specified as being a 3·5mm stereo jack socket, hence JK1a and JK1b, but it is obviously in order to use any audio connector or connectors that fit in well with the equipment with which the transmitter will be used.

The 4046BE used for IC3 and IC6 is a CMOS device, and the normal anti-static handling precautions are therefore required when dealing with these components. In particular, they should be fitted in holders, but not until the board is otherwise complete.

Diodes D1 to D5 are ordinary 5mm infra-red l.e.d.s of the type used in remote control systems. These mostly seem to be sold simply as infra-red l.e.d.s, rather than under a particular type number.

Some components of this type have a relatively high output level, but only a relatively narrow angle of coverage. Others have a lower output level but cover a wider angle. Either type will work in this circuit.

The narrow angle type offer greater range, and are preferable if the system will be used over a range of three to four metres. Otherwise the wider angle l.e.d.s are a better choice, as they make the aim of the Transmitter less critical. Leave the leadout wires full length, and bend them through right angles so that the l.e.d.s are aimed forwards rather than upwards.

CASE

For *safety* reasons the Transmitter MUST be housed in an earthed all-metal case having a screw-fitting lid, and not a clip-on lid or cover. A low cost aluminium and steel instrument case is probably the best choice.

The circuit board is mounted as far to the left as possible, and well towards the front of the case. Use spacers about 12mm long over the 6BA or metric M3 mounting bolts, so that the connections on the underside of the board are kept well clear of the metal base panel. It is also essential to ensure that the board is mounted high enough to keep it clear of the screws which fix the outer casing in place.

A row of five 5mm diameter holes are drilled in the front panel to take the infra-red l.e.d.s. Try to get all the l.e.d.s pointing in pretty much the same direction. A slight lack of alignment will simply spread the signal over a slightly wider angle, and will not be of any major significance.

Getting them all pointing in significantly different directions is unlikely to give satisfactory results. It would produce areas of strong signal with "blind" areas in between.

Socket JK1 is mounted on the rear panel of the case, well towards the left hand end of the unit. The opposite end of the rear panel is drilled to take the mains lead, and this hole must be fitted with a grommet to protect the lead (see photo below).

Mains transformer T1 is mounted on the base panel just in front of the mains input lead hole, and a solder tag is mounted under one of the fixing nuts. This provides a chassis or "earth" (0V) connection point.

Make sure that T1 is positioned where it will not foul one of the mounting screws for the outer casing. The on/off switch is mounted well towards the right hand end of the front panel.

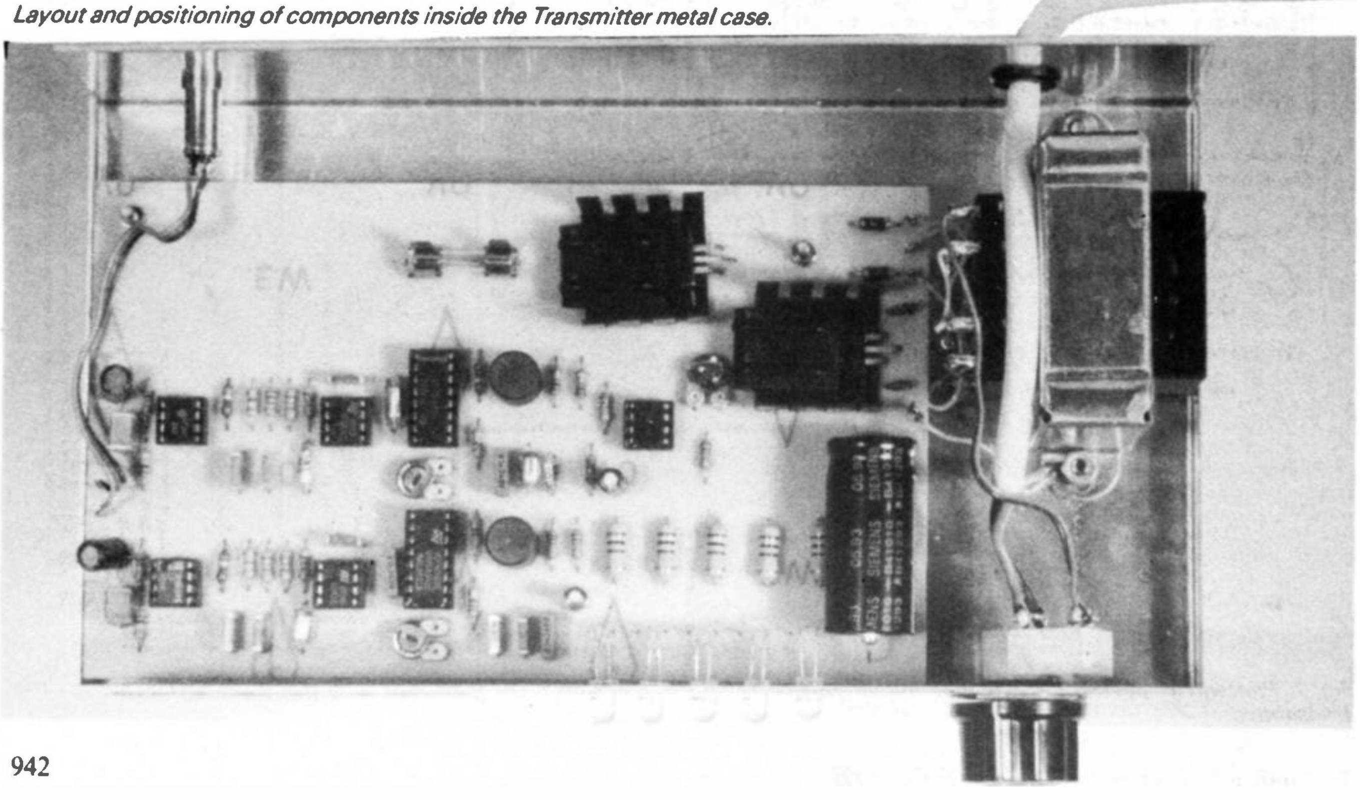
POWER SUPPLY

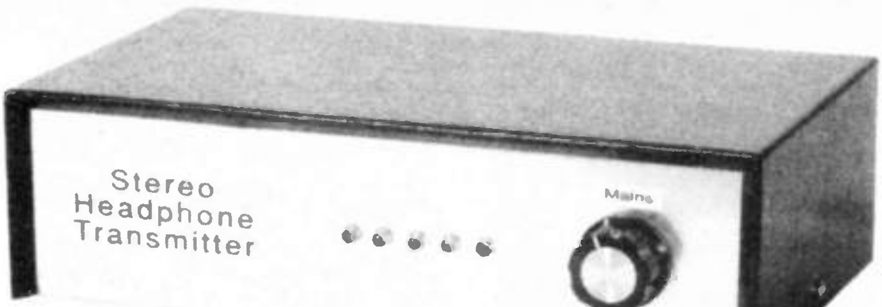
The power supply wiring and wiring to the rear-mounted signal input socket JK1 is also shown in Fig. 7. It is virtually certain that the mains transformer used for T1 will have twin 12V secondary windings rather than a 12V-0V-12V winding. The link across the centre 0V and 12V tags effectively converts the transformer to a 12V-0V-12V type.

Many modern mains transformers have twin 120 volt primary windings. These must be wired in series for operation on the 230V UK mains supply.

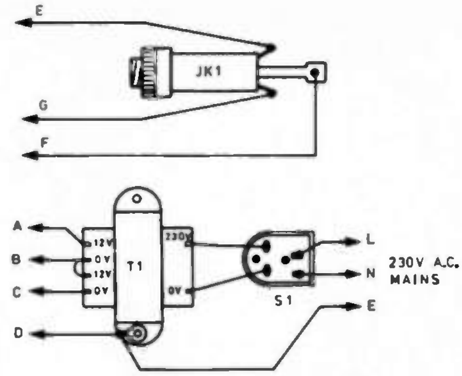
The power supply wiring is very simple and straightforward, but as the dangerous mains supply is involved a great deal of care *must* be taken when wiring-up the supply, and the finished wiring should be thoroughly double-checked. Cover any exposed connection tags on the transformer and on/off mains switch with insulating sleeving.

Layout and positioning of components inside the Transmitter metal case.





Completed Transmitter showing the "in-line" arrangement of the infra-red l.e.d.s.



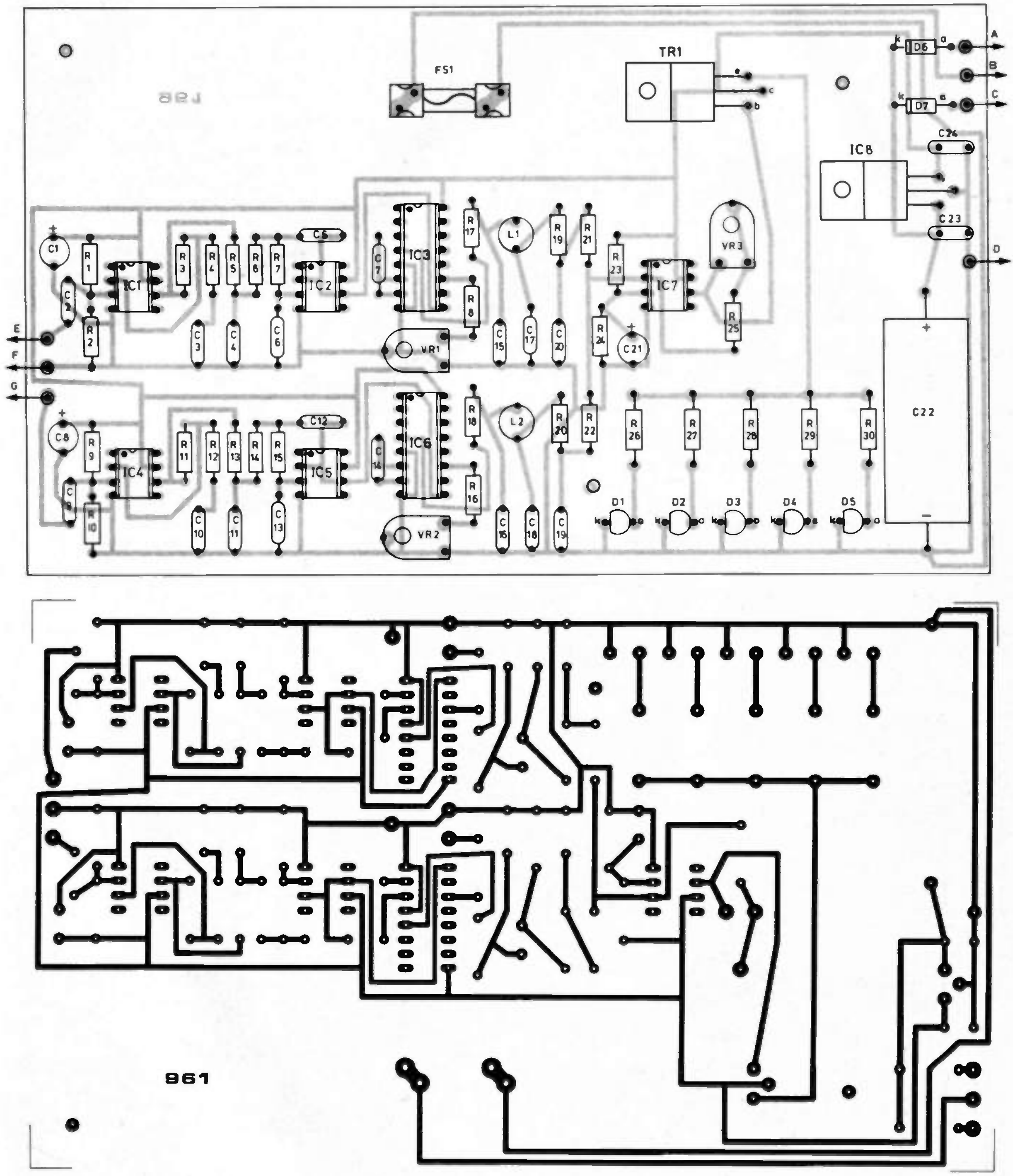


Fig. 7. Printed circuit board component layout, power supply and jack socket wiring, and full size copper foil master for the Transmitter.

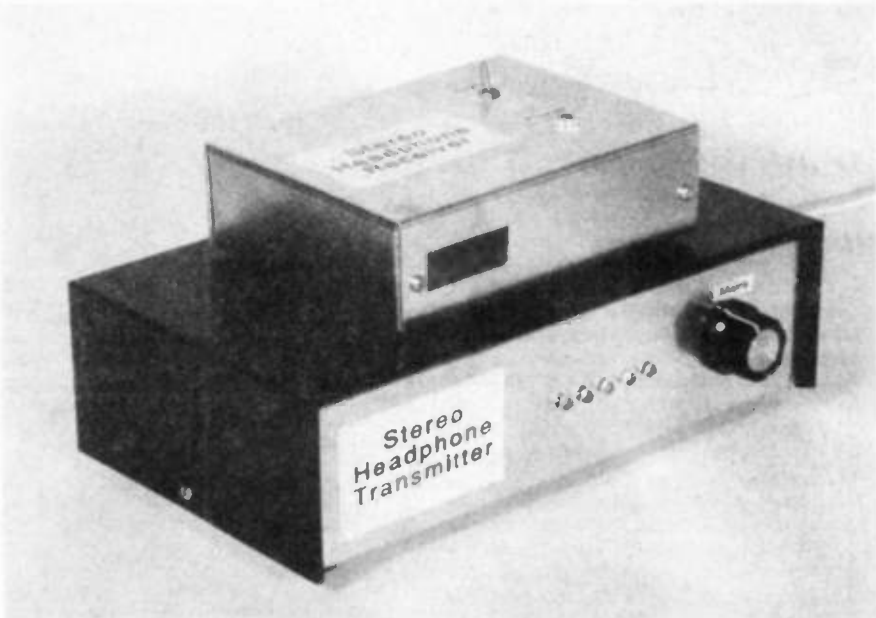
CONSTRUCTION – RECEIVER

The printed circuit board topside component layout, wiring and full size copper foil master for the Receiver is shown in Fig. 8. This board is available from the *EPE PCB Service*, code 962.

Many of the points made previously about the Transmitter board apply equally to this board, and will not be repeated here, apart from a reminder that IC1, IC2, IC4, and IC5 are static-sensitive components. Do not overlook the single link-wire just above capacitor C1.

Photodiodes D1 to D4 are TIL100 type. These are often sold simply as infra-red photodiodes for use in remote control systems, rather than under a type number. Any similar diodes having built-in "daylight" filtering should also give good results.

It is not essential to include all four photodiodes, and the Receiver will work using just a single photodiode. Results are much better using two diodes though, and it is probably best to regard two diodes as the practical minimum. It is advisable to include all four diodes if the system is likely to be used over a range of three to four metres.



The completed Receiver and Transmitter units ready for action. Note the Receiver photodiode window cutout and the protruding l.e.d.s of the Transmitter.

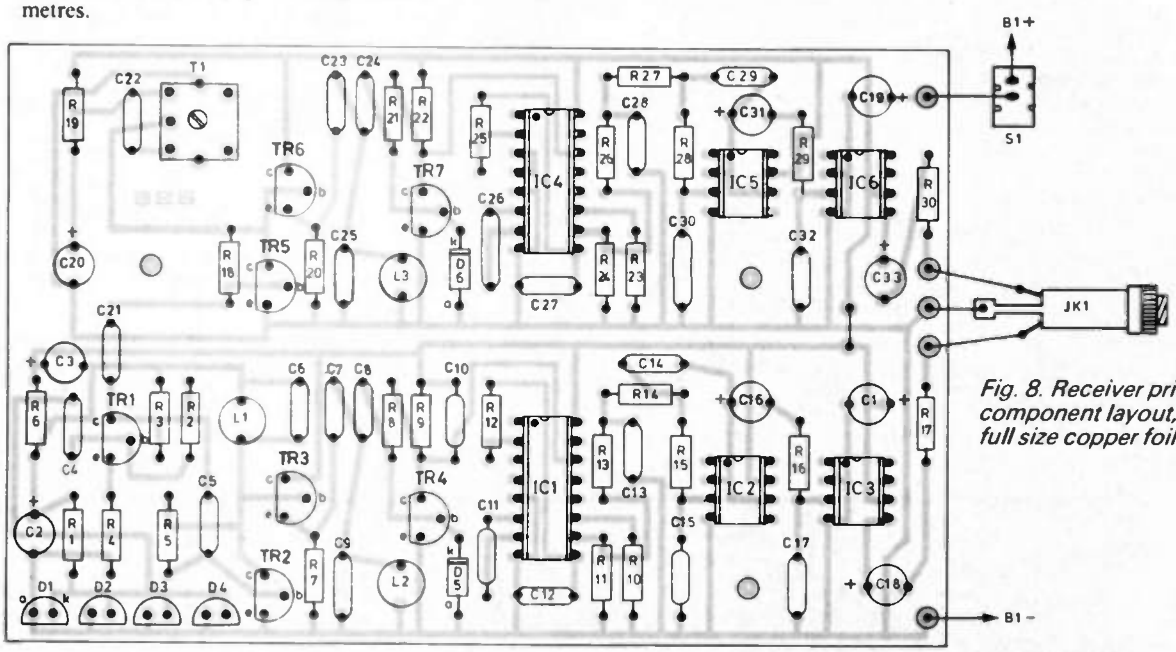
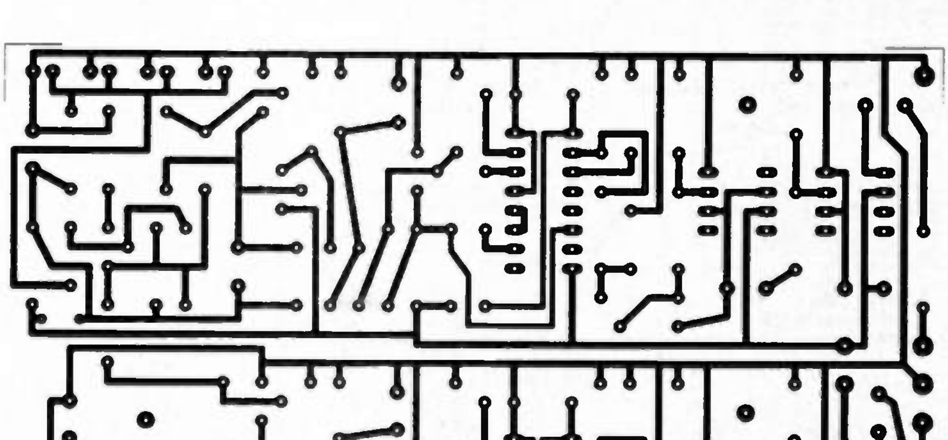


Fig. 8. Receiver printed circuit board component layout, interwiring and full size copper foil master pattern.



CASE

The Receiver will fit into an aluminium box which has dimensions of about 133mm × 102mm × 38mm. This represents about the smallest case that can accommodate the circuit board, on/off switch, headphone jack, and batteries.

It is not essential to use a metal case, although this does help to screen the sensitive receiver circuitry from electrical interference. Also, most of the plastic cases currently on offer do not seem to have the right proportions to take this circuit board, and would result in a finished unit that would resemble a "shoe box" more than a personal stereo unit!

A "window" for the photodiodes to look through must be made at the appropriate place on the lid section of the case. A rectangular cutout about 10mm × 30mm is sufficient, see photographs, and this can be made using a miniature file.

Ideally, a piece of thin transparent plastic should be glued in place behind the cutout, so that dust cannot enter through the cutout. Any window material used here must have a high degree of transparency so that it produces an insignificant signal loss.

MAKING SPACE

The Receiver board is mounted on the base panel of the case, as far as possible to one side so that one of the mounting flanges of the case does not obstruct the first photodiode D1. The offending flange can be filed away slightly in order to give D1 a wider angle of view.

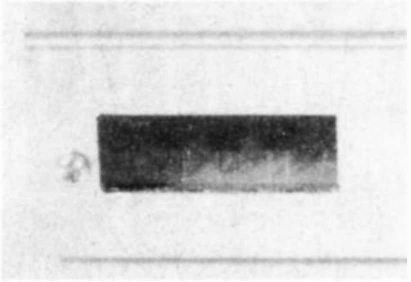
Short spacers up to six millimetres long are used to keep the underside of the board clear of the base panel, but it is not practical to use longer spacers. This would leave insufficient space above the printed circuit board for the battery, S1, and JK1. Switch S1 and jack socket JK1 are mounted on the top panel of the case, well towards one end so that they are close to their connection points on the circuit board.

There is more than ample space in the case for a PP3 size battery. Six HP7 size cells are a bit more difficult to accommodate, as all the holders for six cells of this type seem to be the wrong shape to fit into the available space.

Using two holders for three HP7 size cells wired in series seems to be the best solution. The holders can be glued to the underside of the lid. The connections to the battery holders are made via a pair of ordinary PP3 battery clips.

ADJUSTMENT

The Transmitter is connected to the Headphone socket of the signal source via a twin-screened lead fitted with the appropriate plugs. This enables the volume



Receiver photodiode window (full size).

to be controlled using the volume control of the television, cassette player, or whatever. Using some form of "Aux" or "Line" output might give usable results, but it would probably be necessary to add a volume control at the input of the Transmitter.

Start with preset potentiometer VR3 set almost fully counter-clockwise so that the Transmitter puts out a relatively weak but "clean" signal. With presets VR1 and VR2 at roughly central settings the unit will probably work to some degree, but will almost certainly provide far from optimum results.

Position the Receiver close to the Transmitter but slightly out of line with the main signal from the transmitter so that it receives only a weak signal. Then experiment with various settings for VR1 and VR2 in an attempt to find a combination of settings that provide good results.

The first requirement is to find settings that give good sensitivity and low distortion on the audio output signal. There will probably be no difficulty in finding settings that fulfil these criteria.

The other requirement is that the audio output signal should be free from heterodyne tones. This is more difficult to achieve, but with a little experimentation it should be possible to find settings that provide a reasonably "clean" output signal.

It is not absolutely essential to produce a totally "clean" signal. Even if there is a faint high pitched "whistle" on the audio output signal, this will almost certainly disappear in normal use when the receiver picks-up a signal at normal strength.

The tuning of the i.f. transformer T1 on the Receiver board is quite broad, and its setting is not critical. It is simply adjusted for minimum noise from the left hand channel.

Advancing preset VR3 in a clockwise direction will increase the strength of the signal from the Transmitter, and should give a significantly improved range. Advancing it too far will probably result in the signal being clipped, and background noises becoming apparent on the output from the Receiver. It is just a matter of finding the setting which gives the strongest possible output signal without spurious output signals becoming a problem.

IN OPERATION

In use, bear in mind that the output signal may not cover a particularly wide angle. This obviously depends on the particular l.e.d.s used, and their relative aims. In most cases the Transmitter must be aimed at the Receiver with reasonable accuracy if really good results are to be obtained.

The aim of the Receiver is less important, but it is worthwhile experimenting a little with its aim and orientation in an attempt to obtain optimum signal strength. The stronger the received signal, the lower the background noise level. □

New Technology Update

Ian Poole looks at the drive to eliminate output ringing with the new super hi-speed processors. Also, "having a PERM" may not just mean improving your appearance, but indicate you are using very high density disks.

IN RECENT years there has been a rapid increase in the speed of digital circuits. Only fifteen years ago when microprocessors like the 6502, 6800 and 8080 were widely used, clock speeds of only a few megahertz were normal.

Logic i.c.s were also not nearly as fast as they are today. Even though emitter coupled logic capable of running at speeds of hundreds of megahertz was available, it was very current hungry and used only in specialised applications.

Now speeds of many i.c.s are rising fast. This is probably most noticeable in the microprocessor market. It seems like only a couple of years ago 386SX machines running at 25MHz were fast. Now 486DX machines running at 66MHz are commonplace, and Pentiums running at much higher speeds are widely available.

Anyone who has worked with high speed logic knows that these speeds bring many problems. Board layouts are critical, and lines have to be kept as short as possible. This is hardly surprising as the clock rates extend well into the v.h.f. portion of the radio spectrum.

Ringing the Changes

One of the problems which can be experienced even with a good layout is that of "ringing" or "bounce" on a line. Signals travelling along a line can be reflected in exactly the same way as radio frequency signals travelling along a feeder.

When an output changes from one level to another there can be a significant amount of ringing on the line for some while after the signal has switched, as shown in Fig. 1. In some cases this might be so bad that it could result in spurious triggering of the driven circuit.

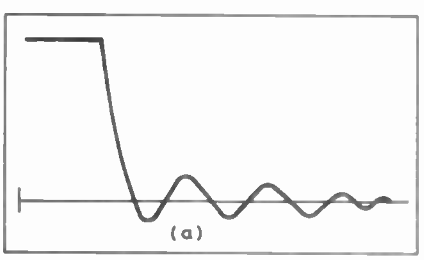


Fig. 1a. Ordinary driver output ringing.

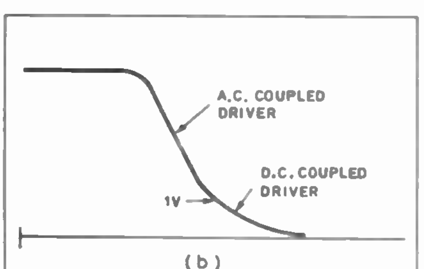


Fig. 1b. Output from logic stages.

To overcome this problem, Applied Micro Circuits Corporation (AMCC) in San Diego, California have developed a circuit called a "dual-sloped output driver". This has two separate circuits for controlling the falling edge of a waveform. These enable the output to reach its final settling point in the fastest possible time without any ringing.

It has a fast a.c. driver for the major transition phase. But once the voltage has fallen to 1V, a second d.c. circuit with a lower drive capability comes into play (see Fig. 2). This circuit slows the edge of the waveform down to ensure that there is no ringing.

Extensive investigations of the problems associated with ringing have been conducted by AMCC. It is found that problems are encountered when circuits are switching from a high to low.

To ensure that the voltage falls a large amount of current is required. This rate of change of current flow with time rises to very high values to an extent that a ringing voltage appears on the ground connection around the i.c. In some instances this can cause spurious triggering of an i.c.

This is particularly important if the i.c. is edge triggered because it will cause the output to add an extra pulse into the system. Whilst edge triggered circuits like counters are an obvious problem, latches could also be affected because the ringing could cause erroneous data to latched.

The dual-slope circuit is more complicated than traditional types, but with the ease of integration of additional circuitry does not add significant cost.

Voltage sensing is used to ensure that the correct driver is used over the correct portion of the curve. The drivers take their supply from the load instead of the normal voltage rails. This can be accomplished because the load has a current source capability as well as a certain amount of stored energy which needs to be removed.

In a normal circuit the power for the driver is derived from the supply, and during switching it can introduce large spikes onto the rail adding to the ringing problem. By using the new approach the switching spikes can be greatly reduced, and as an added bonus the power consumption of the device can be cut down to as little as one third of the normal requirement during switching.

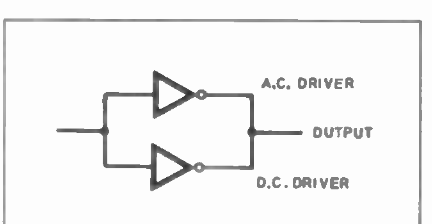


Fig. 2. AMCC driver principle.

It is likely that the new form of driver could be used in a wide variety of chips. Currently AMCC have included it in a number of their clock generators, for both the traditional 5V logic series as well as the new 3·3V logic families.

A PERManent Way to Cut Prices

The price of disk drives has fallen rapidly. It is now possible to buy a 540MB drive for a PC for just over £100 and the price of larger drives is falling as well.

All this is coming about because of the enormous demand for computer components. The PC market is one of the fastest growing areas of electronics, and as a result there is a vast amount of development being invested in new products.

Companies are striving to increase the amount of disk storage whilst reducing sizes and keeping prices to an absolute minimum. In one development called Pre-Embossed Rigid Magnetic (PERM) technology it may be possible to manufacture 2·5 inch disks with a density of 15,000 tracks per inch giving a storage capacity of around 1·5Gbytes. Current drives have a density of around 3000 tracks per inch.

The new drives have adopted a number of new ideas, including some techniques used in CD manufacture. The key to the increase in capacity is largely in the disk itself. Conventional hard disks use either a glass or aluminium base covered with a magnetic material. The new drives use a plastic base.

This is pre-embossed with servo marks which can be either indentations or raised areas with dimensions around 0·6µm.

The next stage in the process is to cover the base with a magnetic coating. By using pre-embossing the tracks can be located far more accurately and the distance between them can be reduced.

As the tracks are so narrow, the output from the read heads is much smaller. As a result new high sensitivity heads have been incorporated to ensure that data is read reliably.

The development of the new drive is being undertaken as a joint venture between Sony and Seagate. Prototypes having a storage capacity of 200Mbytes have been manufactured, but it is expected that production of 1·5Gbyte drives will start shortly.

PUTTING THE TRAIN ON THE BUS

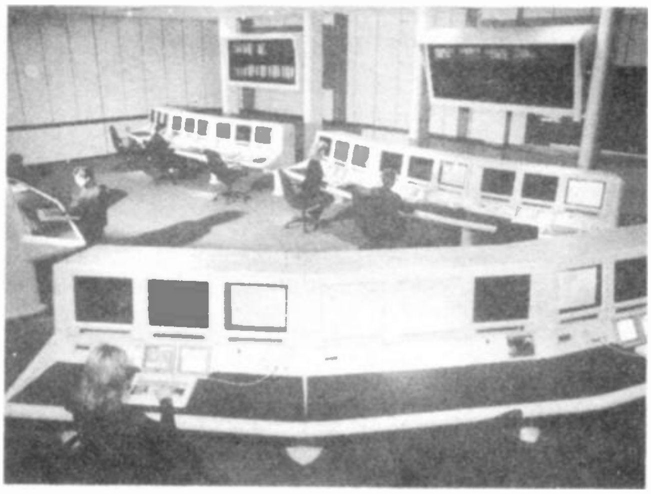
STE-bus hardware and Windows-based software integrate comms on the Tube.

– *by Hazel Cavendish*

LONDON Underground is running an integrated communications control system which is claimed to be the most sophisticated railway communications system in the world. The Central Line has been selected to use the system's innovative mix of electronics and software – put together by two British firms – to enable a single operator in a West London control centre to monitor the entire Underground line, talking to drivers and station staff, and making announcements as well as viewing activity at every key point.

Bosch Telecom's new system integrates control of four major functions: the dedicated telephone system for the stations and the emergency system in the tunnels: all the radios in the drivers' cabs coupled with the associated emergency signals such as the "deadman's handle", plus the radio portables used on the station and lines; the public address systems on both stations and trains, and some 800 video cameras on trains, and along the lines.

Arcom Control Systems of Cambridge – a member of the Fairey Group – provide the rugged STEbus-based PC-compatible computers, together with dual-redundancy techniques for fault tolerance which ensure high levels of reliability.



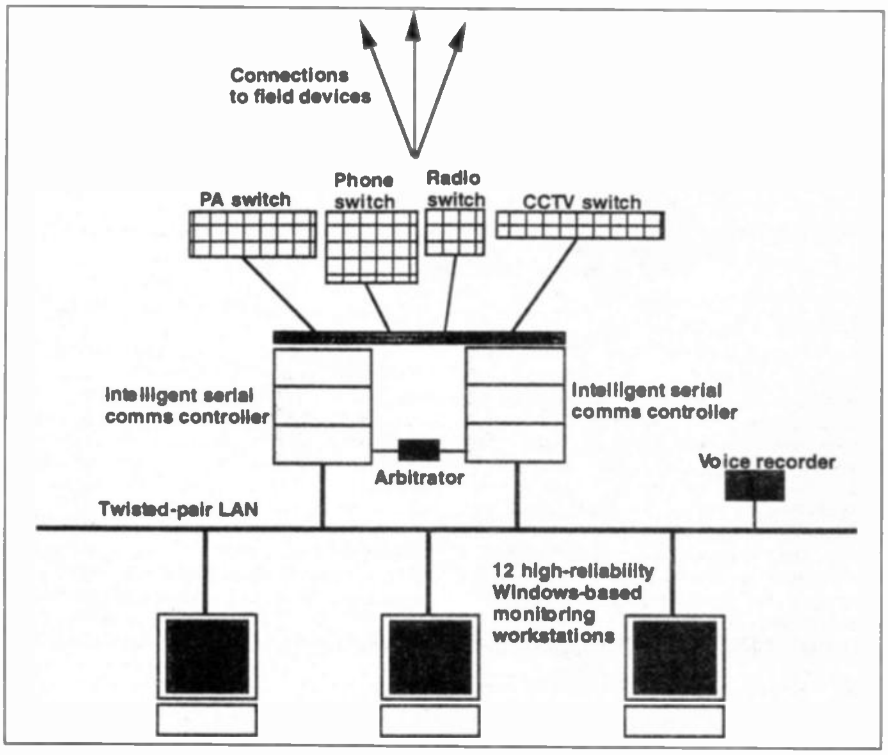
Inside the integrated communications control centre.

INTELLIGENT CONCEPT

The common thread linking the audio, radio and video systems was the conception by Bosch Telecom of a centralised control scheme based on intelligent serial controllers and interrupt-based communications. By allowing each system to send messages via the interrupts, the intelligent serial controller approach avoids the potential delays associated with polled architectures.

Serial sub-stations concentrate control of the various communications functions into a single point which links onto a twisted-pair LAN (local area network), serving twelve PC-compatible workstations running customised Windows-based software to monitor and control the underground line.

To ensure reliability, the entire serial communications control subsystem is duplicated. During operation, the systems are monitored by both hardware and software watchdogs. Several layers of protection are designed into the monitoring system. A key requirement was very high EMC (electromagnetic compatibility) protection to withstand the harsh electrical noise generated by arcing between the train and the 640V d.c. track power supply.



Simplified block diagram of the integrated communications control system.

TRACKING DOWN GREMLINS

Pioneering the system on London's Central Line is said to have been a valuable exercise, proving that even the most high-tech equipment can be prone to gremlins when introduced to a long-established system. Brian Lerigo, London Underground's Liaison Manager for the Central Line Project said, "On testing before commissioning you can simulate some things, but until you actually hook the system up to the real world, you don't fully appreciate all the interaction of a new project.

"One of the great advantages is that this system brings all the communications together in one piece of equipment, resulting in vastly improved communications which enable us to take action immediately if there is a problem with the running of the trains."

HANDYPRINT

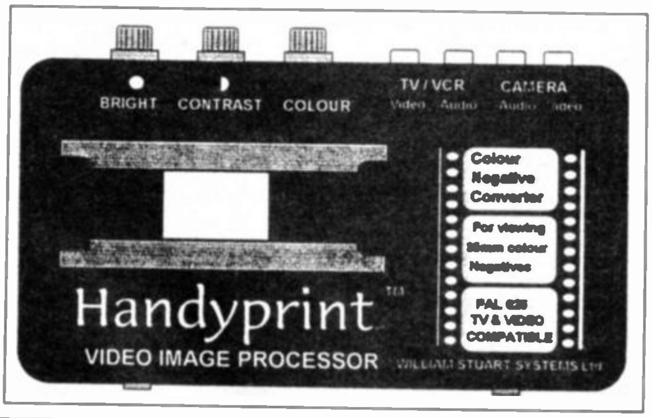
A REALLY useful accessory for video cameras has been introduced by William Stuart Systems Ltd. Called Handyprint, this device allows you to display all your 35mm negatives as full-colour positive prints on any domestic TV screen.

It seems an ideal system for looking through those old negatives which everyone keeps "just in case", but which are otherwise impossible to identify. Often the best prints have been given away or lost, but this gadget will help to find the buried treasures! You could even use it with a VCR to make a living family album, adding a sound track as well.

Handyprint consists of a negative strip guide with a colour-corrected light source, plus the electronics to transform negative images into colour positives. Brightness, contrast and colour controls are provided to compensate for variations in negative quality. The video camera is focussed onto the negative and its signal fed into Handyprint, where it is processed and output to the TV or VCR.

The whole outfit comes complete with a mains adaptor and leads to connect to your camera. Its price is £99.95, inclusive of VAT and delivery.

For more information, contact William Stuart Systems Ltd., Dept. EPE, Hunscote House, Wellesbourne, Warks, CV35 9EX. Tel/Fax: 01789 840228.



MAGBASE

How many readers have wished that there was an index which covered all the projects ever published by every electronics magazine? Probably at lot! Well, an index which approaches fulfilment of that mammoth requirement is Magbase, created by Barry Sandeman.

Barry, having over 300 hobbyist electronics magazines going back to about 1980, has created a PC-based master index of the projects and articles published in them. To date, his Magbase index details over 3000 items, any of which can be accessed via several category routes. Moreover, he is offering it to readers, either *free* by E-mail, or on a 1.44Mb disk for only £10 including p&p to *anywhere* in the world.

If you are interested in obtaining a copy of Magbase, Barry's E-mail address is: sandeman@plessey.co.za. His postal address is: Barry Sandeman, 6 Marloth Road, Tygerhoff, 7441, Cape Town, South Africa.

ADVERTISERS!

WHY NOT send us details of your interesting new products for possible inclusion on these pages?

Drop us a line, with a picture if you've got one.

EASY PICKINGS

In response to the growing number of hobbyists using PIC microcontrollers, Lennard Research has produced a low-cost but powerful modular programming system. The system starts with an entry-level programmer that supports the 16Cxx range of chips. It expands in stages to a powerful development platform that will support the entire PIC16C5x/xx range. It also offers the added capability of In-Circuit Emulation and reading/writing serial EEPROMs.

Of particular interest is the fact that system has been designed to be software upgradable to handle the release of new PIC chips, a service which is FREE to Lennard Research's customers.

For more information, contact Lennard Research, Dept. EPE, 29 Lavender Gardens, Jesmond, Newcastle upon Tyne, NE2 3DD. Tel: 0191 281 8050.

Readers might like to be reminded that various PIC products are also available from I. Bailey (see Classified Ads), Custom Electronic Services, Magenta Electronics Ltd (see Advertisers Index), and Robin Abbott (see November issue ads).

WHERE IT'S AT

Vintage Electric Musical Instrument Auction: 5 November at 1 p.m. Thorverton Mill, Thorverton, near Exeter – 20 mins from M5. (*NOT at the auction rooms stated in Nov. issue*).

YOUNG DESIGNERS '96

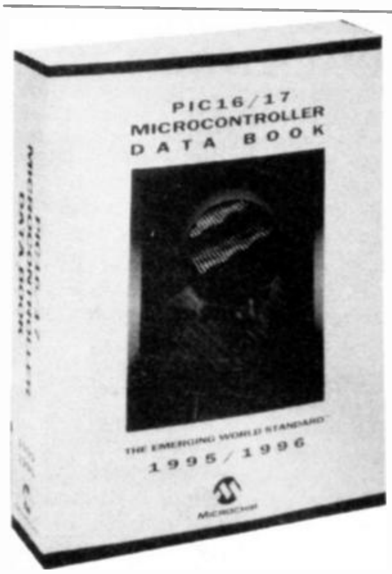
Entries for the *Young Electronic Designer Awards* (YEDA) 1996 are being invited by the YEDA Trust. Under the enthusiastic patronage of HRH The Duke of York and co-sponsored annually by Texas Instruments and Mercury Communications, YEDA recognises the responsibility of Industry to encourage talent at an early age.

Once again the IEE (Institution of Electrical Engineers) is also supporting the Awards, which total £10,000, as well as including many other attractive prizes.

By now entry forms should have arrived at schools and universities across the country, but anyone wishing to find out more should contact: The YEDA Trust, 24 London Road, Horsham, West Sussex, RH12 1AY. Tel: 01403 211048.

The results of the *Young Engineers for Britain for 1995* awards have recently been announced. Electronic inventions received place-recognition in several categories. They include a battery operated spirometer, a device to warn of UVA and UVB radiation, a digital peak expiratory flow meter and a child radio alarm device for location in an emergency. Top award went to a mechanical device: an aerodynamic anti-cross wind bicycle front wheel.

The Young Engineers for Britain awards are organised by The Engineering Council, 10 Maltravers Street, London WC2R 3ER. Tel: 0171 240 7891.



PIC DATA BOOKS

NEW editions of Arizona Microchip's Microcontroller and Memory Data Books are now available.

The 616-page *Non-Volatile Memory Data Book 1995/1996* is a detailed reference tool relating to the company's EEPROM and EPROM devices and development tools.

The *PIC16/17 Microcontroller Data Book 1995/1996* is a 1276-page overview of the PIC16xx and PIC17xx families of 8-bit RISC-based microcontrollers. It contains full product and programming specifications, development system and software support information for designers working on embedded control applications.

This latter book is an *ABSOLUTE MUST* for anyone who has any intentions of programming PIC chips. (We also strongly recommend acquisition of Microchip's *Embedded Control Handbook*, which has over 1000 pages full of programming examples for all PIC chips. The latest edition is that for 1994/5.)

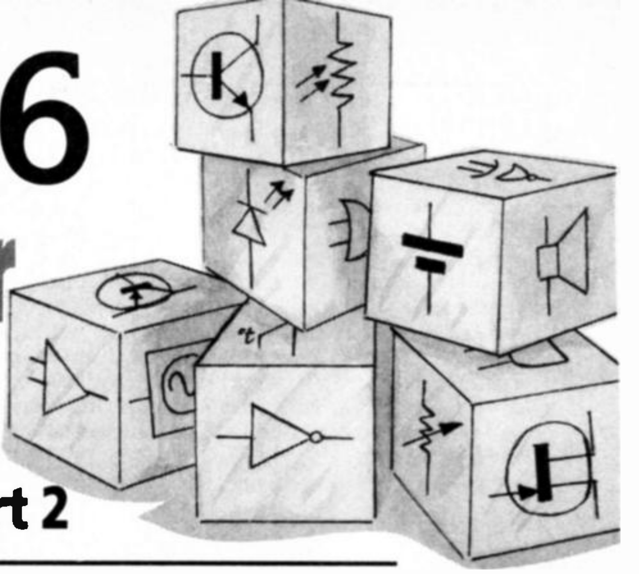
Also of interest is the introduction of yet another PIC device by Arizona Microchip. The latest one is the PIC17C44, which is believed to be the fastest 8-bit microcontroller in the world. It has an instruction execution speed of 160ns at 25MHz and allows unique execution of its two 8 x 8 hardware multiply instructions in a single cycle.

With 8K x 16 one-time programmable (OTP) on-chip Eprom program memory, comparable to at least 24Kb with traditional microcontrollers, and 454 bytes of user RAM, it is claimed to be a cost-effective alternative to more expensive 16-bit microcontrollers.

For more information contact: Arizona Microchip Technology Ltd., Dept. EPE, Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks. SL8 5AJ. Tel: 01628 851077.

TEACH-IN '96

A Guide to Modular Circuit Design



Max Horsey

Part 2

DURING this series of articles, a range of circuit modules is examined, divided into Input, Processor and Output sections. Where possible a choice of module is offered within each section.

Each of the ten Parts of the Series is accompanied by a constructional article explaining how a complete project may be devised by employing the modules described, together with a p.c.b. design. Each project will be one of many possible ideas that could be implemented and it is hoped that readers will design for themselves a variety of circuits by combining modules provided in the whole series.

The proposed range of modules covered by the Series is detailed in Part 1, Table 1.1. Each module is chosen to link easily with adjacent modules in the same Part, but modules may also be linked with modules in other Parts of the Series.

Max Horsey is Head of Electronics at Radley College.

IN THIS second Part of *Teach-In '96*, the following Input, Processor and Output modules are examined:

INPUT MODULES: Alarm switches

PROCESSOR MODULES: Simple capacitor delay, a.c. coupling, CMOS logic monostable, 555 monostable

OUTPUT MODULES: Fail-safe siren circuits, power supply failure warning

The accompanying project, described separately as the Modular Alarm System, has entry/exit and siren timers.

INPUT SENSORS

Alarm sensors are essentially switches. A look back at *Teach-In '96* Part 1 shows how semiconductor switching circuits may be arranged to produce, when activated, either a logic 1 (i.e. a voltage roughly equal to the supply voltage), or a logic 0 (roughly 0V).

Momentary switches (the type used in alarm systems) divide into normally-open and normally-closed types:

Normally-open alarm switches (e.g. push-to-make) include under carpet pressure mats, and some vibration sensors. Several normally-open switches may be connected in *parallel* as shown in Fig. 2.1.

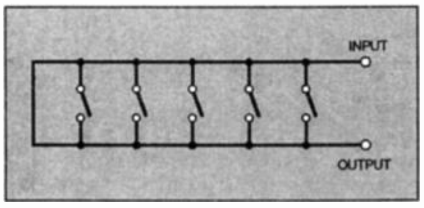


Fig. 2.1 Normally-open switches connected in parallel.

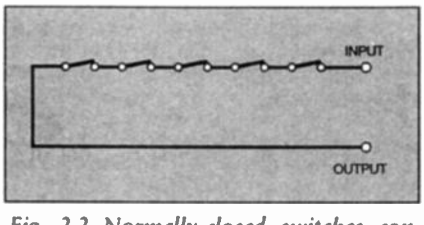


Fig. 2.2 Normally-closed switches connected in series.

Normally-closed types include reed switches (assuming that they are near to a suitable magnetic field), window foil (which breaks if the glass is broken), some vibration sensors and more elaborate sensors such as Passive Infra-Red (P.I.R.) detectors. The latter may include a reed switch relay, the contacts of which are closed during standby (i.e. when nothing is detected).

Several normally-closed switches may be connected in *series* as shown in Fig. 2.2.

Some switches (e.g. microswitches) have three contacts to enable the user to choose the normally-open or normally-closed pair. Tilt switches have two contacts, but the angle of the switch determines whether it is open or closed during standby.

A normally-closed switch has the advantage that if the connecting cable is cut the circuit is broken and the alarm will sound. For this reason, normally-closed switches are generally preferred as alarm sensing devices.

SENSORS SUMMARY

The choice of sensors is between those listed in Table 2.1. These switches and sensors are described fully in any good electronics catalogue.

A typical system will include a main door switch. This often consists of a reed switch fixed to the door frame and a magnet fastened to the door. When the door is closed the magnet activates the reed switch causing its contacts to close.

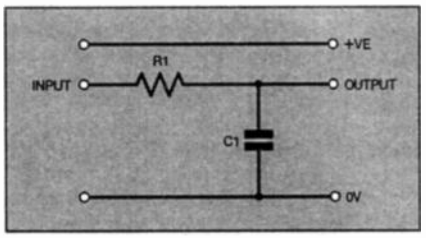


Fig. 2.3. Simple capacitive delay circuit.

Other doors or windows could have reed switches, vibration switches etc., but P.I.R. sensors have become so reliable that in spite of their greater cost they are often used to protect an entire room, so avoiding the extensive wiring needed to connect numerous window/door switches.

PROCESSOR MODULES

The Processor modules examined here are timers, including simple delay circuits, a CMOS logic monostable and a 555 monostable, together with showing how a change of voltage can be changed to a single pulse by means of a.c. coupling.

CAPACITIVE DELAY

A simple capacitive delay circuit is shown in Fig. 2.3. Assuming that both the input and output are initially at 0V, if the input is made positive the output voltage will rise according to the graph shown in Fig. 2.4.

The time taken for the output voltage to reach any particular value will

TABLE 2.1. Summary of Sensor Types.

Type of switch	Place where used	Type of contacts
Reed switch and magnet	Doors and windows	normally-closed
P.I.R.	Rooms and open spaces	normally-closed
Microswitch	Door and windows	either
Window foil	Windows	normally-closed
Vibration sensor	Windows	normally-open
Glass break sensor	Windows	normally-closed
Tilt switch	Equipment	either
Pressure mat	Under carpets	normally-open

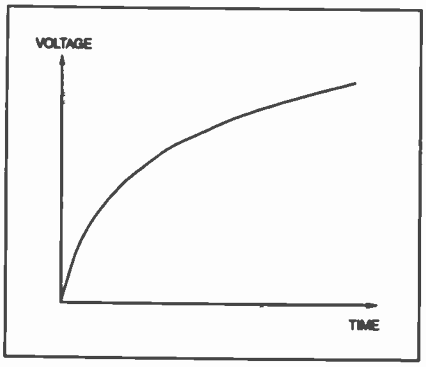


Fig. 2.4. Rate at which capacitor C1 in Fig. 2.3 charges via resistor R1.

depend upon the values of the resistor and capacitor. Higher values will cause a longer time delay. It is possible to calculate the time taken to reach a particular voltage, but such calculations are fairly complex, and the following simple formula will provide a useful guide:

$t = R \times C \times 0{\cdot}7$

where:

t = time taken to reach half the supply voltage
R = value of the resistor in ohms
C = value of the capacitor in Farads

Converting most common capacitor values into Farads can prove difficult because of the number of decimal places involved. A useful alternative is to express the capacitance in microfarads (µF – i.e. millionths of a Farad), and the resistance in megohms (MΩ – i.e. millions of ohms).

For example, a resistor value of 680kΩ (kilohms) and a capacitor value of 2·2µF (microfarads) will produce the following result:

Begin by expressing 680kΩ in megohms, i.e. 0.68MΩ, thus:

Time = $0{\cdot}68 \times 2{\cdot}2 \times 0{\cdot}7 = 1{\cdot}0472$ seconds.

In other words, the output voltage will reach half the supply voltage in about one second.

There is no need to work in exact values since the components themselves will be far from accurate. The actual value of an electrolytic capacitor, for example, can differ by as much as 50 per cent from its stated value.

To sum up the simple capacitive delay circuit in Fig. 2.3:

ADVANTAGES:
Very simple circuit
Useful if a delay is required, rather than a timed 0V/positive/0V transition

DISADVANTAGE:
The output moves slowly from 0V to positive. Many circuits (counters for example) prefer a sudden rise of voltage. (A Schmitt trigger, as described in Part 1, could be used to convert this slow rise into an almost instantaneous change once a predetermined threshold level is reached.)

A.C. COUPLING

Latching circuits, such as the bistables to be described in Part 3, often require a "pulse" rather than a continuous voltage. In fact the CMOS monostable described later is based around this idea.

As shown in Fig. 2.5, a series capacitor (C1) can be used to provide a.c. coupling since a continuous d.c. voltage will be blocked (the capacitor's plate pairs are insulated from each other). Any change of voltage at one side of the capacitor will induce a corresponding change on the other side.

This can be likened to a cylinder with an elastic membrane, as shown in Fig. 2.6. The pulse of fluid into the left hand side will cause a similar pulse from the other end, but the cylinder will not allow a steady stream of fluid to flow.

The fluid analogy illustrates that the cylinder will only "conduct" a single pulse since further pulses of similar strength cannot push the membrane any further. Hence the fluid pressure must be allowed to equalise after each pulse. This can be achieved by controlled leakage (see the use of resistors below) and sometimes one way valves (see the use of the diode below).

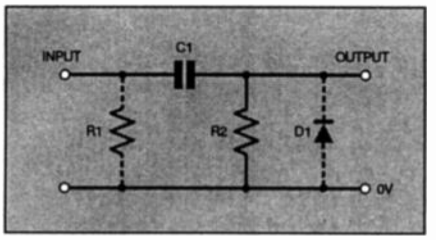


Fig. 2.5. A series capacitor provides a.c. coupling for pulse generation transitions.

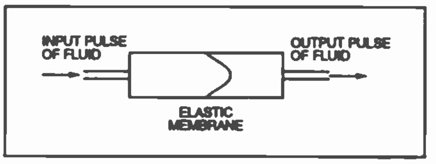


Fig. 2.6. Analogy of a cylinder with elastic membrane illustrates capacitive pulse transfer.

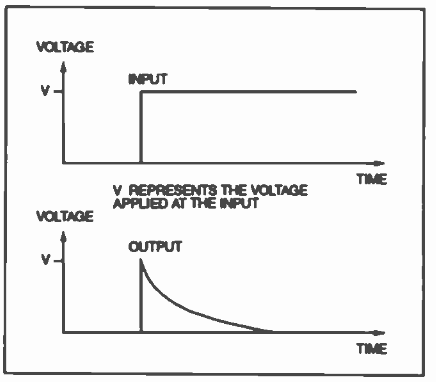


Fig. 2.7. Graphs illustrating the action of the circuit in Fig. 2.5.

In Fig. 2.5, the series capacitor (C1) blocks the flow of d.c., but if the input voltage changes, a similar change appears at the output. The effect is illustrated by the graph in Fig. 2.7. It may be observed by means of an oscilloscope.

The resistors R1 and R2 allow the charge on the capacitor to leak away and they also modify the pulse length. In many instances, only resistor R2 will be needed. Typical component values cannot realistically be quoted since these depend on the application to which the circuit is put.

Note that when the logic level at the input to the capacitor returns to 0V there is likely to be a negative pulse at its output. This could cause problems in some circuits, although CMOS gates are internally fitted with diodes to prevent any damage which may be caused. If in doubt, the addition of a silicon diode as shown in Fig. 2.5 will ensure that the output voltage cannot fall below −0·7V. The diode may be type 1N4148, 1N4001 or similar.

To summarise, this circuit module produces a short logic 1 pulse when the input switches from logic 0 to logic 1. The length of the pulse will be determined by the values of the capacitor and the total output resistance. The latter will comprise the value of resistor shown, in parallel with that of the stage into which the circuit is fed.

NOR GATE MONOSTABLE

A monostable is a form of timing circuit which, as the name implies, has only *one* stable output state. The output will remain in the stable state until triggered by a suitable pulse, whereupon it will change to the opposite state, remain so for a preset delay period, and then return to its original state.

The changing states produce a pulse which, depending on the stable condition, may be either positive or negative going. The length of the delay is known as the *pulse width*.

How two NOR gates may be connected to form a monostable is shown in Fig. 2.8. The pin numbers are shown purely for reference convenience and in practice any of the four gates in the i.c. package may be used, in any order. See Fig. 1.14 in Part 1 for details of the pin numbers available.

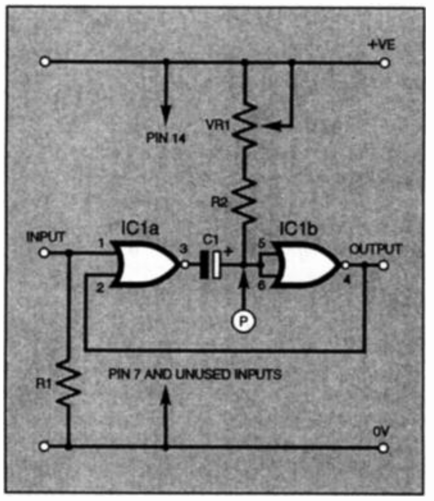


Fig. 2.8. Two NOR gates connected as a monostable circuit.

The formula from which the monostable's pulse width can be calculated is:

$t = 0{\cdot}7 \times R \times C$

Where:

t = time in seconds
R = the resistance in ohms between point P and the power rail
C = value of the capacitor (C1) in Farads

As before, it is more convenient to express R in MΩ (millions of ohms) and C in µF (microfarads). The time, t, can still be expressed in seconds, since millions will cancel with micro (millionths).

For example:

If R = 1MΩ and C = 470µF, then
$t = 0{\cdot}7 \times 1 \times 470 = 329$ seconds

Two resistances are shown between point P and the positive rail in Fig. 2.8. One is variable (VR1 – either a preset or a potentiometer) and the other is fixed (R2). Fixed resistor R2 ensures that the total resistance can never be zero even if VR1 is set to zero ohms.

If it is not necessary to adjust the time, VR1 may be omitted and a single fixed resistor, of between 1k and 2·2M ohms, connected between point P and the positive rail.

The value of capacitor C1 can be as small as required, but should not be larger than about 2200µF otherwise the timing factor may become unpredictable due to current leakage through the capacitor.

Resistor R1 holds input pin 1 of NOR gate IC1a at 0V; a typical value would be 100k. If a positive pulse is received (for example by pressing a pushswitch connected between the input and positive) then pin 1 is made positive (logic 1). Assuming that the other input (pin 2) is at 0V, output pin 3 will switch from logic 1 to logic 0, i.e. 0V.

The NOR gate truth table in Table 2.2 clarifies this, where pin 1 is input A, pin 2 is input B and pin 3 is the output:

TABLE 2.2.
NOR Gate Truth Table.

INPUT A	INPUT B	OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

When the output from IC1a switches from logic 1 to logic 0, the change of voltage is transferred through capacitor C1 making input pins 5 and 6 of IC1b change to logic 0, causing output pin 4 to change to logic 1. This logic level is transferred back to pin 2 of IC1a, thus maintaining the circuit in its new state even if pin 1 is allowed to switch to logic 0 again.

Output pin 4 of the module is now at logic 1. However, a voltage difference exists across the resistance (R = VR1 + R2) connected between point P and positive. Current now flows from positive via the resistance and charges capacitor C1.

After a time (t) given by the formula described earlier, pins 5 and 6 become sufficiently positive to cause output pin 4 to switch back to 0V. The feedback connection causes pin 2 to become 0V, and this makes pin 3 switch back to logic 1. The change of voltage is transferred through the capacitor, reinforcing the logic 1 level at input pins 5 and 6. All this happens very quickly, the net result being a very sudden change of logic level at output pin 4.

To summarise the monostable's action, the Output (pin 4 in this instance) is normally at 0V. When a positive pulse is received at the Input (pin 1 in this instance), the Output changes to positive, and then returns to 0V after a time determined by the values of resistance (R = VR1 + R1) and capacitance (C1).

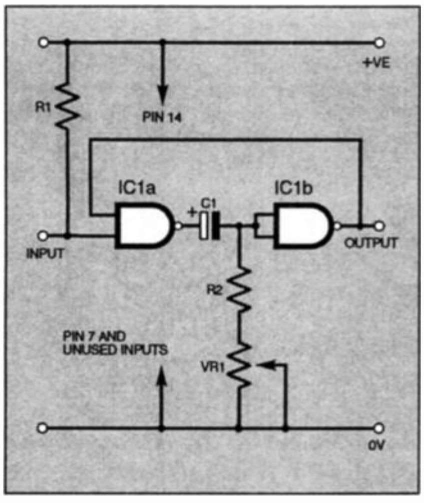


Fig. 2.9. Two NAND gates connected as a monostable circuit.

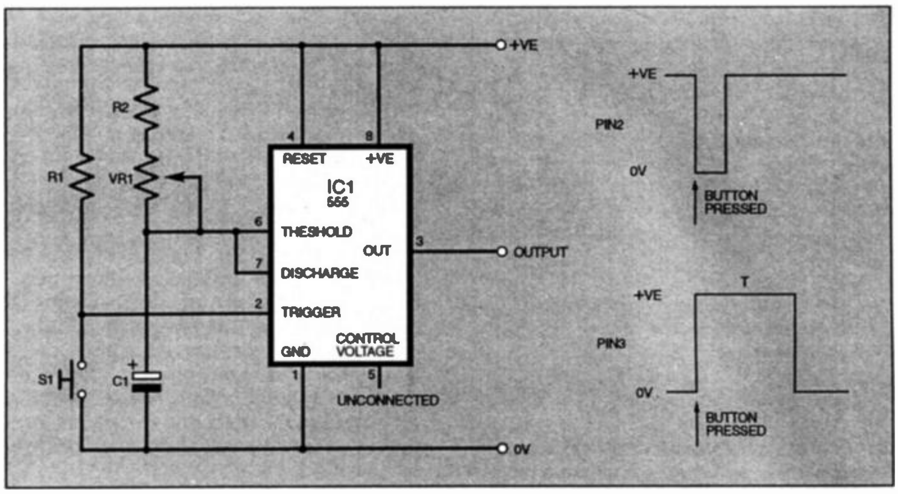


Fig. 2.10. Variable timer circuit and response waveforms.

OUTPUT CURRENT

Assuming that the i.c. used is a CMOS quad two-input NOR gate type 4001B, it is unwise to draw more than about 4mA from the output. Although an l.e.d. will glow dimly if connected directly to the output (via a suitable limiting resistor), the current required may cause the output voltage to fall resulting in the circuit failing to latch correctly.

However, an HC series 74HC02 quad two-input NOR gate can supply up to 20mA output current before its output voltage falls detrimentally, but note that it has a different pin configuration (as shown in Part 1, Fig. 1.14).

INPUT CURRENT

As with all CMOS gates, almost no input current is required, making the circuit very flexible. However, it is possible to damage the input with negative voltages, particularly if the leakage resistor R1 is omitted when the input is fed from a capacitor.

This resistor should be omitted, though, if the input is connected directly (without an intervening capacitor) to a clearly defined logic level (e.g. the output from another gate).

INVERTED OUTPUT

The output (pin 4) shown in Fig. 2.8 is normally at 0V, becoming positive during the timing cycle. Sometimes the opposite of this is required. An inverted output is available from pin 3, but use it with care, since it will not be latched in quite the same way as the normal output. A more satisfactory inverted output can be achieved by means of an additional NOR gate.

To summarise the NOR gate monostable circuit of Fig. 2.8:

ADVANTAGES:

Almost no standby current required (ideal for battery operation)

Only two gates required (leaving two spare)

Almost no input current required

Easily interfaced to other logic circuits

DISADVANTAGES:

Inputs are static sensitive and must be treated with care

Rather low output current available

Timing period not as consistent when compared with a 555 timer i.c.

NAND GATE MONOSTABLE

The NAND gate monostable shown in Fig. 2.9 is very similar to the NOR gate version in Fig. 2.8, except that it responds in the opposite manner. Quad two-input NAND gates are commonly available as types 4011B and 74HC00.

In this circuit, it is necessary for resistor R1 to be connected to the positive rail so as to hold the trigger input at logic 1. The output of this monostable is normally positive, but when the input is triggered by being pulled briefly to logic 0, the output switches to 0V during the timing period, then back to positive at the end of the period.

The timed period is calculated exactly the same as for the NOR gate version, where R equals the total resistance of VR1 plus R2, and C equals the value of capacitor C1.

555 MONOSTABLE

The 555 i.c. is designed specifically for timer (monostable) and astable (oscillator) circuits. There are numerous ways in which it can be used. Its use as a simple timer circuit is shown in Fig. 2.10.

In this circuit, the time is determined by the value of capacitor C1, and the total resistance of R2 plus VR1 (referred to in the next two equations as R). Resistor R2 prevents the flow of excessive current if VR2 is set to zero resistance. If a variable resistor is not required then a single fixed resistor may be employed.

The time t in seconds is given by:

$$t = 1{\cdot}1 \times R \times C$$

where R is expressed in ohms, and C is in Farads.

Again it may be helpful sometimes to express R in MΩ and C in µF. For example, a capacitor of 220µF and a total resistance of 680kΩ (which for convenience is converted to 0·68MΩ) will provide a time of:

$$t = 1{\cdot}1 \times 0{\cdot}68 \times 220 = 165 \text{ seconds}$$

The waveforms in Fig. 2.10 show how the i.c. is triggered. Initially, pin 2 (the trigger) must be held positive, hence the need for resistor R1. To start the timing cycle, pin 2 must be pulled briefly to 0V. This is achieved by pressing the push-to-make switch, S1. Resistor R1 can have any value from 1k to 1M.

When switch S1 is pressed, output pin 3 changes from 0V to positive. Assuming that pin 2 has returned to its normal positive state, pin 3 will return to 0V at the

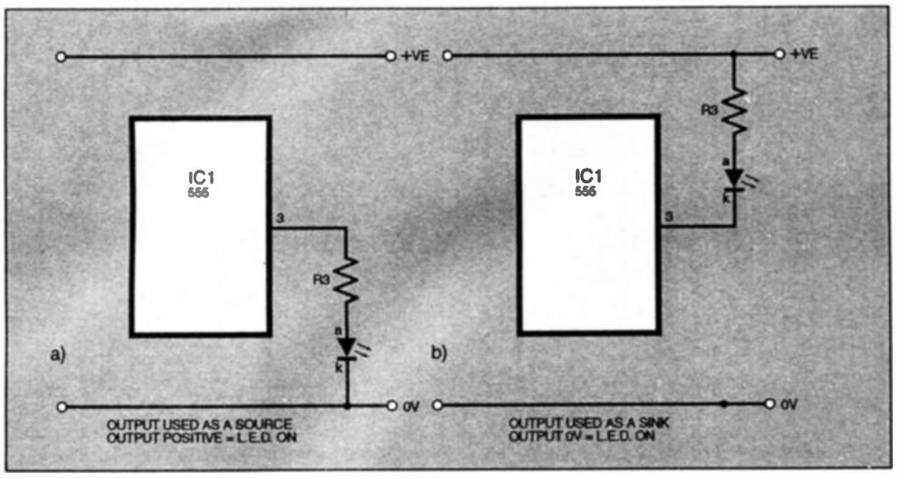


Fig. 2.11. Two methods of connecting an l.e.d. to the timer output.

end of the timing cycle according to the formula above. (The input pulse width to a 555 i.c. must always be shorter than the required output pulse duration.)

OUTPUT CURRENT

Output pin 3 of a 555 i.c. is able to source or sink over 100mA. This means that an output module may not be required. Examples of how an l.e.d. may be driven directly from pin 3 are shown in Fig. 2.11. The value of the l.e.d. series resistor (R3) should be as described in Part 1 (e.g. 680Ω on a 12V supply).

The output can be used to drive buzzers but a capacitor (100n, for example) should be connected between the output and 0V to remove voltage spikes produced by the buzzer which may cause instability. Note that in Fig. 2.11a the l.e.d. is on *during* the timing period. In Fig. 2.11b the l.e.d. is on *before* and *after* the timing period.

PIN FUNCTIONS

Besides trigger pin 2 and output pin 3, briefly, the functions of the other pins, are as follows:

Pin 1. Negative (GND) supply. Should be connected to 0V.

Pin 4. Reset input. When connected to positive the i.c. is active. When connected to 0V the timing cycle ceases immediately. If a pushbutton reset is required, pin 4 can be connected in the same manner as pin 2 in Fig. 2.10.

Pin 5. Control voltage input. Normally left open circuit, but connecting pin 5 to 0V via a variable resistor will enable small changes to be made to the timing period. Useful for "fine tuning". If instability (e.g. false triggering) is a problem, connecting a capacitor (say 100n) from pin 5 to 0V may help.

Pin 6. Threshold. Monitors the voltage on the capacitor. At two-thirds of the supply voltage it ends the timing cycle.

Pin 7. Discharge. During the timing cycle, this pin is open circuit (internally disconnected). At the end of the cycle, pin 7 switches to 0V to discharge the capacitor ready for the next cycle.

Pin 8. Positive supply connection.

AUTOMATIC TRIGGER

The range of circuits possible with the 555 timer i.c. is so immense that entire books have been written about it. The automatic trigger circuit shown in Fig. 2.12 is just one idea.

The current required by the standard 555 will impose a significant drain on a small battery, making an on/off toggle switch (S2) essential. If a simple timer is required, a trigger pushbutton switch will also be needed, as shown in Fig. 2.10 (S1).

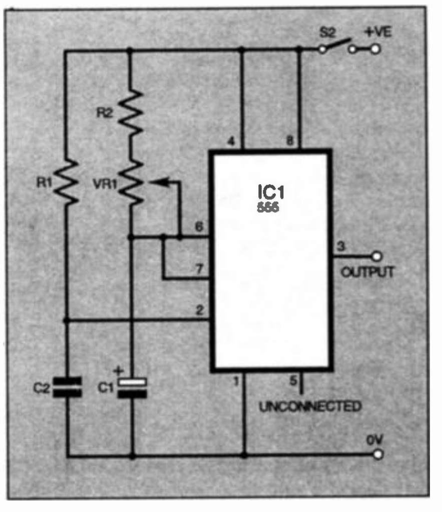


Fig. 2.12. Automatically triggered timer.

If, as shown in Fig. 2.12, the pushswitch is replaced by capacitor C2 (say 100n) and resistor R1 has a value of about 100k, the circuit will start timing automatically when S2 is switched on. This is because the voltage at pin 2 will be zero at the moment of switch-on, causing the trigger to be activated. Resistor R1 will allow the capacitor to charge, and hence pin 2 to rise to positive before the end of the timing cycle – as required for correct operation of the i.c. The value of C1 must by greater than for C2.

The circuit may be employed as a complete timer. Toggle switch S2 will be normally off, when it is turned on timing automatically starts and the output will switch to positive. At the end of the timed period the output will switch back to 0V.

To sum up the automatic trigger circuit of Fig. 2.12:

ADVANTAGES:
Inexpensive
Very consistent time period
Very sharp output voltage swing
High output current
Input pins require very little current

DISADVANTAGES:
Can be prone to false triggering
Does not interface well with CMOS logic i.c.s
Significant current used (although a CMOS version is available which requires far less current)

OUTPUT MODULES

There are two "fail-safe" Darlington drivers offered here in Part 2. The circuits are ideally suited to alarm systems where the siren will sound if the connecting cable is cut. The output circuit would normally be housed in a box containing the siren and a 9V rechargeable battery, which maintains the supply in the event of a power loss. The battery is trickle charged during normal operation.

NPN FAIL-SAFE DRIVER

A fail-safe driver based on an *npn* Darlington transistor is shown in Fig. 2.13. When the input voltage at the transistor's base is at 0V the buzzer (or siren) will not sound. When the input voltage rises above about 1·4V the buzzer will sound.

If the wire between the input and the previous (Processor) circuit is cut the buzzer will also sound. If the 12V power supply is cut the 9V back-up battery will allow the circuit to operate. During normal operation the back-up battery will be trickle charged.

At the heart of the circuit is an *npn* Darlington transistor pair, TR1 and TR2. When sufficient current flows via resistor R1 into the base of TR1, the Darlington pair is turned on and the buzzer or siren will sound.

Transistor TR1 could be a high gain transistor such as BC108 or BC184 and TR2 could be a power transistor such as TIP41A. However, a single *npn* Darlington transistor, such as a TIP121 or TIP122

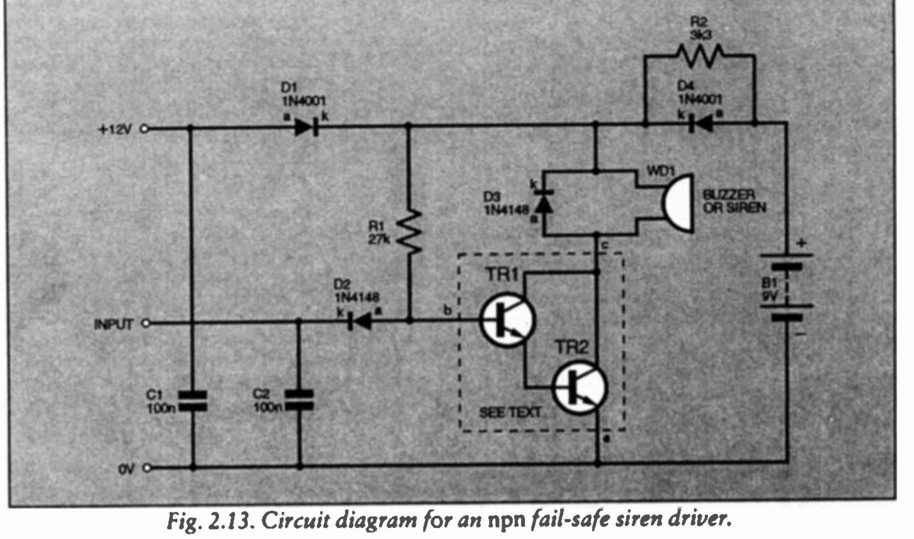


Fig. 2.13. Circuit diagram for an npn *fail-safe siren driver.*

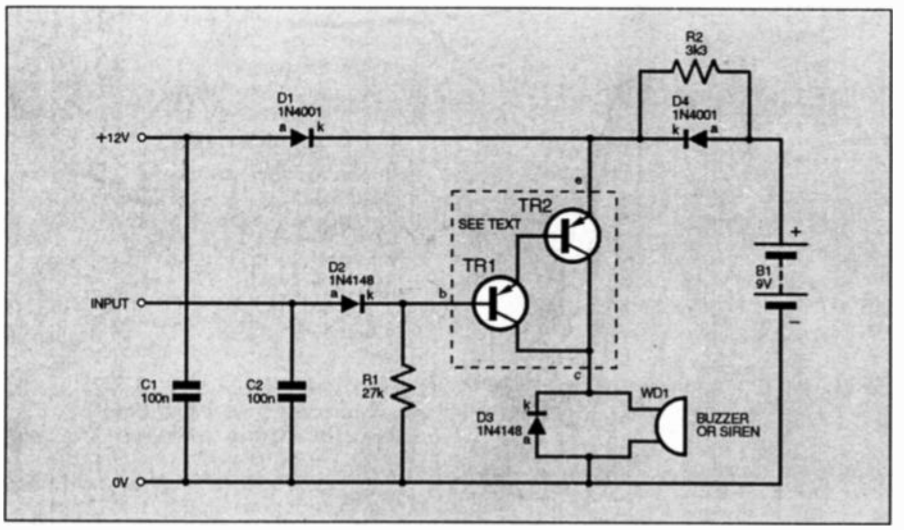


Fig. 2.14. Circuit diagram for a pnp *fail-safe siren driver.*

(represented by the dotted box) could be used instead, reducing the cost and simplifying the layout.

The "normal" state of the circuit is when the transistors are turned on. Hence, if the input is disconnected (or made positive) the siren will sound. The transistors can only be turned off by taking the input to below about 0·7V. When this occurs, the current through resistor R1 flows via diode D2, and the base of TR1 falls below its turn on threshold voltage.

During normal use, current will flow from the 12V supply via resistor R2 to trickle charge the back-up battery, B1. The value of R2 will depend upon the type of battery used. If a PP3 Nicad is used, a value of 3k3 is suggested.

If the 12V supply is removed, diode D1 prevents current from the battery flowing back to the previous module.

Diode D4 prevents excess current flowing to the back-up battery during normal operation, but if the 12V supply is removed, current from the back-up battery can flow via D4, so keeping the siren active.

Diode D3 ensures that any back-e.m.f. (high voltage spikes) produced by the buzzer or siren cannot damage the transistors.

This type of module may well be placed at some distance from the Processor module controlling it. For example, it may be mounted inside a bell box on the wall of a house. The long connecting leads may be subject to electrical noise, so capacitors C1 and C2 are included to help suppress it.

To sum up the input/output states of the *npn* fail-safe driver in Fig. 2.13:

Input at 0V = buzzer off
Input above 1·4V = buzzer on
Input open circuit = buzzer on

PNP FAIL-SAFE DRIVER

A fail-safe driver based on a *pnp* Darlington transistor is shown in Fig. 2.14.

The circuit is similar to Fig. 2.13, except that the input must be at the positive rail potential (high) to hold the siren off. If the input becomes open circuit, or is held at 0V then the siren will sound. Many commercial alarm systems require this arrangement.

The operational principle is exactly as before, except that the *pnp* transistors work in an opposite way to their *npn* equivalents. If the base of the Darlington pair is held at positive rail potential, the transistors are turned off. If the base voltage is lowered to about 1·4V below the positive supply (i.e. about 10·6V on a 12V supply), the transistors will turn on.

Note that, unlike the circuit of Fig. 2.13, if the power supply of the Processor module is removed, the voltage at the input will fall, and the siren will operate (assuming the back-up battery is in place).

If used as part of an alarm system this may be an advantage since the siren will sound if the intruder attempts to switch off the system. However, a back-up battery must also be installed in the alarm processor in case of power cuts which would otherwise trigger the siren.

To sum up the input/output states of the *pnp* fail-safe driver in Fig. 2.14:

Input high = buzzer off
Input at 0V = buzzer on
Input open circuit = buzzer on

POWER FAILURE ALARM

The circuit of Fig. 2.14 may be used to monitor the power supply in any system and sound a warning if the supply fails. Simply join the input to the +12V supply.

When the supply is present, the transistors will be switched off. If the supply fails, the voltage at the base of TR1 will fall and the transistors will turn on, power being supplied by the back-up battery.

PART THREE

Touch and moisture sensors, latching circuits and d.c. motor control modules are examined in Part 3.

CONSTRUCTIONAL PROJECT

A practical example of how the modules in this Part can be used is described in the *Modular Alarm System* elsewhere in this publication.

SHOP TALK

with David Barrington

Stereo "Cordless" Headphones

It is important that the inductors used in the *Stereo "Cordless" Headphones* are types which will operate efficiently at the frequencies specified for this application. It is probably wise to keep to the ones specified.

The inductors used in the model came from the excellent range of TOKO coils stocked by **Cirkit** and should be ordered as follows: Transmitter – 3·3mH type 10RB, code 34-33202; 6·8mH type 10RB, code 34-68202. Receiver – 2·2mH type 10RB, code 34-22202; 1mH type 10RB, code 34-10202 and i.f. transformer type 10EZ, code 35-10980.

Ordinary 5mm infra-red diodes, of the type used in remote control systems, are used in the transmitter and appear to be sold simply as infra-red l.e.d.s. Note the comments in the article about choice of viewing angle and output level. The same observation applies to the TIL100 photodiodes, simply being sold as infra-red photodiodes.

EPE Met Office

Most of the sensors used in the *EPE Met Office* design could almost be classified as "state-of-the-art" devices and had to be specially sourced. This inevitably means that readers' usual component suppliers are unlikely to stock them.

The CGS-H14 humidity sensor came from **Farnell Electronic Services** (☎ *01279 626777*), code 414719X; the TSL214 64x1 linear opto-sensor from **Electromail** (☎ *01536 204555*), code 194-284 and the MPX100AP pressure transducer from **Maplin**, code UH375.

The Lohet I and Lohet II Hall effect sensors should be stocked by the above companies. The 4517 dual 64-bit shift register i.c. is stocked by **Farnell Components** (☎ *0113 263 6311*) and Electromail.

The 40kHz ultrasonic transducers are usually sold as pairs and cost varies from around the £5 mark to £10 per pair. However, checkout the prices from **Greenweld** and **Cricklewood**! The LM35 precision temperature sensor i.c.s and 4MHz crystal should be widely available. The spiral transparency is available *free* with the main sensor board from the *EPE PCB Service*.

Light-Operated Switch

Particular attention must be paid regarding the type and ratings of resistor R1 and capacitor C1 for use in the *Light-Operated Switch*.

Capacitor C1 must be a Class X component rated for *continous* connection directly across the a.c. mains. These devices are normally sold as suppression components and should be available from any good component supplier. A normal high voltage capacitor is NOT suitable and MUST NOT BE USED.

We do not anticipate any component buying problems to be encountered by anyone tackling the *Modular Alarm System* (*Teach-In '96* project) or the *Audio Meter and Amplifier* projects.

Prices and ordering details for *all* this month's printed circuit boards are given on the *PCB Service* page, see page 995.

PLEASE TAKE NOTE

Digital Delay Line — *Nov '95*

Page 844/5. IC4 pins 6, 8 and 9 should be connected to the 0V line on the circuit diagram (Fig. 4) and on the p.c.b. (Fig. 5), this can be accomplished by "bridging" the pins.

Simple Theremin — *Sept '95*

Page 676, Comp List. VR1 (missing) should be 10k lin. Bourns 50 type (see page 724). C18 should be 220µ and C19 100n. Capacitor C10 should be 15p and C11 100p. The circuit is correct. JK1 switch contact lead should be transposed with the speaker +ve lead.

VIDEOS ON ELECTRONICS

A range of videos 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. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.

VT201 54 minutes. Part One; **D.C. Circuits.** This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

VT202 62 minutes. Part Two; **A.C. Circuits.** This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits. **Order Code VT202**

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VT204 56 minutes. Part Four; **Power Supplies.** Guides you step-by-step through different sections of a power supply. **Order Code VT204**

VT205 57 minutes. Part Five; **Amplifiers.** Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

VT206 54 minutes. Part Six; **Oscillators.** Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits. **Order Code VT206**

By the time you have completed VT206 you have completed the basic electronics course and should have a good understanding of the operation of basic circuit elements.

VCR MAINTENANCE

VT102 84 minutes: **Introduction to VCR Repair.** Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the NTSC VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

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 are imported by us and originate from VCR Educational Products Co, an American supplier.

(All videos are to the UK PAL standard on VHS tapes)

Now for the digital series of six videos. This series is designed to provide a good grounding in digital and computer technology.

VT301 54 minutes. **Digital One; Gates** begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation. **Order Code VT301**

VT302 55 minutes. **Digital Two; Flip Flops** will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 54 minutes. Digital Three; **Registers and Displays** is your next step in obtaining a solid understanding of the basic circuits found in todays digital designs. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

VT304 59 minutes. Digital Four; **DAC and ADC** shows you how the computer is able to communicate with the real world. You will learn about digital-to-analogue and analogue-to-digital converter circuits. **Order Code VT304**

VT305 56 minutes. Digital Five; **Memory Devices** introduces you to the technology used in many of todays memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices. **Order Code VT305**

VT306 56 minutes. Digital Six; **The CPU** gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

By now you should have a good understanding of computer technology and what makes computers work. This series is also invaluable to the computer technician to understand the basics and thus aid troubleshooting.

VT401 61 minutes. **A.M. Radio Theory.** The most complete video ever produced on a.m. radio. Begins with the basics of a.m. transmission and proceeds to the five major stages of a.m. reception. Learn how the signal is detected, converted and reproduced. Also covers the Motorola C-QUAM a.m. stereo system. **Order Code VT401**

VT402 58 minutes. **F.M. Radio Part 1.** F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver. **Order Code VT402**

VT403 58 minutes. **F.M. Radio Part 2.** A continuation of f.m. technology from Part 1. Begins with the detector stage output, proceeds to the 19kHz amplifier, frequency doubler, stereo demultiplexer and audio amplifier stages. Also covers RDS digital data encoding and decoding. **Order Code VT403**

VT501 58 minutes. **Fibre Optics.** From the fundamentals of fibre optic technology through cable manufacture to connectors, transmitters and receivers. **Order Code VT501**

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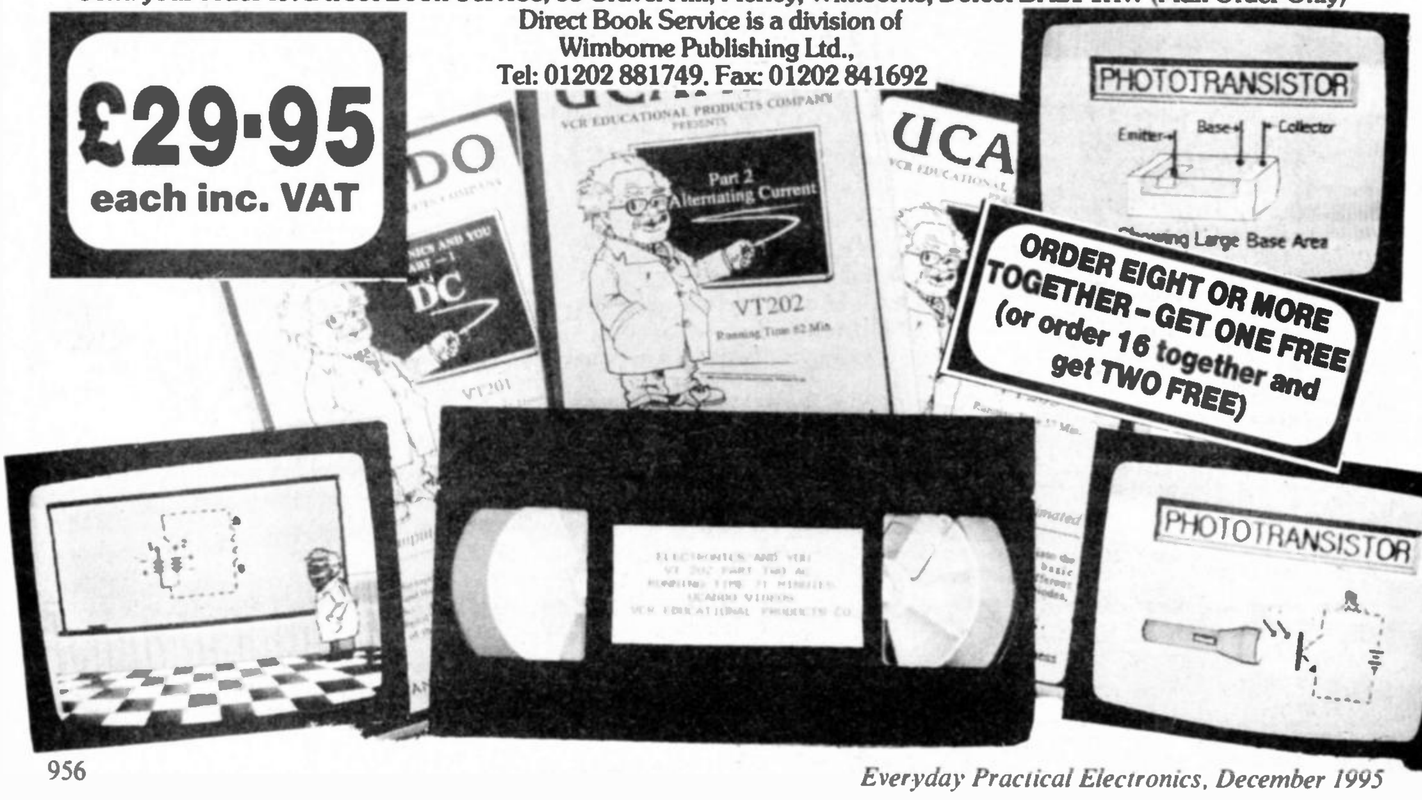


Constructional Project

EPE MET OFFICE

JOHN BECKER

Part One

Whatever weather changes "mother nature" cares to throw at us, this seven-sensed centre can compute them all.

THIS weather centre has been specially designed to allow you to set up your very own home "Met Office". Linked to any PC-compatible computer it will monitor seven aspects of the weather: wind speed; wind direction; barometric pressure; humidity; rainfall; temperature and daylight intensity.

The block diagram for the complete *EPE Met Office*, including the PC-compatible computer interface, is shown in Fig. 1.

DESIGN PHILOSOPHY

A slightly different design philosophy to that generally used in constructional projects has been implemented with the *EPE Met Office*. Usually, a variety of preset potentiometers would be used in a design of this nature, each of them presetting the sensor output gains, biases, tolerance corrections, and so forth. Probably some sensor circuits would also be linked to the outputs from other sensors.

Here, however, since the design is for use with a computer, the majority of the correction factors needed have been left to software control. This concept makes it easier for a particular sensor's data to be modified to take into account the readings from other sensors without recourse to increased circuit complexity.

How this type of software correction can be implemented will be seen in the software control program listing example given in Part Two next month. The example program has been written in GW-Basic, although there is also a short optional machine code routine which speeds up the data access time. The correction factors listed in the example can be readily changed to suit individual circumstances, and other factors can also be written in.

The program example repeatedly samples the outputs from all the sensors, corrects the data, relates it to other data where appropriate, and translates it from voltage readings into specific values such as: millibars; degrees Centigrade; compass bearings; miles per hour, etc. The results are formatted and displayed on the computer screen.

With the exception of the short optional machine code routine, the Basic listing can readily be translated to run with other Basic dialects instead of GW-Basic. Quick-Basic, for example, should be able to run the listing with hardly any change necessary.

Although a printer routine has been included, disk-based record and recall routines have not. In Part Two next month, readers will be referred to a source of information which gives examples of the latter routines. It is regretted that neither *EPE* nor the author can offer advice on using the design with computers which are *NOT* PC-compatible.

GOING SOLID-STATE

It had originally been hoped to design the *EPE Met Office* as a completely solid state monitor without recourse to any mechanical moving parts. It had seemed, during early considerations, that the Wind Speed and Wind Direction detectors could be designed around pressure sensors or ultrasonic transducers.

The first line of research undertaken was to investigate the possibility of using the barometric technique of sensing wind

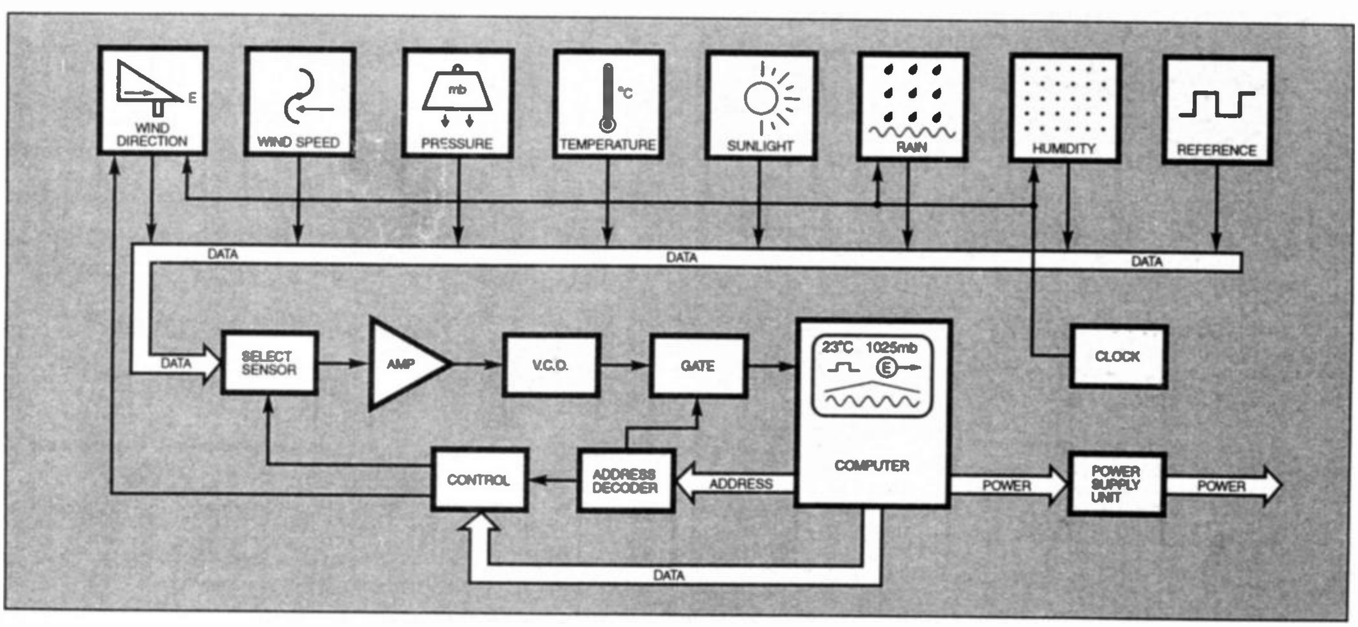


Fig. 1. Block schematic representation of the EPE Met Office.

speed. This is based on the simple principle that wind pressure increases as its speed increases.

It seemed that if two pressure sensors were used, one facing into the wind, and one in an enclosure out of the wind to monitor normal atmospheric pressure, readings from both sensors could be compared and used to provide wind speed data. Tests were initiated to check out the theory.

Regular readers will recall the *EPE Altimeter* design, published in the November 1992 issue. In its basic form, all that this unit does is to monitor air pressure, and so was ideal for the tests.

Also ideal as a travelling wind speed test bed was the author's car. The prototype Altimeter was mounted on the car's passenger side dashboard. A second assembly of the Altimeter was modified and mounted outside the car.

Enlisting help from the wife, wind speed trials on local roads and the M25 were carried out. Repeatedly traversing the same stretches of road, car speed, altitude and wind pressure readings were jotted down on paper. The direction in which the sensor's input port faced the wind was also varied, testing whether wind pressure or wind suction would produce better results.

The accumulated figures were then entered into a computer, a simple software routine written, and the data analysed and plotted out onto paper. At first sight, the principle was proved to work, a simple circuit could derive wind speed from barometric pressure changes.

The response was very slightly higher with the external sensor port facing sideways, with the wind blowing across it. However, the changes in the readings were really only significant at speeds above about 20mph.

It appears that wind pressure increases "proportionately to the *square* of the wind's speed", consequently, the pressure changes at slow speeds would require much sensor output amplification, whilst higher speeds would probably require signal attenuation. The latter did not seem to be a great problem, but it was obvious that a d.c. amplifier of extreme precision would be required to make slow wind speeds readily monitorable.

Such complexity was felt to be undesirable in what was intended to be a simple unit. Perhaps an aircraft engineer or other aerodynamics expert might care to explain how aircraft wind speed sensors work.

SOUND APPROACH

Disappointed, but not deterred, it was decided to try the ultrasonic technique of sensing wind speed. This is based on the fact that changes in wind speed cause minute changes in the speed of sound.

In theory, in order to measure the wind speed, all that is necessary is to send a pulse of sound from a loudspeaker and to monitor the time that it takes to reach a nearby microphone, and then to compare the result to the "normal" speed of sound. For this, an ultrasonic transmitter and receiver pair seemed to be ideal.

WIND TUNNEL

Building a modified version of the *EPE Ultrasonic Tape Measure* (September 1992) as a suitable 40kHz transmitter and receiver, a rudimentary wind tunnel was assembled in the workroom, using the household hairdryer (unheated setting) as the wind source.

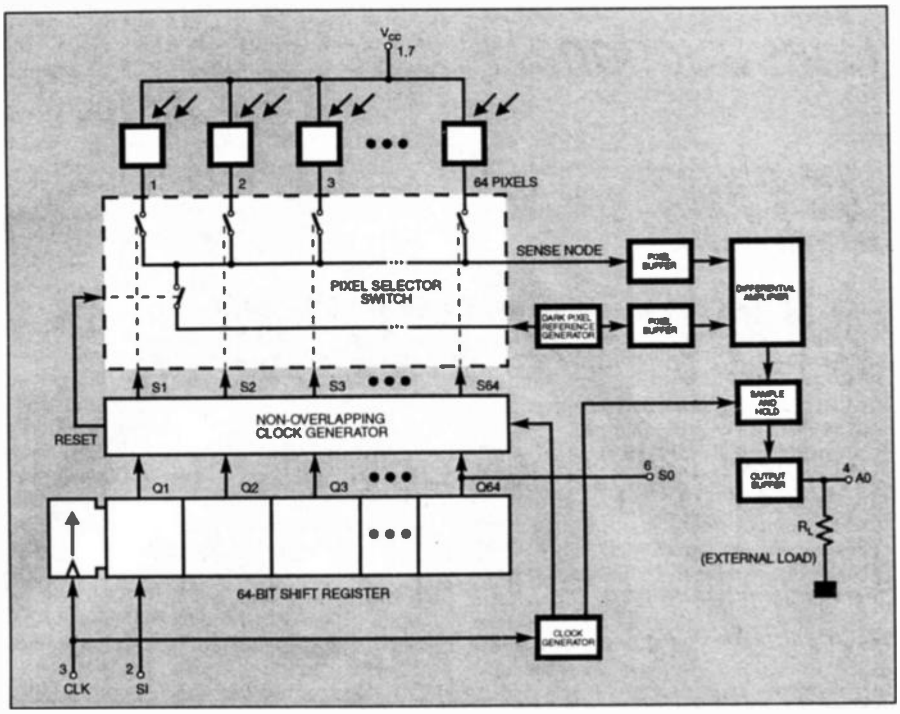


Fig. 2. Internal functional block diagram for the Texas TSL214 opto-sensor.

Monitoring the transmitted and received ultrasonic signal waveforms on an oscilloscope, shifts in signal phase were looked for as the hair-dryer had its blowing power repeatedly raised and lowered. To much surprise, however, no definitive phase shifts could be seen. Such a disappointment!

A third solid state wind speed sensing possibility might have been to monitor the temperature of a heated element. In this method, the element would lose heat by an amount depending on the cooling effect of the air flow rate across it.

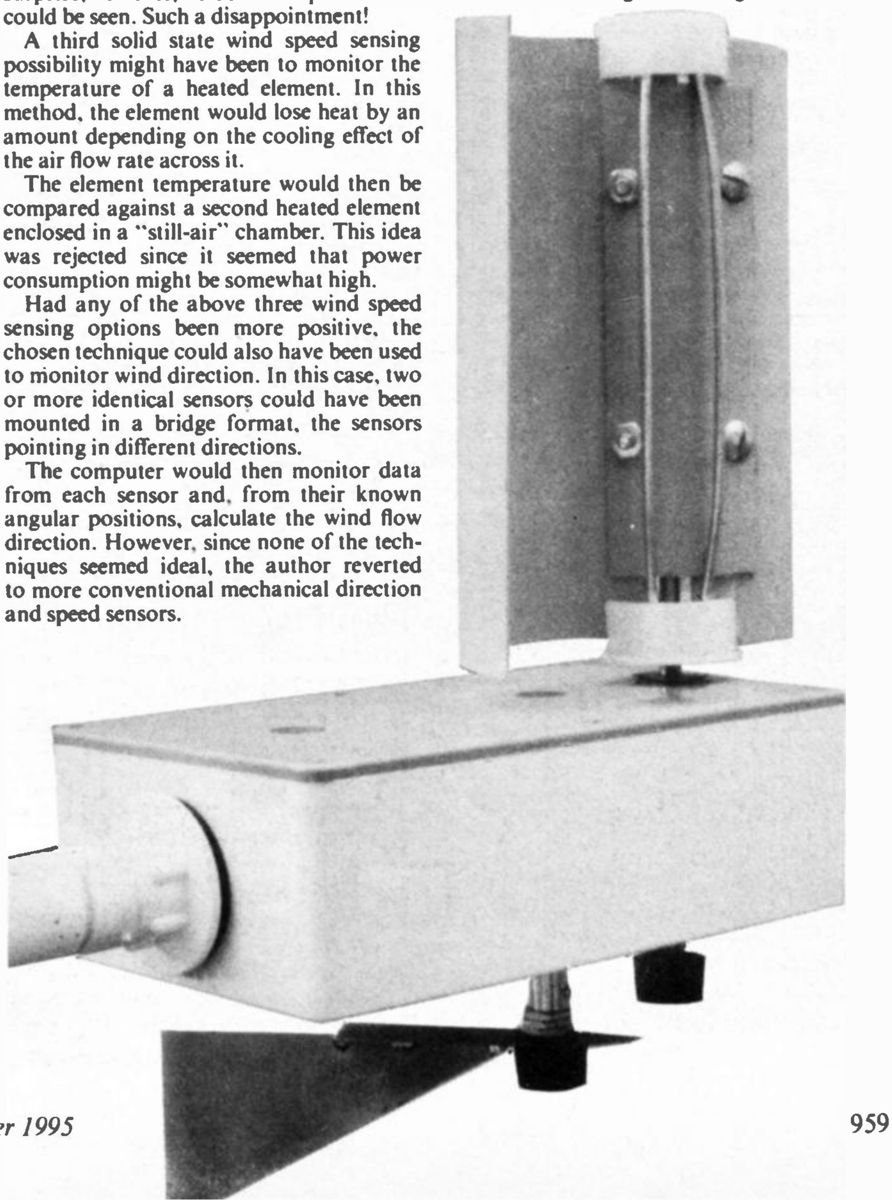
The element temperature would then be compared against a second heated element enclosed in a "still-air" chamber. This idea was rejected since it seemed that power consumption might be somewhat high.

Had any of the above three wind speed sensing options been more positive, the chosen technique could also have been used to monitor wind direction. In this case, two or more identical sensors could have been mounted in a bridge format, the sensors pointing in different directions.

The computer would then monitor data from each sensor and, from their known angular positions, calculate the wind flow direction. However, since none of the techniques seemed ideal, the author reverted to more conventional mechanical direction and speed sensors.

WIND DIRECTION SENSOR

For Wind Direction sensing, an arrowed assembly points into the wind like a normal weather vane. In the past, in similar circumstances, a punched rotating disc and one or more light emitting diode (l.e.d.)



and light detecting pairs might have been used to sense the vane's orientation. Here, however, a recently introduced type of opto-sensor has been used instead, a Texas Instruments TSL214 device.

The TSL214 chip is an integrated opto-sensor consisting of 64 charge-mode pixels arranged in a 64 × 1 linear array. A block diagram for the opto-sensor is shown in Fig. 2.

Light energy striking the pixel elements, each measuring only 120µm × 70µm, causes an electrical charge to build up in the region of the pixels. The amount of charge accumulated is directly proportional to the amount of incident light and to the length of time that the pixels are exposed to it, usually referred to as the "integration time".

In principle, the TSL214 is a much simpler form of the CCD (charge coupled device) image sensor used in the *EPE TV Camera* of April and May 1994. That device had several hundred-thousand pixels.

Operation of the TSL214 sensor comprises two time periods, the integration time during which the charge is accumulated in the pixels, and a "transfer period" during which the charges are serially shifted to an output. Transfer of the pixel charges is under control of a clock signal (CLK) and a serial input (SI) signal.

The signal voltage generated at the output node (A0) is directly proportional to the amount of charge and inversely proportional to the capacitance of the sense node. An internal reset signal is generated by a non-overlapping clock generator and occurs on every clock cycle.

The outputting period is initiated by the presence of the SI input pulse coincident with a rising edge of the clock. The period ends on the rising edge of the 65th clock cycle, at which time the output assumes a high impedance state. The 65th clock cycle also terminates the output of the last pixel and clears the chip's internal shift register in preparation for the next SI pulse.

To the wind direction vane is attached a transparent disc which has an opaque spiral pattern secured to it. The TSL214 opto-sensor is positioned immediately under the spiral, and an l.e.d. is positioned above it.

As the wind moves the vane, so the shadow of the spiral pattern shifts across the line of sensor pixels. When the sensor's data is read by the computer, the rotational angle of the weather vane is calculated from assessment of which pixels are covered by the spiral track pattern.

VANE ROTATION

The circuit diagram which controls the weather vane position sensor is shown in Fig. 3. In the diagram, IC1 is the TSL214 opto-sensor and D1 is its illuminating l.e.d. Since the sensor's exposure time in relation to the brilliance of the l.e.d. must be fairly rigidly controlled, whereas the controlling computer's data acquisition time may vary between types, a temporary data storage stage is included, the heart of which is IC4, a 64-bit shift register.

A 400kHz clock signal, whose source will be described shortly, provides the required clocking rate to opto-sensor IC1. The same clock signal also triggers a 12-stage binary counter, IC5. The Q8 output, pin 12, of IC5 is connected to the A1 clock input, pin 4, of one half of the dual monostable IC6, and outputs a clocking signal at about 1560Hz.

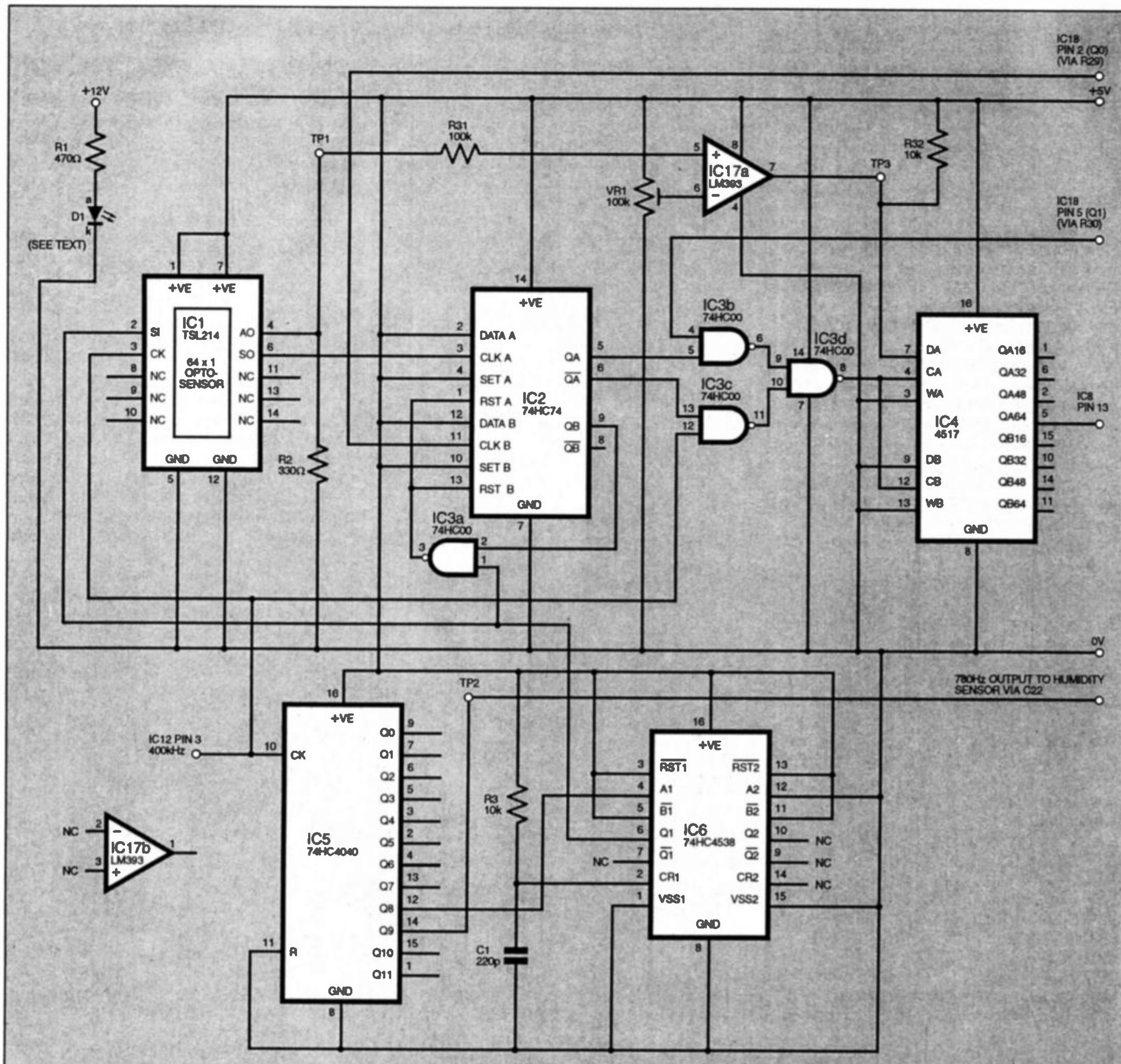


Fig. 3. Circuit diagram for the wind direction vane rotation sensor and interface memory.

On receipt of each positive going-edge of the 1560Hz clock pulses, IC6 is triggered to produce a very short duration pulse at its Q1 output, pin 6. The pulse length is set by resistor R3 and capacitor C1.

Connected to the SI input, pin 2, of IC1, the pulse initiates the start of the sensor's 64-bit output cycle. The sensor's stored pixel data is then shifted out from its A0 output pin 4 at the full 400kHz rate, and taken via resistor R31 to the comparator stage around op.amp IC17a.

Comparator IC17a is required because the analogue output from sensor IC1 may not necessarily have a voltage swing which produces adequate logic levels for storing in the shift register IC4. The sensor's output voltage could, in fact, be at any of four discrete levels, depending on the exposure time and light value.

The purpose of the comparator IC17 is to detect the correct levels at which it will be triggered to produce the required *high* or *low* logic level at its output pin 7. The trigger threshold level for IC17a is set by preset potentiometer VR1.

IN STORE

From IC17a, the logic level data, which indicates whether or not the sensor's individual pixels have the spiral shadow above them, is output to the DA data input pin 7 of shift register IC4. When the shift register is in the high speed record mode, each pixel data bit from IC17a is clocked into it at the 400kHz rate, the gating of the clock signal being controlled by flip-flop IC2 in conjunction with NAND gates IC3b, IC3c and IC3d. The gating is also dependent upon additional clocking signals which are derived from the computer.

Assuming that the required "record" signal has been received from the computer, IC2 $\overline{QA}$ output, pin 6, will be high, thus allowing NAND gate IC3c to pass the 400kHz signals through to NAND gate IC3d pin 10. Simultaneously, IC2 QA output, pin 5, will be low and as a result NAND gate IC3b pin 6 will be high, which in turn allows NAND gate IC3d to pass the clock signals from IC3c through to the clock input CA of IC4.

Since the same 400kHz signal triggers both sensor IC1 and shift register IC4, the latter has the data from comparator IC17a synchronously clocked into it. On the 65th clock pulse after IC1 has had its data output sequence triggered, IC1 pin 6, the SO output, goes high. This event triggers flip-flop IC2 so that its QA and $\overline{QA}$ outputs reverse their logic states.

As a result, gate IC3c closes to the 400kHz signals and its output pin 11 goes high. Simultaneously, IC3b is enabled, allowing it to receive clock pulses originating from the computer, as and when they are sent under software control. When received, each pulse from the computer causes the data bit contents of IC4 to be shifted out from its QA64 output (pin 5).

Once the computer has read the contents of IC4, it sends a reset signal to flip-flop IC2 pin 11 (CLK B). This triggers high IC2's QB output, which enables NAND gate IC3a making it ready to pass the next pulse from monostable IC6 through to both reset pins of IC2, inputs RST A and RST B. On receipt of the latter pulse, the data record sequence recommences.

There are two minor circuit design points to note. Resistor R2 pulls down IC17a's input pin 5 to the 0V level when IC1 output A0 is in a high impedance state. Secondly, although it will be seen that IC3d pin 8 is additionally connected to clock input CB (pin 12) of the second half of dual shift register IC4, this half of the chip is not actively used.

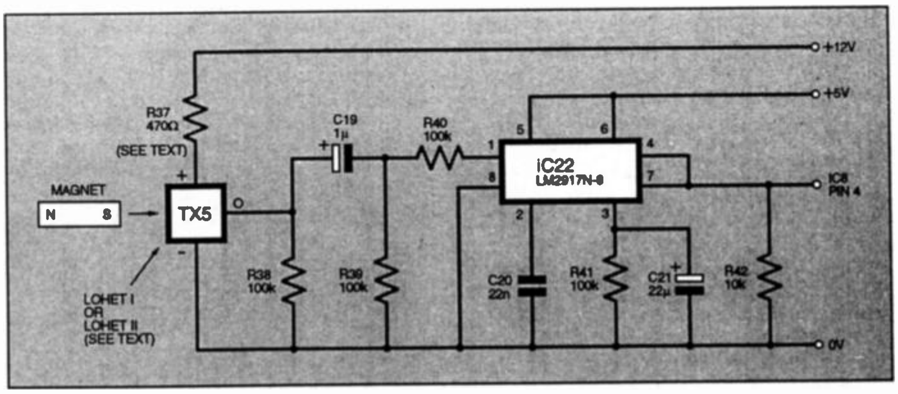


Fig. 4. Wind Speed Detector circuit diagram, using a magnet and Hall effect sensor.

WIND SPEED DETECTOR

The circuit diagram for the wind speed detector is shown in Fig. 4. Mechanically, a rotating wind "paddle" assembly has an attached magnet which passes over a Hall effect sensor, TX5, secured to the lid of the unit's box.

As the magnet passes over the sensor, a change of output voltage is generated across resistor R38. The resulting a.c. signal is coupled via capacitor C19 and resistor R40 to IC22, a tachometer/frequency-to-voltage coverter i.c. This outputs a voltage at pins 4 and 7 which is proportional to the frequency of the pulses input to pin 1.

The chosen values of resistor R41 and capacitors C20 and C21 set the frequency-to-voltage conversion range. Resistors R39 and R42 provide basic input and output loads for IC22.

Hall effect sensor TX5 may be one of two types, either a Lohet I, or a Lohet II. The latter requires the inclusion of resistor R37 in its power line to limit its supply voltage to between 7V and 8V.

The less expensive Lohet I device, however, will accept supply voltages up to 16V and so resistor R37 should be replaced by a link wire. Note, though, that Lohet I is less sensitive than Lohet II and requires a stronger magnetic field in order to produce an output signal amplitude great enough to trigger IC22 satisfactorily.

The bar magnet used with the prototype was taken from a burglar alarm contact breaker assembly. Other types of bar or disc magnet may be used, connecting several in line to increase the magnetic field strength if necessary. The height of the magnet above the sensor also affects the detected field strength.

PRESSURE SENSOR

Circuit diagram details for the Barometric Pressure Sensor are shown in Fig. 5. Regular readers will recognise that this circuit is similar to the front end of the *EPE Altimeter* design referred to earlier.

Transducer TX3 is the pressure sensing element, full descriptive details of which were given in the original Altimeter article. The sensor's two differential outputs (pins 2 and 4) are fed to op.amps IC13a and IC13b which between them provide a d.c. signal gain of about 50, as set by resistors R19 and R20.

The combined output from IC13b pin 1 is buffered and inverted by op.amp IC13c. Here, an offset bias level is superimposed on the d.c. signal by preset potentiometer VR4. This is used to adjust the voltage output from IC13c pin 14 in order to "tune" the barometer to the required basic value. Typically, the output from IC13c pin 14 varies by about 3mV per millibar.

In order to minimise the sensor's voltage output drift with changes in ambient temperature, the resistance in series with its positive terminal, pin 3, needs to be approximately matched to the sensor's resistance. Preset potentiometer VR3 is used for this purpose and its setting will be described when the printed circuit board assembly is discussed.

There are two forms of the type MPX100A pressure sensor TX3 commonly available, one with a plastic enclosure, one

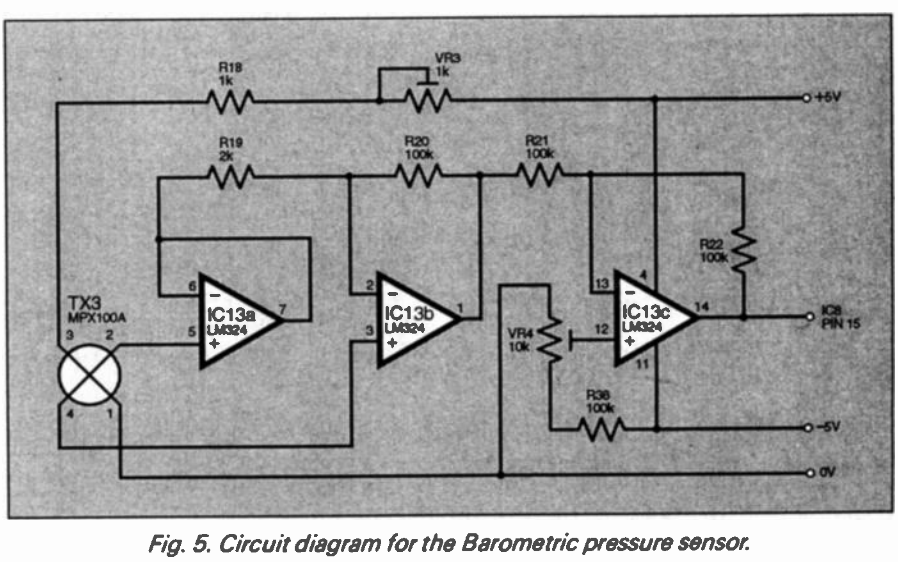


Fig. 5. Circuit diagram for the Barometric pressure sensor.

without. They are identical in operation and either version may be used. It is believed, but not tried, that the SPX100A may be used instead of the MPX100A.

HUMIDITY SENSOR

The circuit diagram for the Humidity Sensor is shown in Fig. 6. Transducer TX4 is the sensing element whose impedance to an a.c. signal decreases with increased humidity. The sensor has a rated working voltage of 1V a.c. between 50Hz and 1kHz. Nominally, its impedance is about 60kΩ when humidity is 50 per cent and ambient temperature is 25°C.

The graphs in Fig. 7 show how the sensor's characteristics change in response to different temperatures and humidity factors. Correction factors for these changes may be incorporated into the controlling software program.

The a.c. signal frequency chosen is 780Hz and is a sub-division of the 400kHz master clock frequency referred to earlier and taken from IC5 output Q9 in Fig. 3. Referring back to Fig. 6, the 780Hz signal is brought in to pin 10 of buffer op.amp IC13d via capacitor C22.

Capacitor C9 and resistors R23 and R24 smooth off the corners of the incoming square wave signal which is then fed from IC13d pin 8, via capacitor C10, to sensor TX4. Attenuated by the humidity-related impedance of TX4, the signal is rectified and smoothed by diode D2, capacitor C11 and resistor R28. Preset potentiometer VR5 is used to provide a minimum d.c. bias voltage through resistor R27.

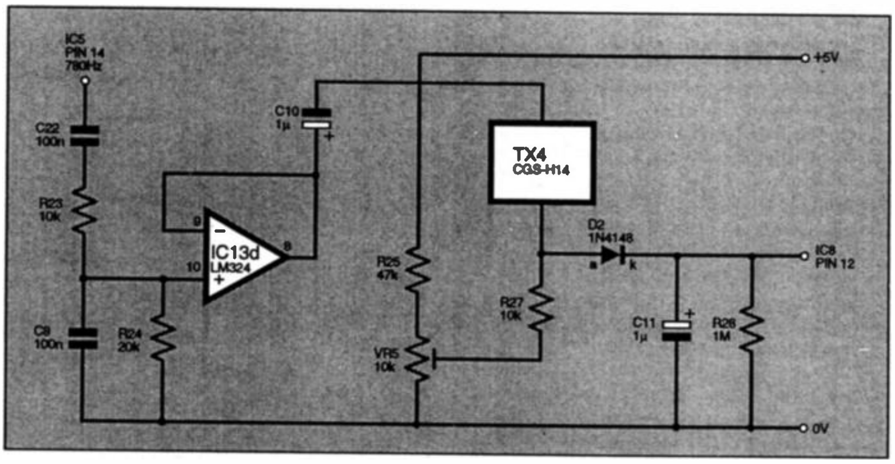


Fig. 6. Humidity Sensor circuit daigram.

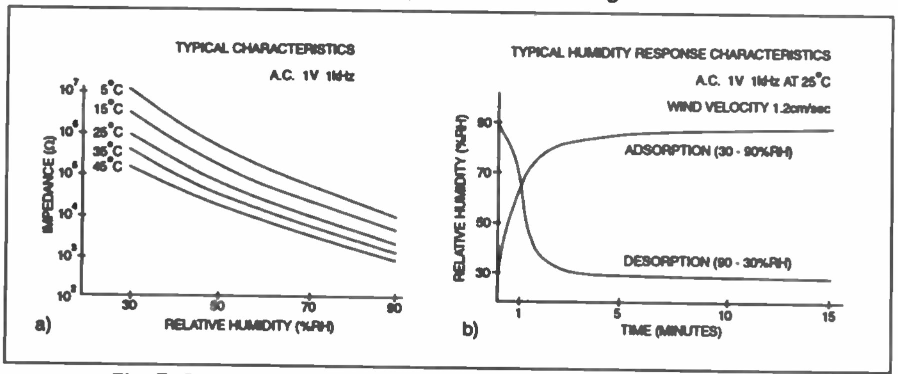


Fig. 7. Sensor response for typical temperature/humidity readings.

TEMPERATURE AND LIGHT SENSORS

The circuit diagrams for the Temperature and light sensor circuits are shown in Fig. 8. Designated as IC14, the temperature transducer used may be either an LM35CZ device, or an LM35DZ. The former has a specified operating range of −40°C to +110°C, whereas the latter's range is 0°C to 100°C. The inclusion of resistor R34 provides a negative output bias voltage which enables the sensor to respond to negative temperatures. The typical output from IC14 is about 10mV per 1°C.

For the light sensor R43, the familiar ORP12 light dependent resistor (LDR) is used as the sensor. In total darkness, it has a resistance of about 10 Megohms.

This resistance decreases as the light level increases, falling to about 150 ohms when illuminated at 1000 lux. Typically, bright sunlight illuminates at about 30k lux, and moonlight at about 0·1 lux.

The sensor is used in series with resistor R35 in a potential divider configuration across the power supply. The output voltage is tapped at the junction of the two components. Basically, the intention of the light sensor is to enable the computer to monitor sunlight conditions and resistor R35 has had its value chosen accordingly.

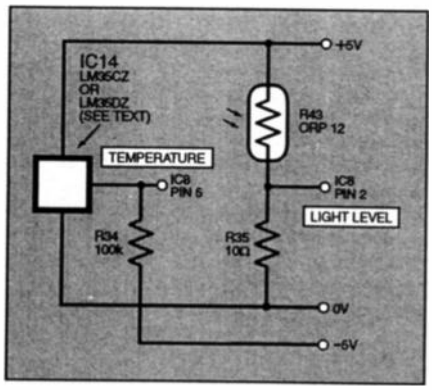


Fig. 8. Temperature and Light sensor circuit diagrams.

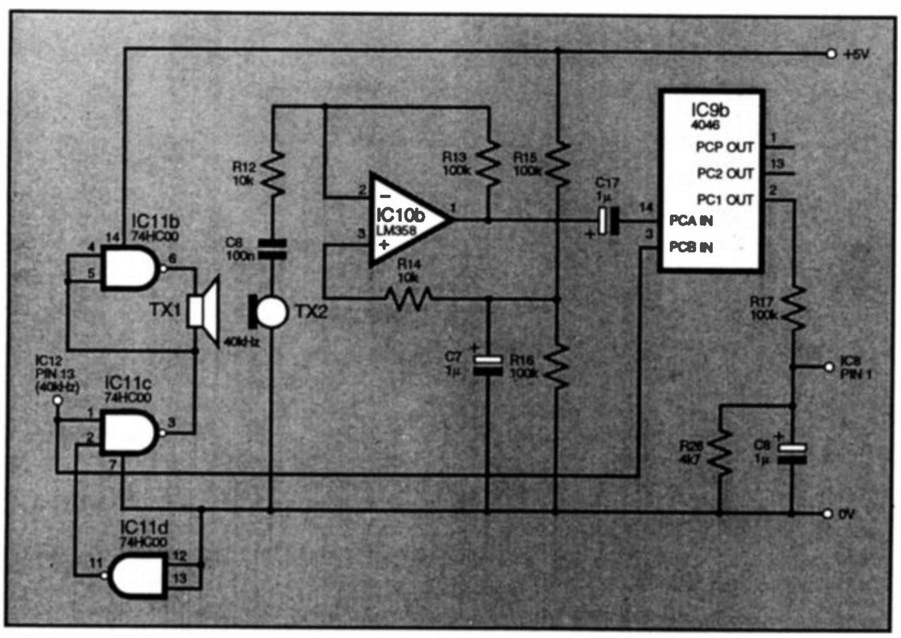


Fig. 9. Circuit diagram for the Ultrasonic Rainfall/Water Level Detector.

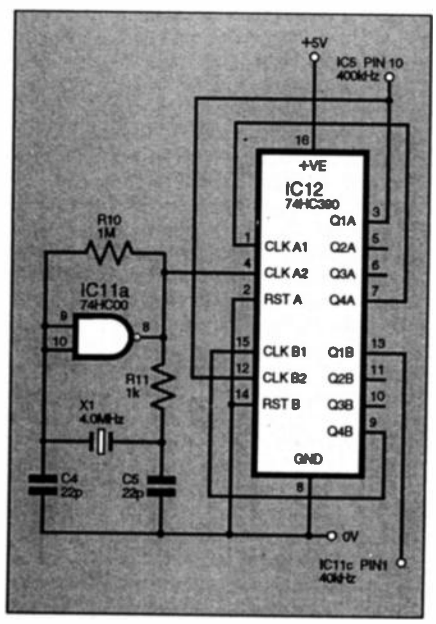


Fig. 10. Master Clock 400kHz and 40kHz Generator circuit.

RAINFALL DETECTOR

Since an ultrasonic transducer phase shift circuit had already been built, but aborted, for the wind speed experiments described earlier, it was decided to modify that circuit in order to monitor rain fall. The constructed ultrasonic circuit is placed above a large rain-collecting container (a rain barrel, for example, or a bucket!) with the transmitter and receiver transducers side by side and pointing down to the water surface.

The transmitter transmits a continuous 40kHz signal which is reflected back from the water surface to the receiver. Both the transmitted and the received signals are monitored and their phase compared. The detected phase shift is directly related to the speed of sound and the distance which the sound has to travel to the water and back to the receiver.

In dry air, the speed of sound is 331·4 metres per second at s.t.p. (standard temperature and pressure = 0°C and 1013·25 millibars). Thus, the wavelength of one cycle of a 40kHz signal is approximately 8·285 millimetres. Since the signal has to travel down to the water and back, the change in the water level for a 360° phase shift (one cycle) is 8·285mm/2 = 4·1425mm. Software can take care of the corrections required for changes in temperature, pressure and humidity.

The circuit diagram for the Ultrasonic Water Level Detector is shown in Fig. 9. The required 40kHz clock signal is derived from the master clock generator described below.

Transmitter

Transmitter TX1 is driven in push-pull mode at 40kHz via the buffer and inverter NAND gates IC11b and IC11c. Gate IC11c is also connected to NAND gate IC11d.

It had been thought that there might be additional uses for the ultrasonic circuit which might require the 40kHz clock signal to be gated on and off by an extra control signal applied via IC11d. However, since the need did not arise, the inputs to IC11d have simply been grounded, so causing gate IC11c to be held constantly open.

Receiver

Ultrasonic receiver transducer TX2 detects the signal reflected from the water surface. Op.amp IC10b then amplifies the signal by about ten times, as set by resistors R12 and R13. The network comprising resistors R14 to R16 and capacitor C7 set the midway bias level for IC10b.

The output signal from IC10b pin 1 is coupled, via capacitor C17, to the PCA input (pin 14) of the phase-locked loop (PLL) chip IC9b. The PCB input (pin 3) of IC9b is connected to the 40kHz output at IC12 pin Q1B.

Comparing the phases of the two signals on its inputs, IC9b generates a related output voltage across resistors R17, R26 and capacitor C8, the latter smoothing the output waveform to a d.c. level. The voltage output from C8 varies according to the phase difference between the input signals.

MASTER CLOCK

Details of the Master Clock Generator circuit are shown in Fig. 10. A 4MHz crystal oscillator is formed around NAND gate IC11a in a conventional configuration. Dual 4-bit binary counter IC12 is configured to sub-divide the 4MHz signal, 400kHz being output from its Q1A output (pin 3), and 40kHz from its Q1B output (pin 13).

COMPONENTS

SENSORS AND INTERFACE

Resistors

R1	470Ω	R9, R10, R28	1M (3 off)
R2	330Ω	R11, R18	1k (2 off)
R3, R6 to R8, R12, R14, R23, R27, R29, R32, R39, R42	10k (12 off)	R19	2k
R4, R25	47k (2 off)	R24	20k
R5, R13, R15 to R17, R20 to R22, R31, R33, R34, R36, R38 to R41	100k (16 off)	R26	4k7
		R35	10Ω
		R37	470Ω (see text)
		R43	ORP12 light dependent resistor

All 0·25W 5% carbon film or better, except R43

Potentiometers

VR1	100k min. enclosed round preset
VR2, VR4 to VR6	10k min. enclosed round preset, lin. (4 off)
VR3	1k min. enclosed round preset

Capacitors

C1	220p polystyrene
C2, C15, C21	22μ radial elect. 25V (3 off)
C3, C6, C9, C22, C23	100n polyester (5 off)
C4, C5	22p polystyrene (2 off)
C7, C8, C10, C11, C13, C14, C17, C19	1μ radial elect. 63V (8 off)
C12	470μ radial elect. 25V
C16, C18	47μ radial elect. 25V (2 off)
C20	22n polyester

Semiconductors

D1	red l.e.d. (high brightness)
D2, D3	1N4148 signal diode (2 off)
IC1	TSL214 64 x 1 linear opto-sensor
IC2	74HC74 dual D-type flip-flop
IC3, IC11	74HC00 quad 2-input NAND gate (2 off)
IC4	4517 dual 64-bit shift register
IC5	74HC4040 12-bit binary counter
IC6	74HC4538 dual retriggerable monostable
IC7	74HC393 dual 4-bit binary counter
IC8	74HC4051 bidirectional 8-way switch (multiplexer)
IC9	4046 phase-locked loop
IC10	LM358 dual op.amp
IC12	74HC390 dual decade counter
IC13	LM324 quad op.amp
IC14	LM35CZ or LM35DZ precision temperature sensor (see text)
IC15	78L05 100mA 5V regulator
IC16	ICM7660 voltage inverter
IC17	LM393 dual comparator
IC18	74HC174 Hex D-type flip-flop
IC19	74HC4075 triple 3-input OR gate
IC20	74HC138 3-line to 8-line decoder
IC21	74HC573 octal D-type latch
IC22	LM2917-8 tachometer

See SHOP TALK Page

Transducers

TX1	40kHz ultrasonic transmitter
TX2	40kHz ultrasonic receiver
TX3	MPX100A pressure sensor
TX4	CGS-H14 humidity sensor (STC-Farnell 414719x)
TX5	Lohet I or Lohet II Hall effect sensor (see text)

Miscellaneous

X1 4MHz crystal

Printed circuit boards available from *EPE PCB Service*, codes 963 (Sensor/Rain), 964 (Comp Interface) and 965 (vane); plastic case 190mm x 110mm x 60mm (l x w x h); 8-pin d.i.l. socket (4 off); 14-pin d.i.l. socket (6 off); 16-pin d.i.l. socket (9 off); 20-pin d.i.l. socket; stacking p.c.b. supports (4 off); nuts and bolts (4 off – to suit p.c.b. pillars); plastic or copper plumbing pipes and connector fittings 21mm diameter – quantities to suit garden mounting requirements (see text and photograph); connecting wire; connecting cable; solder, etc.

WIND SPEED AND DIRECTION MECHANICS

(See Part 2 for construction details)

Spiral transparency (see text), available from *EPE PCB Service*
Knobs with grub-screw fitting (3 off)
Potentiometer - any value (2 off)
Potentiometer washer (3 off)
Potentiometer nut (2 off)
Cable gland, 7mm diameter cable hole
Cable gland, 10mm diameter cable hole
Spindle coupler to suit pot shaft diameter
Perspex disc approx. 2·1 inches (52mm) diameter (see text)
Light weight plastic gutter 3.0 inches diameter
7 inch paint roller frame with handle shaft

Approx cost guidance only **£98** *excluding mechanical parts*

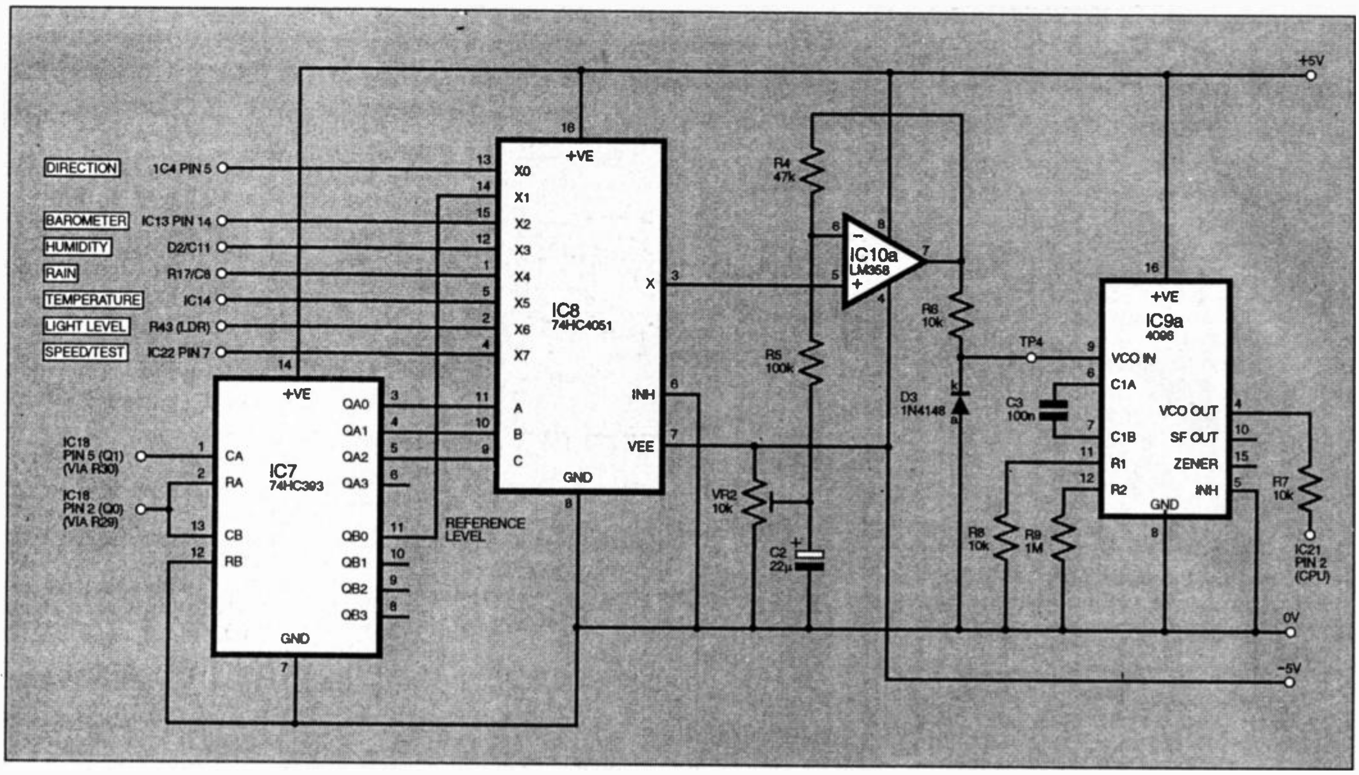


Fig. 11. Circuit diagram for the output sensors multiplexer and v.c.o. (voltage controlled oscillator).

The 400kHz signal is sent to the rotation sensor circuit in Fig. 3. The 40kHz signal is the transmission frequency required by the ultrasonic transducer pair TX1 and TX2 in Fig. 9.

SENSOR MULTIPLEXER

The outputs from all the sensors are brought to a Multiplexer and V.C.O. (voltage controlled oscillator) circuit whose functional diagram is shown in Fig. 11. Any of the signals fed to the X0 to X7 inputs (pins 1, 2, 4, 5 and 12 to 15) of multiplexer chip IC8 can be routed to its X output at pin 3, according to the binary code present on its control inputs A, B and C (pins 9, 10, 11).

Dual 4-bit binary counter IC7 is used to set the control code for IC8. It is additionally used to provide a reference voltage from pin 11, its QB0 output, to IC8 input X1 (pin 14). As will be seen shortly, signals generated by the computer control the clocking and resetting of counter IC7 via its function pins CA, CB and RA (pins 1, 13, 2).

The chosen signal source is routed through IC8 to the op.amp stage around IC10a. Here the signal is amplified by about 1·5 times, as set by resistors R4 and R5.

An adjustable bias level is set by preset potentiometer VR2. Unavoidably, the setting of VR2 also plays a small part in the actual gain provided by IC10a. Capacitor C2 simply smooths the bias level from VR2.

From IC10a, the selected sensor voltage is passed to the linear v.c.o. circuit around IC9a. The latter device is part of the same chip used for the PLL of the ultrasonic circuit (IC9b) in Fig. 9.

The v.c.o. generates an output frequency from IC9a pin 4 according to the voltage on its input, and in relation to the values of resistors R8, R9, and capacitor C3. The v.c.o. output frequency from pin 4 is fed through resistor R7 to the computer via an interface circuit, which will be covered next month.

The inclusion of resistor R6 and diode D3 prevents negative voltage outputs from IC10a from "distressing" the v.c.o. input of IC9a.

POWER SUPPLY

All the circuits described so far are powered from a common power supply, the circuit diagram for which is shown in Fig. 12. The prototype *EPE Met Office* is powered from the 12V line of the computer. It may instead be powered from any 12V d.c. source, such as a bench power supply unit (PSU), or 12V car battery.

The 12V d.c. input voltage is smoothed by capacitor C12. From here, the supply provides power to l.e.d. D1 via resistor R1 in Fig. 3, and to sensor TX5 via R37 in Fig. 4. The 12V supply is also reduced down to +5V by voltage regulator IC15, capacitors C13 and C14 providing power line smoothing.

Most of the sensor circuitry is powered by +5V, some of it, though, requires a −5V supply as well. This is generated by voltage inverter chip IC16, which is configured in the conventional fashion, capacitor C15 setting the inversion clock frequency, and C16 smoothing the −5V output.

The potential divider formed by resistor R33 and preset potentiometer VR6 provide a test voltage point which will be of use when setting up the circuit and the computer software.

CONSTRUCTION – SENSOR BOARD

The printed circuit board (p.c.b.) component layout and full size copper foil master pattern for the *EPE Met Office* Sensor board together with the small Ultrasonic Rainfall Sensor is shown in Fig. 13. This board is available from the *EPE PCB Service*, code 963.

Before inserting components into the p.c.b. cut off the ultrasonic transducer mounting section. Next drill out the hole into which the mounting bush of the wind direction rotor shaft will be secured. Then file out the two large side holes which allow the board to fit alongside the two side pillars within the specified box.

Start the assembly of the p.c.b. by soldering in the on-board wire links, which are best made from 24s.w.g. tinned copper wire. Next solder in the d.i.l. i.c. sockets, followed by resistors, diodes, preset potentiometers, capacitors and then the regulator i.c.s. Ensure that polarised components are correctly orientated.

Insert two rigid wires formed from heavy duty tinned copper wire, of 18s.w.g. for example, each about 50mm long. Temporarily solder l.e.d. D1 to these wires,

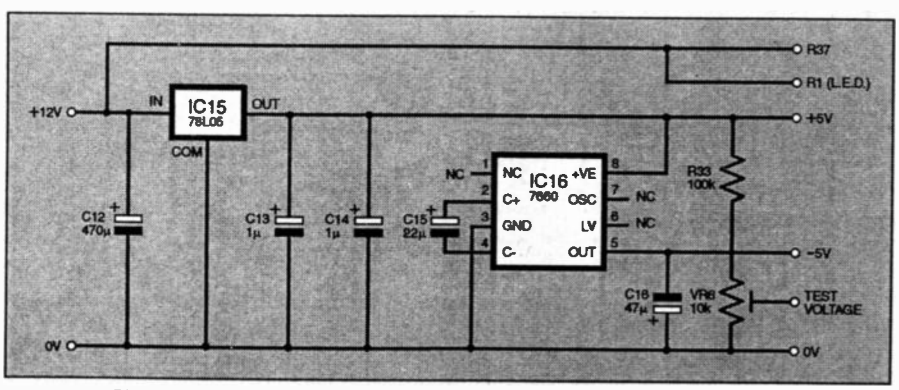
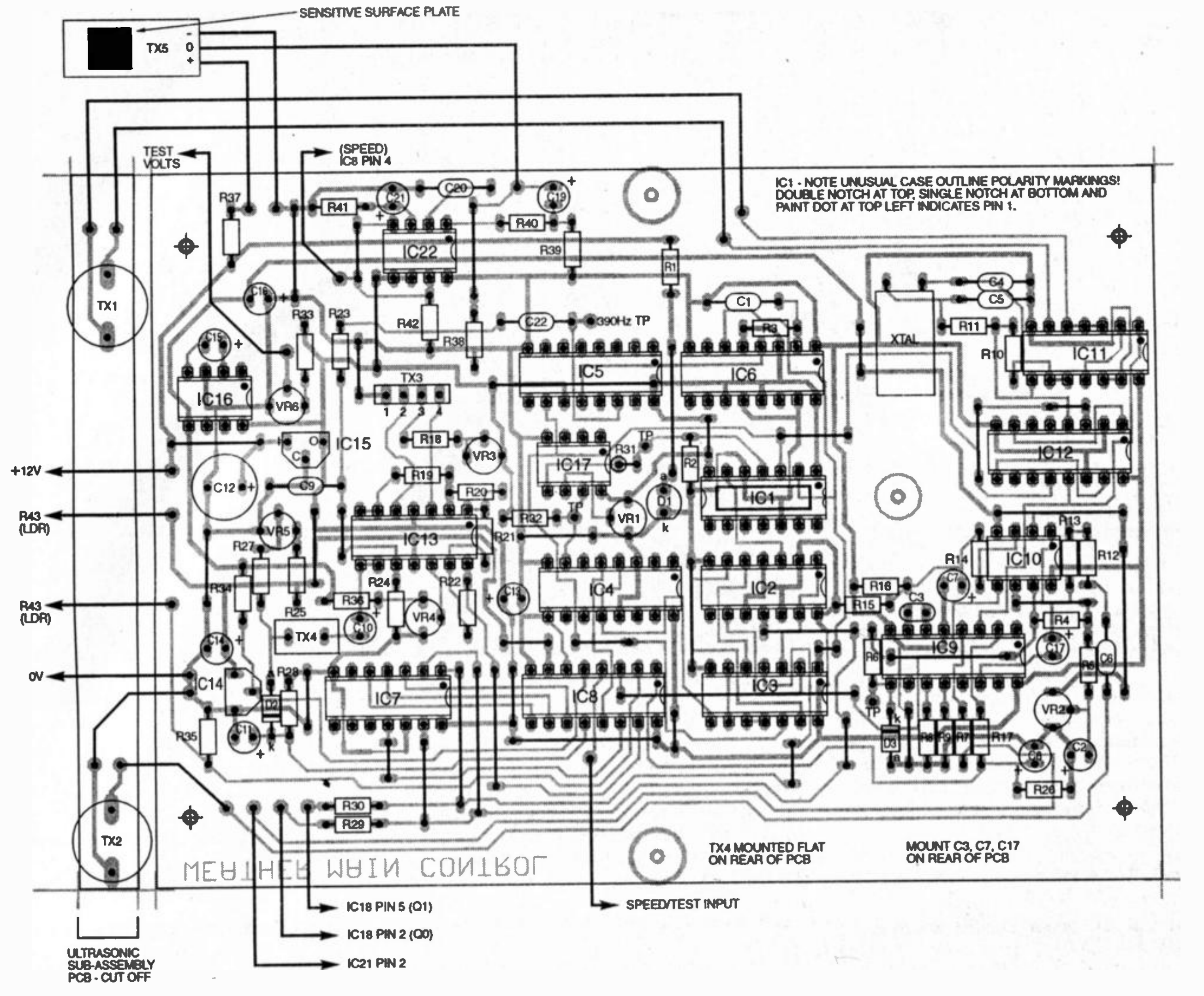


Fig. 12. Circuit diagram for the system dual-voltage power supply.



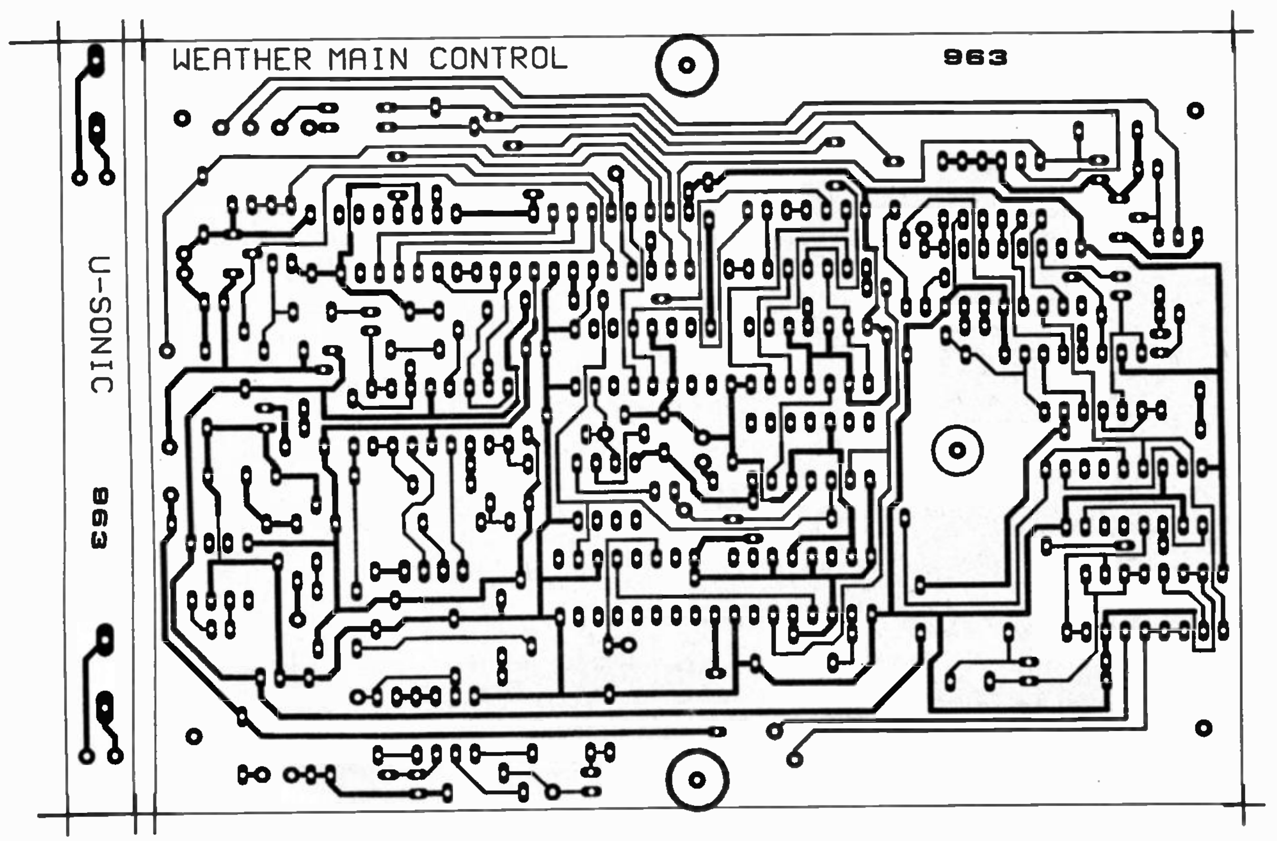


Fig. 13. Component layouts and full size p.c.b. foil masters for the Sensor and Ultrasonic Rainfall Detector boards.

observing its correct polarity. Its final positioning can be made after the Wind Speed Sensor mechanics have been constructed.

Solder the ultrasonic transducers onto their small sub-assembly board and temporarily connect them back to the main board by a couple of metres of cable. Also connect the light sensor LDR (R43) to its designated p.c.b. points.

In the prototype, R43 was mounted under the p.c.b. via two shaped lengths of 18s.w.g. tinned copper wire and then positioned over a hole cut in the base of the case. This allowed the sensor to respond to light reflected from the surface to which the completed unit was mounted on its stand. For an increase in the amount of reflected light, a largish white flat surface could be fixed to the stand a metre or so below the hole in the case.

PRESSURE SENSOR COMPENSATION

Before inserting pressure sensor TX3, measure the resistance between its pins 1 and 3 (see Fig. 14) using a multimeter set to Ohms range. Now place the ohmmeter across the +5V power line and the unconnected end of resistor R18.

Adjust preset potentiometer VR3 so that the total resistance measured approximately equals 3·577 times the resistance of TX3. The multiplying factor is specified by the transducer manufacturer and is intended to minimise the transducer's temperature drift.

Ideally the temperature at which the resistance readings are made should be taken into account. Since, however, the computer software can have correction factors written into it, such precision is probably unnecessary.

Once VR3 has been set, it should not be further adjusted. Sensor TX3 can now be inserted.

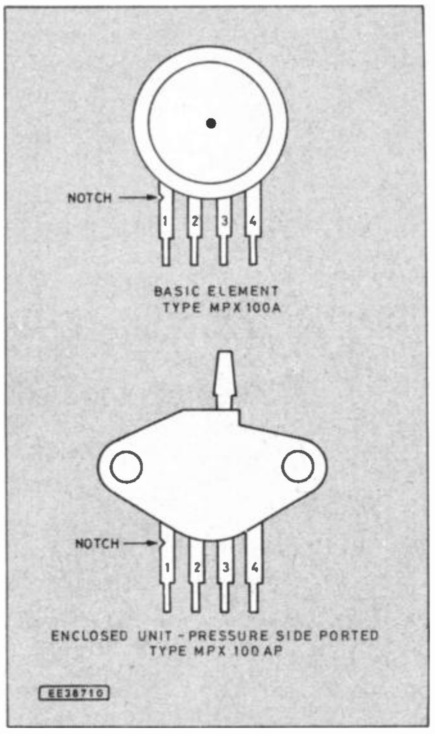


Fig. 14. Pressure transducer pinout details.

PRELIMINARY CHECKING

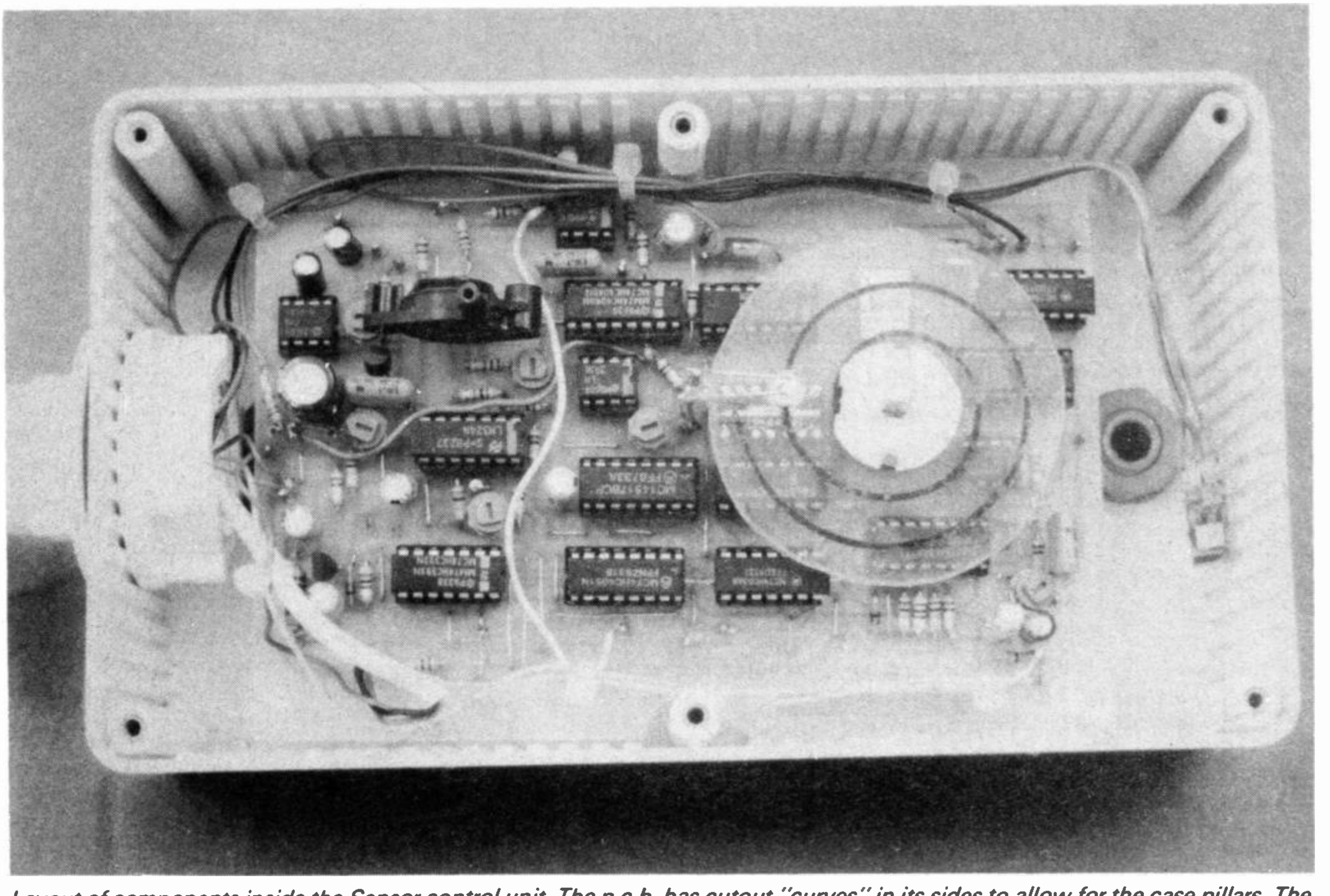
If, when checking any of the circuits, incorrect behaviour is suspected, immediately disconnect the power and recheck the board assembly for the correct insertion of components and the perfection of soldering. Also ensure that the power is *off* before inserting or extracting components.

Note that the majority of the i.c.s are CMOS devices, so treat them all as such, observing the usual handling precautions. These include touching a grounded (earthed) point to discharge static electricity from yourself before handling the chips.

Do not insert the d.i.l. i.c.s into their sockets just yet. After thoroughly checking the p.c.b. for inadequate soldering, and for solder shorts across the tracks, connect the board to a 12V d.c. power supply or battery. Check that the l.e.d. is glowing and with a meter check that +5V is present at the output of regulator IC15.

Now, insert the remaining i.c.s and check that +5V is still present at the output of IC15. Then check that −5V is present at IC16 pin 5. Although other tests could be carried out now, it is best to wait until after the Computer Interface has been connected and the software is running.

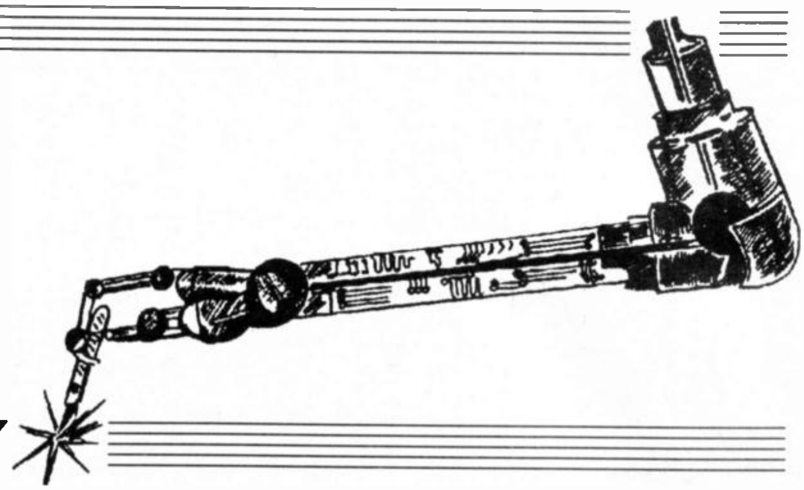
NEXT MONTH: We conclude with the Computer Interface circuit and construction of the wind speed and direction mechanics (they are quite simple). Also, the example software listing, final testing and setting up will be covered.



Layout of components inside the Sensor control unit. The p.c.b. has cutout "curves" in its sides to allow for the case pillars. The pressure transducer is located towards the top left of the board, the wind direction spiral and l.e.d. above the opto-sensor. Finally, the wind speed Hall-effect transducer, which will normally be secured to the underside of the case lid below the "speed paddle", can also be seen to the right of the p.c.b.

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY

Our regular round-up of readers' comments and questions this month includes sources of chip data for constructors, extra refinements for the LM3914 bargraph circuit, together with news for Theremin enthusiasts, too!

Data Sources

FIRST this month, a question related to the "hows and whys" of pinouts and applications data for integrated circuits. ***Mr. J. McCallion***, Bellaghy, Co. Derry, Northern Ireland asks:

Where is it possible to find information on i.c. pin connections and the uses of integrated circuits themselves? For example, the range of LA, LM, MC, TDA prefixes that are commonly found on chips these days?

I often wonder how manufacturers can build electronic equipment without having this information at hand! So how do they know which chip to use where, and how it functions?

It's a good question – where do circuit designers start, and what sources of information do they refer to? All chip manufacturers produce a series of Data Books and Data Sheets for their products. Remember that the chip makers want to *sell* chips, and so it's in their interests to make life as easy as possible for their customers – OEMs (original equipment manufacturers), distributors and engineers.

Data Books are printed by the manufacturers and sometimes freely given away to their industrial users, and they contain all the pinouts for all their chips, together with "application notes" and circuit examples to encourage the use of their products. Many designers use these examples as starting points for developing their own circuits. After all, why re-invent the wheel?

At hobbyist level, it's often harder to get the detailed information and sometimes you need to be a bit more resourceful. Our own magazine projects do contain all the connection information needed to enable the project to be assembled successfully, though the designer will probably have used the relevant Data Sheet or Book for guidance. You will find a variety of Data Books listed in the new **Maplin** catalogue, for example, though it is noted with much sadness that logic chip pinout diagrams have been removed from their latest edition.

Additionally, suppliers such as **Electromail**, the cash-with-order arm of RS Components Ltd., (☎ *01536 204555*) produce their own comprehensive Data Sheets written in-house, and **Farnell** in Leeds (catalogue available to *bona fide* account holders only – ☎ *01132 636311*) have a wide range of manufacturers' books for sale too. I retain a growing list of bulky data books (the record held by International Rectifier's 1,674 page tome on Hexfets!). I confess that I will probably only use a fraction of the material they contain but they're indispensable when researching the background behind certain technologies or applications.

A variety of complete "I.C. Reference Works" is available if you want to stock up your shelves (e.g. Maplin have a range of semiconductor data books) but they can cost hundreds of pounds. I noted too that Maplin stock the National Semiconductor Data Books, a range of data and applications which I wholeheartedly recommend as a starting point to anyone wanting to build up a library. The prices quoted seem to be extremely good value. If you can afford it, they also list a CD-ROM covering 240,000 semiconductor components, yours for just £2,345!

The book *Newnes Electronics Toolkit* by Geoff Phillips (ISBN 0-7506-0929-X) includes about a dozen pages of semiconductor i.c. and transistor prefix listings, so if you only know the device name (e.g. LM324), the listing will enable you to cross-refer the prefix to the manufacturer which is in this case, National Semiconductor. Also, the *Newnes Electronic Engineer's Pocket Book* by Keith Brindley (ISBN 0-7506-0937-0) shows 74 TTL and 4000 CMOS logic chip pinouts, and has a whole host of other useful data as well.

Bargraph Tune-Up

A regular *Circuit Surgery* reader and an amazing *Ingenuity Unlimited* contributor, my thanks once again to the ***Rev. Thomas Scarborough**, Cape Town, South Africa* who added a few comments about my simple *Windicator* Wind Speed Indicator design (*EPE* July 1995), a design which shows the prevailing wind speed on a 10 l.e.d. bargraph display. Thomas says:

"Cape Town having been named the 'Cape of Storms' by a Spanish mariner, the light-emitting diodes at the top end of your Windicator *scale would have a short*

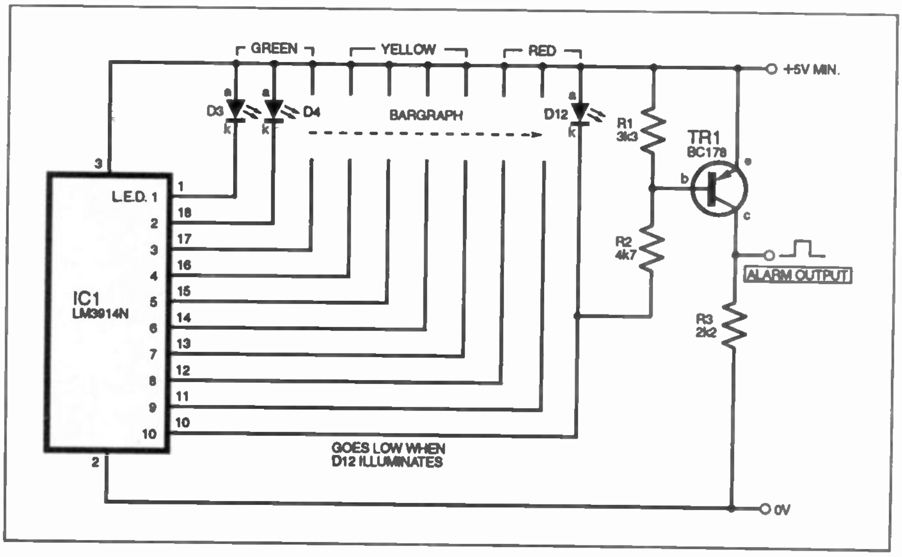


Fig. 1. Using the LM3914N bargraph driver and a single transistor to produce an alarm output.

life expectancy here! I would have liked to have seen some special effects at the top end of the scale – an l.e.d. seems such a sorry way to celebrate a hurricane!"

There are a few neat things you can indeed do with an LM3914 bargraph chip to "hail the arrival of a hurricane" – or warn of an overvoltage, or generally sound the alarm when a particular input voltage is reached.

Readers may also want to cross-refer to Andy Flind's article *Using Bargraph Displays* in the October 1995 issue. It describes the internal operation of the LM3914/5 bargraph driver chips in some depth. Also recommended is National Semiconductor's Data Sheet on this device, e.g. as found in their *Linear Application Specific I.C.s Data Book*.

Using part of the LM3914 bargraph driver i.c., with a single transistor switch TR1 added to an appropriate l.e.d., to

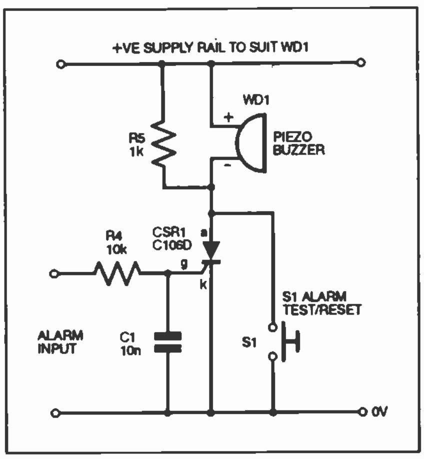


Fig. 2. An add-on, thyristor triggered alarm output circuit.

produce an "alarm" output is shown in Fig. 1. Recall that the outputs are all normally *high* and only go *low* when that voltage is reached. Hence the output pins are gradually pulled low when the input voltage increases.

When D12 l.e.d. illuminates, TR1 will turn on. Its collector (c) then goes towards the supply rail and so an output signal is developed across the 2·2 kilohm resistor R3. This signal can then be used to drive an external alarm system.

A thyristor "triggered" experimental add-on alarm output circuit is shown in Fig. 2. The thyristor CSR1 will trigger and "latch" until the power is removed. Alternatively, an *npn* transistor buffer, Fig. 3, could be added, in place of the thyristor circuit, to drive a load such as a relay. All component values shown are approximate and near equivalents should be fine.

Flashing Alarm

How the display can be made to flash by adding an external *RC* pair is shown in Fig. 4. A resistor (100 ohm) is placed in series with *one* l.e.d. of the bargraph, and is hooked over to the *RC* network as shown.

When the selected l.e.d. illuminates, a negative-going pulse is fed back to the resistor chain (R_{HIGH}) in the LM3914. The l.e.d.s are then disabled until R_{HIGH} is restored again. Thus the circuit oscillates at a low frequency and the display flickers.

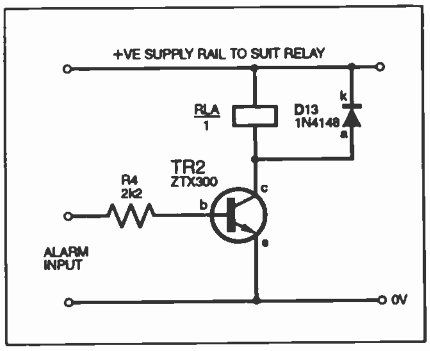


Fig. 3. Transistor relay driver circuit.

The *whole* display will flash once the input voltage is high enough to cause the "rigged" l.e.d. to light. Possibly hook up to the first red l.e.d. (No. 8) in the *Windicator* display so that the entire display will flash once the *red* l.e.d.s start to illuminate. If you select "dot" mode rather than "bar" mode then all the green and yellow l.e.d.s will illuminate individually whilst only the red l.e.d.s will flash – neat!

Surely Rev, here's a strong case for setting up the EPE Met Office *(see this issue) in the Cape? – Would like to see the PC screen pic for a hurricane! – Ed.*

TENS Unit – Ingenuity Unlimited

The Rev. (see earlier) also described a "Truly Simple Tens Unit" back in the March 1995 issue, page 192. This used a 2N2646 unijunction transistor (U.J.T.) relaxation oscillator driving a step-up transformer. Thomas says a reader suggested that slowing down the pulse frequency would improve the effectiveness of the design – perhaps swap the value of R1 for 68 kilohms or so, he offers.

For what it's worth, the Editor tells me that the *EPE* designs for "TENS Units" (designed by Andy Flind) are the most popular constructional projects we have ever undertaken. Refer to the May and June 1994 issues for details. Back issue and photostat are available, see the separate Back Issue page elsewhere in this issue. The reputation of these excellent designs has even reached across the USA, judging by our new subscriptions and my Email!

Theremin Lives!

Our *Pocket Theremin* (*EPE* September 1995) designed by Jake Rothman has certainly captured the imagination of quite a few enthusiastic "Theremaniacs" around the world! Our sister publication *The Modern Electronics Manual* also includes a more advanced Theremin design in its constructional projects (Supplement No. 40) and this has controls for both pitch and volume. Ordering details of the *Modern Electronics Manual* are given elsewhere in this issue.

There seems to be a resurgence of interest in the works of the late Leon Theremin, and anyone with access to the Internet will want to have a look at the (American) World Wide Web *Theremin Home Page*, a growing source of reference for everything to do with creating electronic music in this unique fashion. The WWW page is maintained by a very keen Theremin enthusiast, Jason Barile of the Vanderbilt University Intelligent Robotics Lab., in Nashville, Tennessee, USA, and the URL http://www.vuse.vanderbilt.edu/~jbbarile/theremin.html will get you there. You'll see he's kindly mentioned both *EPE* and yours truly on his Web pages.

Similarly we pop up on the *Theremin Enthusiasts Club International Home Page* which is found at http://www.he.tdl.com/~enternet/teci/teci.html address.

Not to be outdone, we're delighted to see a new *UK Theremin Constructor's Home Page* currently under construction by Jonathan Spanier at the University of Durham, UK. Try looking at http://capella.dur.ac.uk/jon/TheremininUK.html for a further insight into Theremins.

You'll probably find that all the Theremin pages link to each other – it's a friendly community out there on the

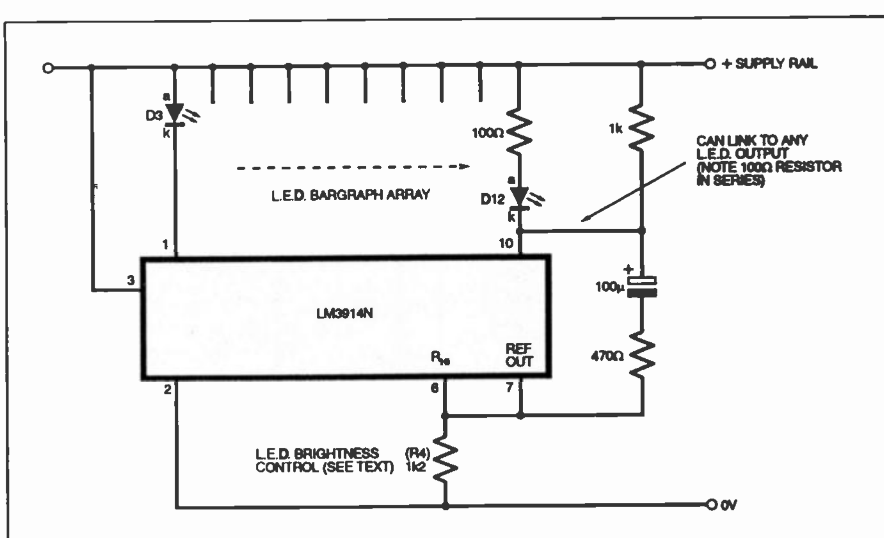


Fig. 4. Flashing alarm display using the LM3914N. Connect to any l.e.d. but include a 100 ohm resistor. (Courtesy National Semiconductor).

World Wide Web! All URL's shown were believed correct at the time of writing. If you know of any further interesting Internet sites, please Email me and I'll share them with the readership.

Newsthreads

My final Internet news is for those who have just joined the Internet and have an interest in electronics. A major news group always with lots going on, is *sci.electronics* which has a wide variety of newsthreads at any one time. Although mainly American, there are a number of European contributors (after all, we can't let the US have it all its own way, can we <*grin*>?) too, and you can learn the "rules" of the group (netiquette) by looking at the Web site http://www.paranoia.com/~filipg.

Have a good look at the pages of *Sci.Electronics.FAQ* (Frequently Asked Questions) beforehand and this will help ensure that your foray into *sci.electronics* will be a happy one! It's generally a friendly and "professional" news group, by UseNet standards anyway. You will be amazed at how help can pop up from anywhere in the world, sometimes a lot faster than you think possible!

This column depends on ***your*** input. If you have any topical comments or questions on electronics which you think would be of interest to readers – or maybe something to say about *EPE* constructional projects – please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom or Email to **alan@epemag.demon.co.uk.**

We cannot answer questions concerning the repair or modification of commercial equipment; an individual answer cannot be guaranteed but we will try our best to offer help.

Next Month – *Ingenuity Unlimited*, a round-up of readers' bright ideas. In the next *Circuit Surgery* – a look at random pulse generation using digital methods, controlling mains loads using low voltages, and hopefully more!

Ohm Sweet Ohm

Max Fidling

As the end of the year approaches, the Boss (my wife and social secretary) reminds me that several family birthday celebrations are looming round the corner. This always causes me a certain degree of alarm, since I know that instead of being allowed to potter in my workshop I'm going to be spending the next few Sunday afternoons acting as a reluctant host, sometimes surrounded by a dozen little terrors, slurping orange juice and scoffing jelly, and then being somewhat ill! (Not me, the terrors, I mean.)

In fact after spending most of the year in peace (notwithstanding the odd electronic mishap) several such birthday parties suddenly arrive at once, a bit like London buses. So this year I decided that I would mix my favourite hobby with the obligations of my social calendar.

Just for once, I intended to enliven the party atmosphere in a memorable way, I thought to myself ... I retired to the workshop and started to sift through my yellowing magazines, ever in search of something electronic to do.

Enlightening Technology

"Make Your Party Swing with our Sound-to-Light Display" – this fanfare screamed at me from the front cover of one ancient issue! Just the ticket! Glancing through the design, I couldn't see anything particularly tricky lurking amongst the circuitry and I quickly decided that this was the way ahead. My problem was that I still had an old radiogram, which formed the centre of entertainment for our modest musical evenings. Not for me the dazzling discs of a CD player, I preferred the mellow tones of good old vinyl whirring around on my record player any day!

So occasionally we dusted down the radiogram and enjoyed some long-playing records, although some of its controls were getting a bit temperamental with age. I sometimes had to give the volume control a squirt of Electrolube to coax it into operation, but for twenty five years old, it soldiered on magnificently. Quite how it would cope with a kilowatt of lighting tacked on to it was anybody's guess, though.

The next morning, the Boss informed that invitations had gone out to several neighbours to attend a weekend party here at *Chez Fidling* – and I ***would*** be there! I knew that whenever the Boss spoke in bold type, she meant business! So clearly my *son-et-lumière* would have to be up and running by then.

Undeterred, I wandered over to the workshop to carry on with the construction of the sound-to-light show, confidently predicting it would be ready in time. Both myself and Piddles, my canny cattie, exited workshop-wards.

Mettle Testing

The design was pretty straightforward – it has to be, in my case, since mains projects always test my mettle especially at "switch on" and so I follow the magazine articles to the letter. I always look at the wiring diagrams closely and tick off the wires one at a time as I merrily solder them into place. Production of this mesmerising modulator was temporarily delayed until some triacs dropped onto the door mat the following day, but meantime I assembled the light show in accordance with the instructions. The unit was a three-channel affair, with low, medium and high-pass filters, each driving a set of mains bulbs which would hopefully strut their stuff when the time came.

Dazzling Dozen

The triacs were finally fitted with a generous squirt of heatsink compound. The light bulbs had been constructed in a simple wooden box in which I sloshed some white emulsion to brighten it up for effect. Piddles managed to tread on the upturned lid of the paint tin, and left a few white paw prints on the workshop bench.

The light bulbs – all twelve of them – were duly fitted and I hooked everything up in the workshop to check that it was OK I gingerly tested the circuitry against my modest home-made signal generator, and selecting various frequencies confirmed that the sound-to-light unit worked in principle at least. Piddles followed me back as I lumbered the freshly-made gadget into the house. I shuffled past the kitchen where the Boss was baking, and made a beeline for the drawing room.

Fawked Lightning

Hooking the sound to light unit up to the oversize radiogram, the big moment ultimately arrived. Dusting down one of my long-playing records, the turntable was spinning perilously as I lowered the stylus gingerly onto my beloved vinyl.

Nothing was heard whatsoever... I wiggled the volume control knob a few times and suddenly an ear-shattering rendition of Max Bygrave's *I'm a Pink Toothbrush* blasted out of the radiogram at somewhat in excess of the threshold of pain!

This accompanied with a blinding display of 1,200 watts of lighting lit up the room like a re-enactment of the Gunpowder Plot!

Piddles scooted out of the room, leaving me to "face the music" with the Boss, who had been baking a birthday cake in the kitchen next door and entered the drawing room armed with the rolling pin.

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We can supply back issues of *EPE* by post, most issues from the past five years are available. An index for each year is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one article* (or *one part* of a series) can be purchased for the same price.

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M12/95

MODULAR ALARM SYSTEM

MAX HORSEY

PCB DESIGN BY HUGO URE

Intruders beware, modular monitoring can detect every move! Illustrates how Teach-In Part Two might be applied.

THIS project is based on the information provided in *Teach-In* Part 2 and shows how modules may be selected and combined to produce a working alarm system which may be installed in a house, garage, shed, etc.

Throughout this article, figure numbers of this style Fig. 2.1, Fig. 2.2, Fig. 2.3, etc, refer to drawings having the same number in *Teach-In* Part 2. Other figure numbers, e.g. Fig. 1, Fig. 2, etc., refer to drawings in this article.

DESIGNER SPECS

Before beginning the design of a modular project such as this alarm, it is necessary to define the specification. In this application there are 12 primary objectives:

1. The alarm will be controlled by means of a keyswitch
2. There will be an exit delay
3. There will be an entry delay (set by the user) with entry warning beeper
4. A siren will be activated if the alarm is triggered
5. The siren will stop after a preset time (set by the user)
6. Battery backup and trickle charging will be included
7. Sensor quantity will be unlimited, with separate inputs for different sensor functions
8. Sensors may be normally-open or normally-closed, or a mixture of both
9. Sensor inputs will be timed or instantaneous, or a mixture of both
10. The siren box will contain a circuit which activates the siren if the wires are cut or if the alarm system main power supply is disabled
11. The circuit will not indicate which sensor caused the alarm to trigger
12. The system will be designed for a 12V main power supply

Note that the number of sensors is unlimited: normally-closed types are connected in series, and normally-open in parallel, as shown in Fig. 2.1 and Fig. 2.2.

SYSTEM REQUIREMENTS

It is important with any circuit, but especially so in this case, to list the requirements of the system in detail. The list above indicates three main input switching requirements, Set switch, Timed switches, and Instant switches. Their separate functions are:

The Set switch will be a keyswitch with contacts which are open when the alarm is off, and closed when the alarm is set. The Set switch will also silence the alarm once triggered.

Timed switches include sensors which are likely to be activated as the user leaves or enters the house. The alarm circuit must allow sufficient time for the user to exit or enter after having set the alarm. The timed switches may be normally-open (e.g. under-carpet pressure mats) or normally-closed (e.g. a reed switch and magnet for the front door).

Most of the alarm sensors should be wired to the instant inputs of the alarm circuit. Once triggered, the alarm will immediately sound. For example, a P.I.R. (Passive Infra-Red) sensor in the lounge will trigger the siren immediately an intruder enters through a window.

These switches may also be normally-open (e.g. another pressure mat) or normally-closed (e.g. P.I.R.). The range of sensors and switches available is discussed in *Teach-In* Part 2.

ALARM SEQUENCE

An alarm system must follow a sequence of events rather like a computer program. This alarm system's sequence will be as follows:

1. SET SWITCH OFF: siren off, batteries in alarm circuit and siren module trickle charged

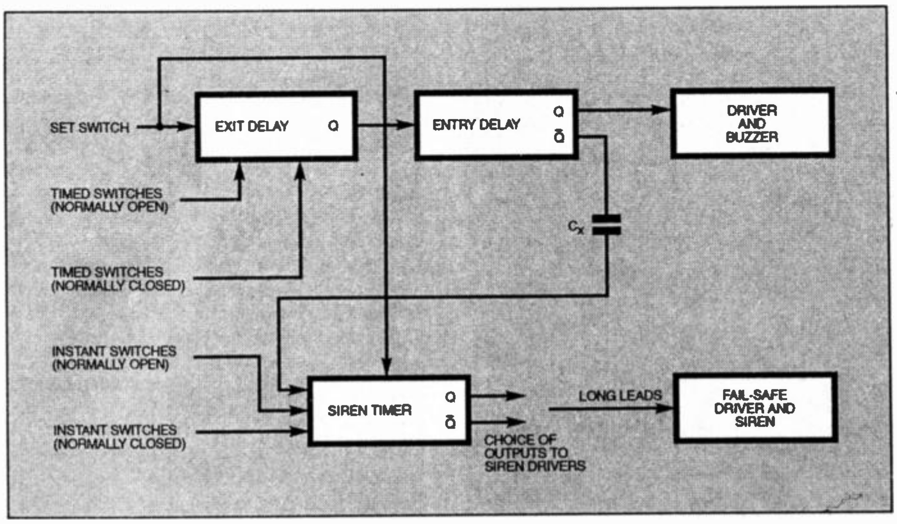


Fig. 1. Block diagram for the Modular Alarm System.

2. SET SWITCH ON: timed inputs inactive, instant inputs active
3. DELAY PERIOD ENDS: all inputs active

4a. TIMED INPUT TRIGGERED: small buzzer sounds for a period set by user before siren is triggered, *or*

4b. INSTANT INPUT TRIGGERED: siren is triggered

5a. SIREN ON: sounds for a period set by user, *or*

5b. SET SWITCH OFF: all timers reset, all inputs are made inactive

6. SIREN CABLE CUT: siren sounds until its backup battery is discharged

BLOCK DIAGRAM

The block diagram shown in Fig. 1 provides a visual interpretation of the above requirements and begins to indicate the types of module required. Note that the letter "Q" indicates an output which is active-high i.e. at logic 1 (positive) when triggered, and "NOT Q" (a Q with a line above it, sometimes typed Q') is the opposite of "Q" (i.e. at logic 0 when Q is at logic 1).

INPUT SENSORS

All sensors used in alarm systems can be treated as switches. The choices were discussed earlier and the circuit must be designed to cope with all possibilities. Note how the timed inputs are via the exit and entry delay modules, but the instant inputs are connected directly to the siren timer.

TIMER CIRCUITS

There are three timer modules: Exit Delay, Entry Delay and Siren Timer. *Teach-In* Part 2 described three choices of delay for each module: a simple capacitive delay, a 555 monostable and a CMOS gate monostable.

The 555 can be rejected for this application on the grounds that exact timed periods are not required. However, another designer may take the 555 option and design an excellent system – it is often a matter of personal preference. There are other options, of course, but only those outlined in *Teach-In* Part 2 are being considered here.

Starting with the Siren Timer, a direct copy of the monostable shown in Fig. 2.8 can be used, the Output (IC1b pin 4) becoming "Q" in Fig. 1. The "NOT Q" can be taken from IC1a pin 3, or if a spare gate is available it could be used to invert the output from IC1b pin 4.

The Entry Delay can also be a copy of Fig. 2.8. Its normal output can drive a buzzer via a suitable current amplifying stage, and the inverted output used to trigger the Siren Timer.

However, there is a problem, since "NOT Q" is always high unless the Entry Delay has been triggered. This would "jam" the Siren Timer (which has only a single input) and prevent the "instant switches" from working.

A positive pulse from the Entry Delay module is needed at the end of its timed period rather than a continuous logic 1. The solution is provided in the form of the a.c. coupling circuit of Fig. 2.5, just using capacitor C1 and resistor R2. Capacitor Cx in the block diagram, Fig. 1, represents the use of this principle.

EXIT DELAY

The Exit Delay has to prevent the timed switches from triggering the Entry Delay Module during the exit period. This could be based on the monostable of Fig. 2.8 but there are several complications which would require more gates to solve. A more simple approach is to use the capacitive delay circuit shown in Fig. 2.3.

Output current available from this module is very small since it is important not to discharge the capacitor prematurely. An enhanced version of this module is shown in Fig. 2.

Note that the original resistor R1 has been split into two, R5 in series with R7, with a diode, D1, bypassing the latter. If the input goes high, current will flow via R5 and D1 to rapidly charge capacitor C6. If the input goes low, current will flow from C6 through both resistors in series.

The relative values of the resistors, 4k7 and 1M respectively, have been chosen so that C6 will be discharged much more slowly than it was charged. The NOR gate, IC1a, is used to buffer and invert the

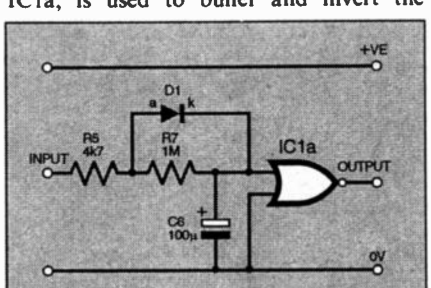


Fig. 2. Buffered capacitive delay circuit.

output pulse level from C6. The net result is as follows:

Input low: Output high
Input goes high: Output goes low
Input goes low: Output goes high after a delay

Notice that the second input of IC1a is shown held at logic 0. In the final circuit this input will be connected to the Timed Switches module.

The value of 1M for resistor R7 is the highest which will give reliable results in the final circuit. The 4k7 value of R5 is chosen so that the input may be driven from the output of another CMOS logic gate, without affecting the logic level at that output. A lower value resistor might allow sufficient current to flow to disrupt this level.

BUZZER MODULE

The current available from a CMOS 4000 series gate is too small to operate a buzzer without affecting the logic level at that output. Hence a single transistor output module is employed, a slight variant (diode omitted) of the circuit shown in Fig. 1.13a.

GATE COUNT

At this stage it is worth making a rough sketch of the circuit, or at least listing the gates required. The Siren Timer module and Entry module will require a total of four NOR gates. At least one more gate is required, for the Exit Delay necessitating another i.c. Hence a total of eight NOR gates become available and the final circuit is based around this total.

FINAL CIRCUIT DIAGRAM

As with all circuit diagrams, the final circuit diagram design, as shown in Fig. 3, appears to be more complicated than its block diagram and basic module stages, particularly with the addition of numerous capacitors!

In fact, capacitors C1 to C5 all do a similar job, suppressing any voltage spikes which may cause a false alarm. Since all the input switches and sensors may be connected via long leads, electrical noise could otherwise be a problem.

The basic breakdown of the circuit timing modules is shown in Table 1. The purpose of other components will be described individually.

INPUT SWITCHES

The "inputs" are all shown as switches within a dotted box. Within each box as many switches as required may be used, the details in Table 2 indicating whether they should be wired in parallel or in series (Fig. 2.1 and Fig. 2.2, respectively).

If the use of a particular input is not required then either of the Normally-Open inputs (from S1 or S3) may be left open circuit (i.e. not connected). However, a Normally-Closed input (from S2 or S4) which is not required must be shorted to 0V by a wire link.

FUNCTIONAL DESCRIPTION

The main alarm setting keyswitch is S5. When S5 is open, the alarm circuit is turned off (although it remains powered). This is so because resistor R4 pulls pins 1 and 2 of IC2a down to logic 0, hence output pin 3 is set to logic 1. This logic level resets both monostables (IC1d/c and IC2d/b) via

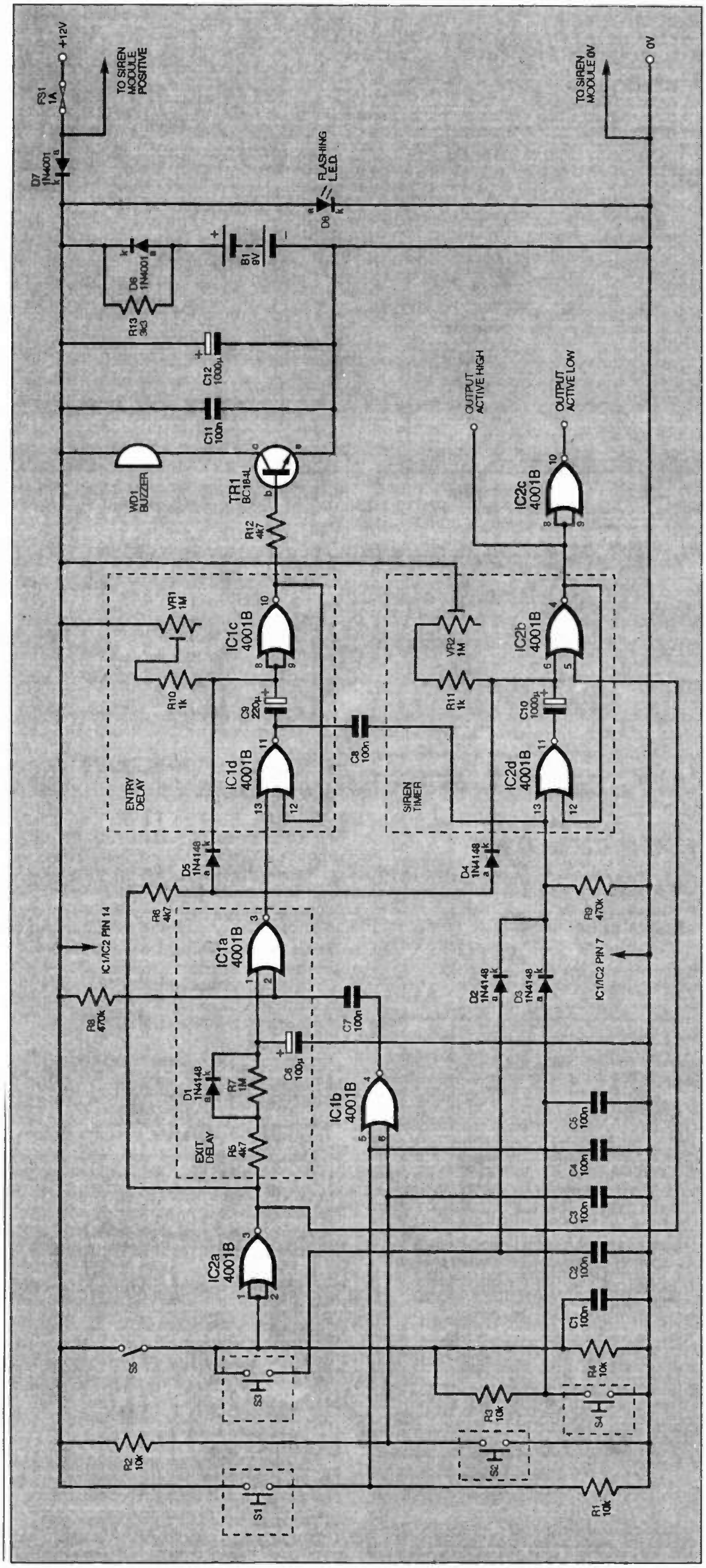


Fig. 3. Circuit diagram for the Alarm Controller.

resistor R6 and diodes D4 and D5, so the alarm will be reset even if caught in the middle of an operation!

Resistor R6 is necessary to prevent an excessive drain of current from IC2a pin 3, which would upset its logic level. Diodes D4 and D5 prevent the two monostables affecting each other.

To ensure that the siren cannot sound even for an instant when switch S5 is opened, IC2a pin 3 is also connected to IC2b pin 5. A logic 1 at pin 5 will ensure that the IC2b output pin 4 will be low.

Switches S1 and S2 are subject to the exit and entry delays. When S5 is open (alarm off) IC2a pin 3 is positive and hence both monostables are disabled via diodes D4 and D5.

Switches S3 and S4 are the instantaneous switches and are not subject to entry or exit delays. However, with keyswitch S5 open, both S3 and S4 are ineffectual, being without a positive power supply from which to trigger the Siren Timer monostable around IC2d and IC2b.

SETTING THE ALARM

When keyswitch S5 is closed, switches S3 and S4 are enabled. Closing S3 or opening S4 will send a logic 1 via diodes D2 or D3 into IC2d input pin 13 of the Siren Timer.

These diodes are used to form an OR gate so that either S3 (and other switches in *parallel* with it), or S4 (and other switches in *series* with it) will instantly trigger the Siren Timer, setting IC2b pin 4 high. This output can be used directly to trigger a siren module which requires an active-high output.

NOR gate IC2c is used as an inverter so that whenever IC2b pin 4 is high, IC2c pin 10 is low. The latter output is suitable for driving siren modules requiring an active-low output.

Switches S1 and S2 (subject to exit and entry delay) are treated differently by the circuit. With keyswitch S5 turned off, IC2a pin 3 is high and so capacitor C6 remains fully charged. This holds IC1a pin 1 high making the logic level at IC1a pin 2 irrelevant. Hence the actions of S1 and S2 have no effect.

AFTER THE EXIT DELAY

Once the exit delay period has ended, the charge on capacitor C6 will leak away via resistors R7 and R5 into IC2a output pin 3, which is now low because its inputs, pins 1 and 2, are high. Eventually, the charge will drop below the threshold voltage for IC1a pin 1 and will be registered as a logic 0.

The NOR gate truth table, Table 2.1, shows that if both inputs are low the output is high. However, at present IC1b pins 5 and 6 are both low, making output pin 4 high. Resistor R8 will in turn hold IC1a pin 2 high, holding IC1a output pin 3 low.

If switch S1 is closed or S2 is opened, then IC1b pin 5 or pin 6 will go high causing IC1b pin 4 to switch to low. This change of voltage will be transferred via capacitor C7 to IC1a pin 2.

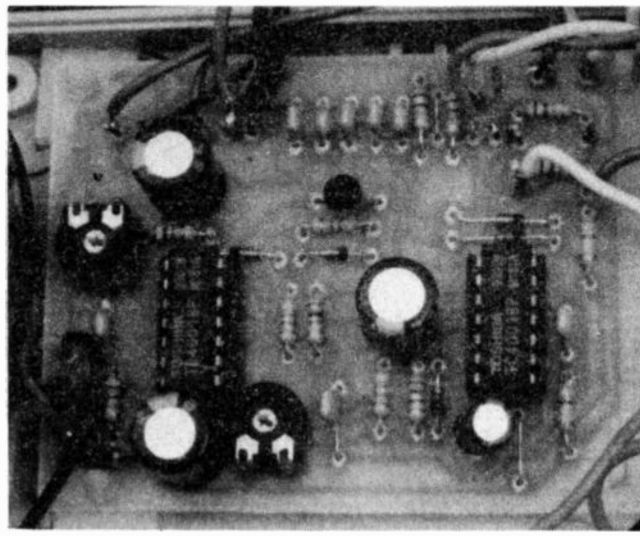
The reason for modifying the signal from IC1b pin 4 to a pulse, rather than keeping a direct connection, is in case switches S1 or S2 remain active during an unauthorised intrusion and hence prevent IC1a pin 3 from returning to 0V. This in turn would prevent IC1d pin 11 from returning to positive at the end of the entry delay, consequently the alarm would not be triggered.

Table 1. Basic breakdown of the Timing Modules.

Module	Components	Module based on
Exit Delay	IC1a plus R5, R7, D1, C6	Fig. 2.3/Fig. 2
Entry Delay	IC1d/c plus C9, R10, VR1	Fig. 2.8
Siren Timer	IC2d/b plus C10, R11, VR2	Fig. 2.8

Table 2. Input Switch Functions.

Function	Condition	Switch	Wiring
Timed	Normally Open	S1	Parallel
Timed	Normally Closed	S2	Series
Instant	Normally Open	S3	Parallel
Instant	Normally Closed	S4	Series



COMPONENTS

MAIN ALARM CIRCUIT

Resistors

See SHOP TALK Page

R1 to R4 10k (4 off)
R5, R6, R12 4k7 (3 off)
R7 1M
R8, R9 470k (2 off)
R10, R11 1k (2 off)
R13 3k3
All 0.25W 5% carbon film or better

Potentiometers

VR1, VR2 1M min. preset horiz. (2 off)

Capacitors

C1 to C5, C7, C8, C11 100n min. ceramic (8 off)
C6 100µ elect. radial, 16V
C9 220µ elect. radial, 16V
C10, C12 1000µ elect. radial, 16V (2 off)

Semiconductors

D1 to D5 1N4148 signal diode (5 off)
D6, D7 1N4001 rectifier diode (2 off)
D8 l.e.d., flashing (see text)
TR1 BC184L *npn* transistor
IC1, IC2 4001B quad 2-input NOR gate (2 off)

Miscellaneous

S1 to S4 alarm switches – see text
S5 s.p.s.t. keyswitch
WD1 solid state buzzer
Printed circuit board, available from the *EPE PCB Service*, code 967a; PP3 9V Nicad battery and clip; dual-tone plastic case 150mm x 79mm x 49mm; terminal pins; 1A fuse and fuseholder (see text); terminal block (see text); connecting wire and cables; solder, etc.

Approx cost guidance only **£19**

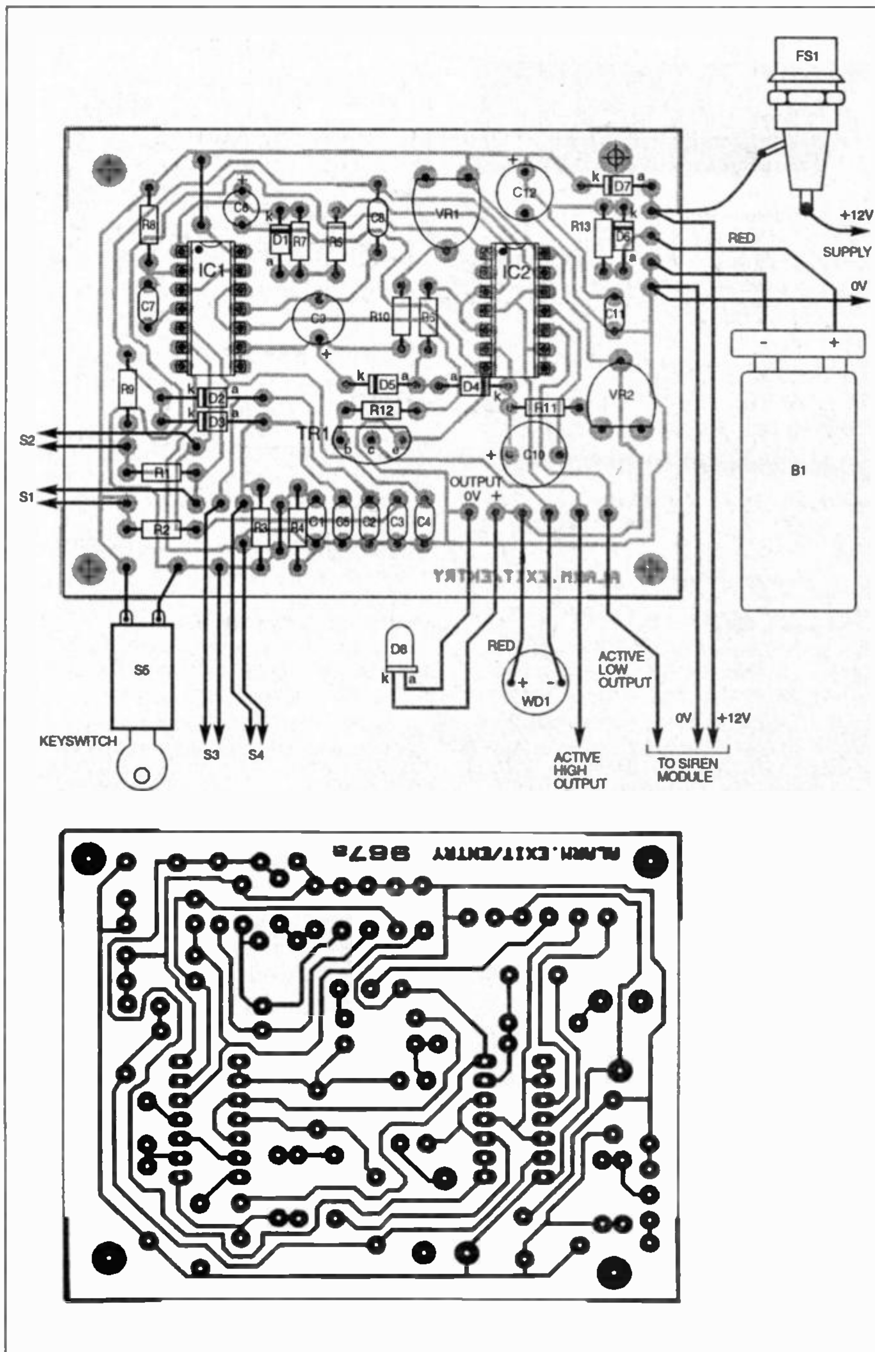


Fig. 4. Printed circuit board component layout and full size underside copper foil track master pattern for the main alarm circuit.

ENTRY DELAY

The output pulse from IC1a pin 3 is fed to IC1d pin 13, which is the input of the Entry Delay monostable. When the monostable is triggered, IC1c pin 10 will go high activating the buzzer via transistor TR1. Simultaneously, IC1d pin 11 will go low. After a time set by potentiometer VR1, the monostable will return to its normal state and IC1d pin 11 go high. This causes a positive pulse to travel via

COMPONENTS

SIREN MODULE

Resistors
R1 27k
R2 3k3
All 0·25W 5% carbon film or better.

See SHOP TALK Page

Capacitors
C1, C2 100n min. ceramic (2 off)

Semiconductors
D1, D4 1N4001 rectifier diode (2 off)
D2, D3 1N4148 signal diode (3 off)
TR1 TIP127 *pnp* Darlington driver (see text)

Miscellaneous
Printed circuit board, available from the *EPE PCB Service*, code 967b; siren (see text); bell box (see text); connectors (see text); 9V NiCad battery; connecting wire; solder etc.

Approx cost guidance only **£6**
excluding Bell Box

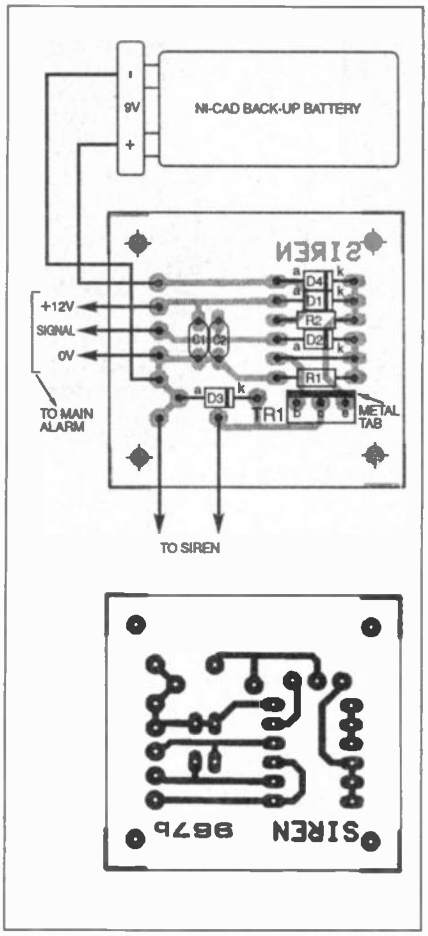


Fig. 5. Component layout and full size track details for the Siren Module.

capacitor C8 to trigger the Siren Timer around IC2d and IC2b.

If keyswitch S5 is turned off before the Entry monostable completes its cycle, the siren is disabled and both monostables are reset.

SIREN TIMER

When the Siren Timer monostable is triggered by a positive-going pulse on IC2d pin 13, IC2b pin 4 goes high for a period set by potentiometer VR2. The output from pin 4 can be delivered directly to the Siren module if an active-high level is required, or from IC2c pin 10 for an active-low level.

BATTERY BACKUP

The rechargeable battery, B1, is trickle charged via resistor R13, whose value has been chosen to suit a PP3 Nicad battery. During a power failure, current will flow from the battery into the circuit via diode D6. Diode D7 prevents the battery discharging into the power supply.

DECOUPLING

As always, decoupling capacitors on the power supply lines are essential. Capacitor C12 removes larger voltage fluctuations leaving C11 to mop up smaller voltage spikes.

SIREN MODULE

Two fail-safe siren-activating modules are described in *Teach-In* Part 2, Fig. 2.13 and Fig. 2.14. Both are triggered if the wire linking the output of the alarm system with the input of the siren module is cut.

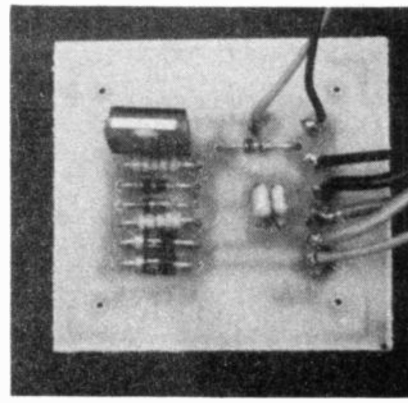
However, if the alarm power supply fails only the second siren module, Fig. 2.14, will be activated. Consequently, this is the module chosen for this practical application. It requires an active-low output from the alarm system and its input is thus fed from IC2c pin 10.

In place of the two individual transistors, designated in Fig. 2.14 as TR1 and TR2, a Darlington transistor is used, designated in the Siren Module Components list as TR1.

The backup battery should be a NiCad PP3 type. The siren will not be as loud when powered by this battery but its small capacity will prevent undue annoyance to neighbours if the connecting wires are cut!

CONSTRUCTION

The main alarm unit and siren circuit are constructed on separate printed circuit boards (p.c.b.s). Complete details of these boards are shown in Fig. 4 and Fig. 5. They are available from the *EPE PCB Service*, codes 967a and 967b, respectively.



Build and test the main p.c.b. first. Begin by inserting the i.c. sockets, followed by the smallest components, checking that the diodes are fitted with their polarity bands facing the correct way.

The resistors and small capacitors can be fitted either way round, but the electrolytic capacitors and transistor must be the way shown. The negative end of the electrolytic capacitor is normally indicated by arrows.

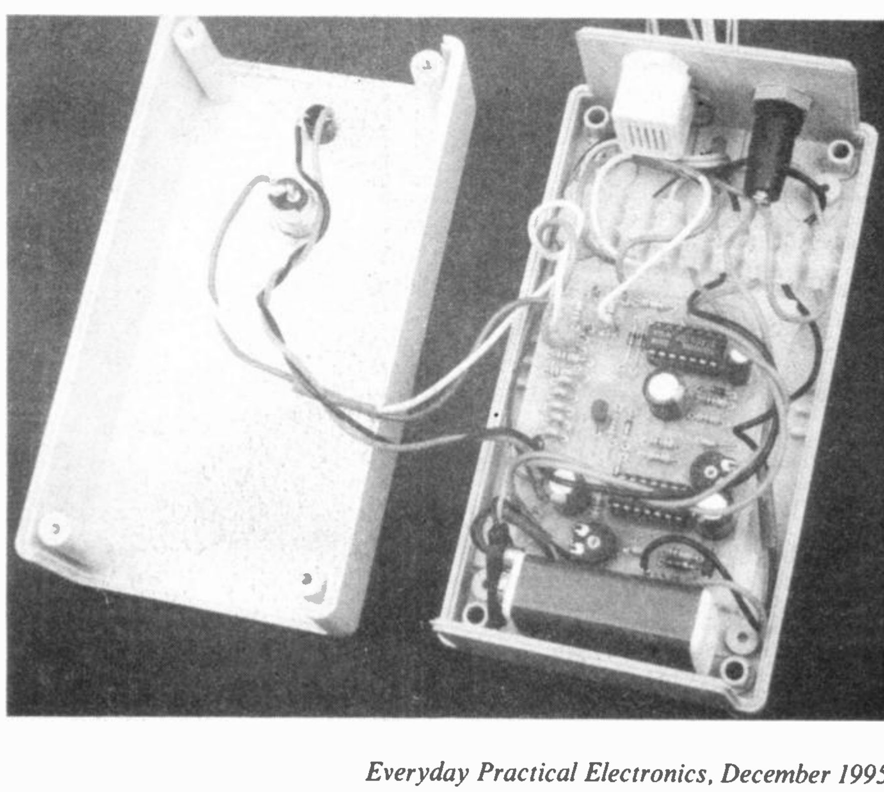
Presets can only be fitted in the correct manner because of their pins layout. The various inputs and siren module connections are via terminal pins.

Insert the i.c.s into their sockets, taking special care (since they are static sensitive) to earth your fingers by touching an earthed metal object before removing each i.c. from its protective package or foam. Ensure that the i.c.s are fitted with their notches as indicated.

TESTING

When testing, it is essential to connect a wire link across each pair of normally-closed input terminals (S2 and S4). Connect wires to the normally-open inputs (S1 and S3) so that they can be touched together to simulate a sensor.

The circuit is best tested by connecting it to a **regulated and current limited** 12V 100mA supply. If such a supply is not available, take extra care, and switch off if any component becomes hot. Note that the positive rail of the circuits will be about 0·7V below that of the power supply output, due



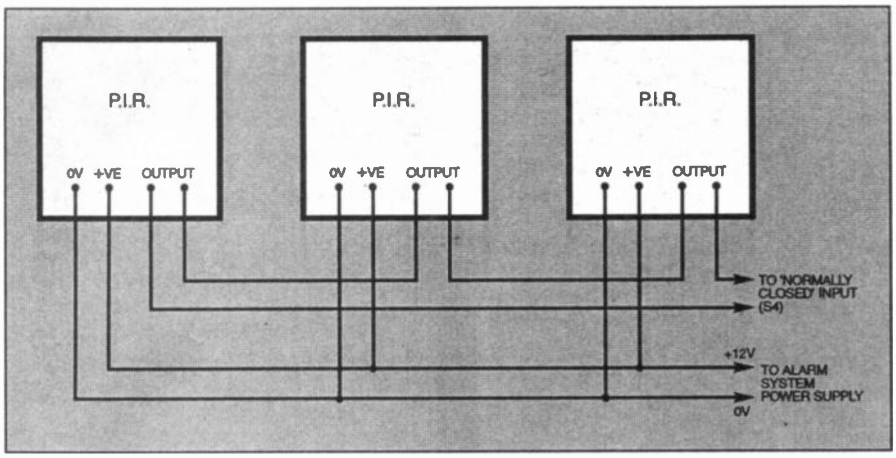


Fig. 6. Connecting P.I.R. sensors to the alarm controller.

to the action of the diodes in series with it (D7 in main circuit, and D1 in siren circuit).

Set the two presets VR1 and VR2 to their mid positions. Connect a voltmeter between the Active-High output and 0V to simulate the siren module, and switch on. The meter should read 0V. If it does not, check that keyswitch S5 is turned off (i.e. open).

Turn on keyswitch S5 and touch together the instant normally-open wires (S3). The voltmeter should indicate a positive reading, about 11·3V for a 12V power supply. Turn off the keyswitch and check that the voltmeter reading returns to 0V.

Turn on the keyswitch again and touch the delayed normally-open wires (S1) together. Nothing should happen. After about 100 seconds or so (i.e. the exit delay time) try touching the same wires together again. The buzzer should sound indicating that the circuit is in Entry mode.

After a further 100 seconds or so (less if VR1 is turned anti-clockwise to a lower value) the buzzer should stop and the voltmeter should indicate a positive reading again.

This time, wait and check that the voltmeter stays positive for about eight minutes (less if VR2 is turned anti-clockwise to a lower value). Finally check that the Active-Low output gives the opposite results to the Active-High output.

If an ammeter is available, it would be worth checking that the backup battery is charging, by connecting the ammeter in series with the battery. Expect a small current of about 1mA if the battery is already charged, or around 2mA for a discharged battery. When the battery is charged, check that it maintains a supply of about 8V when the main 12V supply is removed.

SIREN MODULE

The siren module is constructed in the same manner as the main p.c.b., again checking carefully the direction in which the diodes and transistor are fitted.

When testing, a small buzzer may be connected in place of the siren, unless ear plugs are used!

Connect the module to the 12V power supply, but do not connect the siren's backup battery for now.

Connect the active-low input of the siren module to the positive supply rail. The siren should not sound.

Now disconnect the input. The siren should sound. If the input is connected to 0V the siren should continue to sound. Now connect the backup battery – if possible via an ammeter (connected in series) to monitor the charge current as described before. If all is well, remove the ammeter and connect the siren module to the main alarm circuit.

FAULT FINDING

Check that all the components are fitted the correct way round and follow the fault finding guide in *Teach-In* Part 1. Remember that the circuit is divided into primary modules: check the output of each module with a voltmeter to identify the incorrect area. Note that voltmeter readings taken at the positive side of the timing capacitors (C6, C9 and C10) may prevent the capacitors charging properly due to the current flowing through the voltmeter.

THE CASE

Begin by drilling holes for mounting the case and for the external wires and power supply connector. The main body of the case may be mounted on the wall, and later the lid screwed into position.

The power supply should be concealed unless a backup battery system is employed and some thought should be given with regard to the route taken by the sensor and siren wires before drilling the holes. For example, it may be possible to route all the wires through the rear of the case.

Keyswitch S5 should be mounted on the lid, together with the flashing l.e.d. D8, which indicates that the power supply is functioning. If a non-flashing l.e.d. is used do not forget to include a series resistor of about 680Ω.

A fuse rated at 1A is also a worthwhile safety measure and should be connected in series with the power supply as shown in Fig. 4. A panel mounting fuseholder is shown in the diagram, but if this is considered a security risk an internally mounted fuseholder could be used. However, although it would not take an intruder long to remove the front cover of the system, attempts to disrupt the alarm would be protected against by the backup battery in the siren.

INSTALLATION

All external connections may be made via a terminal block. Eleven ways are required if all switch inputs S1 to S4 are used. The siren module occupies three of the eleven ways, and its power supply lines may be used to power other devices such as P.I.R. sensors.

The siren housing acts as a visible deterrent and a standard bell box should be employed which will house the siren, siren p.c.b. and backup battery.

When connecting the various sensors and switches, note that S2 and S4 both have one side connected to 0V. One side of S1 is connected to positive. It may be possible to save wires if some switches share the positive and 0V wires connecting the siren module.

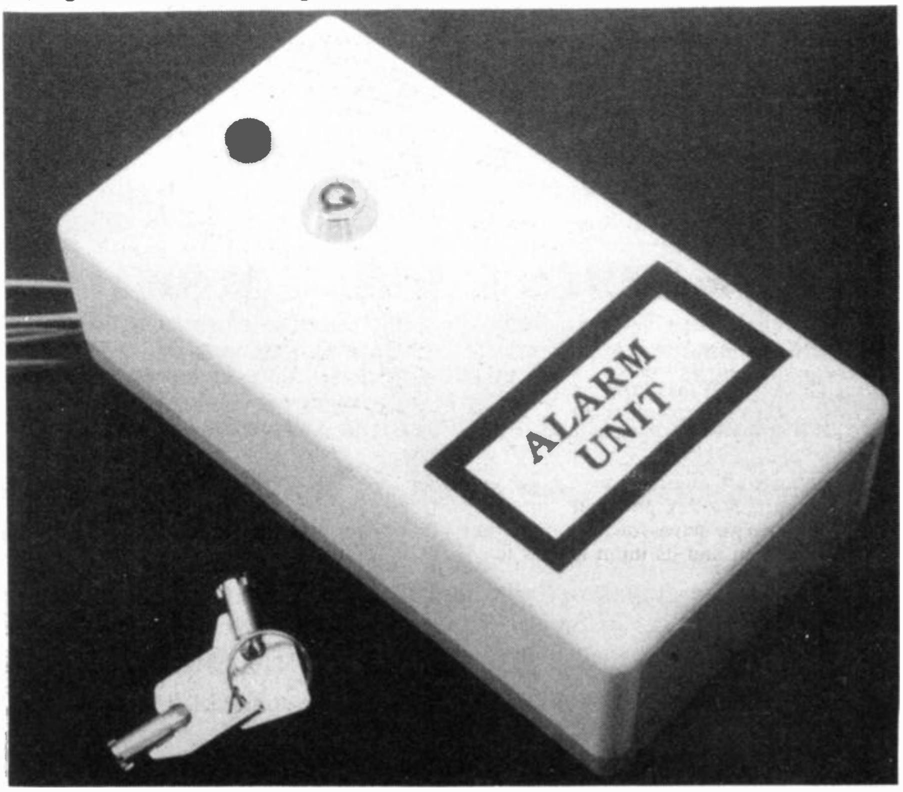
Sensors such as P.I.R.s require a 12V supply. They should be connected to the 12V and 0V outputs from the alarm system. Again, save wires by using the same 0V connection for S4.

MULTIPLE SENSORS

If several P.I.R.s are employed, ensure that their power supplies are connected in parallel so that each receives a full 12V supply. However, each P.I.R. output must be connected in series with each other P.I.R. output, assuming that each output is normally-closed, as shown in Fig. 6. □

PART THREE

An Automatic Camera Panning system is the constructional project for *Teach-In* Part Three.



INTERFACE

Robert Penfold

OCCASIONALLY a reader's letter is received querying if there is any simple way of getting a computer to display information without using the monitor. This may seem an odd request, but there are problems in using a conventional monitor in situations where the system will be kept running for long periods of time.

One of these is simply that the cost of running a monitor continuously can soon start to mount up. The main problem though, is that a monitor is generally considered to be a slight but significant fire risk, and it should *not* be left unattended while in use.

The whole point of using a computer in many control applications is that it frees the user to go away and do other tasks while the computer gets on with things. Having someone continuously monitor the monitor rather defeats the object of the exercise.

Another regular query runs along the lines "is there is a simple way of connecting pushbutton switches to my PC so that they can be read by a GW BASIC program?" This is usually where the computer is to be used as something like a television style quiz monitor, and control via a number of individual pushbutton switches is clearly more practical than having everyone try to use the keyboard!

L.E.D. Monitor

Neither of these problems require any particularly complex or expensive hardware. We will consider simple solutions to both problems, starting with methods of monitoring a PC without using a conventional monitor.

There are two simple ways of avoiding the need to have the monitor running continuously. If you simply require something to show that the system is up and running and has not crashed, some form of simple l.e.d. display driven from an output port should suffice.

If the display must provide the user with data or relatively complex status information, then a liquid crystal display having a built-in microcontroller can be used. A display of this type can provide a few lines of ASCII characters, and can be driven from an output port that provides eight data lines plus two or three handshake outputs.

Displays of this type are now surprisingly inexpensive. Using one of these displays goes beyond the scope of the present article, but it is a subject we will return to at a later date.

In its most basic form, an l.e.d. status indicator can simply be an ordinary l.e.d. driven from a spare digital output of the computer. The software is then designed to flash the l.e.d. on and off at a rate of (say) one hertz. If the program is running properly the l.e.d. will flash at the appropriate rate, but if the system crashes or hangs-up for some reason, the l.e.d. will stop flashing or will do so erratically.

This method can be taken a step further, with several l.e.d.s driven from individual digital outputs. Each l.e.d. can be used to represent a different phase of the program, with the appropriate l.e.d. being activated as its phase of the program is reached.

This type of thing is not relevant to every type of program, and it is not really applicable to programs that undertake simple monitoring tasks. Many programs of this type just idle for the majority of the time, with the occasional burst of activity when a reading is actually taken.

With programs such as this the l.e.d.s could simply be activated in sequence, for about 200ms each. With the l.e.d.s providing the correct "moving light" display the computer is certain to be functioning normally.

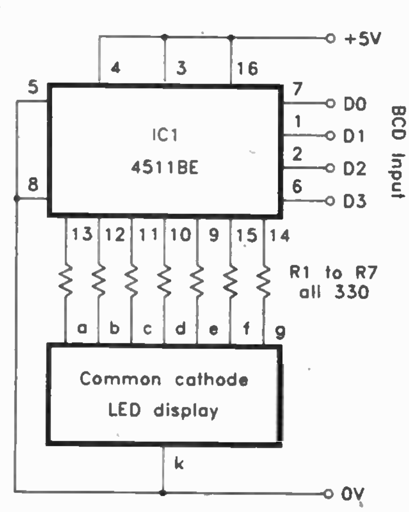


Fig. 1. Driving a 7-segment display from a b.c.d. signal from the PC.

More usefully perhaps, the display could show (in binary form) the number of readings taken since the system was started. The person supervising the system could then keep a check on the running count, and should soon notice if something goes wrong. Either the count would "freeze", or the l.e.d. display would operate erratically.

On Display

My preferred method of handling this sort of thing is to use a seven-segment display plus a suitable b.c.d. (binary coded decimal) decoder/driver. The circuit diagram of Fig.1 shows a simple arrangement of this type.

This circuit is based on a CMOS 4511BE BCD to 7-segment decoder/driver i.c., which can drive any reasonably efficient common cathode seven-segment l.e.d. display. Resistors R1 to R7 simply provide current limiting on IC1's seven outputs.

The 4511BE has a built-in four bit latch, but it is assumed here that the circuit will be fed from latching outputs. Consequently, pin 5 is connected to ground so that the latch becomes "transparent". The "lamp test" and "blanking" inputs serve no useful purpose either, and are taken permanently high, which is their inactive state.

The data inputs (pins 7, 1, 2, 6) can be driven from any latching output port that has at least four spare lines. This could be something like an add-on 8255 PIA card, or even just the four least significant data lines of a printer port. For printer ports one and two (respectively) the values for the decoder are written to input/output addresses &H378 and &H278.

Two Digits

For decimal values from 0 to 9 there is no difference between b.c.d. and ordinary binary. Values from 10 to 15 (decimal) are valid in normal four-bit binary, but will just produce "garbage" from a b.c.d. decoder/driver. Decimal values above 9 require a second digit.

From the hardware point of view, there is no difficulty in using a second decoder driver circuit if an eight-bit output port is available. Drive the least significant digit from the four lowest outputs (D0 to D3), and the most significant digit from the four most significant output lines (D4 to D7).

Matters are slightly more awkward as far as the software is concerned, as there is no really easy method of converting from decimal/plain binary to b.c.d. The two digits of the binary value have to be separated using the MOD function to divide by 10, and effectively strip off the most significant digit. Then integer division by 10 is used to shift the decimal point to the left and strip off the least significant digit.

Multiplying the most significant digit by sixteen gives the correct value for this digit. Finally, adding this value to the least significant digit gives the full value to write to the eight-bit output port.

The following simple GW BASIC program provides the conversion for an integer value from 0 to 99 which is input by the user. Note that in line 30 the " \ " symbol must be used, and not the "/" symbol. Otherwise, floating point rather than integer division will be obtained, and the program will not function correctly:

```
 5 REM BCD CONVERSION
   PROGRAM
10 INPUT A
20 B = A MOD 10
30 C = A \ 10
40 C = C * 16
50 D = B + C
60 PRINT D
```

Trigger Finger

When trying to interface a few pushbutton switches to a PC the obvious starting point is the Games Port. Most PCs seem to be supplied with a games port as part of the standard specification, but it only requires the addition of a very inexpensive expansion card if your PC lacks this facility.

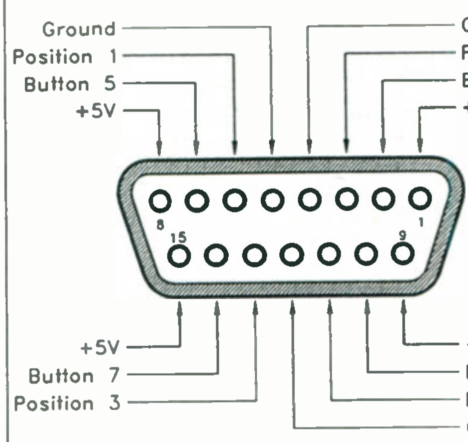


Fig. 2. The pin functions for the PC Games Port.

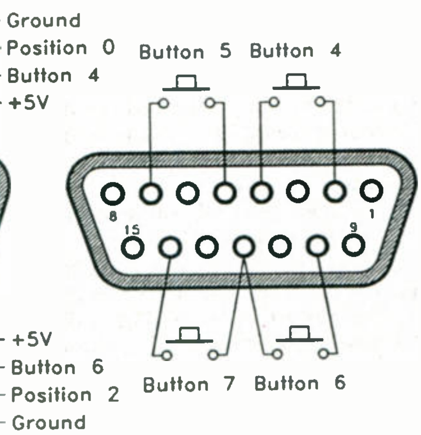


Fig. 3. Connecting four pushbutton switches to the PC "games" port.

The PC games port has provision for two potentiometer style joystick ports, with two "firebuttons" per joystick. Fig.2 shows the pin functions for the games port, and Fig.3 shows the correct method of connection for the four pushbutton switches. A 15-way male D-type connector is needed to make the connections to the games port.

The switches can be read using the GW BASIC "STRIG" function, but in many applications it is better to directly read the appropriate input port. This is at address &H201, or 513 in decimal.

Each input is normally high, and is pulled low when its pushbutton switch is activated. Buttons four to seven are at bits four to seven (respectively) of the port. To read each of these bits it is a matter of bitwise ANDing the value read with the appropriate value.

The masking numbers for bits four to seven are 16, 32, 64, and 128 respectively. The value returned is equal to the masking number if the pushbutton has not been pressed, or zero if it has.

Quiz Monitor

The GW BASIC program (Listing 1) provided here, together with four pushbuttons connected to the games port, acts as a Four-Station Quiz monitor. This program probably represents something less than the most efficient solution, but it works quite well and demonstrates the direct reading of the joystick port.

Listing 1: 4-Station Quiz Monitor

```
 10 REM QUIZ MONITOR PROGRAM
 20 CLS
 30 X = INP(513)
 40 IF X AND 16 THEN GOTO 70
 50 PRINT "PLAYER 1 PRESSED FIRST"
 60 GOTO 180
 70 IF X AND 32 THEN GOTO 100
 80 PRINT "PLAYER 2 PRESSED FIRST"
 90 GOTO 180
100 IF X AND 64 THEN GOTO 130
110 PRINT "PLAYER 3 PRESSED FIRST"
120 GOTO 180
130 IF X AND 128 THEN GOTO 160
140 PRINT "PLAYER 4 PRESSED FIRST"
150 GOTO 180
160 A$ = INKEY$
170 IF LEN(A$) = 0 THEN GOTO 30
180 A$ = INKEY$
190 IF LEN(A$) = 0 THEN GOTO 180
200 CLS
210 IF ASC(A$) = 115 THEN END
220 GOTO 30
```

The port is read at line 30, with the returned value being placed in variable "X". This variable is then bitwise ANDed with the appropriate values to determine whether or not one of the pushbutton switches has been operated.

Normally the program loops around lines 30 to 170, but when a pushbutton is operated, an on-screen message shows which player has operated his or her button. Pushbuttons four to seven are allocated to players one to four respectively.

Once the message has been printed, the program branches to a second loop at lines 180 and 190. The program loops here until the quizmaster presses any character key apart from the "S" key. The screen is then cleared and the process is repeated. If the "S" (for "stop") key is pressed, line 210 brings the program to an end.

AUDIO METER AND AMPLIFIER

ANDY FLIND

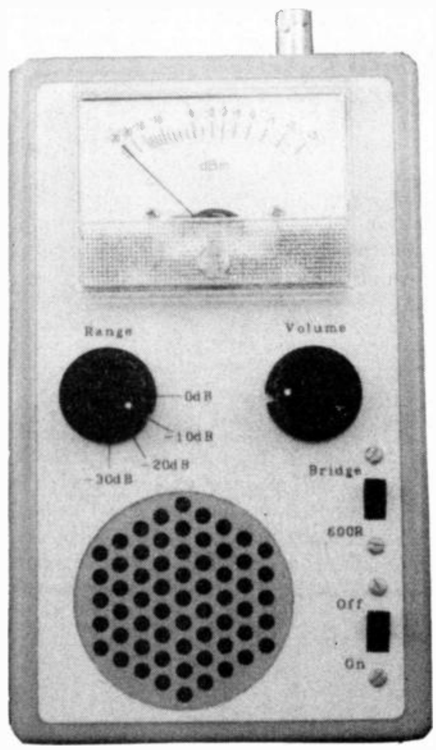
A dual-purpose workshop test instrument which displays audio signal strengths on a meter and incorporates its own monitoring speaker.

THIS compact instrument should prove extremely useful to anyone involved in the repair, maintenance or setting up of audio equipment of any kind. It aids with the investigation of signals by displaying on a meter their strength over a wide range and simultaneously allowing them to be heard through a loudspeaker. The frequency coverage extends over the entire audio spectrum from 20Hz to 20kHz.

The meter is calibrated in decibels, the standard unit used by most audio engineers, though it could be calibrated in other units if required. At the high end of the amplitude range, signals of +3dBm (decibel-milliwatt) can be measured, whilst low level signals of −40dBm and below can be read with reasonable accuracy.

Sound output quality is good. It is heard clearly down to −40dBm and is still audible at −60dBm.

Only a minimum of equipment is needed to build and test the instrument, although a digital voltmeter (DVM) with an a.c. voltage range of 2V r.m.s. is required for calibration.



BLOCK DIAGRAM

It can be seen from the block diagram in Fig. 1 that the audio and meter sections of the unit are treated separately. The audio side consists of an input buffer stage followed by the volume control, power amplifier and loudspeaker.

The meter section also has a buffer amplifier but with switchable gain arranged in steps of 10dBm. This drives an "absolute value" detector, effectively a "perfect" full-wave signal rectifier. From here, the rectified voltage goes to a driver providing output for a 1mA meter movement.

A switchable 600 ohm load is provided at the input. Such loads are common in telephony work, where signals are generally assumed to be sourced from, and terminated into, 600 ohms resistance. Instruments used for testing these circuits can either "terminate" a circuit by loading it with a 600 ohm resistor, or listen to it with the usual load still connected.

The latter is known as "bridge" measurement, and requires a high impedance at the test instrument to avoid additional circuit loading. This feature can be omitted but it is often useful to be able to place a load across a signal source to obtain some idea of its impedance, even if accurate 600 ohm loading is not required.

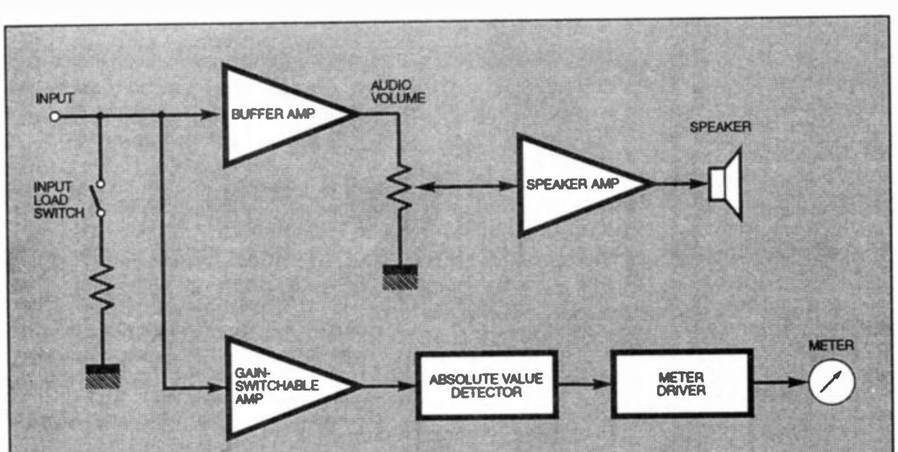


Fig. 1. Block diagram of the Audio Meter and Amplifier.

CIRCUIT DIAGRAM

The full circuit diagram is shown in Fig. 2. Starting with the audio section, the signal is first buffered by the TL071 f.e.t. op.amp IC1. This provides the high impedance input required for "bridge" operation, in this instrument almost 200k, which should be adequate for most high-impedance audio sources.

From IC1 the signal passes through Volume control VR1 to output amplifier IC2. This is a TDA7052 device designed specifically for battery-powered applications. It has a "bridge" output to increase available power from low supply voltages. As can be seen, it is very simple to use, requiring no additional components, except the loudspeaker and volume control. Capacitors C3 and C4, prior to the amplifier, define the frequency response.

The input signal also goes to the level indication part of the circuit, the first stage of which is another f.e.t. op.amp, IC3. As with the audio section, the op.amp buffers the signal, but here it has a gain switch, S3, with resistor combinations (R9 to R14) calculated to provide voltage gains corresponding to 0dB (×1), 10dB (×3·162), 20dB (×10) and 30dB (×31·62).

Since the impedance at the input of IC3 is one megohm (1M), the overall input impedance of the unit remains high.

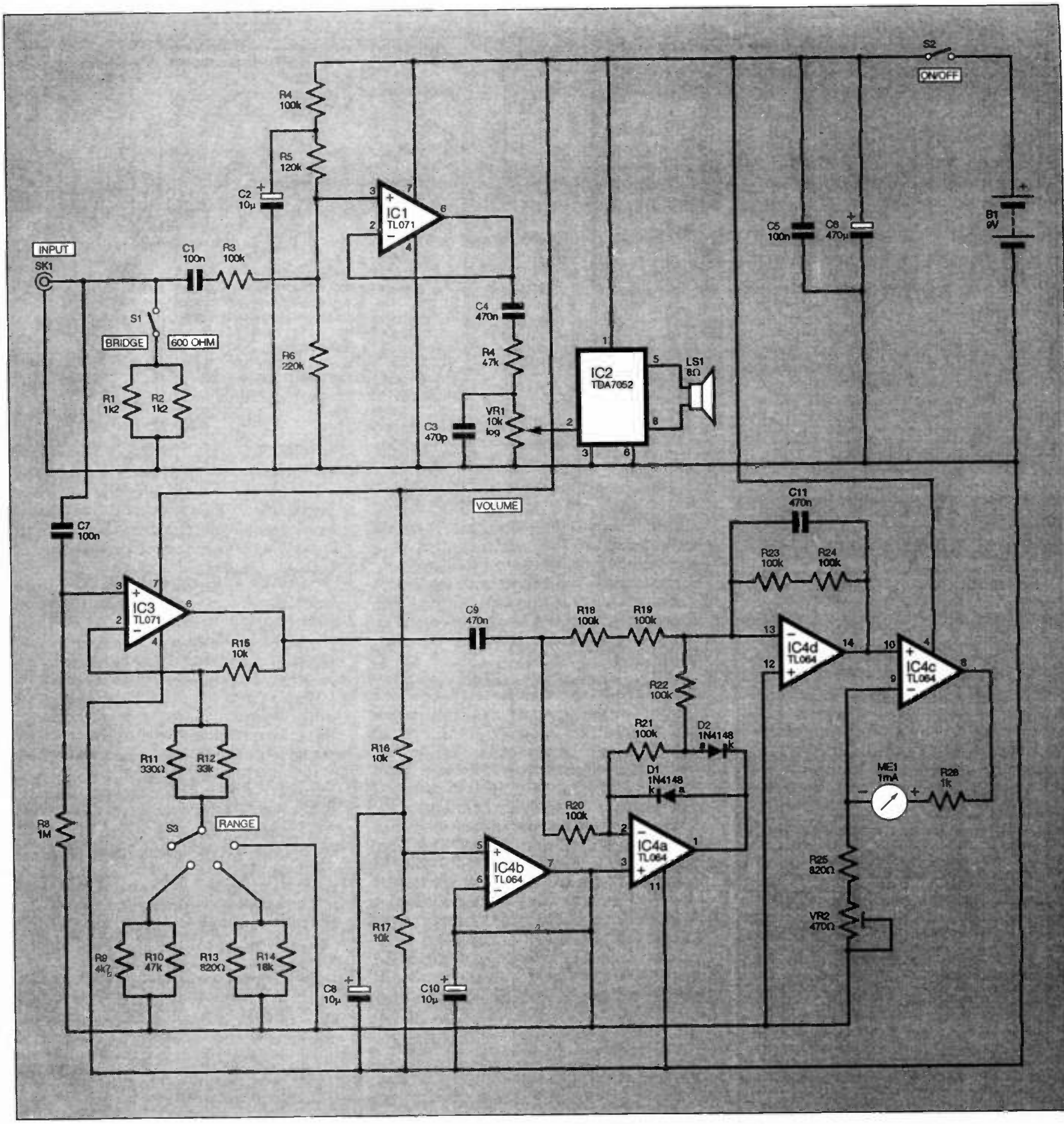


Fig. 2. The complete circuit diagram for the Audio Meter and Amplifier.

RECTIFIER

The output from IC3 goes to the "absolute value" signal rectifier circuit around op.amps IC4a and IC4d.

How this part of the circuit behaves may be understood by examining its response to positive and negative inputs independently. In effect, "ground" here is a voltage midway between the supply rails, supplied by amplifier IC4b, which buffers the voltage at the junction of resistors R16 and R17.

This voltage is applied to the non-inverting inputs (pins 3 and 12) of op.amps IC4a and IC4d which, under normal operating conditions, will always match it at their inverting inputs (pins 2 and 13) through negative feedback.

If the signal voltage from capacitor C9 is one volt below "ground" voltage, the output at IC4a pin 1 will rise until sufficient current flows through diode D1 to maintain "ground" voltage at IC4a pin 2.

Under these conditions, diode D2 is reverse biased and so the voltage at its junction with resistors R21 and R22 is also at "ground", thus no current can flow through R22 from IC4d pin 13. However, a current of 5µA will flow through resistors R18 and R19, from the inverting input of IC4d, which will balance it with a current from R23 and R24 by a one volt rise in output voltage at IC4d pin 14. An input of minus one volt thus results in an output of plus one volt at IC4d pin 14.

If the input is now made one volt positive, the output of IC4a will adjust by falling until the voltage at the junction of R21, R22 and D2 is one volt negative, at which point the current flowing through R21 into the inverting input, IC4a pin 2, is balanced by the current flowing out through R20.

Op.amp IC4d's inverting input pin 13 now has 5µA flowing into it through R18 and R19, but also has 10µA flowing out through R22, making a net input of minus 5µA. This is the same as before, so once again the output is positive with a value of one volt. In this way, "perfect" full-wave rectification of the signal is obtained.

Because IC4a is not driven into saturation at any point, the circuit has a reasonably good frequency response, extending to well beyond the 20kHz required for this application.

Capacitor C11 smooths the output of the rectifier, so that it is a d.c. voltage rather than a lot of peaks corresponding to the input signal. This smoothed voltage is then passed to IC4c, which converts it to a current output for the meter, ME1. A small presettable adjustment range for calibration is provided by potentiometer VR2, wired as a variable resistor.

The value indicated by the meter is actually the "average" a.c. voltage of the

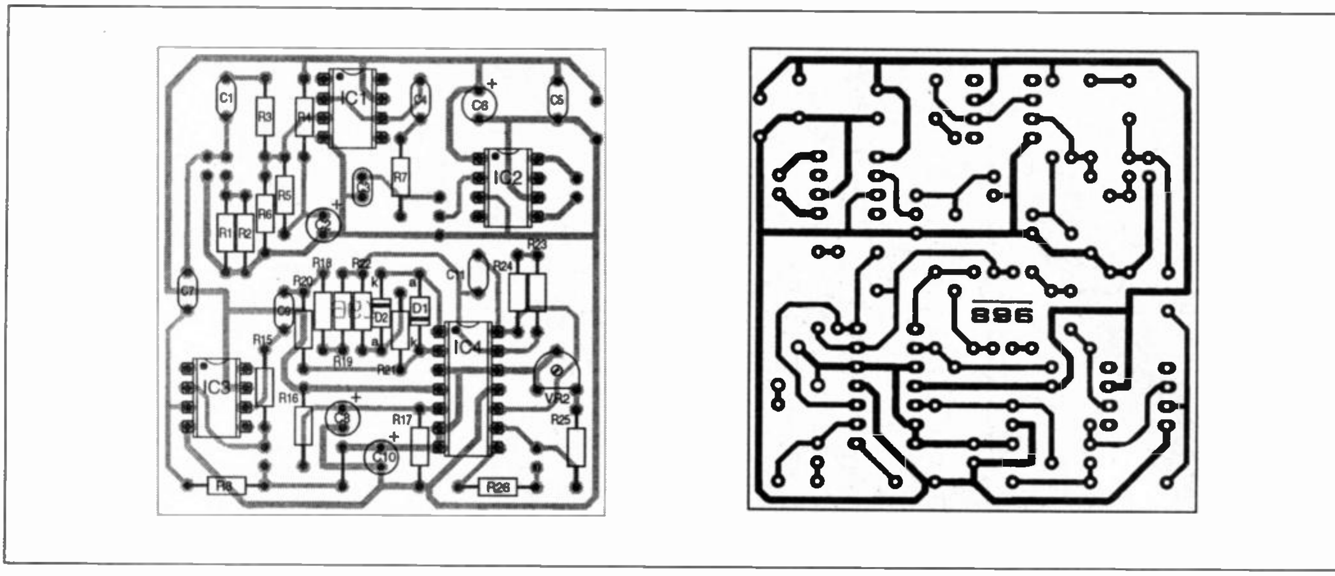


Fig. 3. Component layout and full size copper foil tracking layout for the printed circuit board.

COMPONENTS

Resistors

R1, R2	1k2
R3, R4, R18 to R24	100k (9 off)
R5	120k
R6	220k
R7, R10	47k (2 off)
R8	1M
R9	4k7
R11	330Ω
R12	33k
R13, R25	820Ω (2 off)
R14	18k
R15 to R17	10k (3 off)
R26	1k

All 0.6W 1% metal film.

See SHOP TALK Page

Potentiometers

VR1	10k rotary carbon, log.
VR2	470Ω cermet preset

Capacitors

C1, C5, C7	100n resin-dipped ceramic (3 off)
C2, C8, C10	10µ radial elect. 50V (3 off)
C3	470p resin-dipped ceramic
C4, C9, C11	470n resin-dipped ceramic (3 off)
C6	470µ radial elect. 16V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
IC1, IC3	TL071 f.e.t. op.amp (2 off)
IC2	TDA7052 audio power amplifier
IC4	TL064 quad f.e.t. op.amp

Miscellaneous

S1, S2	s.p.s.t. slide switch (2 off)
S3	2-pole 6-way rotary switch
LS1	loudspeaker, 8Ω, 66mm diameter
ME1	1mA panel meter

Printed circuit board, available from the *EPE PCB Service*, code 968; 8-pin d.i.l. socket (3 off); 14-pin d.i.l. socket; BNC chassis socket, 50Ω; ABS plastic case, 90mm x 149.5mm x 52.5mm; knob (2 off); PP3 battery clip.

Approx cost guidance only **£25**

input signal. This is only truly related to the r.m.s. value, and hence to the dBm level, so long as the input is a reasonably pure sinewave. Consequently, for tests where strict accuracy is required, a sinewave source should be used. However, for more general non-sinusoidal measurements this instrument is still an extremely useful indicator.

CONSTRUCTION

Most of the components for this project are mounted on a small printed circuit board (p.c.b.), as shown in Fig. 3. This board is available from the *EPE PCB Service*, code 968.

To simplify construction and testing, the following step-by-step sequence is recommended. First, fit the single wire link, then all resistors, except for R9 to R14 which are mounted on switch S3. Diodes should be fitted next, ensuring their correct polarity. Now fit the d.i.l. sockets for the i.c.s.

Next, fit the capacitors, starting with the tiny C3, followed by the others in order of size. Note that all the electrolytics have their positive ends towards the top of the board. Now fit preset VR2.

Wiring of the various components, including the resistors fitted to switch S3, is shown in Fig. 4. In the prototype a rotary six-way two-pole type was used for S3. With these switches, an adjuster located behind the securing nut determines the number of ways available, in this case four are needed. Pin 12 of the switch is not required by the circuit and so can be used as an anchor for a lead from the board and two of the resistors.

Now attach leads between the p.c.b. and all off-board components. Ribbon cable, although not essential, will result in a neater appearance. Leave the leads a bit long at this stage, only cutting them to length when everything is mounted in the case.

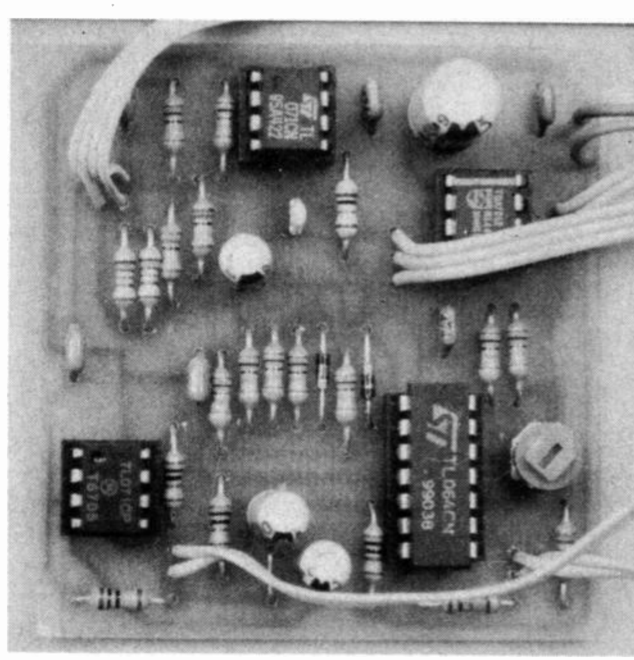
FIRST CHECKS

Thoroughly examine the board for good soldering and correct component positioning. As an initial check, power can be applied to the board before the i.c.s are inserted (but only insert them when the power is off!). This should result in an initial surge as the electrolytics charge, after which the current drawn from the supply should be about half a milliamp.

If this test is successful, insert IC1 into its socket. Powering up again, the current drain should have risen to about two milliamps. The output of IC1, from pin 6, should have a d.c. potential of half the supply, about 4·5V.

Now fit IC4 and check the voltage at pin 7. This is the output of IC4b, "ground" for the rectifier circuit and bias for IC3. It too should be at half the supply voltage, about 4·5V.

Fit IC3, which will raise the current drain to about 4·1mA. The output voltage at IC3 pin 6 should be about 4·5V. This assumes that the leads for S3 are open-circuit.



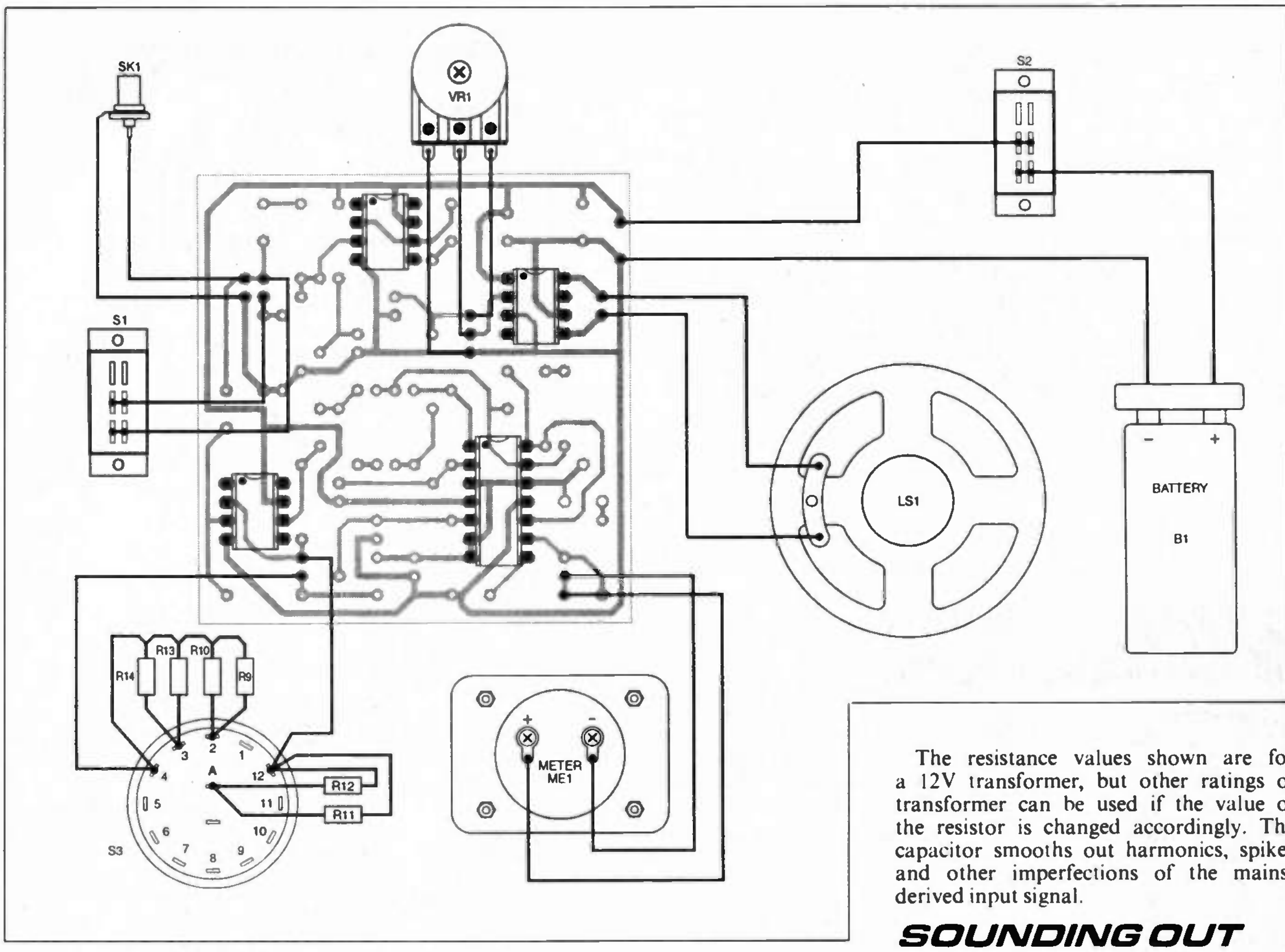


Fig. 4. Wiring details for the off-board components.

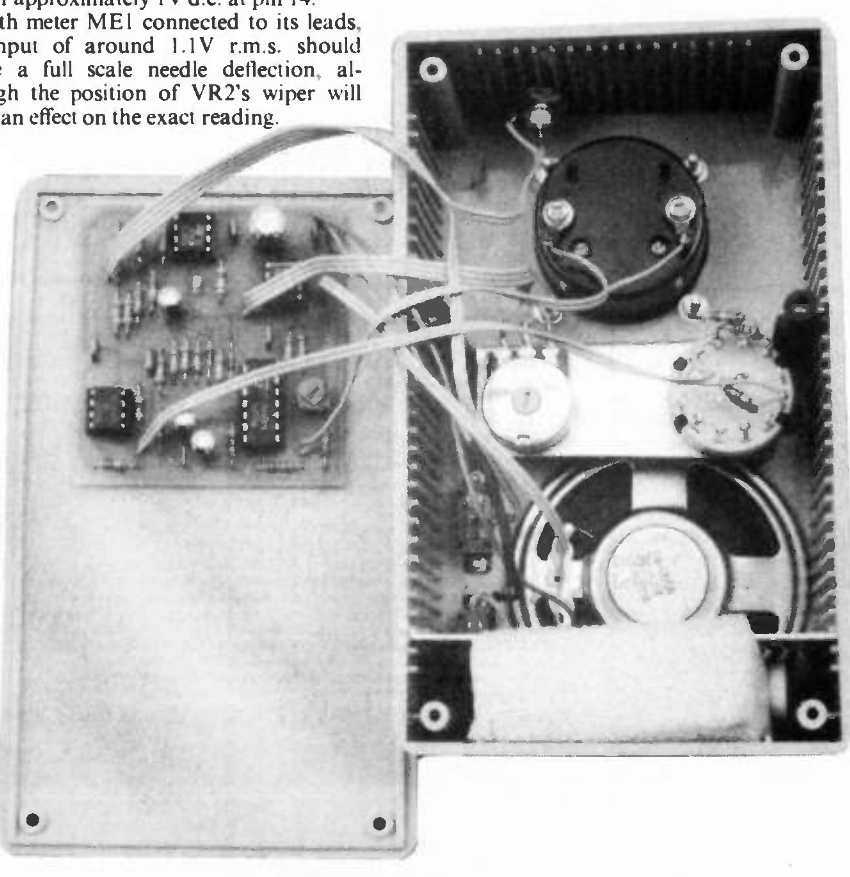
METER TESTING

As there is no input signal at this stage of testing, IC4b pin 14 should also be at about 4·5V. It might rise a little if the input is touched, but the effect will probably be tiny. If a sinewave signal source is available, a 1V r.m.s. signal should produce a rise of approximately 1V d.c. at pin 14.

With meter ME1 connected to its leads, an input of around 1.1V r.m.s. should cause a full scale needle deflection, although the position of VR2's wiper will have an effect on the exact reading.

The total current drawn by the circuit will now be about 4mA with no signal, rising to 5mA for full scale.

If a signal generator is not available, the output from a small transformer can be used as a source, connected as shown in Fig. 5. TAKE CARE WHEN MAINS POWER IS CONNECTED.



The resistance values shown are for a 12V transformer, but other ratings of transformer can be used if the value of the resistor is changed accordingly. The capacitor smooths out harmonics, spikes and other imperfections of the mains-derived input signal.

SOUNDING OUT

Next, the speaker and volume control VR1 should be connected to their leads and IC2 inserted. Before turning on the power, VR1 should be turned right down. The supply current will be increased to about 8mA by the quiescent current of IC2. The input level should be adjusted for about half scale on the meter, following which increasing the setting of VR1 should result in sound from the speaker.

A word of caution applies here. Whilst the speaker is placed on the bench and driven by a low-frequency sinewave, the apparent sound level will be low. This is due to the signals from both sides of the speaker trying to cancel each other out. With a 50Hz signal produced by the transformer shown in Fig. 5, the sound output will be especially low!

Power consumption depends on the sound level and on the ability of the speaker cone to move freely. With the speaker on the bench, if VR1 is turned up too far, power consumption could rise to over 300mA and cause overheating of IC2.

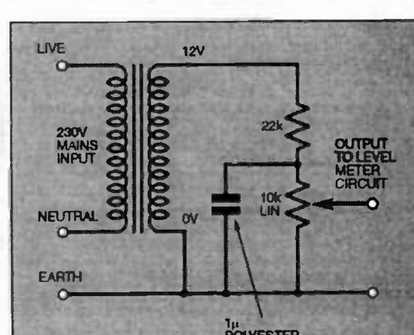


Fig. 5. Mains power sinewave test source.

Once fitted in the case, sound from the rear of the speaker will not be able to cancel that from the front so it will sound much louder and the overheating problem is unlikely to arise.

HOUSING IT ALL

As can be seen from the photograph, fitting the project into the specified case required some ingenuity. The speaker is a 66mm diameter type, chosen as the largest practical size for the case. The larger the speaker, the better the sound quality, and good sound is a useful bonus in an instrument of this type.

Slide switches for power and input loading were fitted to the right of the speaker, as viewed from the front. The switch and pot were fitted using a bracket which slides into slots in the sides of the case, so that their bodies are situated behind the speaker with their shafts passing through the front of the case close to the speaker edge. This complication could be avoided by using a smaller speaker, but with the test model the additional effort was worthwhile.

CALIBRATION

Calibration can be carried out with a signal generator or the transformer arrangement described above. With the instrument switched on but with no input signal, the needle position of meter ME1 should be set to zero. This is done with the power on since offsets in the circuit may alter the zero point slightly.

A sinewave input can now be applied. Monitoring the input with a digital voltmeter (DVM), set the input signal level for 1·0941 volts r.m.s. (or as near as the DVM will allow). Now adjust VR2 so that meter ME1 shows a needle reading of exactly a full scale, or +3dBm. Remaining points can be marked on the meter scale by adjusting the input signal level to the r.m.s. values given in Table 1, and marking the meter scale accordingly.

Alternatively, the test model's meter scale shown in Fig. 6 might be suitable. If so, this can be photocopied and glued over the existing scale on the meter. The use of a Pritt Stick is suggested for this as it is easy to use and will not stain the paper. It is also water-soluble, so if the meter's original scale is ever required it can easily be restored by soaking off the new one.

METER USING

In use, the meter is simply connected to the signal to be monitored and the volume control adjusted as required. The level can be read from the meter, though it should be remembered that it will only be accurate if the signal is a fairly pure sinewave, and will only represent a true dBm value if working into a 600 ohm load.

If the reading is towards the lower end of the scale, the range switch can be used to increase the sensitivity. Because decibel values are added, not multiplied, the difference indicated by the switch should be simply added to that on the scale. For instance, a reading of "–5" on the meter coupled with a switch position of "–20" indicates a value of –25dBm.

The 600 ohm input resistance (R1, R2) can be used to load a monitored circuit with this precise value and determine, by the level drop it produces, what sort of impedance the source has. For example, it will make no difference to an output intended to drive a loudspeaker, but it will knock around 25dBm off a signal from a 10k source. This can be a quick way to obtain useful information about a signal under test.

It is possible to change the calibration of this instrument. It could be calibrated in millivolts, r.m.s., average or peak-to-peak, and the resistors on the range switch could be changed to give decade or "1-2-5" steps.

For extended use, the PP3 battery could be replaced by a pack of six AA cells, or a socket fitted for external power. A mains adapter could be used, although one with good regulation may be needed to avoid hum. *(See Andy Flind's* Hum-Free Battery Eliminator *constructional article in* EPE *Sept. '95. Also, have a read of Andy's other interesting feature next month* – Decibels and the dBm Scale. *Ed.)*

Table 1.
dBm and Corresponding Values.

dBm	Relative power	Volts r.m.s.	% meter scale
3	1·995	1·094	100·000
2·5	1·778	1·033	94·406
2	1·585	0·975	89·125
1·5	1·413	0·921	84·140
1	1·259	0·869	79·433
0·5	1·122	0·820	74·989
0	1·000	0·775	70·795
–0·5	0·891	0·731	66·834
–1	0·794	0·690	63·096
–1·5	0·708	0·652	59·566
–2	0·631	0·615	56·234
–2·5	0·562	0·581	53·088
–3	0·501	0·548	50·119
–4	0·398	0·489	44·668
–5	0·316	0·436	39·811
–6	0·251	0·388	35·481
–7	0·200	0·346	31·623
–8	0·158	0·308	28·184
–9	0·126	0·275	25·119
–10	0·100	0·245	22·387
–11	0·079	0·218	19·953
–12	0·063	0·195	17·783
–13	0·050	0·173	15·849
–14	0·040	0·155	14·125
–15	0·032	0·138	12·589
–20	0·010	0·077	7·079
–30	0·001	0·024	2·239

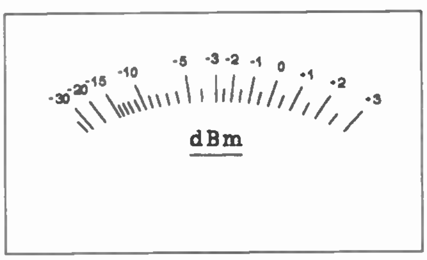


Fig. 6. Meter scale used on the test model.

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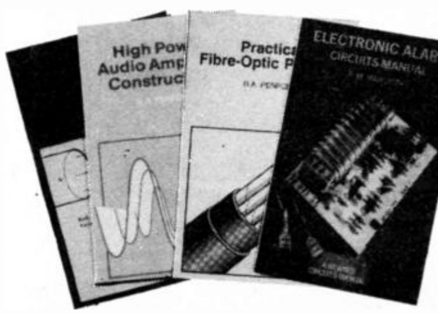

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Electronic devices surround us on all sides and their numbers are increasing without mercy. Ours is the problem therefore in keeping up with this relentless expansion. Unfortunately we cannot know it all and most of us do not wish to afford the cost of large reference books which explain many concepts in fair detail. Here is an answer, an inexpensive reference guide which explains briefly (but we hope, well) many of the underlying electronics features of practical devices, most of which, to a certain extent, control our lives.
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Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
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R. A. Penfold
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REPORTING AMATEUR RADIO

Tony Smith G4FAI

RSGB PROTESTS AT RA MORSE DECISION

The Radio Society of Great Britain has protested to the Radiocommunications Agency (RA) about its decision (reported in this column last month) to support any proposal at a World Radio Conference to abolish the amateur Morse test.

The Agency based its decision on a survey carried out in 1993 which, it said, showed the majority of class A licensees wished to retain the test while the majority of class B licensees saw no need for this requirement.

The RSGB has now published copies of its correspondence with the RA. It points out that the Agency has based its decision on letters received from individual amateurs, and has ignored the results of a national survey carried out by the Society at the request of the Agency – which showed a 67·5 per cent majority in favour of retaining the test.

Furthermore, the Agency has ignored the recommendations made in the recent report of the International Amateur Radio Union, which are supported by all three IARU Regions, that no changes be made at the present time.

Previously, the RSGB had pointed out to the Agency the chaos that would result from leaving countries to set their own requirements. If any change was to be made to the regulations, it felt strongly that proposals should come from within the Amateur Service itself. These should be discussed and agreed by the IARU so that the purpose and benefits of a new approach could be agreed and a smooth and coordinated changeover could be made.

CUSTOMER POLICY IGNORED

The RSGB points out that the RA has continually publicised its policy of "Quality of Service to our Customers", but in this matter it has chosen to completely ignore the customer.

The Society has requested the RA to reconsider its position which, it says, "if pursued will not only affect the UK, but will undermine one of the established cornerstones of the Amateur Service worldwide."

For the RSGB an even more important question than the Morse test arises. As the national organisation representing Britain's radio amateurs it has enjoyed a close working relationship with the successive radio licensing authorities over many years.

In that capacity, it has negotiated many improvements to the regulations covering all aspects of amateur radio. The arbitrary decision of the RA on such a sensitive issue, taken without any discussion with the RSGB, now raises questions about the validity of that relationship in the future.

By the time this appears in print, *WRC-95* will have been held and the news of what decision has been made, if any, will have been flashed round the world. More on this later.

YOUNG AMATEUR OF THE YEAR

The *Young Amateur of the Year Award* has been won by 16-year old Leroy Kirby, GW0ULC, from Cardigan, Dyfed. He was presented with the first prize of £300 at the RSGB's HF Convention at Windsor on 10 September.

He also received a Sony general coverage receiver from the RSGB, and other prizes, and will be invited to visit the RA's Radio Monitoring Centre at Baldock, Herts, for a conducted tour.

Leroy has done much to promote amateur radio, through both the Scouts and the Air Training Corps. He has run a number of special event stations, including two for "Jamboree on the Air".

He is an active member of his local amateur radio emergency service and has successfully revived a local YMCA amateur radio club, of which he is now vice-chairman. He has also won a number of contest awards.

His main interest is packet radio, and he has helped set up a new local Bulletin Board System (BBS), acting as the remote systems operator for a time.

The close runner-up is 15-year old Charles Banner, G7UBA/2E1CHY, from Birmingham. Charles is an RSGB News Service reader. He has set up a number of special event stations, and is currently helping run a Novice licence training course.

He is assistant secretary of his school's amateur radio society, and his main interest is low power operation. He won an Icom handheld transceiver, courtesy of Icom UK, a £75 cheque from Lowe Electronics, a cheque for £50 from the RA and other prizes. He will also be invited to visit Baldock.

RSGB SEEKS INFO ABOUT RAE

The Radio Society of Great Britain seeks input from anyone applying for Radio Amateur's Examination courses or RAE examination places. They are seeking details of the college applied to and its reply; also the fees charged for courses and examinations.

The society is gathering evidence to discover whether potential candidates are being discouraged from taking courses or the examination by some colleges. There have been reports of fees not returned when a course has been terminated, of courses given by lecturers who know little about amateur radio, and of colleges refusing facilities for external candidates to take the examination.

Members and non-members of the RSGB are invited to help in this survey to establish how widely the practices described exist in colleges. Please write, describing your experiences, to the *Membership Liaison Committee, RSGB, Dept EPE, Lambda House, Cranborne Road, Potters Bar, EN6 3JE,* mentioning that you read about the survey in *EPE.*

AMATEUR NUMBERS DOWN

The annual report of the Radiocommunications Agency for 1994/95 records a total of 61,457 amateur radio licences on issue as at 31 March 1995. This is a drop of 1,576 compared with the previous year, and reverses the earlier encouraging upward trend which seemed to reflect the introduction of the Novice licence.

In March 1992, when the Novice licences were first included in the figures, the number of amateurs was 61,442. Over three years, therefore, the overall increase is only 15.

During the year, two persons were prosecuted and convicted, and two warning letters were sent, relating to amateur radio offences. Thirty-two others were convicted, and 356 warning letters were sent, for CB offences.

The Agency remains concerned at the continuing abuse of these services. Within available resources, it says, it will do what it can to continue to police the airwaves in co-operation with representatives of the amateur radio and CB communities. It will also, in suitable cases, give publicity to cases of abuse which come to its attention.

Financial deficits are reported against all services, including an amateur radio deficit of £463,000. The objective is to recover in each case the full cost from customers (i.e., the licence holders), and a three-year plan is being developed to achieve this. Presumably this will mean an increase in licence fees in due course.

WINTER SWL GUIDE PUBLISHED

The International Short Wave League publishes its useful *Guide to English Language Short Wave Broadcasts to Europe* twice a year. These enable listeners to keep up to date with seasonal programming changes.

The A4 size guide to winter schedules, 1995/96 is now available. It lists all broadcasts in 24-hour UTC order, and the information provided includes time periods, frequencies, country and station names, together with brief programme details.

This A4 booklet is packed solid with information for the keen short wave listener. It costs just £2.00 (IRCs or postage stamps to that value also acceptable), from *ISWL, 10 Clyde Crescent, Wharton, Winsford, Cheshire CW7 3LA.* Please mention that you read about the guide in *EPE.*

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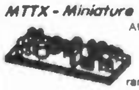

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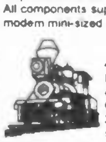

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3 CHANNEL SOUND TO LIGHT KIT Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w power handling, microphone included. £14 Ref 1014.

MOTORBIKE/CYCLE TREMBLER ALARM KIT Adjustable sensitivity, preset alarm time, auto reset. Could be connected to horn etc. £12 Ref 1011.

0-5 MINUTE TIMER KIT adjustable, will switch up to 2A mains. Perfect for alarms, photography, etc. £7 Ref 1020.

4 WATT FM TRANSMITTER KIT Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £20 Ref 1028.

STROBE LIGHT KIT Adjustable from 1-60 hz (a lot faster than conventional strobes). Mains operated. £16 Ref 1037.

ULTRASONIC RADAR KIT Ideal as a movement detector with a range of about 10 metres, automate your cat flap! 12v dc. £15 Ref 1049.

LIQUID LEVEL DETECTOR KIT Useful for tanks, ponds, baths, rain alarm, leak detector etc. Will switch 2A mains. £5 Ref 1081.

COMBINATION LOCK KIT 9 key, programmable, complete with keypad, will switch 2A mains. 9v dc operation. £10 ref 1114.

PHONE BUG DETECTOR KIT This device will warn you if somebody is eavesdropping on your line. £6 ref 1130.

ROBOT VOICE KIT Interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £9 ref 1131

TELEPHONE BUG KIT Small bug powered by the 'phone line, starts transmitting as soon as the phone is picked up! £8 Ref 1135.

FUNCTION GENERATOR KIT Produces sinusoidal, saw tooth and square waves from 20-20khz, separate level controls for each shape. Will produce all 3 together. 24vac. £16 ref 1008.

3 CHANNEL LIGHT CHASER KIT 800 watts per channel, speed and direction controls supplied with 12 LEDS (you can fit triacs instead to make kit mains, not supplied) 9-12vdc £17 ref 1026.

12V FLOURESCENT LAMP DRIVER KIT Light up 4 foot tubes from your car battery! 9v 2a transformer also required. £8 ref 1069.

VOX SWITCH KIT Sound activated switch ideal for making bugging tape recorders etc, adjustable sensitivity. £8 ref 1073.

INCAR SOUND TO LIGHT KIT Put some atmosphere in your car with this mini 3 channel sound to light. Each channel has 6 led's. £10 ref 1086.

7W HI FI AMPLIFIER KIT Useful, powerful, ideal for audio systems, intercoms etc. 12-18vdc £7 ref 1025.

PHONE CALL RELAY KIT Useful device that operates a relay whenever the 'phone rings. Switches mains at 2A. £10 ref 1122.

LEAD ACID CHARGER KIT Two automatic charging rates, visual indication of battery state, ideal for alarm systems etc, 100mA 12vdc £12 ref 1095.

CAR ALARM KIT Works on voltage drop and vibration, entry/exit delays, adjustable alarm duration. Ideal caravans etc £12 ref 1019.

PORTABLE ALARM KIT Based on mercury switch, alrm continues to sound until reset by owner. Buzzer inc. £11 ref 1150.

PREAMP MIXER KIT 3 input mono mixer, sep bass and treble controls plus individual level controls, 18vdc, input sens 100mA. £15 ref 1052.

METAL DETECTOR KIT Range 15-20cm, complete with case, 9vdc. £8 ref 1022.

SINGLE CHANNEL SOUND TO LIGHT KIT Mains operated, add rythum to your party for only £8 ref 1006.

SOUND EFFECTS GENERATOR KIT Produces sounds ranging from bird chips to sirens. Complete with speaker, add sound effects to your projects for just £9 ref 1045.

GUITAR PREAMP KIT Complete with tone controls, small enough to fit in any guitar, based on TL082 IC, 9-12vdc £8 Ref 1091.

15 WATT FM TRANSMITTER (BUILT) 4 stage high power, preamp required 12-18vdc, can use ground plane, yagi or open dipole. £69 ref 1021.

TELEPHONE AMPLIFIER KIT Very sensitive amplifier which uses a pickup coil (supplied) will let you follow a conversation with out holding the 'phone. £11 ref 1059.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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PC TIMER KIT Four channel output controlled by your PC, will switch high current mains with relays (supplied). Software supplied so you can program the channels to do what you want whenever you want. Minimum system configeration is 286, VGA, 4.1,640k, serial port, hard drive with min 100k free. £24.99

DIVINING RODS Expensive technology cannot challenge the fool proof art of water divining, passed down from generation to generation. Seeing is believing. Use in the home, garden, countryside or desert, it's divinely simple! £4.99 a pair ref E/3.

HUGE BUBBLE MAKING KIT You'll be amazed at the the size of the bubbles you can acheive with this bubble making kit. Once you have got the knack it is possible to make bubbles of up to 40 feet long. £11.99 ref E/9.

FM CORDLESS MICROPHONE This unit is an FM broadcasting station in minature. 3 transistor transmitter with electret condenser mic+fet amp design result in maximum sensitivity and broad frequency response. 90-105mhz, 50-1500hz, 500 foot range in open country! PP3 battery required. £15.00 ref 15P42A

MAGNETIC MARBLES They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref GI/R20

STETHOSCOPES A fully functioning stethoscope for all those intricate projects. Enables you to listen to motors, pipes, heartbeats, walls, insects etc. £6 ref MAR6P6.

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HY24060m, 240v adjustable from 0-60 mins. £6.99

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SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit just £5.99 REF: MAG6P8

BUGGING TAPE RECORDER Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1.

PLUG IN ACORN PSU 19v AC 14w, £2.99 REF MAG3P10

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

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COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync. and video. 12v DC. £8.00 **REF: MAG8P2.**

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GYROSCOPE About 3" high and an excellent educational toy for all ages! Price with instruction booklet £6 Ref EF15.

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VENUS FLYTRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34.

TWEETERS 2" diameter good quality tweeter 140R (ok with the above speaker) 2 for £2 REF: MAG2P5 or 4 for £3 REF: MAG3P4

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

ROCK LIGHTS Unusual things these, two pieces of rock that glow when rubbed togethert belived to cause rain! £3 a pair Ref EF29.

3' by 1' AMORPHOUS SOLAR PANELS 14.5v, 700mA 10 watts, aluminium frame, screw terminals, £44.95 ref MAG45.

ELECTRONIC ACCUPUNCTURE KIT Builds into an electronic version instead of needles! good to experiment with. £7 ref 7P30

SHOCKING COIL KIT Build this little battery operated device into all sorts of things, also gets worms out of the ground! £7 ref 7P36.

FLYING PARROTS Easily assembled kit that builds a parrot that actually flaps its wings and flies! 50 m range £6 ref EF2.

HIGH POWER CATAPULTS Hinged arm brace for stability, tempered steel yoke, super strength latex power bands. Departure speed of ammunition is in excess of 200 miles per hour! Range of over 200 metres! £7.99 ref R/9.

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Phone/Fax: (01255) 850596

For Editorial address and phone numbers see page 927.

Published on approximately the first Friday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Benham & Co. Ltd, Colchester, Essex. Distributed by Seymour, Windsor House, 1270 London Road, Norbury, London SW16 4DH. Sole Agents for Australia and New Zealand–Gordon & Gotch (Asia) Ltd., South Africa–Central News Agency Ltd. Subscriptions INLAND £24 and OVERSEAS £30 (£47.50 airmail) payable to "Everyday with Practical Electronics" Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF. EVERYDAY with PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

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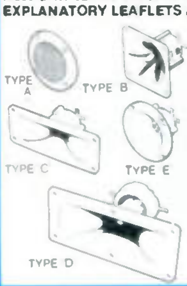

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PRICE £64.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

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12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. PRICE £36.67 + £3.50 P&P

12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. PRICE £46.71 + £3.50 P&P

12" 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
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15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. PRICE £50.72 + £4.00 P&P

15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. PRICE £73.34 + £4.00 P&P

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RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. PRICE £30.39 + £3.50 P&P

12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz. SENS 93dB. PRICE £42.12 + £3.50 P&P

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5¼" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. PRICE £9.99 + £1.50 P&P

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RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. PRICE £10.99 + 1.50 P&P

8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. PRICE £12.99 + £1.50 P&P

10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. PRICE £16.49 + £2.00 P&P

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PHOTO: 3W FM TRANSMITTER

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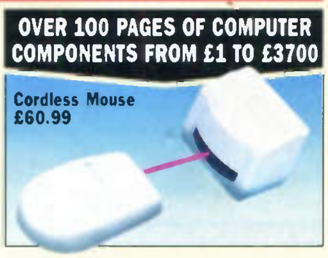

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