THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY

AUGUST 2005

EVERYDAY PRACTICAL ELECTRONICS

£3.30

AUDIO SYSTEM - COMMUNICATIONS

Automatic gain and switched filtering for communications and surveillance

PAIN MONITOR

Assess and log pain levels

MOTOR AMPLIFIER UNIT

Bomb-proof power from RC speed controllers

PLUS

BACK TO BASICS - 5

Room Thermometer
Kitchen Timer

www.epemag.co.uk

Colour CCTV camera, 8mm lens, 12vdc200m a 582X628 Res 380 lines Automatic aperture lens Mirror function PAL Back Light Comp MLR, 100x40x40mm ref EE2 £75.90

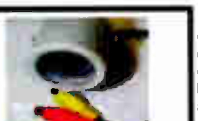
Built in Audio .15lux CCD camera 12vdc 200ma 480 lines s/n ratio >48 db 1v P-P output 110x60x50mm ref EE1 £108.90

Metal CCTV camera housings for internal or external use. Made from aluminium and plastic they are suitable for mounting body cameras in.Available in two sizes 1-100x70x170mm and 2-100x70x280mm Ref EE6 £22 EE7 £26 Multi position brackets Ref EE8 £8.80

Excellent quality multi purpose TV/TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV ideal for use in boats and caravans 49.75mhz-91.75mhz VHF channels 1-5, 168.25mhz-222.75mhz VHF channels 6-12, 471.25mhz-869.75mhz, Cable channels 112.325mhz-166.75mhz Z1-Z7, Cable channels 224.25mhz-446.75mhz Z8-Z35 5" colour screen,Audio output 150mW,Connections, external aerial, earphone jack, audio/video input,12vdc or mains, Accessories supplied Power supply Remote control Cigar lead power supply Headphone Stand/bracket. 5" model £139 Ref EE9,

Self cocking pistol plcr002 crossbow with metal body. Selfcocking for precise string alignment Aluminium alloy construction High tec fibre glass limbs Automatic safety catch Supplied with three bolts Track style for greater accuracy Adjustable rear sight 50lb draw weight 150ft sec velocity Break action 17" string 30m range £23.84 Ref PLCR002

Fully cased **IR light source** suitable for CCTV applications. The unit measures 10x10x150mm, is mains operated and contains 54 infra red LEDs. Designed to mount on a standard CCTV camera bracket. The unit also contains a daylight sensor that will only activate the infra red lamp when the light level drops below a preset level. The infrared lamp is suitable for indoor or exterior use, typical useage would be to provide additional IR illumination for CCTV cameras. £53 90 ref EE11



Colour CCTV Camera measures 60x45mm and has a built in light level detector and 12 IR leds .2 lux 12 IR leds 12vdc Bracket Easy connect leads £75.90 Ref EE15

A high quality external colour CCTV camera with built in Infra red LEDs measuring 60x60x60mm Easy connect leads colour Waterproof PAL 1/4" CCD542x588 pixels 420 lines .05 lux 3.6mm F2 78 deg lens 12vdc 400ma Built in light level sensor. £108.90 Ref EE13

3km Long range video and audio link complete with transmitter, receiver, 12.5m cables with pre fitted connectors and aerials. Acheive up to 3km. Cameras not included Ideal for stables, remote buildings etc. Mains power required £299

A small colour CCTV camera just 35x28x30mm Supplied with bracket, easy connect leads. Built in audio. Colour 380 line res, PAL 0.2 lux +18db sensitivity Effective pixels 628x582 6-12vdc Power 200mw £39.60 Ref EE16

Complete wireless CCTV sytem with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4ghz 3 lux 6-12vdc manual tuning Available in two versions, pinhole and standard.£79 (pinhole) Ref EE17, £86.90 (standard) Ref EE18

Peltier module. Each module is supplied with a comprehensive 18 page Peltier design manual featuring circuit designs, design information etc etc. The Peltier manual is also available separately Maximum watts 56.2 40x40mm Imax 5.5A Vmax 16.7 Tmax (c-dry N2) 72 £32.95 (inc manual) REF PELT1, just manual £4.40 ref PELT2

GASTON SEALED LEAD ACID BATTERIES

1.3AH 12V @ £5.50 GT1213
3.4AH 12V @ £8.80 GT1234
7AH 12V @ £8.80 GT127
17AH 12V @ £19.80 GT1217

All new and boxed, bargain prices. Good quality sealed lead acid batteries

COMPAQ 1000mA 12vdc power supplies, new and boxed. 2 metre lead DC power plug 2.4mmx10mm £5.25 each, 25+ £3.50 100+£2.50

1.2ghz wireless receiver Fully cased audio and video 1.2ghz wirelessreceiver190x140x30mm metal case, 4 channel, 12vdc Adjustable time delay, 4s, 8s, 12s 16s. £49.50 Ref EE20

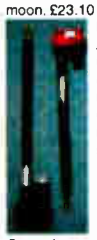
The smallest PMR446 radios currently available (54x87x37mm). These tiny handheld PMR radios look great, user friendly & packed with features including VOX, Scan & Dual Watch. Priced at £59.99 PER PAIR they are excellent value for money. Our new favourite PMR radios! Standby: - 35 hours Includes:- 2 x Radios, 2x Belt Clips & 2 x Carry Strap £59.95 Ref ALAN1 Or supplied with 2 sets of rechargeable batteries and two mains chargers £93.49 Ref Alan2

The TENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart pacemaker. Batteries supplied. £21.95Ref TEN327 Spare pack of electrodes £6.59 Ref TEN327X

Dummy CCTV cameras These motorised cameras will work either on 2 AA batteries or with a standard DC adapter (not supplied) They have a built in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with fixing screws. Camera also has a flashing red led. £10.95 Ref CAMERAB

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infrared output using standard light bulbs Easily cut to shape. 6" square £16.50 ref IRF2 or a 12" sq for £34.07 IRF2A

THE TIDE CLOCK These clocks indicate the state of the tide,Most areas in the world have two high tides and two low tides a day, so the tide clock has been specially designed to rotate twice each lunar day (every 12 hours and 25 minutes) giving you a quick and easy indication of high and low water. The Quartz tide clock will always stay calibrated to the moon. £23.10 REF TIDEC



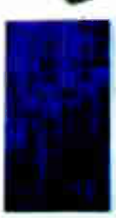
LINEAR ACCTUATORS 12-36VDC BUILT IN ADJUSTABLE LIMIT SWITCHES POWDER COATED 18" THROW UP TO 1,000 LB THRUST (400LB RECOMMENDED LOAD) SUPPLIED WITH MOUNTING BRACKETS DESIGNED FOR OUTDOOR USE These brackets originally made for moving very large satellite dishes are possibly more suitable for closing gates, mechanical machinery, robot wars etc. Our first sale was to a company building solar panels that track the sun! Two sizes available, 12" and 18" throw. £32.95 REF ACT12,

Samarium magnets are 57mm x 20mm and have a hole (5/16th UNF) in the centre and a magnetic strength of 2.2 gauss. We have tested these on a steel beam running through the offices and found that they will take more than 170lbs (77kgs) in weight before being pulled off. With keeper. £21.95 REF MAG77

New transmitter, receiver and camera kit. £69.00

Kit contains four channel switchable camera with built in audio, six IR leds and transmitter, four channel switchable receiver, 2 power supplies, cables, connectors and mounting bracket. £69.00 Wireless Transmitter Black and white camera (75x50x55mm) Builtin 4 channel transmitter (switchable) Audio built in 6 IR Leds Bracket/ stand Power supply 30 m range **Wireless Receiver** 4 channel (switchable) Audio/video leads and scart adapter Power supply and Manual £69.00 ref COP24

This miniature **Stirling Cycle Engine** measures 7" x 4-1/4" and comes complete with built-in alcohol burner. Red flywheel and chassis mounted on a green base, these all-metal beauties silently running at speeds in excess of 1,000 RPM attract attention and create awe wherever displayed. This model comes completely assembled and ready to run. £106.70 REF SOL1



High-power modules using 125mm square multi crystal silicon solar cells with bypass diode Anti reflection coating and BSF structure to improve cell conversion efficiency: 14%. Using white tempered glass, EVA resin, and a weatherproof film along with an aluminum frame for extended outdoor use. system Lead wire with waterproof connector. 80 watt 12v 500x1200 £315.17, 123w 12vdc 1499x662x46 £482.90
165 w 24v 1575x826x46mm £652.30

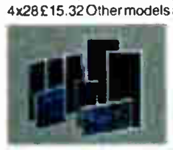
Ultra-compact, lightweight, easy to use and comfortable to hold, the new NVMT is unique for a night scope in offering a tactile, suregrip plastic bodyshell and, for extra protection/grip, partial rubber armouring. Currently the top of the range model, the NVMT G2+ features a 'commercial grade' Gen 2+ Image Intensifier Tube (IIT). The NVMT has a built-in, powerful Infrared (IR) Illuminator for use in very low light/total darkness. Power for the scope and IR is provided by 1 x 3V Lithium CR123A battery (not supplied). A green LED next to the viewfinder indicates when the Image Intensifier Tube is switched on while a red LED indicates when the IR Illuminator is switched on.Type Gen Weight Size Lens Mag 2x, Weight 400g, 125x82x35mm angle of view 30 deg, built in infra red, rang 3 - 400m, supplied with batteries £849 ref COB24023.

55 - 200 WATT INFRA RED TORCHS

Search guard 1 infrared torch Plastic bodied waterproof infrared rechargeable lamp. 100mm diameter lens, 200mm body length. 55 watt bulb, 1,000,000 candle power (used as an indication of relative power) Supplied complete with a 12v car lighter socket lead/charger and a 240v mains plug in charger. £49 REF sguard 1. Also available, 70watt @ £59, 100 watt @ £79, 200watt @ £99.

AIR RIFLES FROM £24.70

B2 AIR RIFLE Available In .177 and .22• 19" Tapered Rifled Barrel• Adjustable Rear Sight• Full Length Wooden Stock• Overall Length 43" approxBarrel Locking Lever • Also available in CARBINE Grooved for Telescopic Sight model with 14" barrel • no front sight for use with scope. Weight approximately 6lbs Extremely Powerful .22 £28.90, .177 £24.70, pellets (500) £2.55, sights 4x20 £6.80. 4x28 £15.32 Other models available up to £250 www.airpistol.co.uk



12V SOLAR PANELS AND REGULATORS
9 WATT £58.75
15 WATT £84.25
22 WATT £126.70
Regulator up to 60 watt £21.25
Regulators up to 135 watt £38.25

The combination of multi-crystal cells and a high-reliability module structure make this series of solar panels the ideal solar module. For large-scale power generation hundreds or even thousands of modules can be connected in series to meet the desired electric power requirements. They have a high output, and highly efficient, extremely reliable and designed for ease of maintenance. Separate positive negative junction boxes and dual by-pass diodes are a few examples of some of its outstanding features. Supplied with an 8 metre cable. Perfect for caravans, boats, etc. Toughened glass.

LOCK PICK SETS 16, 32 AND 60 PIECE SETS

This set is deluxe in every way! It includes a nice assortment of balls, rakes, hooks, diamonds, two double ended picks, a broken key extractor, and three tension wrenches. And just how do you top off a set like this? Package it in a top grain leather zippered case. Part: LP005 - Price £45.00

This 32 piece set includes a variety of hooks, rakes, diamonds, balls, extractors, tension tools ... and comes housed in a zippered top grain leather case. If you like choices, go for this one! Part: LP006 - Price £65.00

If your wants run toward the biggest pick set you can find, here it is. This sixty piece set includes an array of hooks, rakes, diamonds, balls, broken key extractors, tension wrenches. and even includes a warded pick set! And the zippered case is made, of course, of the finest top grain leather. First Class! Part: LP007 - Price £99.00

Mamod steam roller, supplied with fuel and everything you need (apart from water and a match!) £85 REF 1312 more models at www.mamodspares.co.uk

Mamod steam roller, supplied with fuel and everything you need (apart from water and a match!) £130 REF 1318 more models at www.mamodspares.co.uk

PEANUT RIDER STIRLING ENGINE This all metal, black and brass engine with red flywheel is mounted on a solid hardwood platform. comes complete with an alcohol fuel cell, extra wick, allen wrenches, and Owner's Manual.Specifications: Base is 5-1/4" x 5-1/4", 4" width x 9" height, 3/4" stroke, 3-1/2" flywheel £141.90

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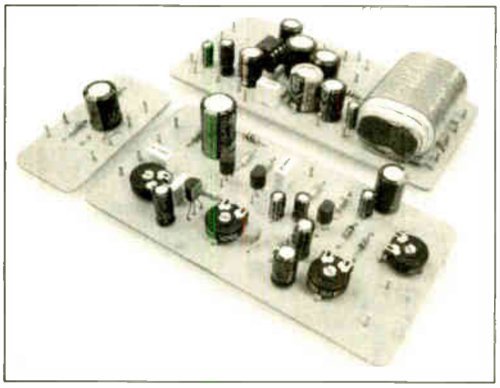
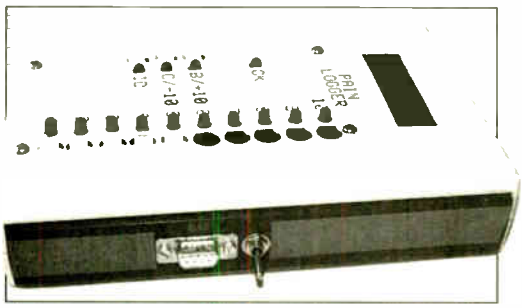
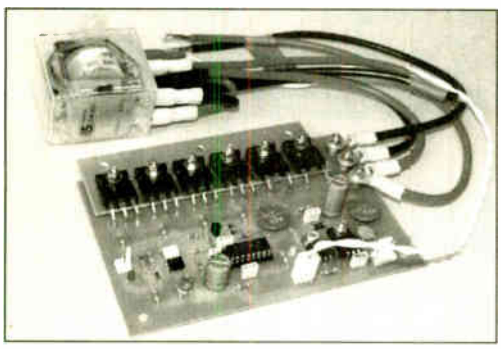
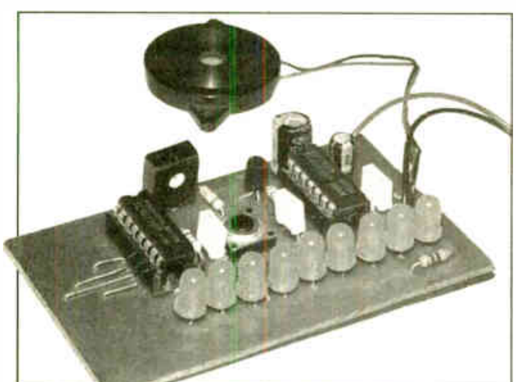








Our September 2005 issue will be published on Thursday, 11 August 2005. See page 523 for details

Projects and Circuits

Series and Features

Regulars and Services

NEXT MONTH

SNOOKER AND DARTS SCOREBOARD

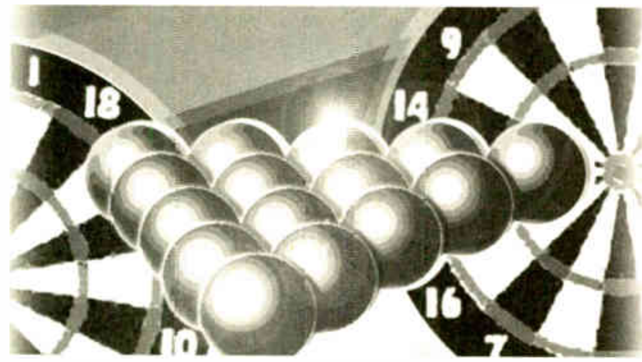
This Snooker and Darts Scoreboard was suggested by a reader – so standby your cues and arrows ready for next month's issue!
Score data is entered via a 4 x 4 matrixed data keypad, processed to suit the game type by a PIC microcontroller. The resulting data values are output to a matrixed 8-digit 7-segment l.e.d. array, suitable for viewing by a small audience, and an alphanumeric l.c.d. display module for the benefit of the scorer (adjudicator). The l.e.d. digits are basically 50mm size, although larger ones can be used.
In snooker mode, each player's frame score is shown, together with the current break count, the value of the balls left on the table, and the number of frames won by each player, and fouls can be awarded.
In darts mode, each player's leg score is shown and the number of legs won. The starting leg value can be set for any between 101 and 1001, in steps of 100. In both games adjudicator errors in data entry can be amended.

CONTROLLING MODEL RAILWAY SIGNALS

In modern railways semaphore signals have mostly given way to coloured-light signals, or no signals at all, at least those at the side of the track. But in the model railway world there is a desire to include semaphore signals since part of the attraction of the hobby is the ability to show the way things were.
This article follows on from that by the late Andy Flind, PIC Quickstep *of June '04, which gave a very good introduction to stepper motors and the means of testing them. Here a specific application for stepper motors is described, using them to control the movement of semaphore signal arms.*
A number of matters are covered which will need to be considered for any stepper motor application. Even if a reader is not interested in model railway signals, the solutions adopted here may be a useful guide.

PLUS *BACK TO BASICS – 6*

- **Daily Reminder**
- **Whistle Switch**



MULTICORE CABLE TESTER

The number of fairly complex multicore cables in the home and workshop is is steadily increasing, and whether you buy or make them, so too is the chance that they may develop a fault. This unit is designed to test cables of up to eight cores, with cables having more than eight conductors being split into groups of tests.
The unit can be used with leads for Ethernet, audio, SCART, keyboard, mouse, computer monitor, modem, USB etc. It identifies a cable, checks continuity of all cores and identifies a "crossover" type. It outputs testing results via l.e.d.s and beeps from a buzzer.

ALL BAND RADIO

One might call this a "dog" of a radio. It doesn't pretend to any finesse and it doesn't have high fidelity sound. However, it has good coverage, and good sensitivity. Moreover, it is a robust design that, unlike many others. does not depend on daintily wound coils, obscure parts, or a carefully constructed antenna.
Built in Cape Town, the prototype brought in a good many stations from all around the world – loud and clear. This included the BBC, the Voice of America, Radio China, Radio Iran, the Deutsche Welle, and many more besides.
Well into the night, it even picked up local Australian stations on the medium waves.
This is a regenerative set and has sharper tuning and greater sensitivity than many other tuned radio frequency (t.r.f.) sets. On the medium waves, it works well even without an external antenna or earth, although an aerial may be attached to very good effect. Also, while its volume is modest, it is strong enough to serve as a bedside radio, or in a small workshop.

NO ONE DOES IT BETTER

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see page 547

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see page 572

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PIC & ATMEL Programmers

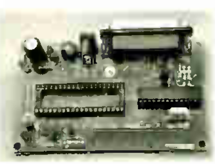
We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £15.00
18VDC Power supply (PSU010) £19.95
Leads: Parallel (LDC136) £4.95 / Serial (LDC441) £4.95 / USB (LDC644) £2.95

NEW! USB 'Flash' PIC Programmer

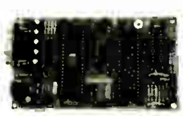
USB PIC programmer for most 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows Software. ZIF Socket and USB Plug A-B lead not incl.
Kit Order Code: 3128KT – **£34.95**
Assembled Order Code: AS3128 – **£39.95**

"PICALL" ISP PIC Programmer



"PICALL" will program virtually all 8 to 40 pin *serial-mode** AND *parallel-mode* (PIC16C5x family)* Programmed PIC micro controllers. Free fully functional software. Blank chip auto detect for super fast bulk programming. Parallel port connection. Supply: 16-18V dc.
Assembled Order Code: AS3117 – **£39.95**

ATMEL 89xxx Programmer

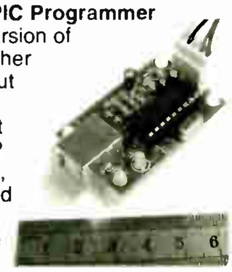


Uses serial port and any standard terminal comms program. 4 LEDs display the status. ZIF sockets not included. Supply: 16VDC.
Kit Order Code: 3123KT – **£29.95**

NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows software. See website for PICs supported. ZIF Socket and USB Plug A-B lead extra. 18VDC.
Kit Order Code: 3149KT – **£34.95**
Assembled Order Code: AS3149 – **£49.95**

USB Flash ICSP PIC Programmer



Fully assembled version of our 3128 USB Flasher PIC Programmer but WITHOUT the programming socket. It just has 5-pin ICSP header (GND, VCC, CLK, DAT, VPP) and cable. No external PSU required. Free Windows software.
Order Code: AS3182 – **£37.95**

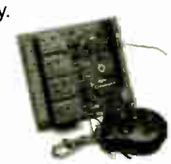
ABC Maxi AVR Development Board

The ABC Maxi board has an open architecture design based on Atmel's AVR AT90S8535 RISC microcontroller and is ideal for developing new designs.
Features:
8Kb of In-System Programmable Flash (1000 write/erase cycles) ● 512 bytes internal SRAM ● 512 bytes EEPROM
● 8 analogue inputs (range 0-5V)
● 4 Opto-isolated Inputs (I/Os are bi-directional with internal pull-up resistors)
● Output buffers can sink 20mA current (direct l.e.d. drive) ● 4 x 12A open drain MOSFET outputs ● RS485 network connector ● 2-16 LCD Connector
● 3·5mm Speaker Phone Jack
● Supply: 9-12VDC.
The ABC Maxi STARTER PACK includes one assembled Maxi Board, parallel and serial cables, and Windows software CD-ROM featuring an Assembler, BASIC compiler and in-system programmer.
Order Code ABCMAXISP – **£89.95**
The ABC Maxi boards only can also be purchased separately at £69.95 each.

Controllers & Loggers

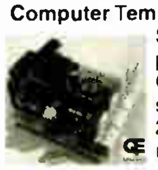
Here are just a few of the controller and data acquisition and control units we have. See website for full details. Suitable PSU for all units: Order Code **PSU445 – £8.95**

Rolling Code 4-Channel UHF Remote



State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 TXs can be learned by one Rx (kit includes one Tx but more available separately). 4 indicator LEDs.
Rx: PCB 77x85mm, 12VDC/6mA (standby).
Two & Ten Channel versions also available.
Kit Order Code: 3180KIT – **£39.95**
Assembled Order Code: AS3180 – **£47.95**

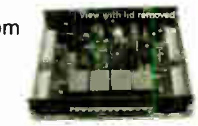
Computer Temperature Data Logger



Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Inclues one DS1820 sensor and four header cables.
Kit Order Code: 3145KT – **£16.95**
Assembled Order Code: AS3145 – **£23.95**
Additional DS1820 Sensors – **£3.95 each**

Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

NEW! DTMF Telephone Relay Switcher

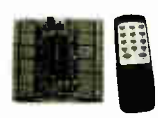


Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12VDC.
Kit Order Code: 3140KT – **£39.95**
Assembled Order Code: AS3140 – **£59.95**

Serial Port Isolated I/O Module

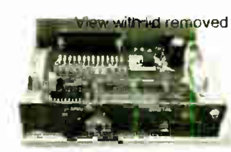
Computer controlled 8-channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130 x 100 x 30mm. Power: 12VDC/500mA.
Kit Order Code: 3108KT – **£49.95**
Assembled Order Code: AS3108 – **£59.95**

Infra-red RC 12-Channel Relay Board



Control 12 on-board relays with included infra-red remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12VDC/0·5A.
Kit Order Code: 3142KT – **£39.95**
Assembled Order Code: AS3142 – **£49.95**

PC Data Acquisition & Control Unit



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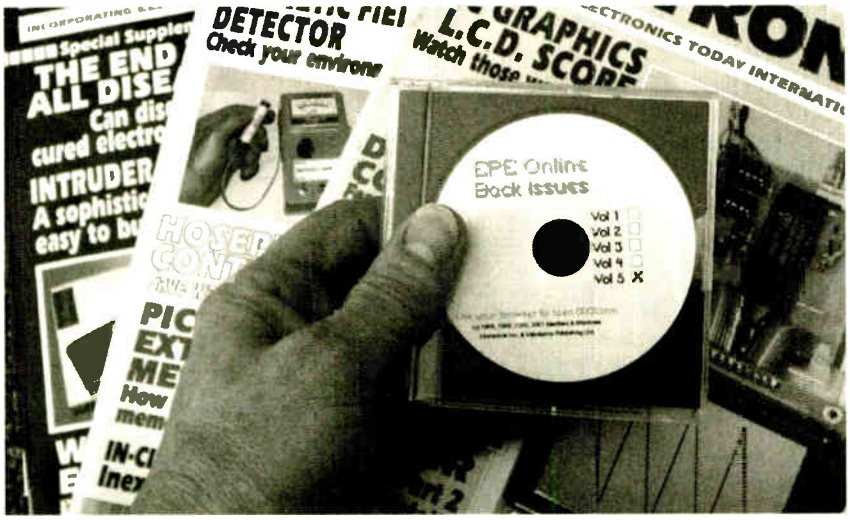

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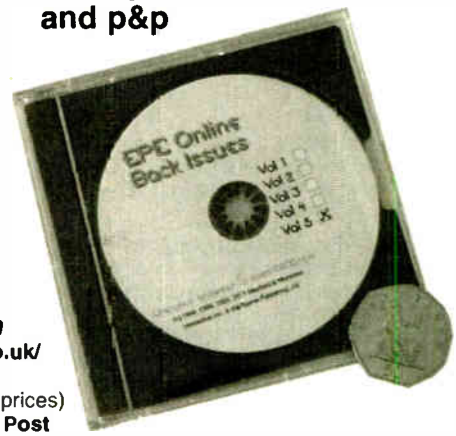

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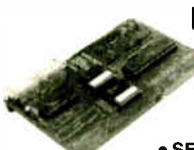

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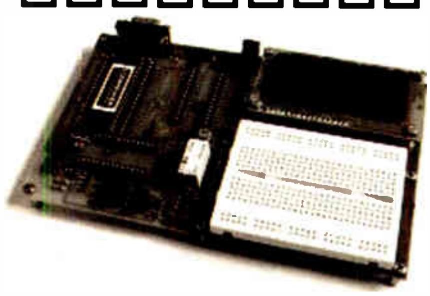

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- Works with MPASM assembler

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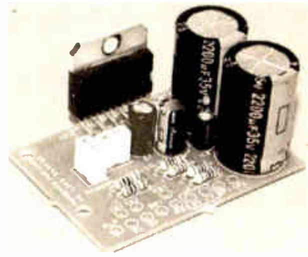

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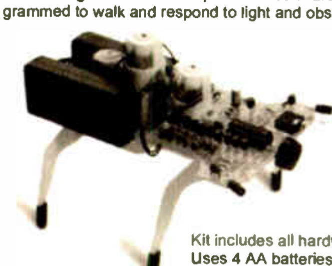

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Email: stewart.kearn@wimborne.co.uk

We're At It Again

Dosen't seem like nearly two years ago does it? What am I referring to? Our next *Teach-In* course – *Teach-In '06* – starts in the November issue. As regular readers will know we run a different *Teach-In* series every other year; they generally run for nine or ten months and the last one ran from November '03 through to August '04.

Teach-In '06 is being written by Mike Tooley BA who has been responsible for many books and articles on electronics and who has over 30 years experience teaching electronics at all levels from GCSE through to degree level. Mike has also been a regular contributor to *EPE* over the past 25 years. The new series is primarily aimed at GCSE (Level 2) standard but with some subjects (e.g. microprocessors and PICs) developed to Level 3. So if you know of someone who will be starting GCSE soon, or someone who simply wants to learn about electronics, or brush up on their knowledge, please make sure they are aware of this new series. The November issue will be published on October 13 – less than three months away now.

The course will culminate in a multiple choice on-line test which will test readers' knowledge and cover the whole series. A printed certificate will be awarded to those who gain a "pass" mark.

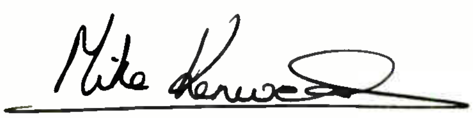
Very shortly we will be circulating advertisers with a list of parts used for the practical aspects of the series and we expect a number of them to make kits available to ease the way for newcomers to get into electronics. We will also be leafletting all UK schools with information and *special* student/teacher offers so please watch out for that in September if you are in education or are teaching electronics.

Our aim is to encourage more people into our fascinating hobby both in the UK and around the world.

Further Development

The *Speed Camera Watch* project we published back in the January '05 issue led to some criticism from readers about us encouraging people to speed – which was never our intention. The correspondence was published in *Readout* in the February to April issues. A number of readers also made suggestions about possible additions to the project and our contributor Mike Hibbet is now working on a Mark 2 version which will also provide warnings if you are exceeding the speed limit at any time, plus a number of other additions/improvements like heading in degrees, altitude, current position etc.

We expect to be able to publish the new version in the November issue. Don't miss it, to make sure of your copy every month please place a regular order with your newsagent – see page 547 or take out a subscription and save on the cover price – see page 572.



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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 £7.95 plus £3.50 p&p (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.*

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E-mail: techdept@epemag.wimborne.co.uk
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.**

PROJECTS AND CIRCUITS

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.

A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*). **We advise readers to check that all parts are still available before commencing any project in a back-dated issue.**

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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; readers should check local laws.

Constructional Project

Audio System – Communications

Raymond Haigh

A preamplifier with automatic gain control (a.g.c.) and a power amplifier with switched audio filtering for communications receivers and surveillance systems

WITH a preamplfier designed around discrete components this project should overcome the problem of specialist i.c.s disappearing from the hobbyist market that has dogged previous projects published over the years.

Using widely available transistors, the design featured here is sensitive enough to permit the direct connection of dynamic microphones, effective in compressing the dynamic range, and has low noise and distortion levels.

Also included is a single i.c. (TBA820M) audio amplifier with switched filtering. Teamed with the Preamplifier, the two circuits will considerably improve the performance of simple communications receivers and, when used with electret microphones, will ensure good performance for surveillance purposes.

Preamplifier Circuit

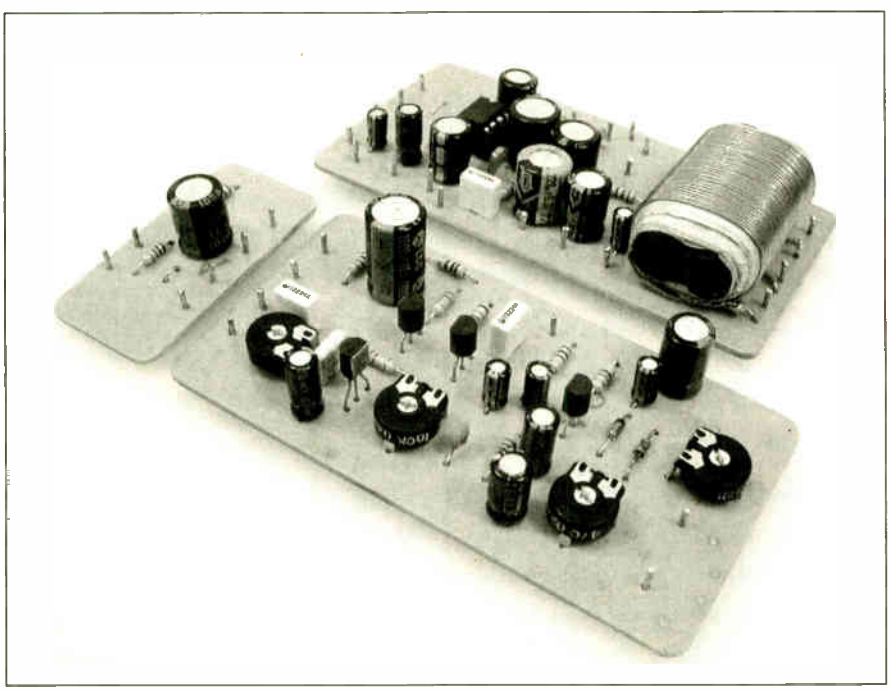
The full circuit diagram of the automatic gain controlled (a.g.c.) preamplifier is shown in Fig.1. Transistors TR1 and TR3 form a directly coupled audio amplifier.

Direct current negative feedback, via resistor R2, sets the working points of the transistors. Signal frequency negative feedback, via preset VR2, sets the gain.

Gain Control

Field effect transistor (f.e.t.) TR2 is connected as a voltage controlled resistor (in place of a conventional resistor) between the emitter (e) of TR1 and the 0V rail. The relationship between the f.e.t.'s drain-source resistance and feedback preset VR2 determines the gain of the circuit. Increasing the resistance presented by the f.e.t. reduces the gain.

In the absence of a control voltage, for example, under weak signal conditions, the f.e.t.'s drain-source channel has a resistance of around 400 ohms and the gain of the circuit is about 250 times. When a negative-going control voltage is applied to the gate (g) of TR2, its drain-source resistance rises and gain is reduced. If the control voltage is high enough, for instance, under strong signal conditions, the f.e.t.'s resistance increases to several thousand ohms, and gain falls to single figures.



Line-up of circuit boards that combine to make this simple audio system. Small board, electret mic power supply; power amplifier (top) and (foreground) the preamplifier

Control Voltage

Field effect transistor characteristics vary widely, but most display greatest resistance change over a control voltage swing of around –1.5V (low resistance) to –2V (high resistance). Our two-transistor preamplifier (Fig.1.) with its 9V supply cannot deliver an output of this magnitude without severe distortion, so transistor TR4 further amplifies the signal in order to provide an adequate control voltage.

The gain of TR4 is set between around 10 and 100 times by varying the application of negative feedback via its emitter. Bypass capacitor C10 is connected to the slider (moving contact) of preset VR3, which acts as TR4's emitter resistor.

As the slider is moved towards the 0V rail, more of the emitter resistor becomes un-bypassed, negative feedback increases, the gain of the stage is reduced, and the magnitude of the control voltage, for a given signal input, falls. By this means, the amount of signal compression can be set to suit individual requirements.

On the Double

The voltage doubling rectifier system formed by diodes D1 and D2 makes the most of the signal delivered by transistor TR4. With this arrangement, the charge developed across capacitor C12, during one half-cycle, is added to the rectified voltage delivered during the next, and the output at the anode (a) of D2 approaches twice the peak value of the signal voltage.

The control voltage must be negative going with respect to the 0V rail (to suit the *n*-channel f.e.t.), and the diodes, signal strength meter and capacitor C5 are connected accordingly.

On the Attack

Reservoir capacitor C5, and the resistance presented by the signal strength meter circuit, have a time-constant that determines the speed with which the system responds to changes in signal level. It should be as rapid as possible, but too short a time constant (resulting from a low value of capacitance or resistance) will produce a noticeable "breathing" or "pumping" sound as the system goes in and out of action during passages of speech.

A compromise has to be struck, and the value quoted for C5 will be found suitable for most applications. Reducing it below 4·7μF will result in severe distortion, while values above 100μF or so will make the attack too slow.

Noise Limiting

Care has to be taken when amplifying low-level signals to minimize the introduction of additional noise. The noise generated by a bipolar transistor can be reduced by operating it at a low collector current, typically between 10μA and 50μA. This technique is adopted here, where feedback and biasing resistors R2 and R4 and the collector load resistor R1 fix the current through TR1 at about 40μA.

Many readers will be familiar with this arrangement which, until the widespread introduction of integrated circuits, formed the basis of most high-fidelity preamplifiers for use with low-output tape heads, microphones and turntable pick-ups. Indeed, the only novel element is the addition of the automatic gain control system.

Input impedance, at the base (b) of TR1, is around 50 kilohms, but the optimum signal source impedance, for minimum noise, is between 5 kilohms and 10 kilohms. This has influenced the value of input potentiometer VR1.

Frequency Response

The frequency response of the basic circuit is flat over the audio spectrum, but the values of d.c. blocking capacitors C1 and C2, at the input, C8, at the output, and bypass capacitor C4, have been kept small in order to attenuate the lowest audio frequencies. Accordingly, response rolls off below about 300Hz, and is about 18dB down at 50Hz.

This reduces the low frequency rumble that can be introduced by microphones in some environments. Alternative component values are listed (see Fig.1) to assist readers who require an extended low-frequency response. More is said about reducing audio bandwidth in order to improve clarity later.

Preset potentiometer VR2 is the amplifier's gain-setting signal feedback "resistor". Its slider (moving contact) is connected to bypass capacitor C6. Moving the slider towards the emitter (e) of TR1 increasingly bypasses the resistor at high frequencies, and the additional negative feedback further reduces gain in this region of the audio spectrum. This measure greatly reduces the "hiss" introduced by the amplifier at high gain settings.

Supply Decoupling

The Preamplifier is decoupled from the supply rail by resistor R5 and capacitor C3, the latter having a high value in order to ensure stability, particularly when the unit shares a common battery supply with a power amplifier. The control voltage amplifier, transistor TR4, is decoupled by resistor R7 and capacitor C11.

The function of most of the components has now been covered. All that remain are TR3's collector (c) load resistor R3, d.c. blocking capacitors C7, C8 and C9, and TR4's base (b) bias resistor R6 and collector load resistor R8.

Bypass capacitor C4 across TR3's emitter resistor, R4, has been given a low value in order to produce negative feedback at low frequencies and help with rolling off the response below 300Hz.

Signal Strength Meter

Some readers may wish to install a Signal Strength Meter (ME1), and preset potentiometer VR4 acts as a series resistance so that a 50μA instrument can be used to measure the voltage across the a.g.c. line. Full-scale deflection is set by

BASICS

At the heart of all audio compressor amplifiers is a voltage or current controlled signal attenuator. The control voltage is obtained by rectifying the output from the amplifier. As the output tries to increase, so does the voltage fed back to the attenuator, and the rise in output for a given change in input is reduced, i.e., the dynamic range of the signal is compressed.

Junction field effect transistors (f.e.t.s) can be used as voltage controlled resistors. At very low values of drain-source voltage, varying the gate-source potential changes the resistance of the drain-source channel from a few hundred to several thousand ohms. This phenomenon is exploited in Dolby noise reduction systems and in most modern circuits for altering the dynamic range of audio signals.

The f.e.t. can be connected as one half of a potential divider in the signal path, or it can be used to vary gain-reducing negative feedback applied across the controlled amplifier. This is the method adopted in the circuit described here.

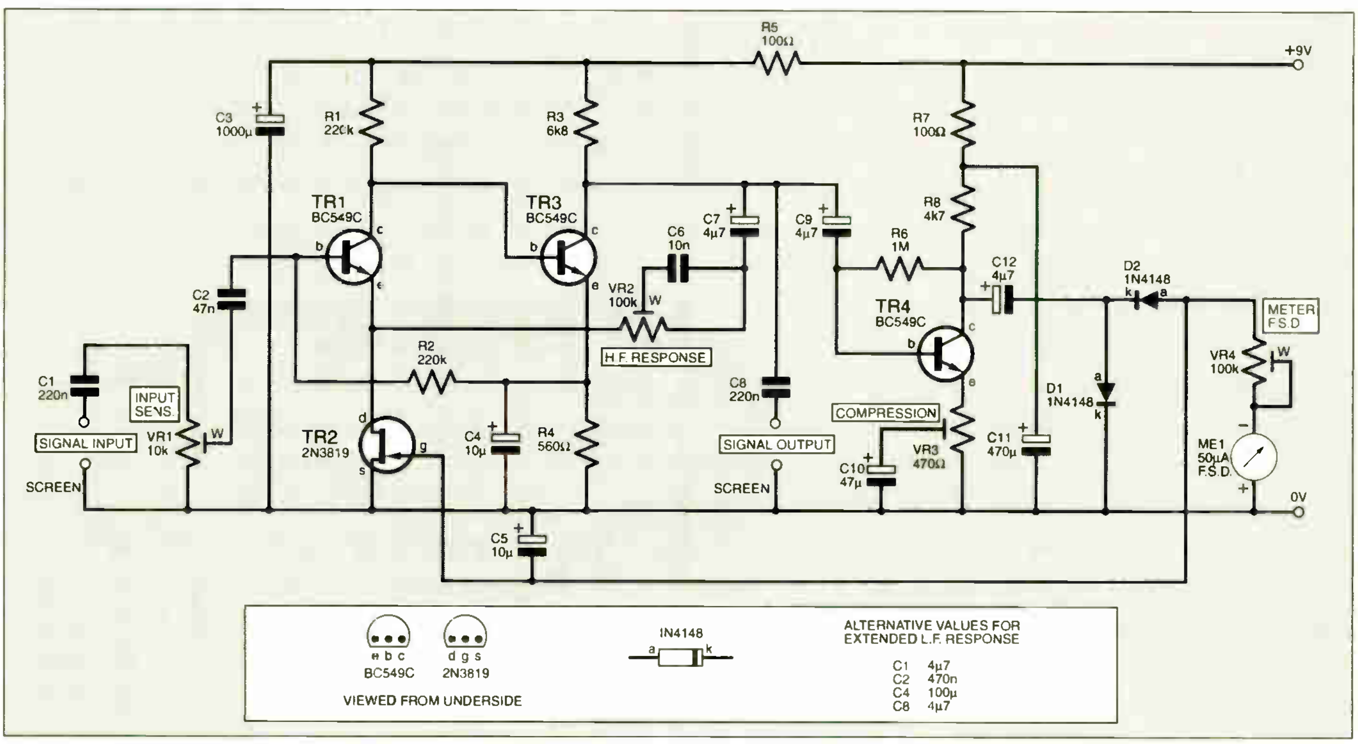


Fig.1. Complete circuit diagram for the audio Preamplifier, with variable compression. The signal strength meter ME1 is optional – see text

COMPONENTS

Approx. Cost Guidance Only **£11** *excl meter & batts*

PREAMPLIFIER

Resistors

R1,R2	220k (2 off)	**See SHOP TALK page**
R3	6k8	
R4	560Ω	
R5,R7	100Ω (2 off)	
R6	1M	
R8	4k7	

All 0·25W 5% carbon film

Potentiometers

VR1	10k enclosed carbon preset
VR2,VR4	100k enclosed carbon preset (2 off)
VR3	470Ω enclosed carbon preset

Capacitors

C1,C8	220n polyester (2 off)
C2	47n polyester
C3	1000µ radial elect. 16V
C4,C5	10µ radial elect. 16V (2 off)
C6	10n polyester or ceramic
C7,C9, C12	4µ7 radial elect. 16V (3 off)
C10	47µ radial elect. 16V
C11	470µ radial elect. 16V

Semiconductors

D1,D2	1N4148 signal diode (2 off)
TR1,TR3, TR4	BC549C *npn* transistor (3 off)
TR2	2N3819 *n*-channel field effect transistor

Miscellaneous

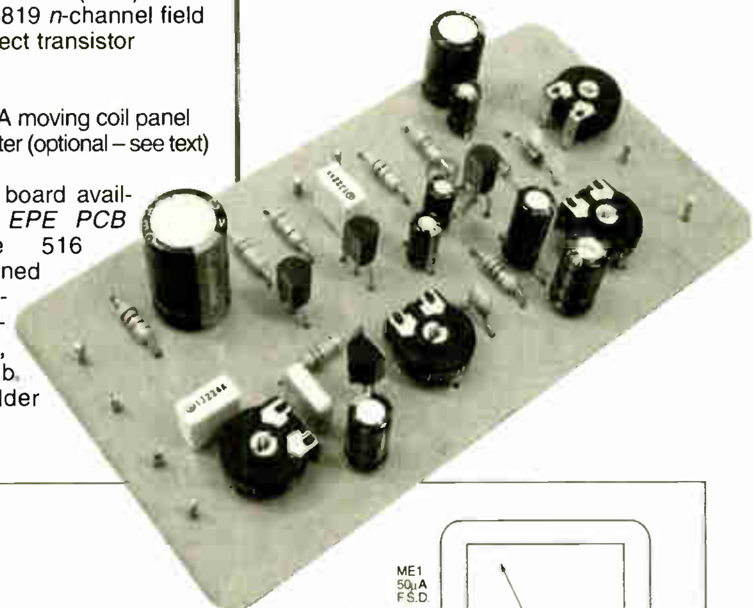
ME1	50µA moving coil panel meter (optional – see text)

Printed circuit board available from the *EPE PCB Service*, code 516 (Preamp); screened audio cable; multistrand connecting wire; nuts, bolts and p.c.b. stand-offs; solder pins; solder etc.

as shown in Fig.2 and Fig.9. If it is connected to a mains power supply, locate the mains transformer and the mains wiring as far away as possible from the input circuitry.

Testing

On completion, check the board for poor soldered joints or bridged copper tracks, and check the placement of components and the orientation of electrolytic capacitors and semiconductors.



adjusting VR4 when a very strong signal is being processed.

A less sensitive 100µA meter can be fitted at a pinch, but a higher current instrument will load the output from the diode voltage doubler excessively and reduce the control voltage available at the gate (g) of TR2. Most of the inexpensive units retailed as signal strength meters have full-scale deflections of 250µA or more, and *are not* suitable for use in this circuit.

The time constant of the a.g.c. network is affected by the setting of preset VR4, and it may be necessary to increase the value of capacitor C5 to 22µF if a 100µA meter is fitted.

If a signal strength meter is not required, set VR4 to maximum resistance and wire a link across the meter output pins. ***Failure to do this will remove the discharge path from C5 and the a.g.c. circuit will not function.***

Construction

All the components for the Preamplifier, except the optional signal strength meter, are assembled on a single printed circuit board (p.c.b.). The topside component layout and full-size underside copper foil master pattern are shown in Fig.2. This board is available from the *EPE PCB Service*, code 516.

Solder pins, inserted at the lead-out points, will simplify the off-board wiring, and they should be inserted first. Follow these with the resistors and then the capacitors, beginning with the smallest. The semiconductors should be mounted last, and it is good practice to attach a miniature crocodile clip to the leads of the f.e.t. (TR2) to act as a heat shunt whilst soldering.

Do not rely on signal cable screening braid to connect the 0V power rail to the Preamplifier. Make a separate connection,

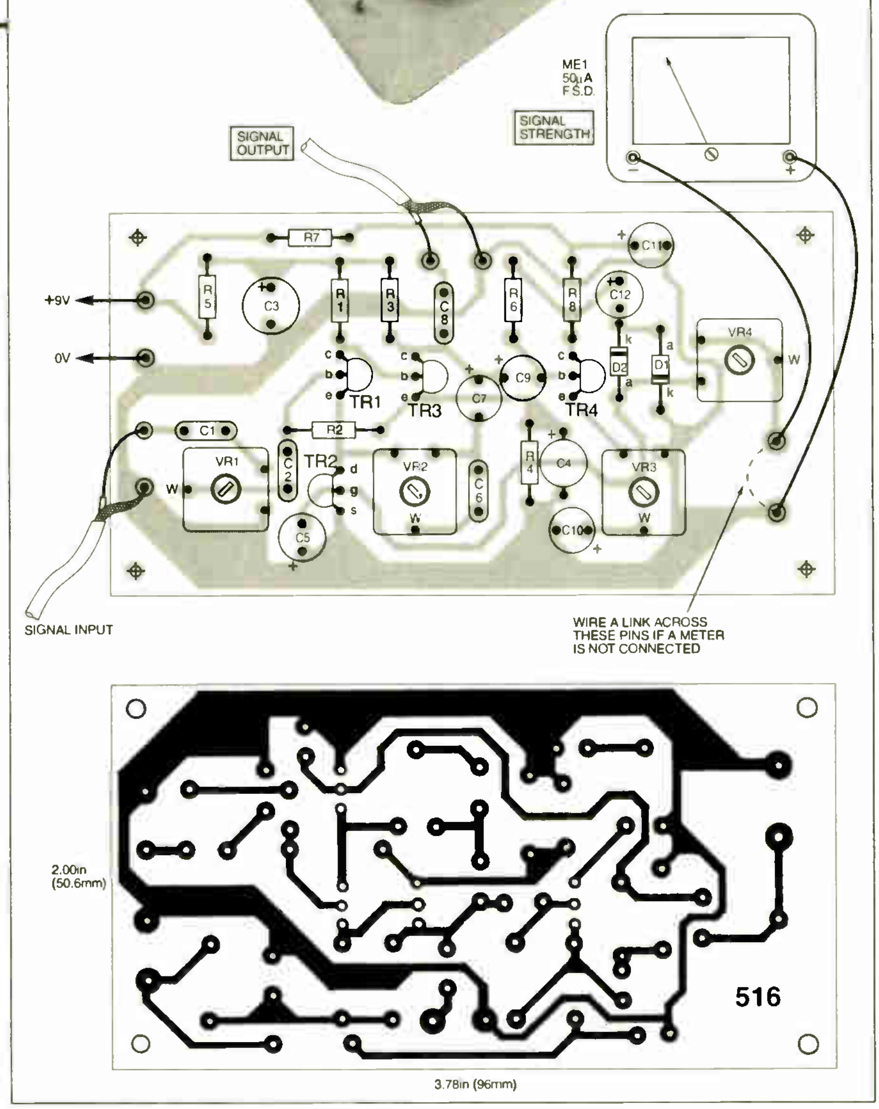


Fig.2. Printed circuit board component layout, wiring details and full-size copper foil master pattern for the Preamplifier. A photograph of the completed circuit board is shown above

If all is in order, set preset pots VR1, VR2, VR3 and VR4 at minimum (fully anti-clockwise) and ***bridge the output pins to the signal strength meter if this facility is not being used.*** Note that a digital test meter cannot be connected in place of the moving coil signal strength meter: its input resistance is likely to be too high. A digital meter can, however, be connected ***across VR4 to check the control voltage.***

Using screened cable, connect the Preamplifier input to a suitable signal source, and its output to an audio power amplifier and speaker. Connect a well-smoothed mains power unit or a fresh 9V battery to the board. Current consumption should be approximately 2mA.

With the input Sensitivity control, VR1, set to deliver a signal large enough to activate the a.g.c. system, rotate Compression control VR3 clockwise. The output from the amplifier should reduce quite dramatically if the input level has been set high.

Clockwise rotation of H.F. Response preset VR2 will reduce the high frequency response of the unit and have a noticeable effect on noise levels at high gain settings. If a Signal Strength Meter is connected, clockwise rotation of preset VR4 will move the needle pointer clockwise when the a.g.c. system is operating, and full-scale deflection can be set under strongest signal conditions.

The settings of the various preset potentiometers should, of course, be refined to optimize performance when the unit is brought into use.

Performance

A plot of the signal input and output at two settings of the Compression control, VR3, is given in Fig.3.

With the control set for maximum compression (curve B), signals up to 0·08mV peak-to-peak (0·03mV r.m.s.) are amplified about 250 times. Above this level, the gain of the preamplifier is progressively reduced and the dynamic range of the signal compressed.

With inputs in excess of 0·5mV peak-to-peak (0·17mV r.m.s.) the control voltage moves into the region where f.e.t. TR2's resistance change is most pronounced and the output is held at between 30mV and 35mV peak-to-peak (10mV r.m.s.) over the normal input range of the preamp.

Turning back Compression preset VR3 (curve A) raises the compression threshold and increases the output from the preamp.

Sensitivity

Although the above figures define the sensitivity of the unit, they are not necessarily a clear guide to suitable signal sources, and the following notes may prove useful.

Normal (low cost) dynamic microphones will usually deliver a more than adequate signal, and electret microphones, with their larger output, will ensure good performance when the unit is used for surveillance purposes.

The output from the detector in a regenerative receiver will fully load the Preamplifier, as should the output from an active detector in a direct conversion receiver. Passive product detectors in direct conversion sets may require additional amplification ahead of the preamp.

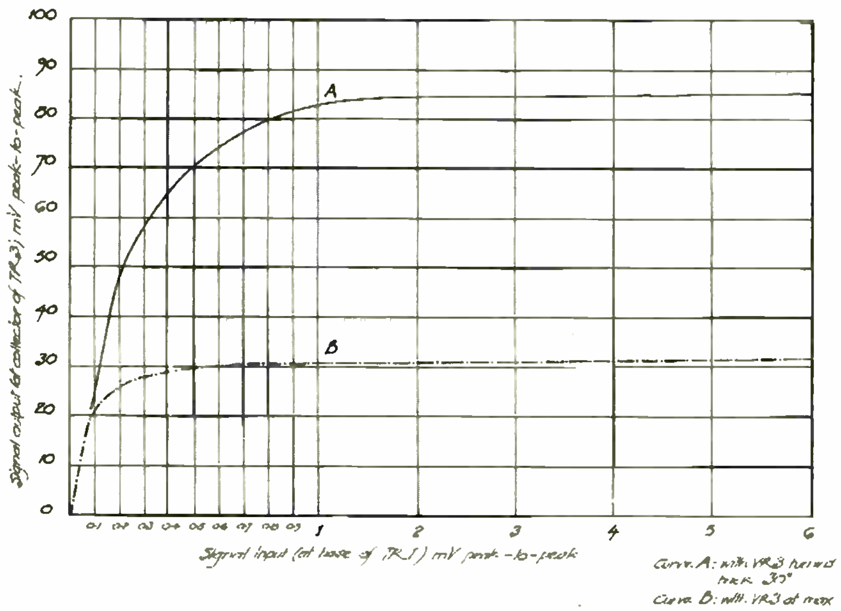


Fig.3. Waveform plot of the input/output voltages, at two settings of compression control VR3, of the automatic gain control (a.g.c.) Preamplifier

The input control, VR1, will have to be set almost at zero when the Preamplifier is connected to the detector in a superhet receiver, and an additional attenuator, between receiver and preamp, may prove helpful.

Microphones

Very high quality studio microphones can be insensitive, and they often require a balanced input to minimize hum pick-up. They are not suitable for use with the preamplifier described here.

Screened cable ***must*** be used to connect any microphone to the preamplifier, and the various types are described, very briefly, below.

Dynamic (Moving Coil)

Dynamic microphones can be connected directly to the input of the Preamplifier. Manufactured with impedances ranging from 50 ohms to 600 ohms, the units with the highest impedance tend to give the greatest output, and are best for use with this amplifying system.

Electret

Electret microphones are a modern development of the capacitor microphone. They contain a permanently charged plate, the electret, which eliminates the need for an external charging voltage. Basic output is very low, but the units incorporate a field effect transistor (f.e.t.) to amplify the signal to a useable level.

A power supply is required for the f.e.t., and some electret units have a battery compartment in the handle. Remote powering is to be preferred, especially when the microphones are used for surveillance purposes, and a suitable circuit is given in Fig.4.

Remote powering, via the signal cable, is made possible by locating the microphone amplifier's load resistor, R1, at the preamplifier end of the line. The supply voltage is dropped by R2, and this resistor, together with capacitor C1, decouples the microphone from the power supply. Approximately 4·5V is maintained across the microphone amplifier and its

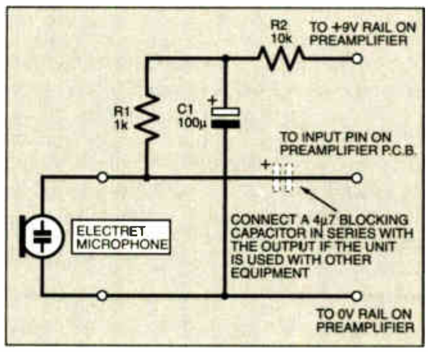


Fig.4. Circuit diagram for powering an electret microphone

COMPONENTS

ELECTRET MIC. POWER BOARD

Resistors — **See SHOP TALK page**

R1	1k	
R2	10k	
All 0·25W 5% carbon film		

Capacitors

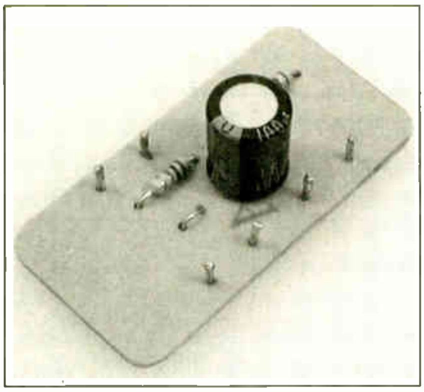
C1	100μ radial elect. 16V

Miscellaneous

MIC1	min. electret mic insert

Printed circuit board available from the *EPE PCB Service*, code 517 (Elec.Mic); screened audio cable; multistrand connecting wire; solder pins; nuts, bolts and p.c.b. stand-offs; solder etc.

Approx. Cost Guidance Only **£7** *excl meter & batts*



load, R1, and this is in accordance with the recommendations of most electret manufacturers.

If the circuit is used with other amplifiers, the value of resistor R2 ***must*** be adjusted to suit the supply voltage. A d.c. blocking capacitor should also be provided in the output lead; shown dashed in the circuit diagram.

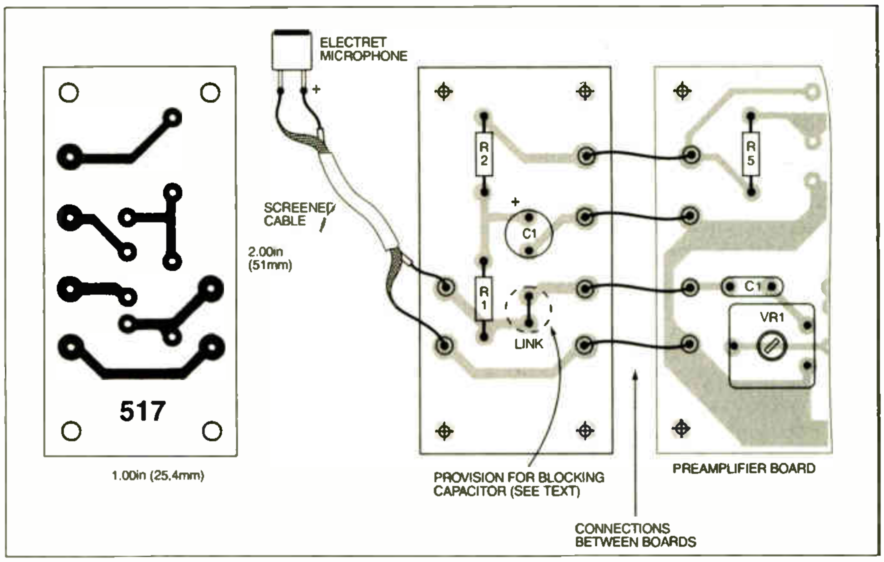


Fig.5. Printed circuit board layout, copper foil master and wiring to the Electret Mic. board

Circuit Board

A small printed circuit board (p.c.b.) for remote powering of electret microphone inserts from the Preamplifier board is shown in Fig.5. This board is available from the *EPE PCB Service*, code 517.

The connections to the electret microphone board align with the connections on the Preamplifier board, and the units should be mounted as close together as possible. If, for some reason, the boards have to be parted, use screened cable for the signal connection. Remember to insert a wire link on the p.c.b. if the blocking capacitor is not fitted in the output circuit.

Crystal and Ceramic

Crystal and ceramic microphones rely on the piezoelectric effect to convert the movement of a diaphragm into electrical impulses. Rochelle salt is generally used for crystal microphones, and lead zirconium titanate compounds for ceramic units.

The impedance of both types is high, typically between one million and five million ohms, and the output can approach 50mV. Connecting these units directly to the Preamplifier will impair their low frequency response (which might not be a bad thing), and performance may be improved by connecting them via a series resistor of 100 kilohms (100kΩ), or even 220 kilohms (220kΩ).

The audio quality delivered by these microphones is inferior to that of electret and dynamic types.

Power Amplifier

THE clarity of speech signals can be greatly improved by reducing the response of the audio system to frequencies below 300Hz and above 3000Hz. This practice is adopted by telephone companies world-wide.

Fairly complex active filters are commonly used to tailor the frequency response in this way, but simpler measures can produce very acceptable results. An arrangement of this kind has been adopted for the Power Amplifier circuit, designed around a TBA820M audio power amplifier i.c., depicted in Fig.6.

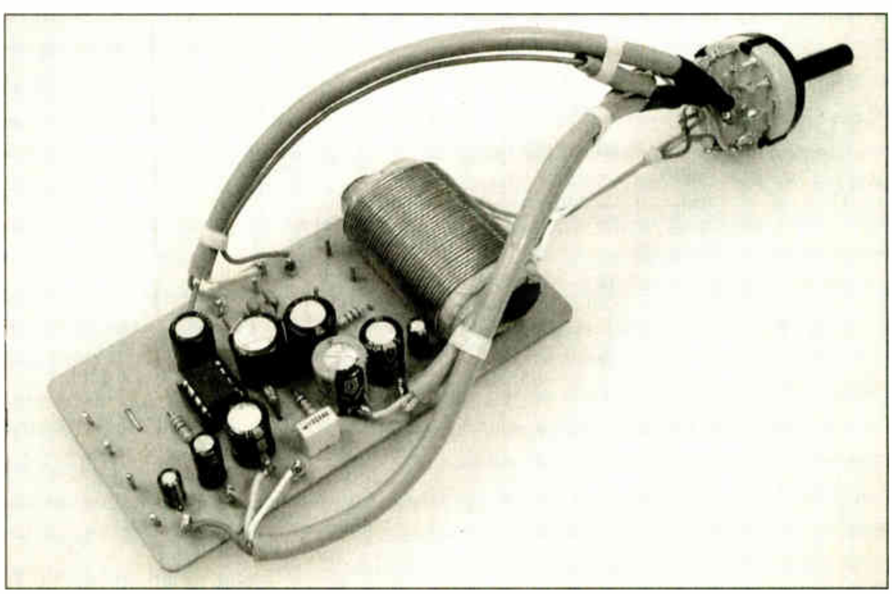
Feedback

The TBA820M i.c. (IC1) has two accessible feedback networks. The first, brought out at IC1 pin 2, uses resistor R1, connected to the 0V rail via a capacitor, to control the gain. The lower the value of the resistor, the greater the gain.

Reducing the value of the blocking capacitor progressively increases feedback, and reduces gain, as frequency is lowered. Switch S1a connects capacitors of different value, C1, C2 and C3, into circuit in order to produce the different levels of low-frequency attenuation.

The second feedback network, brought out at IC1 pin 1, controls the high frequency response of the amplifier. Negative feedback from the output at pin five is connected to pin one via a switched capacitor. The larger the value of the capacitor, the greater the negative feedback, and the greater the reduction in the high frequency response of the amplifier.

Switch S1b connects capacitors of different value, C5 and C6, into circuit in order to produce different levels of high frequency attenuation. Note that the lowest value capacitor, C7, is permanently connected in order to ensure stability.



Reactance

The above measures, by themselves, have a very noticeable effect on the frequency response of the amplifier. Roll-off at the low and high frequency ends of the spectrum is not, however, very steep, and further measures need to be taken to increase the rate of attenuation.

By placing a capacitor or inductor in series with the loudspeaker or phones, its reactance (frequency dependant resistance) can be used in a more direct way to modify the response of the system.

Output pin 5 is held at half the supply voltage, and the speaker, LS1, has to be connected via a d.c. blocking capacitor. Switch S1c selects capacitors of different value, C10, C11 and C12. The smaller the value of the capacitor, the greater its reactance at low frequencies, and the more the low frequency output to the speaker is attenuated.

Conversely, the reactance of inductors increases as frequency increases. Switch S1d connects different inductance values in series with loudspeaker LS1 in order to modify the high frequency response.

The full winding of L1 has an inductance of 1·5mH. An inductor of this value presents a reactance of almost 48 ohms at 5kHz. Placing it in series with an 8 ohm speaker will, therefore, produce an attenuation of 8dB at 5kHz.

Centre tapping L1 produces an inductance of around 0·5mH. Connecting this into circuit gives a reduced level of high frequency attenuation.

COMPONENTS

Approx. Cost Guidance Only **£14** *excl speaker, batts & extras*

POWER AMPLIFIER

Resistors

R1	22Ω	
R2	56Ω	
R3	1Ω	
R4	3k9	

All 0·25W 5% carbon film

See SHOP TALK page

Potentiometers

VR1	10k rotary carbon, log.

Capacitors

C1,C8	100μ radial elect. 16V (2 off)
C2	22μ radial elect. 16V
C3,C10	10μ radial elect. 16V (2 off)
C4,C11	47μ radial elect. 16V (2 off)
C5	680p ceramic
C6	220p ceramic
C7	68p ceramic
C9	220n polyester
C12	220μ radial elect. 16V
C13	100n ceramic
C14	470μ radial elect. 16V

Semiconductors

D1	2mA low current red l.e.d.
IC1	TBA820M audio power amp i.c.

Miscellaneous

L1	1·5mH inductor coil – see text. Ferrite rod, 9mm (3/8in) dia. × 102mm (4in) long. 50g (2oz) reel of 22s.w.g. (21a.w.g.) enamelled copper wire
S1	4-pole 3-way rotary switch
S2	s.p.s.t. toggle switch
SK1	6·35mm (1/4in.) stereo jack socket, with switched contacts
LS1	8 ohm loudspeaker (see text)
B1	9V battery pack (6 × AA), with holder

Printed circuit board available from the *EPE PCB Service*, code 518; 8-pin d.i.l. socket; l.e.d. holder; 3-core screened audio cable; 4-core screened audio cable; multistrand connecting wire; nuts, bolts and p.c.b. stand-offs; solder pins; solder etc.

Note: If the preamp and amplifier are assembled as a single stand-alone unit, a metal or plastic case, phono sockets, and speaker terminals, will be required.

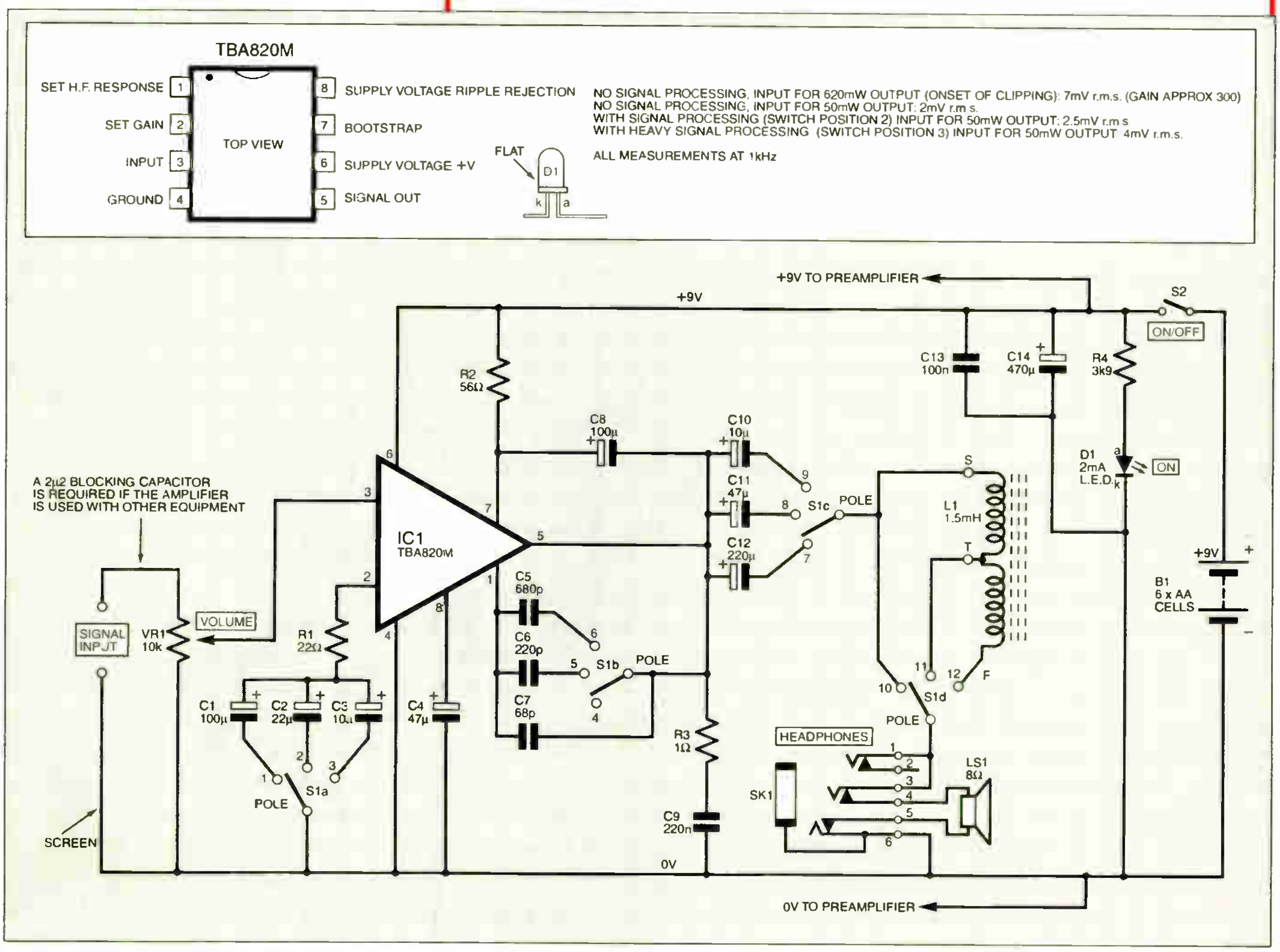


Fig.6. Full circuit diagram for the audio Power Amplifier with switched high and low frequency attenuation

Response

Combining these measures produces the frequency response curves displayed in Fig.7. Because of the simplicity of the arrangement, response is humped rather than flat over the speech frequency range. However, the 12dB per octave roll-off beyond the band limits greatly improves the clarity of signals overlaid by noise.

The first level of processing, curve B, is usually all that is required. Background rumble is eliminated from microphone signals, and the muffled, bass-heavy response of a critically adjusted regenerative receiver is corrected.

When high gain settings have to be used to make very weak signals audible, heavy processing, as depicted in curve C, may prove helpful. Reproduction is very "thin" in this mode, but voices are still clearly recognizable and readers involved in surveillance, as well those interested in radio reception, should find it useful.

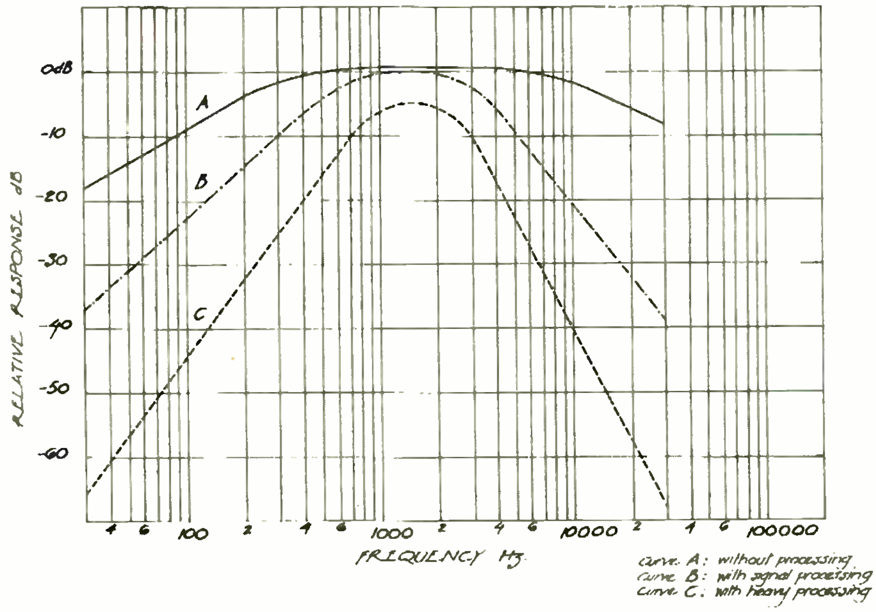


Fig.7. Frequency response plots of the audio Power Amplifier, with and without signal processing

Amplifier

Turning now to the actual Power Amplifier circuit Fig.6, potentiometer VR1 acts as the Volume control and resistor R1 pre-sets the gain of the circuit. The d.c. blocking capacitor for the input is located on the Preamplifier board. If the Power Amplifier is used with other equipment, fit a 2·2μF electrolytic d.c. blocking capacitor in series with the input (negative plate to the top-end of VR1).

Supply line ripple is rejected by capacitor C4 and resistor R3 and capacitor C9 form a Zobel network that protects the internal output transistors from damage by high level transients. Stability at high and low frequencies is ensured by bypass capacitors, C13 and C14.

Although quite rugged, the TBA820M chip does *not* contain overload protection circuitry. Care should, therefore, be taken to avoid shorting the speaker leads, and the maximum supply voltage (12V with an 8 ohm speaker; 9V with a 4 ohm unit) should not be exceeded.

Inductor Coil

Details of the inductor (L1), which is wound on two short lengths of ferrite aerial rod, are given in Fig.8. The wire gauge is not critical, but it ought not to be smaller than 26s.w.g. (25a.w.g.). The author's inductor was wound with 22s.w.g. enamelled copper wire.

Use masking tape to bind the rods together and to hold individual layers of the winding in place. The rod can be cut by filing a deep groove around its circumference before snapping it.

Only half of the coil is in circuit when S1d is in mid-position. This should be the two layers of the winding closest to the ferrite rods, and the correct conections are shown in Fig.6 and Fig.9 (the inductances of the two halves of the centre-tapped winding are not equal).

Construction

The topside printed circuit board component layout, interwiring details and full-size underside copper foil master for the Power Amplifier are shown in Fig.9. This board is also available from the *EPE PCB Service*,code 518 (Power Amp).

Assemble the board in the usual order of ascending component size, ensuring that the electrolytic capacitors are inserted the correct way round as shown. Use an 8-pin d.i.l. socket for IC1, but do not insert the i.c. until the assembly has been completed and checked for accuracy.

Using a holder for the i.c. will make substitution and checking easier, and the socket should be located on the board first. Solder pins should now be inserted at the lead-out points, followed by the resistors and then the capacitors, smallest first. The inductor coil L1 can be stuck in position with cyanoacrylate adhesive (Superglue).

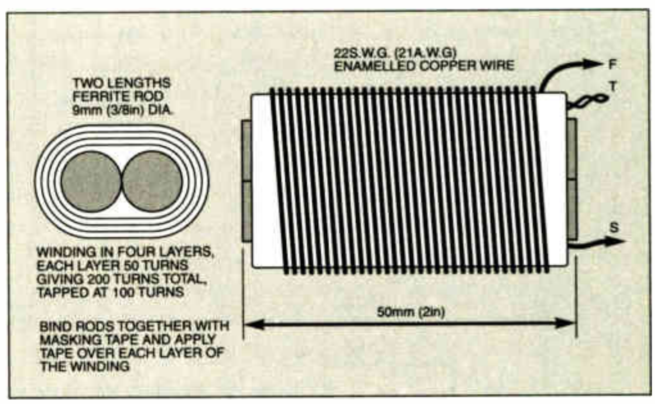
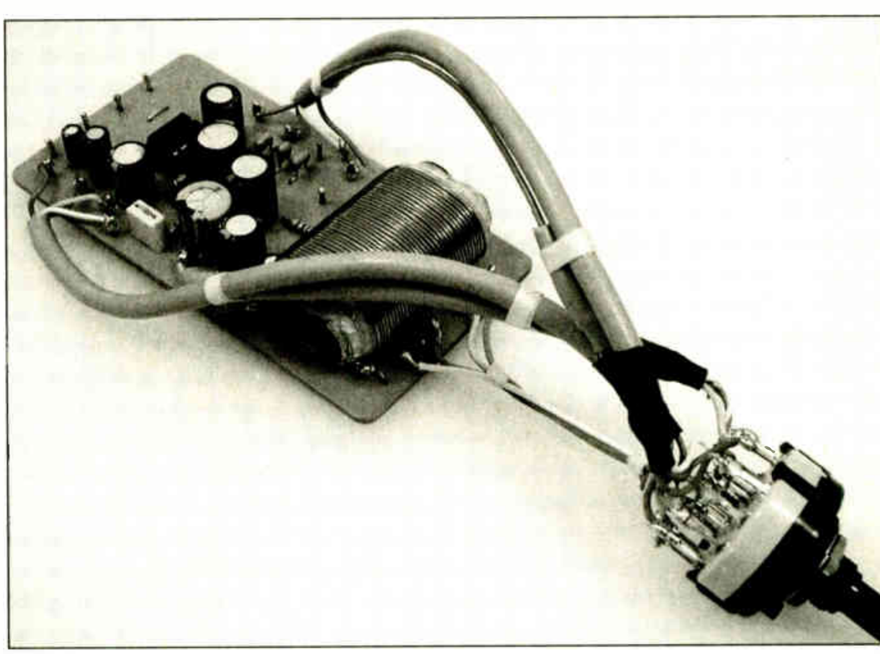


Fig.8. Construction and winding details for inductor coil L1

Remember to insert a wire link at the input if a d.c. blocking capacitor is not fitted.

Provision is not made on the printed circuit board for the l.e.d. indicator D1 and its dropping resistor R4. These components form part of the off-board wiring (see Fig.9).



Power Amplifier circuit board wired to the 4-pole 3-way attenuator/filter switch using screened cables

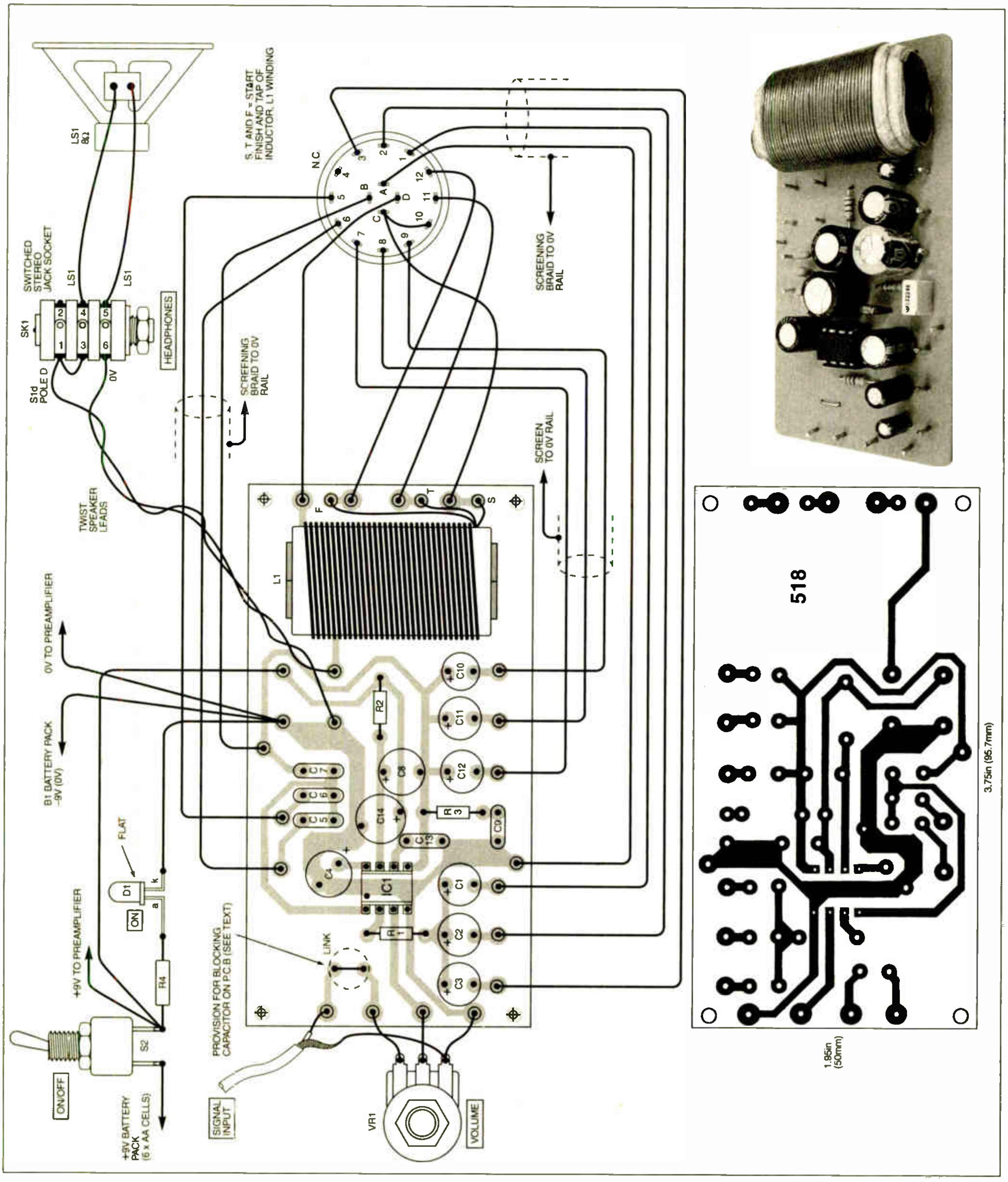


Fig.9. Printed circuit board full-size underside copper foil master and off-board wiring details for the Power Amplifier. The screened leads between the p.c.b. and S1a to S1d must not be longer than 152mm (6in). Note the separate 0V lead to the Preamplifier board. The completed board is shown above right

Switch Wiring

In the prototype unit, four-core screened cable is used to connect switch-ways A, B and C to the board. Screening may not be necessary (unscreened leads were not tried), but it does make the wiring neater and easier to follow.

Keep the switch wiring away from the input pins, and twist the speaker leads to minimize radiated fields.

Testing

As before, check the board for poor soldered joints and bridged copper tracks, and check the placement and orientation of components.

If all is in order, connect Volume control VR1, an 8 ohm speaker and a 9V battery or power supply to the p.c.b. Current consumption, without the l.e.d. indicator, should be approximately 5mA.

Connect a signal source and operate the filter switch. The progressive reduction in bandwidth should be very evident.

Details of amplifier sensitivity are given inset at the top of Fig.6.

Speakers

If very small size is not important, use a 100mm (4in) or 150mm (6in) diameter speaker. Larger units produce a bigger output for a given electrical input, and reproduction is usually clearer. Speakers with a high power rating can be insensitive and are best avoided for this purpose.

Enclosure venting should be equal to the effective cone area or the sound quality will be muffled and "boxy". □

TECHNO-TALK MARK NELSON

SHORTENING THE WAIT

Will that bus *ever* come? Yes, maybe sooner rather than later as new technology is brought into service, as Mark Nelson reveals

THERE are few acts of human faith greater than waiting for a bus. Fortunately new technology is reducing the uncertainty of this boring activity and along with more accessible and comfortable buses is assisting the renaissance of public urban transport. The embodiment is new but the thinking behind it goes back more than half a century.

But first, a personal observation – it's funny how people waiting for a train or bus start talking sometimes. I shall never forget how a total stranger in London once told me that he never consulted a timetable before he travelled, as the chances were he'd have to run the last five minutes to make sure of catching his bus or train. By turning up when it suited him, he avoided the aggravation of knowing he had just missed one.

If only all public transport users were so easily satisfied. They expect frequent services that keep to time and adequate information when things go awry. And at the prices they pay these days, perhaps this request is not an unreasonable one. Be that as it may, the technology of keeping passengers informed is our topic this time.

Terms of Reference

PIS and CIS IT and communications people are sometimes guilty of choosing rather uninspired acronyms for their creations. Their chosen term Passenger Information Systems (PIS) has fortunately fallen into disuse these days but its replacement, CIS, is barely an improvement. It stands for Customer Information Systems, which always annoys traditionalists since these people are passengers, not customers. Wags, however, quote the old joke, what's the difference between a passenger and a customer? Answer: a customer is a passenger who has paid his fair!

Producing timely information displays is not difficult but deploying them at an economic cost often is. The airlines and railways have managed this for years but they have a relatively small number of airports and stations to look after, with the added advantage of existing fixed communications infrastructures. When it comes to delivering comparable information and displaying it at several thousand bus stops in a network the figures soon add up to telephone numbers, not helped by much lower average fares to pay for this system.

Meshed Net

The solution, so far as we passengers are concerned, is an l.e.d. "next bus" display installed under the roof of bus waiting shelters. Most of these are three-line affairs, showing the route number and destination of the next three buses to arrive along with a countdown of the number of minutes until expected arrival.

Making this possible is a GPS satellite tracking system, a central computer and a data delivery mechanism. The tracking system monitors in real time the position of each vehicle, which the central computer then analyses and uses to estimate the buses' arrival times at each stop along the route.

Put like that it sounds quite straightforward, but how do you get the data to each indicator? First-generation systems used modems and telephone lines but these were fearfully expensive. The latest thinking is mesh radio, which does away with the need for high-powered conventional base stations.

The system instead relies on a large number of "nodes" connected by low-power point-to-point radio links. Each bus stop receiver site is also a transmitter and repeats the signal to other nodes in range. Messages are coded and are ignored by all nodes except the one identified by the code. The fact that messages reach their destination via a series of links is no great disadvantage in this application.

Far more important is the fact that the mesh radio approach allows the use of low power microwave devices at the nodes, reducing start-up costs and making it feasible to provide information over a wider area.

The city of Portsmouth leads the way in Britain with this technology and since last November has equipped its entire fleet of 308 buses and 37 bus shelters for this advanced information system. So far the network has cost £4.2 million but is already saving money, with an annual expenditure of £70,000 on phone line charges eliminated.

Long Wait?

Knowing that your bus won't arrive for another ten minutes is not much of a consolation, but it does at least allow you to wander off to buy a paper or a cup of coffee, assured the bus won't turn up while your back is turned. It also eliminates another form of doubt, as I recall from when I was a bus conductor in Canterbury. "You're late," exclaimed a thunder-faced woman as we arrived at her stop. But before I could reply my driver put her right, shouting for all to hear: "No we're not, we're the next one running five effing minutes early!"

Funny perhaps, but leaving ahead of the booked time is very bad business, whereas running late is excusable if the traffic is congested. For this reason large bus systems like London's have controllers who can turn buses back if their chances of reaching their destination are hopeless. They can also draft in extra buses or delay one vehicle if buses become bunched together.

London is implementing its own satellite tracking system for buses, although currently its automatic vehicle location (AVL) scheme relies on 5,000 beacons attached to lampposts across the metropolis. Bus locations are calculated at least once a minute using odometers on vehicle wheels and microwave signals from the beacons. In turn the beacons relay their signal to control systems in 80 bus garages and thence to a central hub in Chingford.

BESI Before Beacons

London's new GPS vehicle location system is amazingly the fourth embodiment of the concept. Before the microwave beacon system mentioned above came the Bus Electronic Scanning Indicator (BESI for short). Developed in 1959, this is generally regarded as the world's first modern bus tracking system.

Revolutionary in its day, it involved fitting small reflective panels carrying binary codes to the side of buses. A number of optical scanners at traffic hot spots recorded the identities of passing buses and transmitted this data to a central point for analysis.

This was not London's first stab at regulating bus services with electronics, however. The first experiment took place as long ago as 1938. Known as the "electric bus inspector", it involved fitting buses with a simple inductive transmitter connected to a 15-turn energiser coil on the roof of the vehicles, the signal being detected when the bus passed under antennas strung across the roadway.

The received impulses were amplified and sent by telephone line to London Transport headquarters, frequency-coded to indicate the route of the bus. Here the signal was filtered and further amplified so as to print a mark on a slowly revolving paper chart and indicate the exact time a bus passed the way point in question. Charts were changed daily and analyzed subsequently to study and trace the cause of repeatedly recurring delays.

Basic as the "electric bus inspector" appears to our eyes, it was portrayed at the time as a marvel of the age, with enthusiastic descriptions in *Wireless World* and the *Meccano Magazine*. London Transport had great plans for the system and hoped to install pick-up antennas all over central London, connected by landlines in tube train tunnels. Alas World War Two was only just around the corner and these ambitious plans had to be abandoned. With luck their replacement will be in service seventy years later!

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RD Research

News . . .

A roundup of the latest Everyday News from the world of electronics

ANALOGUE TV SWITCH-OFF UPDATE

Barry Fox reports the latest news on the planned switch off of the UK's analogue TV transmissions

OFCOM has now decided on what it sees as the best way to switch off Britain's analogue TV, starting in 2008 and ending by 2012.

The three multiplexes used by the public service broadcasters (BBC, ITV, Channels 4 and 5) will all use 64QAM modulation, to deliver 24Mbps and six or seven TV programme channels. Currently the BBC and Freeview use the more robust 16QAM system, which delivers 18Mbps and thus fewer programme channels. As the risk of interference to analogue services disappears, digital transmitters are able to work at higher powers, so there is less need for a robust signal. Virtually all receivers automatically switch between 16QAM and 64QAM, so no screens will go dark.

Ofcom also wants the broadcasters to switch from 2K Coded Orthogonal Frequency Division Multiplex modulation to 8K COFDM, with around 8000 carriers used instead of around 2000. This will let the UK use single frequency networks, where several transmitters work on the same frequency and the receiver picks up the strongest signal and rejects weaker signals which arrive with different delays.

The 2K system was adopted to let the UK start digital terrestrial TV before 8K receiver chips were ready. Modern receivers now have chips that automatically work either with 2K or 8K signals. But receivers sold for use with the failed On Digital/ITV Digital service, early IDTVs and some early Freeview boxes will not cope with 8K broadcasts and thus stop working. The total number of affected sets is around a hundred thousand.

The UK did have a single frequency free for the whole country (UHF channel 35), but it was given to Channel 5 in 1996 for analogue use when C5 started broadcasting in 1997. New single frequencies can be unlocked as analogue transmissions end.

Government Deliberating

The Department of Culture Media and Sport, which is the government ministry responsible for broadcasting, says it has yet to make a final decision on whether to follow the Ofcom recommendations. But the DCMS says the phased transition from analogue to digital, starting in 2008 and ending in 2012, was a Labour Party "manifesto commitment".

Intellect, the trade association for the UK hi-tech industry, says Ofcom's final report is a "leap forward" to the provision of the best, most robust, and future-proof DTV network possible for the UK.

Says Laurence Harrison, Director of Consumer Electronics at Intellect: "We welcome Ofcom's decision to adopt a 64QAM/8K network (but) it is important that capacity is available for HD content on the DTT platform as manufacturers are already producing HD-Ready products in anticipation of this increased demand and it is therefore vital that Public Service Broadcasters have the channel capacity available to broadcast in HD."

Intellect also worries about the reaction from consumers who are left with dark screens by the 8K switch. Intellect's fear is that manufacturers and dealers will be left pacifying angry customers and perhaps have to give them new sets.

But Intellect's message is so mildly worded that the message may not get through: "We are disappointed that Ofcom has failed to recommend support to consumers with legacy products with 2K only receivers", is all that Intellect says for public consumption.

Proteus VSM

Labcenter Electronics have added the ARM7-based LPC2000 family to the range of microcontrollers supported by their Proteus VSM co-simulation software. Users can now simulate an LPC2000 device along with external peripherals such as displays and keypads, and also general electronics such as signal processing or power control circuitry. Firmware code running on the target device can be single stepped and debugged as it interacts with the rest of the system.

Chairman and Chief Software Architect John Jameson said, "this is the first time we have supported a 32-bit microprocessor within the VSM architecture and it makes for an impressive demonstration of the power of Proteus – it's quite something to see a hardware/software co-simulation of a system powerful enough to run Linux!".

For details about Labcenter's full range of products, including p.c.b. design and microcontroller co-simulation, contact Labcenter Electronics, Dept EPE, 53-55 Main Street, Grassington, N.Yorks BD23 5AA. Tel: 01756 753440. Fax: 01756 752857. Web: **www.labcenter.co.uk**.

New Quasar Digital Labs

Quasar Electronics have extended their range of Electronic Projects Labs with four new products:

Their Electronic Digital Recording Laboratory (EPLDR) at £24.95 makes a great introduction to the world of advanced electronic digital recording technology. It contains all the parts and instructions to build over 50 educational and fun experiments.

With their Metal Detector kits, one of them handheld, you can learn by building your own treasure hunter, for just £9.95 – and who knows what you might find! The fourth introduction is an Electronic Room Alarm kit. At only £4.95, even on pocket money you can keep your room off-limits to unwanted invaders!

For more information contact Quasar Electronics Ltd, Dept EPE, PO Box 6935, Bishops Stortford CM23 4WP. Tel: 0871 717 7168. Fax: 07092 203496.
Email: sales@quasarelectronics.com.
Web: **www.quasarelectronics.com**.

Ezireader

It's good to hear of electronic devices which are intended for use by the disabled. Ezireader is a new device that falls into that category. It is a light-weight handheld unit that allows partially-sighted people to read their newspapers, or whatever, in large print on a TV or VCR screen.

Ezireader is simply plugged into the SCART socket, its power supply connects to a normal mains power socket. Point the device at the text to be read, press AV on the TV's or VCR's remote control, and the image can be seen enlarged by about 10 to 15 times on the screen.

Ezireader's inventor Harry Mitchell is partially sighted and registered blind. Although TV readers were already available commercially, he felt they were too expensive for most people. So he put his mind to work, basing his creative ability on his previous history in the field of electronics. The result is Ezireader, currently costing £135 for a black and white unit, or £165 for colour.

Harry is also looking for people who would be prepared to assemble these units, and he has an advert in respect of this in our *Classifieds* section.

For more details contact Harry Mitchell, 17 Woodpath House, Woodpath, Southsea, Hants PO5 3DX. Tel: 02392 830158.

WCN's Latest Arrivals

WCN Supplies have sent us a shorty-catalogue detailing their "latest arrivals". Amongst the items are a 12V 24Ah sealed lead-acid rechargeable gel-type battery, for £19.95, that you might consider if you are building the Motor Amplifier elsewhere in this issue. For less-demanding applications, their 12V 2.3Ah rechargeable battery for £4.95 could well be of interest to you.

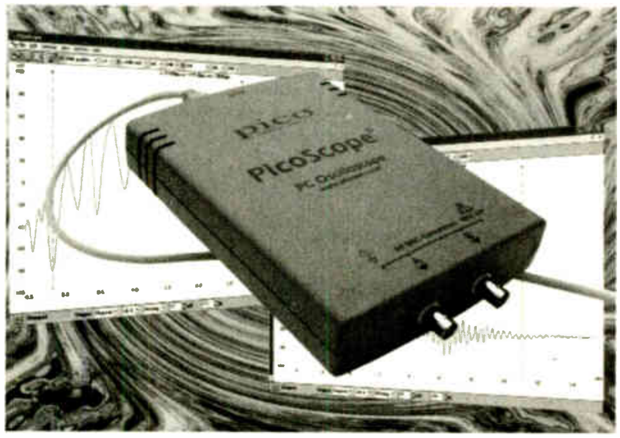
WCN have a good selection of electronics components, some at prices which you'd be hard pressed to match elsewhere. If you are not already on their mailing list – you should be.

For more information contact WCN Supplies, Dept EPE, The Old Grain Store, Rear of 62 Rumbridge Street, Totton, Southampton SO40 9DS.
Tel/Fax: 023 8066 0700.
Email info@wcnsupplies.fsnet.co.uk.

PicoScope 2202 PC Scope

Pico Technology tell us that they have released the latest addition to their range of PC oscilloscopes, the PicoScope 2202. Connected to your PC and powered by its USB 2.0 port, this dual-channel scope has 8-bit resolution, 20MHz sampling rate and a 32KB memory. In combination with the PicoScope and PicoLog software included, the unit acts as an oscilloscope, spectrum analyser, multimeter and data logger.

This new unit has been designed with the hobbyist and educational markets in mind. With its high sampling rate, the oscilloscope is useful in a variety of electronic applications, including audio amplifiers, switched-mode power supplies and microcontrollers, and for displaying waveforms obtained from laboratory experiments.



The USB 2.0 port makes the device easy to use with all standard desktop and laptop PCs and removes the need to configure printer ports.

The PicoScope 2202 is priced at £199 plus VAT. For more information contact Pico Technology Ltd., Dept EPE, The Mill House, St Neots, Cambs PE19 1QB. Tel: 01480 396395. Fax: 01480 396296.
Email: sales@picotech.com.
Web: **www.picotech.com.**

Wave Goodbye to the Mouse?

Anyone who uses a mouse or joystick knows the problem – fatigue and aches and pains caused by precise repetitive finger clicking. British research company Qinetic lets the user share control of the PC between ordinary mouse finger action and sweeping hand gestures (WO 2004/102301).

A mat like a mouse mat has crossed lines of l.e.d.s embedded in the surface, to emit timed pulses of infra-red. Sensors in the mat detect reflections from a hand moving above. In learning mode the PC is taught to associate the user's chosen gestures with basic commands, like open and close programmes, scroll through a page or read email. From then on the user can either use the mouse or wave commands.

Motorola has a different answer to the same problem (WO 2004/061751). Some PCs already have an optical sensor that reads the user's fingerprint instead of asking for a password. Motorola will make the sensor larger so that the user can slide a finger tip over the surface. The sensor detects the direction and speed at which the finger print ridges and furrows are moving.

Barry Fox

Abracadabra!

Perhaps slightly off-topic for an electronics mag (but we have occasionally published designs of an illusory/magical nature), the Science Museum in London is putting on two shows, in which "the secrets of magic and illusion are debunked".

Their press release says that "the enigmatic world of magic and illusion is to be unlocked after centuries of secrecy at the UK's only venue dedicated to debates on contemporary science, the Science Museum's Dana Centre." There are to be two "unique" evenings of spectacle, discussion and illusion on 27 and 29 July at the Centre, which is fast developing a reputation for creating innovative science events for adults.

The events will be hosted by one of the UK's leading physiologists and former magician, Professor Richard Wiseman, and will involve jaw-dropping performances by critically acclaimed Las Vegas magician Jeff McBride.

"This is the first time that science and magic have been brought together in this way", says Professor Wiseman. "Conjuring is undergoing a renaissance in the UK. It is great to have this opportunity to explore the topic."

The tickets are free but *must* be pre-booked on 020 7942 4040 or via tickets@danacentre.org.uk. The Dana Centre is at 165 Queens Gate, London SW7 5HE. Note that the Centre is for over 18s only. The events will be webcast live on **www.danacentre.org.uk**.

Hitchhiker's Pocket Guide

Hitchhiker fans will be delighted to know that a real version of the *Hitchhiker's Guide to Galaxy* (H2G2) can be purchased and, in a manner of speaking, kept in your pocket. The BBC's website recently highlighted this intriguing fact, stating that "the mobile edition has been made by the BBC rather than the 'great publishing houses of Ursa Minor' who, in Douglas Adam's book, created the original". It was released to coincide with the UK release of the H2G2 film.

Owners of smartphones and handheld computers will be able to access the guide while they are out and about. The portable edition contains 7000 articles from the H2G2 site, covering life, the Universe and everything. To access it send "H2G2" in a text message to 81010, or simply visit **www.bbc.co.uk/mobile/h2g2**.

PIC N' MIX

JOHN BECKER

Our periodic column for your PIC programming enlightenment

How to get the DS1307 RTC chip working with PICs

THIS time we examine an example of how to use a Real Time Clock (RTC) chip, the Maxim DS1307. The first time the author tried to use this chip, he had difficulty getting it to work due to inadequacy of its datasheet. It took a considerable amount of time to resolve.

The DS1307 is the RTC used in the *Pain Monitor* described elsewhere in this issue (Aug '05). It is an 8-pin device that once programmed with the correct time and date, will continue to update that data every second for as long as the chip's backup battery is connected to it, even though the +5V supply to the rest of the circuit is switched off.

It counts seconds, minutes, hours, days of the week, days of the month, month and year, and is leap year compatible. It requires its own external 32768Hz clock crystal, which should have a specified capacitance of 12·5pF to ensure good accuracy. A practical circuit diagram for its use is shown in Fig.1.

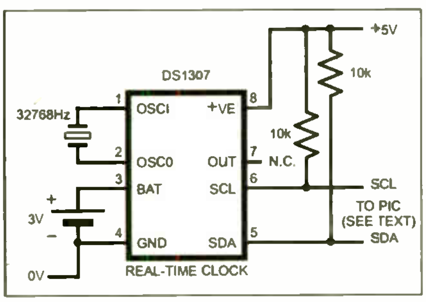


Fig.1. Basic connection diagram for the DS1307

The backup battery used in the *Pain Monitor* is a Saft LP142503PF, 1/2AA, 950mAh, 3·6V non-rechargeable Lithium battery with p.c.b. tags. This will keep the RTC running for about 10 years. Its RS stock number is 203-3894. Other batteries from 2V to about 3·6V can also be used.

Control Logic

The RTC has two control lines, SCL and SDA (clock and data) which in the *Pain Monitor* are connected to the PIC's Port C pins RC3 and RC4, which also have the same functional names of SCL and SDA. In reality, however, the chip can be connected to any two PIC port pins, with suitable adjustment to the software.

The chip operates in I^2C mode, a technique that allows 2-line data transfer between a host device and a slave. In this case the host is the PIC and the slave is the RTC. Since I^2C devices only respond to commands that are addressed specifically to them, several I^2C devices can share the same two lines.

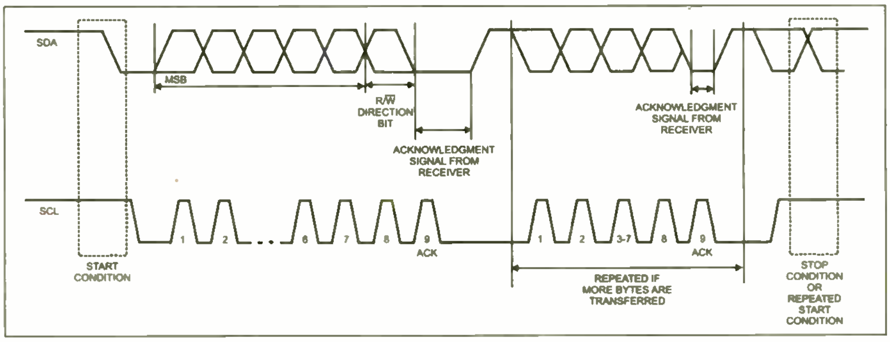


Fig.2. Timing diagram for the DS1307

Because the RTC SCL and SDA pins can be left floating when the PIC's controlling pins are put into high-impedance read-mode, these lines are each biased high by a resistor, typically of 10kΩ, although the value is not critical.

Any time the RTC is to be read from or written to, its address command is sent serially to the chip via the SDA line, each data bit being clocked into the chip using the SCL line. Only if that address is valid to the RTC will it accept further commands, either telling it to receive new data being written to it, or to output its current clock and calendar data. The control waveforms are shown in Fig.2.

Example Control Code

The initial stage of the routine for writing data to the RTC is shown in Listing 1.

In it the equated names for the SDA and SCL lines are SDATA and TCLK. At label RTCLOCK, the port pins used are first set to output mode (these commands could be set elsewhere in the program). Both port pins are then set high, and then SETSTOP (Listing 2) is called to ensure that the RTC is in Stop mode.

After this, SETSTART is called, telling the RTC to expect an ID address to be sent to it. The only ID address it will respond to at this time is B'11010000' (the serial EEPROM chip in *Pain*

LISTING 1: Send address code to RTC

```
RTCLOCK:   BANK1
           bcf TRISC,SDATA      ; ensure port pins are in output mode
           bcf TRISC,TCLK
           BANK0
           bsf PORTC,SDATA      ; set data and clock line pins high
           bsf PORTC,TCLK
           call SETSTOP         ; send Stop command to RTC
           call SETSTART        ; send Start command to RTC
           movlw B'11010000'    ; ID address for write mode
           call RTCCLKOUT       ; send ID to RTC
           movlw B'00000000'    ; set RTC for data address 0
           call RTCCLKOUT
```

LISTING 2: Stop and Start mode commands

```
SETSTOP:   bcf PORTC,SDATA      ; take data low while clk is low
           bsf PORTC,TCLK       ; take clk high while data is low
           bsf PORTC,SDATA      ; take data high while clk is high
           return

SETSTART:                       ; TCLK & SDATA assumed to be high
           bcf PORTC,SDATA      ; take data low while clk is high
           bcf PORTC,TCLK       ; take clk low while data is low
           return
```

LISTING 3: Send data byte to RTC

```
RTCCLKOUT:   movwf BYTEOUT      ; store W value in BYTEOUT
             movlw 8            ; set loop counter to 8 (bits to do)
             movwf LOOP

CLK1:        rlf BYTEOUT,F      ; rotate BYTEOUT left to get MS bit first
             bcf PORTC,SDATA    ; set SDATA low
             btfsc STATUS,C     ; is CARRY set ?
             bsf PORTC,SDATA    ; yes, set SDATA high
             bsf PORTC,TCLK     ; clk up
             bcf PORTC,TCLK     ; clk down
             decfsz LOOP,F      ; decrement loop, is it now zero?
             goto CLK1          ; no, so repeat loop
             call WAITACKRTC    ; yes, wait for RTC to acknowledge
             ; code now follows on directly to Listing 5
```

LISTING 4: Wait acknowledgement from RTC

```
WAITACKRTC:  BANK1
             bsf TRISC,SDATA    ; set SDATA as input
             BANK0
             bsf PORTC,TCLK     ; take clk high

WAIT1:       btfsc PORTC,SDATA ; wait for SDATA to go low
             goto WAIT1
             bcf PORTC,TCLK     ; take clk low
             BANK1
             bcf TRISC,SDATA    ; set SDATA as output while clk is low
             BANK0
             return
```

LISTING 5: Send clock and calendar data to RTC

```
             movf CLKSEC,W
             call RTCCLKOUT     ; send secs to RTC & wait ACK
             movf CLKMIN,W
             call RTCCLKOUT     ; send mins to RTC & wait ACK
             ;repeat for CLKHRS, WKDAY, CLKDAY, MONTH, YEAR
             call SETSTOP       ; set RTC into Stop mode
             return
```

Monitor only responds to an ID code of B'10100000').

In the RTC ID code bit 0 determines whether the code sets the RTC into Write mode (0) or Read mode (1). It *must* be set for Write mode (0) in this routine. The ID code is sent via routine RTCCLKOUT, in Listing 3.

The comments in Listing 3 explain what happens, but it's worth commenting that the bits are sent serially in order of most significant (MS) bit first, least significant (LS) bit last. After all eight bits have been sent, WAITACKRTC is called (Listing 4), in which acknowledgement from the RTC is awaited to confirm data receipt.

It is assumed in Listing 4 that acknowledgement *will* be received and the routine waits indefinitely until it is. Whilst a timeout could be inserted here, there seems little point as any failure would be due to a catastrophic event (such as chip failure), from which recovery could not be made.

Next the address at which the first data byte to be stored is sent, zero in this case (B'00000000'). Now the actual time and calendar data can be sent to the RTC. Listing 5 shows part of the routine. Here the register values have all been previously preset (see later) and they are output to the RTC in the order stated. The register names should be self-explanatory.

Note that after each write operation, the RTC address counter is automatically incremented, ready for the next data byte to be sent.

The formatting for the data is shown in Table 1. Note in particular the CH bit (bit 7) in address line 00H. This bit controls the RTC's oscillator. When the bit is set to 1 the oscillator is disabled. The oscillator is only enabled when the bit is set to 0.

The default value is 1 when the RTC is powered up for the first time (and after the backup battery has been renewed). This means that the RTC can only increment its time keeping after bit 7 is cleared to 0. Any program sending the seconds data to the RTC must also clear this bit (in the example program, the bit is automatically cleared to 0 in the CLKSEC register).

Having set the current time and calendar data into the RTC, from now on it can be read as real time data whenever you want, by calling the READRTC routine partially illustrated in Listing 6.

At label GETRTCVALUE, the five commands for reading the CLKSEC data are shown. The same commands are repeated for all values required, but with the ANDed value being changed to suit the specific value being read, and with a different destination register of course (see Table 1).

Subtle Points

There is a subtlety here that must not be overlooked in the full program. When reading the last data value from the RTC, it is not SENDACKREAD which is called after calling RTCCLKREAD, but SENDNOTACKREAD, in which the acknowledgement bit is now inverted.

Neither SENDACKREAD nor SENDNOTACKREAD are listed here, but may be examined in the *Pain Monitor* ASM code.

As with writing to the RTC, when reading data the first few commands must send the RTC ID and the first address that will be accessed.

It should be noted though, that when setting for Read mode, the RTC must first be set into Write mode, by the ID byte bit 0 being cleared to 0. Then the start address is sent and the RTC is put into Stop mode. Now the Start command is sent, followed by the ID code again, but this time with bit 0 set to 1, to put it into Read mode. This is another subtlety that was not at first appreciated when the RTC chip was investigated by the author for the first time.

It was here that the RTC datasheet was found to be most unclear. It was not obvious at first that the RTC must initially be put in Write mode through its ID value as in Listing 1, and then put into Read mode.

Table 1: Timekeeper Registers

ADDRESS	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	FUNCTION	RANGE
00H	CH	10 Seconds			Seconds				Seconds	00-59
01H	0	10 Minutes			Minutes				Minutes	00-59
02H	0	12 / 24	10 Hour / PM/AM	10 Hour	Hours				Hours	1-12 +AM/PM 00-23
03H	0	0	0	0	0	DAY			Day	01-07
04H	0	0	10 Date		Date				Date	01-31
05H	0	0	0	10 Month	Month				Month	01-12
06H		10 Year			Year				Year	00-99
07H	OUT	0	0	SQWE	0	0	RS1	RS0	Control	–

It had appeared that Write mode could be set directly, without Listing 1 being repeated first – not so! This fact was eventually revealed by Googling the web.

When sending the address from which to read (or write), you could in principle read any time or date value by amending the Start address accordingly.

At each Read step RTCCLKREAD is called (not shown here) in which the eight data bits of the required value are read back serially, again in order of MS to LS, and built up into a byte within STORE.

LISTING 6: Read time and date from RTC

```
READRTC:

; repeat Listing 1 here (excl BANK/TRIS), to put RTC into Write mode first

             call SETSTOP          ; set RTC into Stop mode
             call SETSTART         ; set RTC into Start mode
             movlw B'11010001'     ; set ID for read mode (bit 0 = 1)
             call RTCCLKOUT        ; send ID
             BANK1
             bsf TRISC,SDATA       ; set SDATA as input
             BANK0
GETRTCVALUE: call RTCCLKREAD       ; read 1 byte
             call SENDACKREAD      ; send acknowledgement of read
             movf STORE,W          ; get read byte value from STORE
             andlw 127             ; AND value with 127 (B'01111111')
             movwf CLKSEC          ; put it into destination register
```

Getting Data for RTC

Having shown how clock and calendar data can be written to and read from the RTC, we come to the question of how that data can be set into the PIC in the first place.

There are several options, the best of which is that used in the *Pain Monitor*. Its PC program has been written to take the data from the PC's own time and date registers, split it into its component parts and then sent via a serial link from the PC to the PIC. The process is too complex to illustrate here, and interested readers should extract the relevant sections of the *Pain Monitor* PC and PIC codes and copy them into their own program.

A second option is to allocate PIC EEPROM data space for the values, and then program the values into the PIC from a data file. When the PIC is reset following this data send, it should be programmed to read the EEPROM locations and store those values into the RTC. *Toolkit TK3* allows this to be done via its Send EEPROM Message facility.

The drawback is that it will be slightly difficult to set the time exactly. The suggestion, though, is that the data file should be prepared in advance of the time required, and then sent to the PIC when the required time arrives. Data sending and its extraction by the PIC only takes a few seconds, and so moderately accurate time could be set this way.

The other option is to use switches to set the data into the PIC. As has been shown in several *EPE* PIC projects, only three push-button switches are needed for this. One to step through the registers to be programmed, and two for incrementing or decrementing the value of each register. Such a technique was used in the author's *PICronos Wall Clock* of June '03.

Data Display

You will, of course, probably wish to display the time and date data on an l.c.d. controlled by the PIC. The *Pain Monitor* uses such a routine for the time values. It should not be difficult to extend that routine to also show calendar data as well on a cyclic basis (time/date/time etc).

It will be seen from Table 1 that each value must usually be sent to the l.c.d. as two nibbles, MS first, LS second. Each nibble value should be ORed with 48 to convert it to the ASCII code for that value.

Resources

All software referred in this article can be downloaded from the *EPE* Downloads site, access via **www.epemag.co.uk**. Maxim's datasheet for the DS1307 can be downloaded from **www.maxim-ic.com**.

Motor Amplifier

Ken Ginn

The power with which this unit can drive a heavy-duty motor is astonishing!

SOME years back the author was bitten by the bug to build a radio controlled combat robot. Plans were laid and the mechanics were built with a lot of work from a team of three engineers including himself.

The classic wedge shape robot was born with a pair of 24V d.c. permanent magnet electric motors, previously used on an electric wheelchair. These were needed to supply drive for the robot. Mild steel square section tubing and a few square metres of 3mm aluminium sheeting was also used in the construction.

The weapon was an angle grinder attached to the front of the monster, this weapon was driven by a 24V Canadian electric shower pump motor. The assembly weighed in just within the maximum weight limit at the time – which was 70kg.

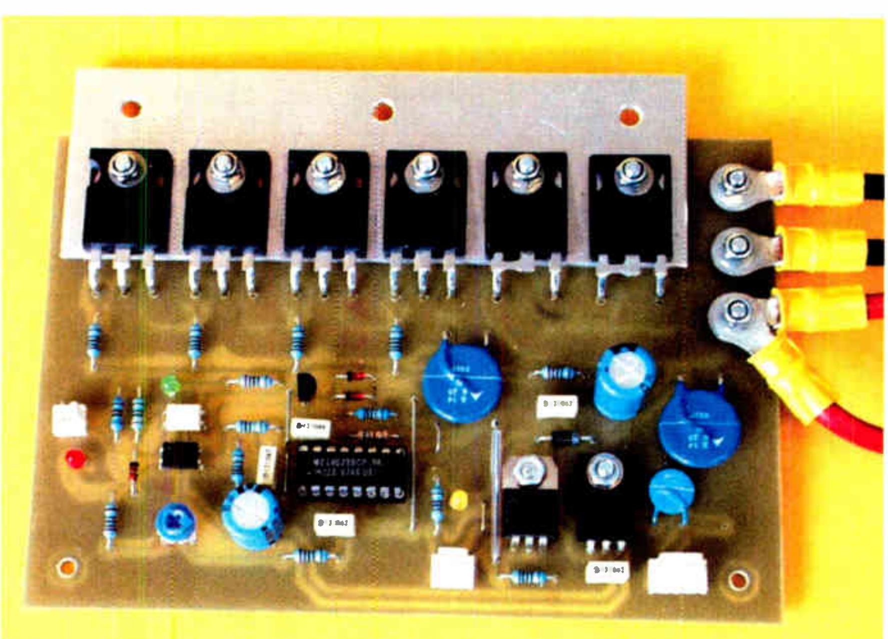
Looking around at the time of building, all of the conventional radio control model speed controllers were found to be unsuitable for use with the robot. Despite the stated current ratings of some (120A peak), they could not take the load and stall currents of the robot's motors.

Design Concept

Consequently the author set out to build a unit that would integrate with a conventional model speed controller, and also take the stall current of the motors. This was calculated to be about 40A for each motor with a supply voltage of 24V drawn from a pair of onboard 12V gel-cell batteries arranged in series.

The following design conditions had to be met:

- Run from an on-board 24V d.c. supply
- Run permanent magnet 150W d.c. motors
- Interface with readily available radio control (RC) model speed controllers
- Easy to install and maintain
- Be able to trim each motor speed independent of the transmitter joystick
- Emulate the function of the conventional RC model speed controller – having full proportional speed control forward and reverse
- Run the drive motors to stall condition and automatically recover. The stall current rating of each motor would have to be within the current capability of the controller, since in combat the motors are expected to stall.
- Bomb proof (if at all possible)!



Radio Control

Most RC systems use PPM (Pulse Position Modulation) or PWM (Pulse Width Modulation) to convey the information from the handheld Transmitter to the model's RC Receiver. Essentially the RC system in the transmitter translates the position of a joystick or switch into a pulse width of approx 1·0ms to 2·0ms every 20ms or so. The actual timing may vary slightly from manufacturer to manufacturer.

This pulse width signal is fed to a servo which responds by either moving (rotating) to a new position, or, if fed with an unchanging signal, will remain in a steady-state condition, i.e. not moving. The servo can be replaced by a speed controller.

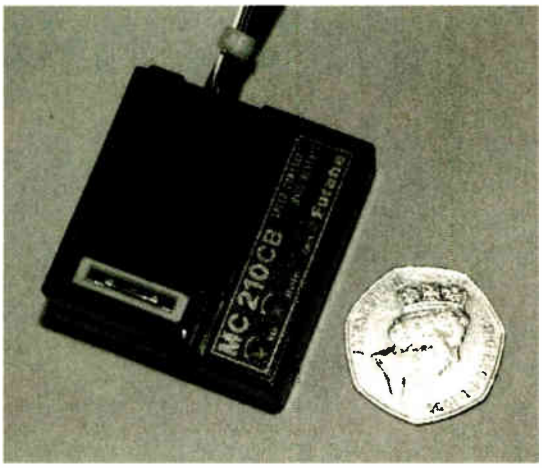
When the transmitter joystick is moved from the central position, i.e. stop then forward, the speed controller will then cause the motor to rotate in one direction. Moving the joystick back through the dead zone (stop or neutral) to the other extreme will cause the motor to reverse direction.

On Time

For a number of years the means to control d.c. electric motors has been to use the PWM technique. Essentially what happens is that the full supply voltage is switched on and off very fast to the motor. The On to Off period (mark-space ratio) is varied to set or alter the motor's speed. In essence, with a short On and long Off ratio, the motor will rotate slowly.

As the On time increases, the greater the rotation speed. By varying the On/Off ratio, the speed can be almost infinitely variable between stop and full speed. Full torque is essentially available from the motor throughout the whole range of speed.

The Futaba MC 210CB speed controller used with the prototype drives motors at approximately 50Hz, and the motor amplifier keeps in step with the Futaba.



Futaba MC210CB Speed Controller

Design Detail

This circuit is designed to interface with a simple primary speed controller. The latter does all the signal processing and sorts out the relationship between the joystick position and the speed and direction. The secondary speed controller (amplifier – this unit) increases the current and voltage capacity and delivers power to the d.c. motor allowing, for example, a 150W 24V wheelchair motor to be controlled with considerable ease.

Higher rating motors have not been tested with this unit, but there seems no reason why a motor rating of 500W or more could not be successfully driven. This design went through considerable testing, and at the end of two fights, in which there was considerable abuse of the motors and the controller, the controller remained cool.

Each power f.e.t. driving the motor has a maximum continuous current rating of 60A. A safe limit to the current would, with four f.e.t.s, be in the order of 150A, although this has not been tried. At 200A, the f.e.t.s would have to dissipate about 160W maximum as heat. With a supply voltage of 24V the power delivered to each motor would be 4·8kW!

Speed Control

The primary speed controller relates the controlling pulse width to a form which provides forward, stop and reverse speeds, typically varying from 1·0ms to 2·0ms. For example, pulse width varying from 1.4ms to 1ms would set the motor's forward speed going progressively faster up to full speed. The dead zone between 1.4ms and 1.6ms will provide no drive to the motor. With a pulse width of 1·6ms to 2·0ms, the primary speed controller will drive the motor in reverse,

The longer the pulse from the receiver servo's output the faster the reverse speed will be. This pulse width information is updated every 20ms, producing a PWM drive at about 50Hz.

There is also a variable pulse width monostable included in an attempt to equalize the drive to the two main motors. Where two robot drive motors are sourced, maybe from two separate places, or a replacement motor does not match the one replaced, the monostable tags another pulse on the end of the main drive pulse to attempt to equalize the drive to the weaker motor.

This was actually noticed in the first of many controllers built, where the robot did a neat right hand turn, when it should have been running straight. A few tweaks of the preset on the right hand motor drive (the weakest motor) and the robot ran in a straight line.

Circuit Diagram

The main circuit diagram for the Motor Amplifier is shown in Fig.1. It basically has two parts. One part takes the drive signal and increases its current carrying capability – the amplifier. The second part is a means to detect the polarity of the initial drive signal. Since the model's speed controller has a forward and reverse function, this has to be detected by the primary speed controller. The motor current reversing relay also has to be switched when the primary speed controller's polarity reversal is detected.

The control signal is derived from the primary speed controller. Its supply voltage has to be greater than 4·5V, preferably 5·0V. This ensures the correct drive current for the input to the amplifier. The drive signal is input at connector PL1 and is fed to load resistor R1, which partly simulates the motor to the primary speed controller.

In parallel with R1 are two opto-isolators. The first, IC1, isolates and permits the pulses of either polarity (a.c.) from the primary speed controller to pass onto the following circuit for conditioning. The second, IC2, permits the primary speed controller's d.c. signals to pass only when the polarity of the signal permits the optoisolator diode to be forward biased. When reverse biased, diode D1 conducts instead.

The a.c. signal through IC1 is passed to monostable IC3a. Its falling edge triggers the input at pin 5, causing the output at pin 6 to go high for a period set by capacitor C1 and the combined resistance of R5 and preset VR1. The latter sets the pulse width at a value from 70μs to 2·5ms. From pin 6, the output controls transistor TR1 via diode D3.

Diode D2 also sends the main drive signal to the base (b) of TR1, bypassing IC3a, and effectively forming an OR gate with D3, so that the pulse produced by the monostable tags onto the end of the drive pulse.

Transistor TR1 forms an emitter-follower and its emitter (e) drives l.e.d. D7, via buffer resistor R10, to indicate that pulses are being fed to the drive f.e.t.s, TR3 to TR6. Diodes D5 and D6 are additional protection for the drive circuitry to limit negative transitions

COMPONENTS

AMPLIFIER

Resistors

R1	680Ω	**See**
R2	330Ω	**SHOP**
R3, R4	10k (2 off)	**TALK**
R5, R9, R10, R15	2k2 (4 off)	**page**
R6	1M	
R7	6k8	
R8	1k	
R11 to R14	100Ω (4 off)	
R16	4k7	
R17	PTC thermistor, 450mA, 30V	
R18, R19	SIOV-S14K25 31V d.c. varistor (2 off)	

All 0·6W 5% metal film unless stated

Potentiometer

VR1	100k preset, min. round

Capacitors

C1 to C3, C5, C7	100n polyester, 63V, 5mm pitch (5 off)
C4	220μ radial elect, 25V
C6	470μ radial elect, 35V
C8	10,000μ, can elect. 50V, chassis mounting, plus clip

Semiconductors

D1 to D3	1N4148 signal diode (3 off)
D4	1N4002 rectifier diode
D5, D6	40EPS08 power diode, 40A (2 off)
D7	green l.e.d., 3mm
D8	amber l.e.d., 3mm
D9	red l.e.d., 3mm
TR1	BC182L *npn* transistor
TR2	TIP122 *npn* Darlington transistor
TR3 to TR6	STW60NE10 or FQA70N10 *n*-channel power MOSFET (4 off)
IC1	TLP620 optoisolator (a.c.)
IC2	SFH618A-2 optoisolator (d.c.)
IC3	4528 dual monostable
IC4	7812 12V 1A voltage regulator

Miscellaneous

RLA	d.p.d.t. relay, 24V, contacts rated for motor current
B1, B2	12V 15Ah gel-cell battery (2 off)

Printed circuit board, available from the *EPE PCB Service*, code 520; 16-pin d.i.l. socket, tinned copper wire, 24s.w.g.; 2-way pin header; 3-way pin header; 4-way pin header; transistor thermal insulating washers, plus bolts and nuts; heatsink, 16s.w.g. aluminium sheet, approx 120mm x 40mm; heavy-duty connecting wire, to suit relay current; heavy-duty p.c.b. terminal bolts with nuts and cable connectors (3 off); solder.

Approx. Cost Guidance Only **£37** *excl robot hardware*

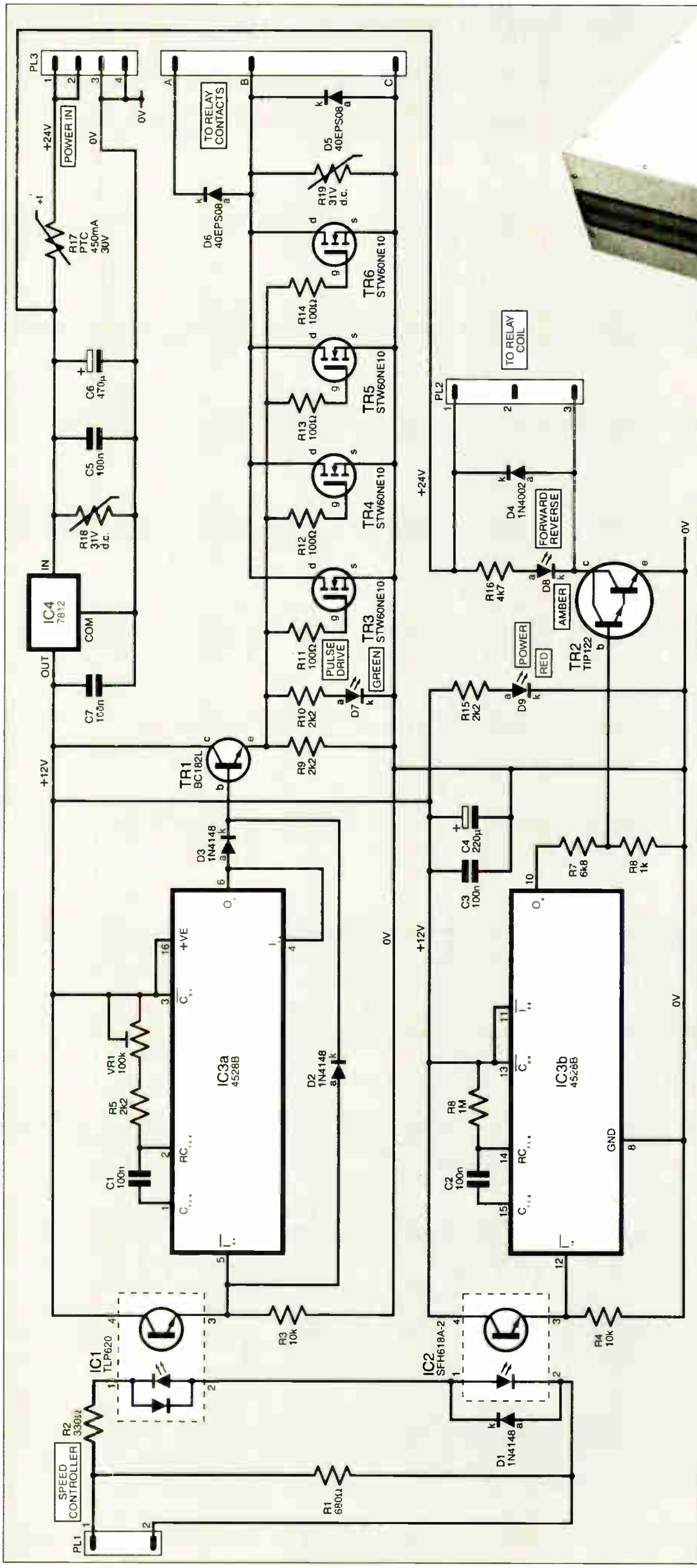
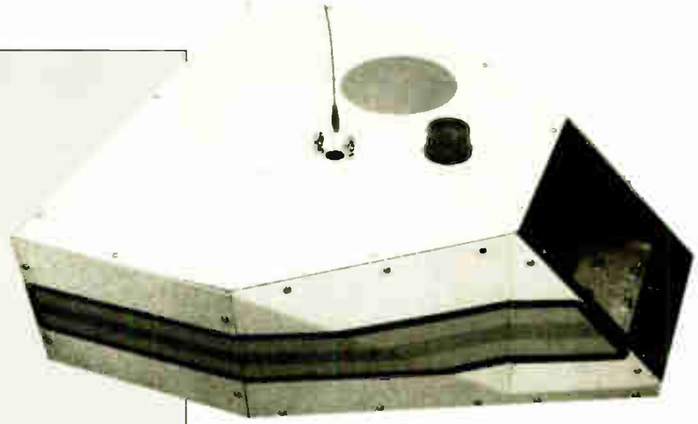


Fig. 1. Circuit diagram for the Motor Amplifier



Author's combat robot in early stages of development

and protect the circuitry from inductive pulses generated by the motors. Component R19 is a 31V varistor incorporated to limit any positive voltage transients occurring that might destroy the drive transistors.

Monostable IC3b will receive a trigger pulse only when the forward drive signal polarity causes IC2 to conduct and pass the signal through the opto-isolator. A reverse drive signal will not be accepted.

This monostable's timing is set to be greater than the frame rate of the RC system used. In this case the pulse repetition rate is 20ms. However, once triggered, the time for which the monostable remains On is set for 28ms (by C2 and R6), so the monostable will be retriggered before it has a chance to time out, so keeping its output pin 10 constantly high (On). This provides current to drive the relay driver, TR2, a Darlington transistor which provides current for the drive motor reversing relay via connector PL2.

In this circuit, protection is arranged for brief input supply voltage transients to be limited to 31V by a second varistor, R18. Thermistor R17 limits any excesses caused by longer transients.

F.E.T. Selection

One important consideration for this circuit was the selection of the f.e.t.s to drive the motors, those having the lowest R_{DS} (On resistance), being preferable, subject to price. The R_{DS} of the chosen STW60NE10 f.e.t. is only of the order of 16mΩ (milliohms), the alternative FGA70N10 is 23mΩ.

It is worth noting though, that the effect of the R_{DS} within each individual f.e.t. is negligible compared to the cabling of the entire robot and the internal resistance of the robot's motive batteries and relays etc. Consequently, the additional expense of "better spec" components was not felt to be worthwhile.

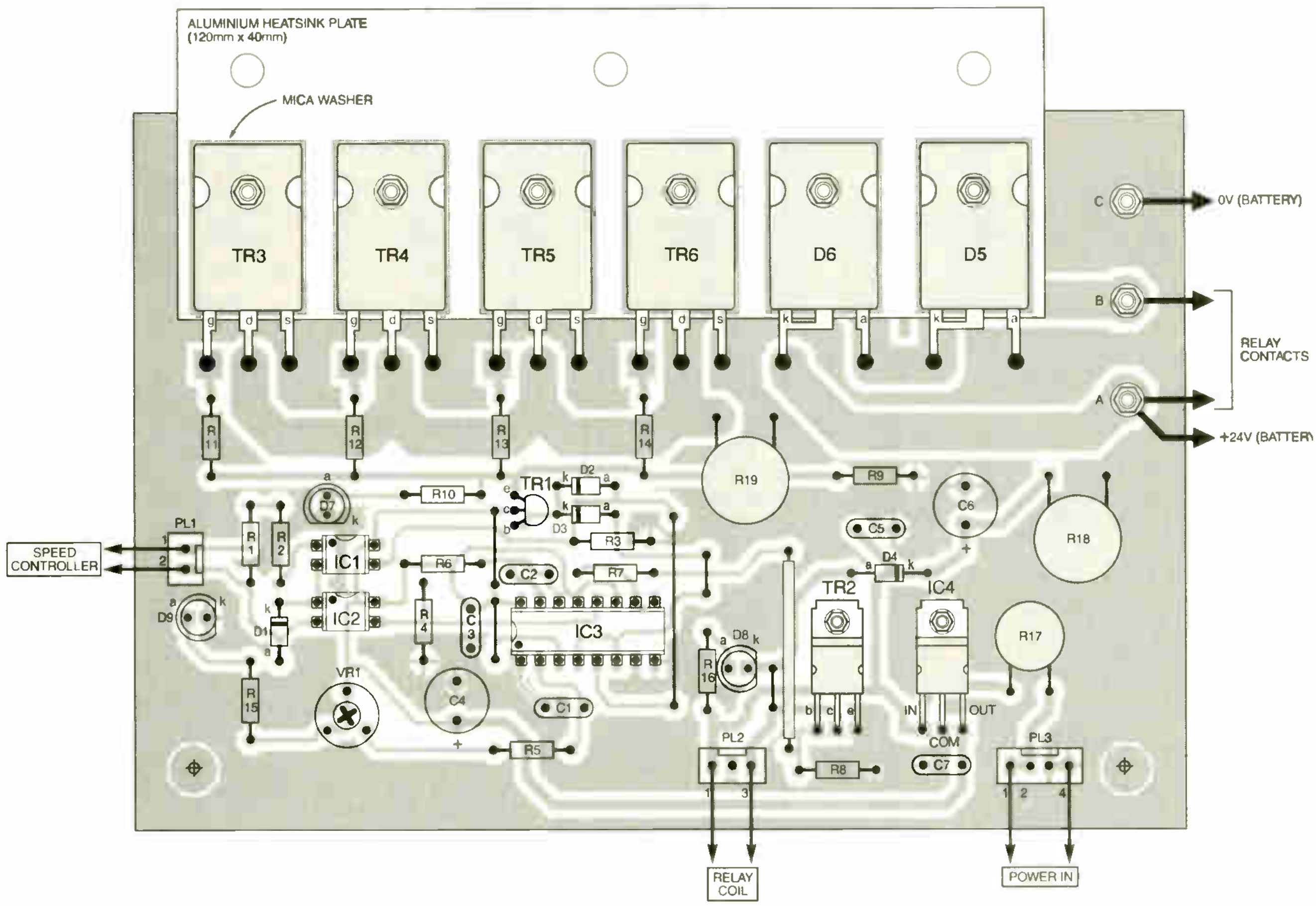
During two heavy fights the controller remained cool, despite several times being thrown around and the motors stalling.

Choice of Relay

In the case of a combat robot using a relay to achieve reverse drive to the motor a suitable relay has to be sourced, bearing in mind the energising current for this design is supplied from a 24V source. The majority of relays readily available appear to stop at about a contact current of 25A a.c., with a contact life expectancy of around 100,000 operations.

Such relays may seem capable of operating at greater currents than those specified, but their life will be substantially reduced.

Motor Amplifier – Circuit Board Construction



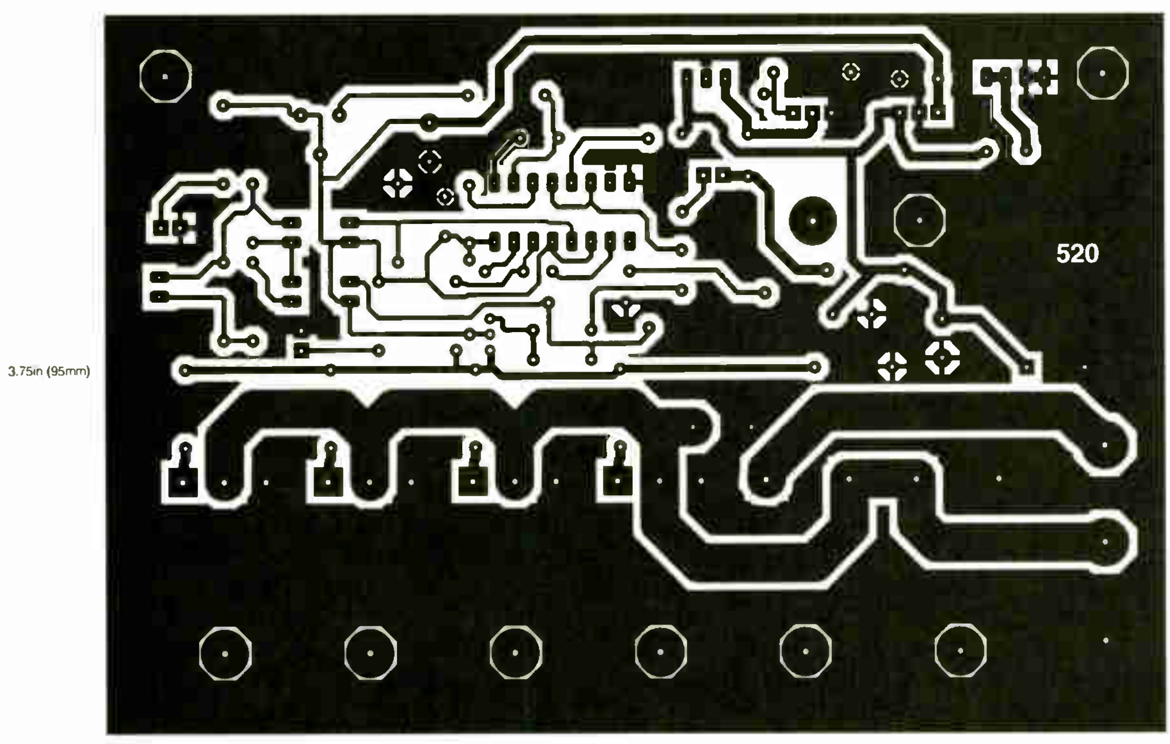


Fig.2. Printed circuit board component layout and full-size copper foil master for the Motor Amplifier. Note the heavy-duty lead-off wires from the terminal bolts A, B and C

Construction

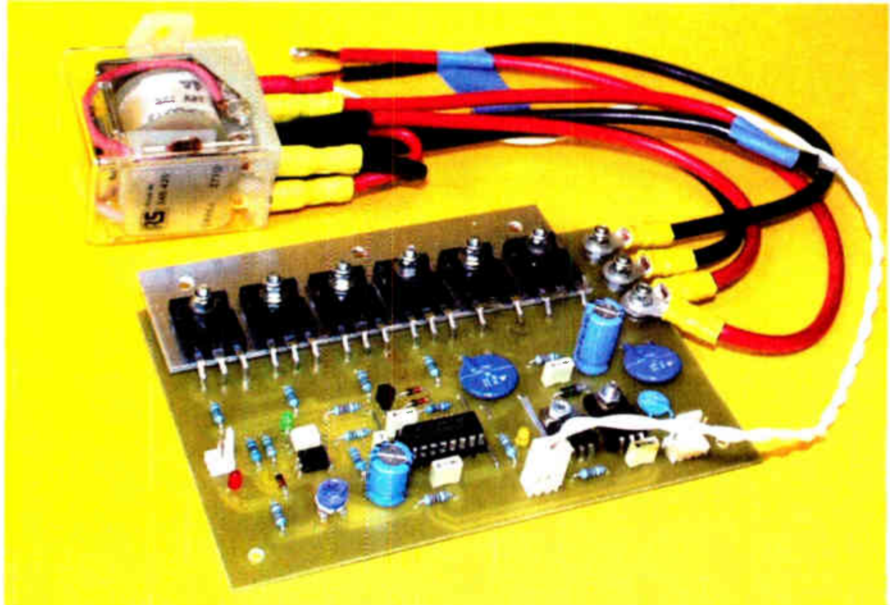
Details of the printed circuit board component and track layouts are shown in Fig.2. This board is available from the *EPE PCB Service* code 520. One board is required for each motor.

First solder the on-board link wires since three may be obscured by varistor R19. Note that the wire link to the left of TR2 is best sheathed with a length of sleeving, to prevent the possibility of it shorting to TR2's tab.

Assemble the rest of the components in ascending order of size, with static sensitive components last, taking the usual precautions with latter. The f.e.t.s (TR3 to TR6) and power diodes (D5, D6) are attached to the board together with a heatsink plate and insulating washers. A socket is used for monostable IC3, but not for optoisolators IC1 and IC2.

Once construction is complete a number of tests have to be performed, since the circuit is going to take a high amount of power in use. Spending five minutes on each circuit checking for faults could save a great deal of heartache, and perhaps prevent the circuit from suffering a catastrophe. The amount of power available from a pair of 12V gel-cells is phenomenal!

Check the board for any wrongly placed components, and for the correct polarity of capacitors and diodes. Check too for any solder bridges between pads and tracks.



Completed amplifier board wired to the heavy-duty motor relay

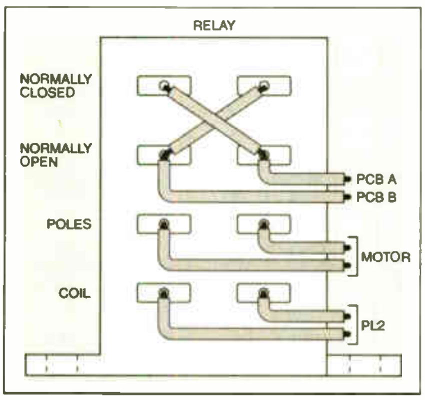


Fig.3b. Relay contact wiring details

Before any power is applied to the circuit check the following with a Multimeter:

- resistance between PL3 pins 1 and 4, this should be greater than 5kΩ
- resistance between points "A" and "B", "A" and "C", with the meter's positive lead remaining on "A". This should read high. Connecting the multimeter around the wrong way will put the diodes into conduction and cause a misreading.
- most importantly, the resistance between the heatsink and "B" and "C" should be very high (open circuit)

Should any faults be detected, sort out the problem before applying full current.

Setting Up

Once satisfied with the tests, the 24V power source can be applied at connector SK3/PL3 pins 1 and 4, observing the correct polarity. If a current limited power supply is not to hand, insert a 100Ω 1W resistor in the positive line. This will serve to limit any fault current which may occur.

Once the initial surge has subsided, the current drawn should drop down to a quiescent level of less than 15mA. Check that the voltage at the input to regulator IC4 is the same as the supply voltage.

The output from regulator IC4 should be 12V, within 100mV or so and l.e.d. D9 should illuminate, indicating that power is applied to the circuit. The other l.e.d.s, D7 and D8, should remain off.

Connect a radio control receiver and primary speed controller to the input of the amplifier, see Fig.3a. In place of the motor, connect the test circuit shown in Fig.4. These components should be temporarily

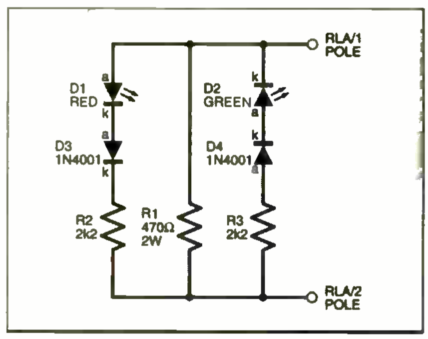


Fig.4. Low current "motor" test circuit

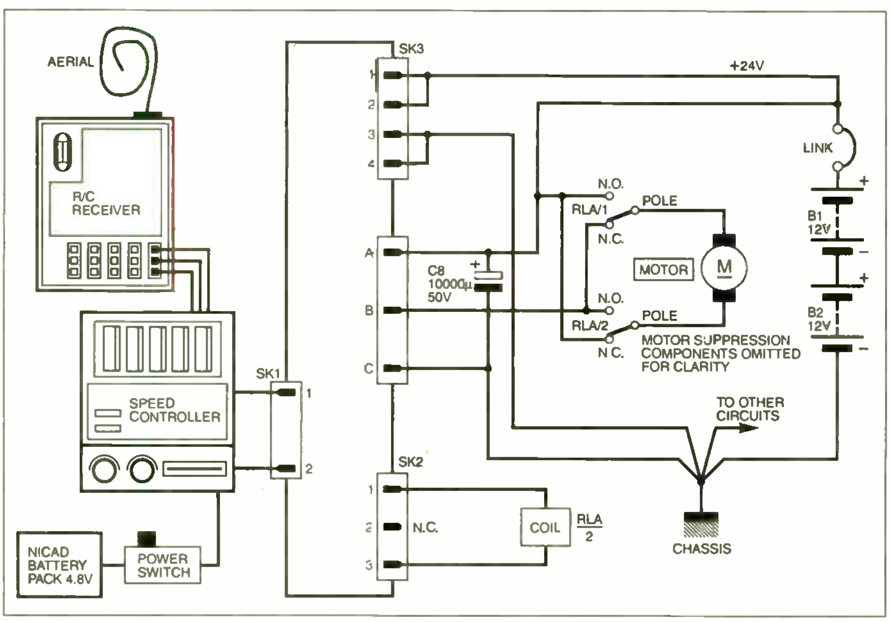


Fig.3a. Circuit for the battery supply, relay contacts, motor and coil. Also shown are the R/C receiver and speed controller connected to the p.c.b. signal input SK1/PL1

COMPONENTS

TEST CIRCUIT

Resistors

R1	470Ω 2W
R2, R3	2k2 0·6W 5% (2 off)

Semiconductors

D1	red l.e.d.
D2	green l.e.d.
D3, D4	1N4001 rect. diode (2 off)

Approx. Cost Guidance Only **£0.70**

hard-wired to the poles of the relay, although they could be mounted on a piece of stripboard if preferred.

The test circuit is a safety measure to check out the motor driver and relay connections before a high power motor is connected and large amounts of current are drawn, thus avoiding any problems should there be a component or wiring fault.

Switch on the radio control equipment and set the transmitter joystick to the central position. L.E.D.s D7 and D8 on the p.c.b. should remain off. Follow the setting up instructions for the primary speed controller as per the manufacturer's instructions. Set the speed controller as though it were being used without the amplifier, as with a small motor for example.

Note that when the joystick is moved out of the neutral position, one or other of the test circuit l.e.d.s of Fig.4 will begin to pulse and illuminate in sympathy with l.e.d. D7 on the amplifier board. As the joystick is moved progressively away from the neutral position, the active l.e.d. in the test circuit will progressively get brighter.

Reverse the joystick, and this test l.e.d. will extinguish as the joystick passes through neutral. The other test l.e.d. will now illuminate as the motor changeover relay operates and changes polarity. Again, as the joystick is moved progressively away from the neutral position, this l.e.d. will illuminate, and l.e.d. D8 on the amplifier board should also now be illuminated, indicating that the relay has energised.

If all is well, it is now safe to disconnect the test circuit of Fig.4, and the 100Ω 1W current limiting resistor if used, and connect the drive motor to the circuit. Bear in mind that the circuit will now draw large amounts of current and the source has to cope with the increased power. Be aware the motor should be clamped down if the unit is tested without it being in the robot. Mount smoothing capacitor C8 (Fig.3a) close to the relay.

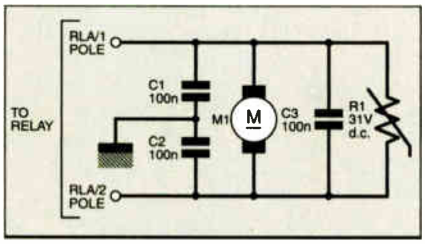


Fig.5. Circuit diagram for the motor suppression components

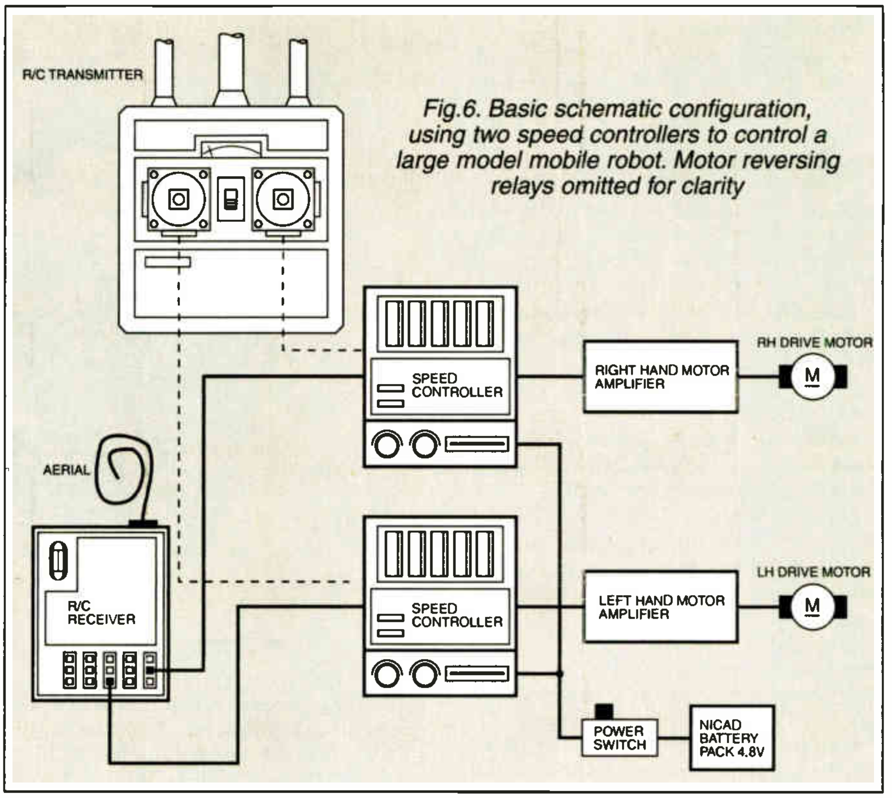


Fig.6. Basic schematic configuration, using two speed controllers to control a large model mobile robot. Motor reversing relays omitted for clarity

COMPONENTS

MOTOR (EACH)

Resistor		
R1	varistor 31V d.c.	See SHOP TALK page
Capacitors		
C1 to C3	100n ceramic disc, 5mm pitch (3 off)	
Motor	24V d.c. power to suit application	

Approx. Cost Guidance Only **£1** *excl motor*

Noise Suppression

There is a need to reduce the electrical noise generated at the drive motor's terminals. This can be significantly reduced with a handful of components preferably close to the motor commutator where the electrical noise is generated, see Fig.5.

Capacitors placed from each terminal to ground, and across the two supply terminals will reduce the noise significantly. The addition of a varistor serves to reduce any transients which may be generated at this point to within safe limits.

Next Stage

With the unit(s) assembled in the robot, further testing is best accomplished with the drive wheels off the ground, so imposing a minimal load on the circuit. Check for correct rotation of both motors when they are going forward and in reverse.

Next, in a safe area only, put the robot on the ground and check operation of the speed controller. Check for correct forward and reverse motion, and for straight running. Should the robot turn to one side, adjust preset VR1 of the amplifier on the weakest side. That will be the side to which the robot will turn in a straight run. Adjust VR1 until the robot achieves a straight run. Clockwise rotation of VR1 shortens the timing of monostable IC3b, anti-clockwise lengthens the pulse.

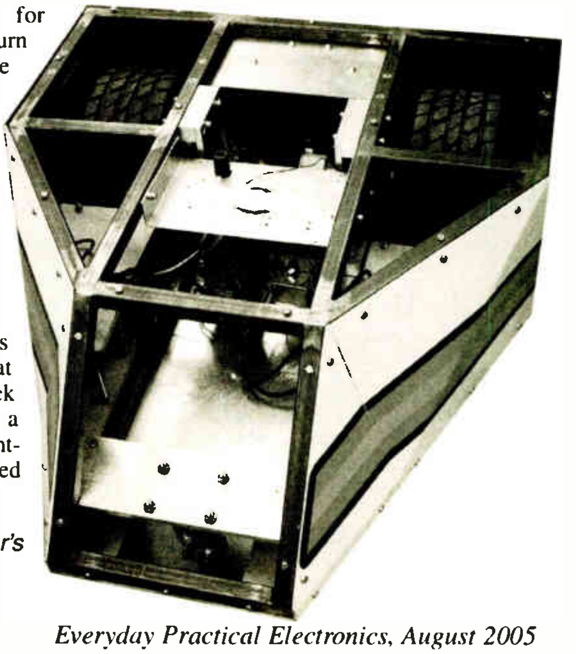
Conclusion

This motor amplifier was designed for use with a combat robot, and arranged with one joystick controlling the left-hand motor and a second controller driving the right-hand motor (see Fig.6). This allowed independent control of each motor, giving the robot a good degree of manoeuvrability. Tests prove that it is more than able to cope with running and stalling currents up to 80A.

The amplifier may also be used as a single unit to boost the drive current of a single speed controller, in a model boat for example. The design here is not limited to use with just combat robots.

When running the unit in the model or robot, if the relay appears to chatter or oscillate when changing over to being energised, this is not a fault of the circuit. Rather, it is more a function of the internal resistance of the power source being too high in relation to the starting current of the motors.

The combination of the internal resistance of the power source and the internal resistance at start up of the motors could reduce the voltage supply from a healthy 24V down to 15V. Use batteries that are well able to supply the starting current. □



Internal structure of the author's prototype combat robot

READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

WIN AN ATLAS LCR ANALYSER WORTH £69

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd., will be awarded to the author of the *Letter Of The Month* each month.

The Atlas LCR automatically measures inductance from $1\mu H$ to 10H, capacitance from 1pF to $10,000\mu F$ and resistance from 1Ω to $2M\Omega$ with a basic accuracy of 1%.

★ LETTER OF THE MONTH ★

Water Monitoring for Boats

Dear EPE,

A friend of mine came up with this idea and I send it in on his behalf. The thing I like about it is that it is very inexpensive and does not resort to unnecessary complexity. We spent many hours discussing possible schemes, including flow monitoring and measuring head of water – all of which presented quite difficult mechanical as well as electronic problems. In the end we decided that no matter what solution was chosen there were going to be significant errors and a crude indicator like a petrol gauge would probably be sufficient.

We have a narrow boat with a large water tank located at the front and batteries/control panel at the rear. We wanted a way of determining very approximately how much water was in the tank without having to use a dipstick. The water tank is actually part of the boat's hull so the geometry is not a simple rectangular structure. Also, the motor that pumps the water to the point of use is located at the front of the boat along with the relay that operates it.

Back at the power distribution panel the pump has its own circuit breaker, but because the switching relay is remote, it is not easy to monitor the voltage at the pump. Instead, I used a reed relay with 10 turns of copper wire wrapped round it. The current to the pump is fed through this coil. The contacts of the reed are used to turn on a small mechanical battery travel clock (not l.c.d.).

When the tank is full, the clock is zeroed. Thereafter, the time indicated on the clock is an indication of how much water has been used. Once a year the boat gets drained down providing an opportunity to find out how long it takes to empty. There are many reasons why this is not an accurate measure but it is a simple and low hassle solution.

Richard Edwards,
via email,
somewhere on the UK canal system

Thanks Richard, that's an interesting solution, and long may the current take you where you wish! I might even add, "may the force (of the weir) not *be with you" – but perhaps not ...*

Stripboard

Dear EPE,

In response to Godfrey Manning's soldering problems with stripboard (May '05), one solution and the method I've been using for years without any problems is to polish the board in your usual way (I use wire wool) then wipe the tracks/pads down with white spirit. The solder will then flow and leaving smooth shiny joints.

Plumbers use a similar method when soldering sheet zinc on flat roofs. The joints are first cleaned with spirit of salt prior to soldering. Hope this info helps.

Craig Patterson,
via email

Thanks Craig, I would add that whilst this solves your stripboard cleanliness problems, you have to be very cautious about the use of any abrasive on p.c.b. tracks for fear of cutting through them, especially the thin ones. With p.c.b.s I use a special abrasive pad designed for the purpose that does the job nicely. Good p.c.b. supplies stockists sell them.

Musical Frequencies

Dear EPE,

Just a "quicky" that might help readers. Referring to *Smart Karts* May '05 page 366, the frequencies of musical notes is required (Calculating Values box on that page). I have my own HTML/JavaScript program that offers this and covers the two most conventional scales. You are welcome to ask readers who would like a copy to send me a preformatted floppy disk with pre-paid/pre-addressed return mailing facilities.

The conditions are that the program is for free distribution, remains my copyright and the copyright declaration (that appears on the program's screen) is not to be erased. It is offered without warranty, although I'll do my best to fix any bugs that are drawn to my attention.

Godfrey Manning G4GLM,
63 The Drive, Edgware,
Middx. HA8 8PS

Thanks Godfrey, that looks useful. I use various methods through QB and VB for similar but not as nicely as you've done it.

GPS Validity

Dear EPE,

With reference to Mike Hibbett's letter (May '05). The GPS validity flag in a \$GPGGA data string can have one of three values:

0 = Invalid GPS position
1 = Valid GPS position
2 = Valid differentially corrected GPS position

Colin Gill,
via email

Thanks Colin, but there are also the codes V and A which I referred to in my original PIC to GPS Interfacing *article of Jan '04, and which my Garmin GPS handset outputs.*

However, if you take the ASCII values of A and V they are 65 and 86 respectively, thus their binary values have bit 0 set to 1 for A, and bit 0 set to 0 for V. Perversely in one sense, A is used for Valid, and V for invalid, but if you relate the bit 0 value to your 0 and 1 values, they have the same meaning.

Going one step further, the ASCII for 0 is 48 (bit 0 = 0), and that for 1 is 49 (bit 0 = 1), and so the argument holds true, indicating that it is perhaps better to check the value of bit 0 of the validity code rather than its actual character value. Perhaps I'll use that technique in any future GPS design I do. Character 2 does not seem to have a Garmin letter equivalent.

Can anyone see a problem with my logic on this?

Text Editor

Dear EPE,

Referring to *Readout* June '05, another editor to use with your excellent *TK3* is Microchip's IDE editor with its colour sensitive text and line number options. Ignoring any MPlab options, I run both programs together and use the task bar to change from one to the other, which is useful when working with large files.

Brian Milner,
via email

We all have our favourite editors Brian. For normal article text writing I actually use an ancient steam-driven thing called Volkswriter 3 which I've used for maybe 18 years and is DOS-based. I just prefer its no-nonsense simplicity over such bells and whistles packages as Word etc.

I must repeat the caution, though, that any text editor for use with PIC program writing must not *insert hidden formatting commands into its files.*

L.C.D. Problems

Dear EPE,

Just to let you know I've solved the problem of l.c.d. contrast that I reported to you. It turned out that the contrast pin had to be connected to the wiper of a 20kΩ pot with the other ends connected to +5V and 0V (rather than just taking the contrast pin to 0V via the pot).

Ed Haslam, via email

Thanks Ed, this is worth highlighting. Whilst most alphanumeric l.c.d.s. on the market are what I would call "industry standard", in as much that several manufacturers use the same basic control protocol, there are still those available which are not.

When purchasing an l.c.d. for a published design, always check that it has the same pinouts and that its contrast pin can be controlled in the same manner as we show. Note also that some l.c.d.s require a negative voltage on one side of the controlling pot, although this seems to be rare.

RC Switching

Dear EPE,

Regarding the *Radio Controlled Model Switcher* (June '05). This shows three wires coming from the receiver to a three pin connection, with pin 2 connected to the input of the PIC, which detects the PPM signal. However the standard for RC equipment is to use pin 2 (the middle one) as the +5V line from the receiver with the ground and signal wires either side. This removes the possibility of shorting out the receiver or blowing up any device connected to it should the connector be plugged in the wrong way round.

Malcolm Crabbe, via email

The RC unit's designer Ken Ginn replied to Malcolm:

As far as I am aware there is no standard configuration for the servo output socket of radio control equipment. This may be as the reader implies for Futaba manufactured RC equipment, which is probably the most popular in the UK. But there are certainly many manufacturers, such as Graupner, Fleet, Robbe and many more who have adopted their own configuration.

My thinking on the configuration I have chosen was that is was far safer to have an intermediate pin, the signal path, separating the power lines. The reason is that if there was ever a solder bridge at this point, from pad to adjacent pad, it would not short out the NiCad battery pack. In the RC receiver, doing so would certainly burn out the wiring and even damage the printed circuit in the receiver! These rechargeable batteries will supply a hefty current if shorted out.

Ken Ginn, via email

Ultrasonic Radar

Dear EPE,

I was fascinated with your design for your *PIC Ultrasonic Radar* (June '05). I think it is perhaps a little difficult for readers like myself to integrate within their own robot designs. As an alternative I would suggest an "off the shelf" module ready-assembled sensor featuring an analogue output signal which can interface to a PIC directly. Using your motor drive circuit the area could be scanned for obstacles.

I enjoy *EPE* immensely although I tend to cheat and use a PICAXE as it is easy to program in BASIC so you can get the project up and running very quickly.

Chris Lewis, via email

Thanks for that Chris

Laser Radar?

Dear EPE,

Referring to your *PIC Ultrasonic Radar* (June '05), I could not help thinking that an IR l.e.d. receiver and a cheap laser pen instead of the ultrasonic bits would give a much sharper image and a lot bigger range.

If the laser unit was mounted on an electric motor shaft with an indexing disk an almost instantaneous 2D picture could be obtained. No doubt if the motor unit could be induced to tilt up and down as well in synchronisation a 3D image could be produced.

George Chatley, via email

I've thought about such techniques many times George, but it's timing the return echo that is beyond me. Light travels at 186,000 miles a second. What sort of frequency would be needed to time an echo across say three metres? Beyond my calculator at this moment! And certainly beyond the scope of timing electronics on the hobbyist scene. But in terms of safety, Mike says he'd have no problem if a laser pen or keyring were to be used in a published project.

Well readers, any thoughts you can offer me about resolving my perception of the timing problem?

NiMH Charger

Dear EPE,

This is in response to the letter concerning NiMH battery chargers in March '05.

I have designed several chargers for NiMH batteries and make them for various voltages from 500mAh NiMH prism cells. These I buy surplus for $0.25 US each.

No proper NiMH charger should ever overcharge any NiMH battery so long as the correct number of cells in series are involved. However, if used at excessive rates with batteries of smaller capacity than those for which it was designed, this can lead to overheating and damage.

Such chargers utilize the property of NiMH (and NiCad) cells that under quick charge (= C/4) their charging voltage increases to significantly above nominal cell voltage and reaches a maximum near full charge, after which it declines on further quick charging. After the maximum is reached the charger switches to trickle charging (< C/16). The chargers also impose a maximum charging time in case of defective cells.

The cheap chargers that come with sets of batteries are often not properly designed and should only be used with the included batteries. In order to avoid damage, they are often designed only for trickle charging. Even then, if used with cells of much lower capacity they can damage them, and if used with cells of higher capacity they may not do a satisfactory job.

In my chargers I use the Dallas-Maxim MAX712 charger controller i.c. Except for a d.c. "wall wart", few other components are required for a very effective charger. But, it must be designed for a specified number of cells in series and a specified cell capacity. I use a six position rotary switch to select the number of cells; all are 500mAh. For a fixed number of cells the sensing resistor can be switched to allow for different cell capacities. It just depends on what is wanted.

Ed Grens, via email

Thanks Ed.

Valves Offer

Dear EPE,

I have been given a box of old TV set valves like the PL500, plus sundry other bits like carbon speakers, phone inserts etc. They are of unknown condition. I am loth to throw them away as by now they must be like gold dust, but if anybody wants them and will pay the postage, let me know via email.

George Chatley, via email, HX1YAMAHA@aol.com

Thanks for that kind offer George. Looking via Google a photo of the PL500 is shown on the National Valve Museum site, ***www.t-type.org/static/museum.htm****, and is defined as a purpose designed television line output valve, the American name for which is a sweep tube. Its peak anode voltage is quoted as 7000V.*

Electronics Woodenly Disguised

In Techno Talk *some time ago it was reported that mobile phone masts are being manufactured to look like the natural surroundings in which they are installed, pine trees for pine forests, palm trees for the desert, and so on.*

Recently I spotted one, to my left a mile before the Orpington turn-off from the M25 anti-clockwise carriageway. It took a later second pass to confirm what it was. And did it blend in with its surroundings? What do you think – a cross between a conifer and monkey-puzzle tree on the edge of deciduous woodland? I find it hilarious!

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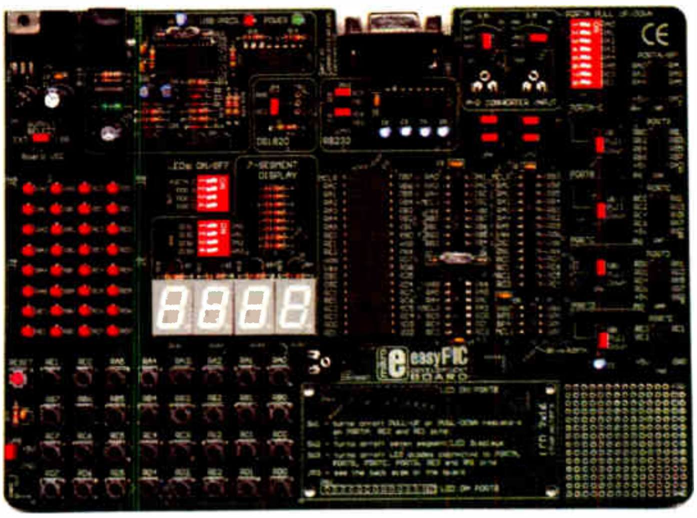

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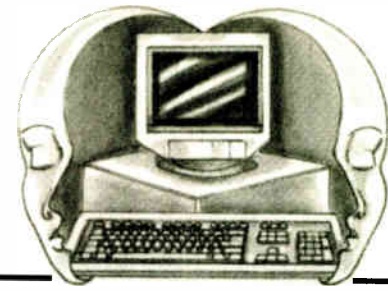
INTERFACE

Robert Penfold



USING A D/A CONVERTER TO GIVE AN A/D CONVERSION

Digital-to-analogue conversion has recently formed the subject of several *Interface* articles. This type of conversion is used in numerous practical applications, but a conversion in the opposite direction is probably used to an even greater extent. With the aid of analogue-to-digital conversion it is possible for a computer to be used for anything from simple monitoring tasks to making highly accurate measurements.

At one time it was quite common for a digital-to-analogue converter chip to be used as the basis of a simple analogue-to-digital converter. Although this might seem pointless, the D/A chips of the time were much cheaper than the A/D variety. Where something less than the ultimate in speed and accuracy would suffice, an A/D converter based on a D/A chip was often a good choice.

Converter economics have changed somewhat over the years, and currently there is probably no point in using this technique on price grounds. The basic technique can still be useful though.

The general scheme of things used in this type of A/D conversion is shown in Fig.1. The input voltage is applied to the inverting (–) input of a voltage comparator, and the comparator's non-inverting (+) input is fed from the output of the D/A converter. In practice the voltage comparator is usually an operational amplifier (op. amp) used "open loop".

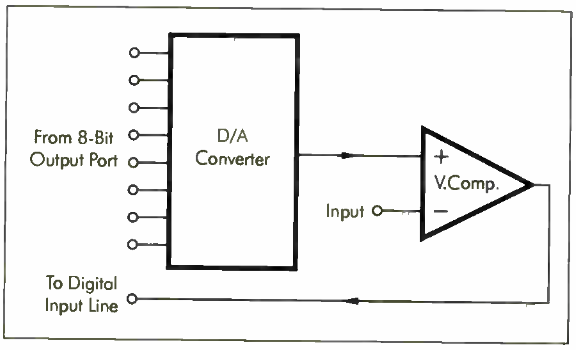


Fig.1. It is easy to use a D/A converter in an A/D converter but the software has to make up for the lack of hardware

Filling in the Blanks

This type of A/D converter needs some software to compensate for the shortcomings in the simple hardware. The converter is essentially a basic counter type, but with software filling-in for some missing hardware.

In order to take a reading it is necessary for the software to steadily increase the value fed to the D/A converter, starting from zero. The state of the comparator's output is checked prior to each increment in the value supplied to the D/A converter. Initially, the output voltage of the D/A converter will be zero, and the input voltage will usually be at the higher potential. The output of the comparator is therefore low initially.

As the output potential of the D/A converter is increased, it approaches and eventually exceeds the input potential. When this occurs, the output of the comparator goes high. This is detected by the software's monitoring routine, and the value supplied to the D/A converter is not incremented any further. The value currently output to the D/A converter provides the result of the A/D conversion.

All this system is actually doing is to steadily increment the output potential of the D/A converter until it is (more or less) equal to the input voltage. When the input shifts to a higher or lower voltage, the converter reaches this equilibrium point at a correspondingly higher or lower output potential. This is reflected in a higher or lower value fed to the converter.

The system works equally well if the input signals to the voltage comparator are swapped, with the input voltage being fed to the inverting (–) input. The output of the comparator will be high initially, and will go low when the output of the converter exceeds the input potential. Correct operation will be obtained provided the software is written to accommodate this method of working.

Shortcomings

Provided the D/A converter and voltage comparator are of a suitably high standard, it is possible for this type of A/D conversion to achieve quite accurate results. However, it is probably not the best choice where the ultimate in accuracy is required. A more serious drawback of this method is that it is not particularly fast. Using an 8-bit D/A converter it can take up to 255 increments of the output voltage before the conversion is complete.

Even using parallel interface to the D/A converter, the maximum number of conversions per second is unlikely to be very high. Using software written in a relatively slow language such as Visual BASIC would slow things down still further, giving perhaps a hundred conversions per second under worst case conditions. The time taken for each conversion actually varies enormously, and is roughly proportional to the input voltage. A high reading takes about 100 times longer than a very low reading.

Some Gain

Despite its limitations, this method of conversion can be used to advantage in some applications. As a simple example, here we will consider its use in measuring the current gain of a transistor. The conventional approach is to feed a small current to the base of the test component and then measure the resultant collector current. The current gain is equal to the collector current divided by the base current. Since the base current is the same for every device tested, the gain is proportional to the collector current.

This makes it very easy to convert the collector current into a gain reading, but this method has its drawbacks. The main one is that the gain is not being measured at a certain current. Low gain test devices produce a small collector current, while high gain transistors produce a much higher collector current. The practical importance of this is that, in general, the current gain is greater at higher test currents.

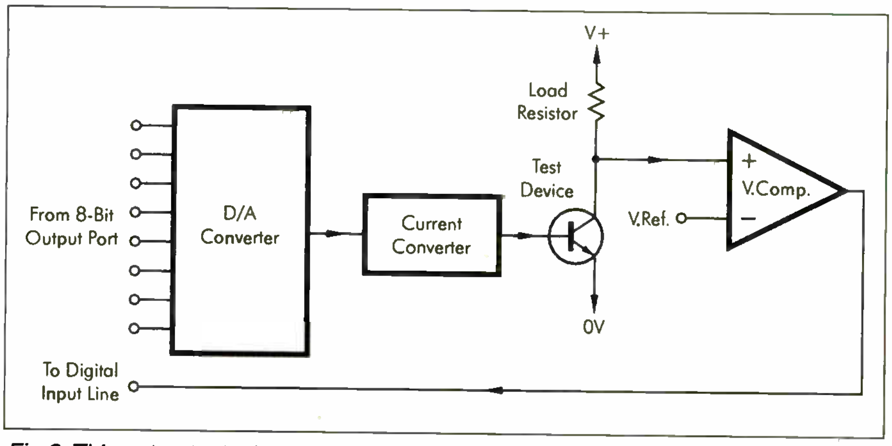


Fig.2. This setup tests the transistor at a fixed collector current, giving more reliable results than the more common method of using a fixed base current

This method of measurement therefore has the effect of exaggerating the difference between low and high gain devices.

This can give the impression that a low gain but serviceable device is a dud. Testing the device at a higher collector current would give a more realistic assessment of its gain.

A few additions to the A/D setup of Fig.1 provide a method of transistor gain measurement that avoids this problem. The new scheme of things is shown in Fig.2. The base (b) of the test transistor is driven from the output of the D/A converter via a current converter, which provides an output current that is proportional to the output voltage of the D/A converter. This gives a range of 255 different base currents.

The voltage comparator has one input fed with a reference voltage and the other input monitors the collector voltage of the test transistor. The value of the collector load resistor, the supply voltage, and the reference potential are chosen to produce a balance at the inputs of the voltage comparator when the required test current is achieved. A measurement is made by steadily incrementing the base current while monitoring the output of the voltage comparator.

Initially the comparator's non-inverting (+) input will be at the higher potential, and its output will therefore be high. As the base current is increased, the collector current of the test device also increases. This produces a higher voltage drop through the load resistor and a reducing voltage at the collector of the test transistor. Eventually, the collector voltage drops below the reference potential and the output of the comparator goes low. This is detected by the software's monitoring routine, and the base current is not incremented any further.

With this method of measurement the gain is measured at a fixed collector current, and it is the base current that is varied. The value from the converter is proportional to the base current, but there is no easy correlation between the base current and the gain of the test transistor. However, the base and collector currents are both known quantities, and a simple software routine is all that is needed in order to calculate and display the appropriate figure for current gain. An advantage of using a PC based system for awkward measuring applications is that any complications can usually be handled by the software, keeping the hardware reasonably simple.

Converter Circuit

The circuit diagram for a very simple A/D converter, based on the method outlined in Fig.1, is shown in Fig.3. IC1 is an AD557JN 8-bit D/A converter chip. This chip has been covered in recent *Interface* articles so it will not be considered in detail here. It uses parallel interfacing, so its data inputs (pins 1 to 8) can be driven direct from the data outputs of a PC's printer port. The output voltage range is 0 to 2·55V, giving a resolution of 10mV

The voltage comparator is a CA3130E op. amp (IC2). This can operate from a single 5V supply, which avoids the need for dual supplies and (or) a higher supply potential for the comparator. It also means that its output operates at levels that will directly drive a handshake input of the printer port without any problems. The input used in this case is the Select In line,

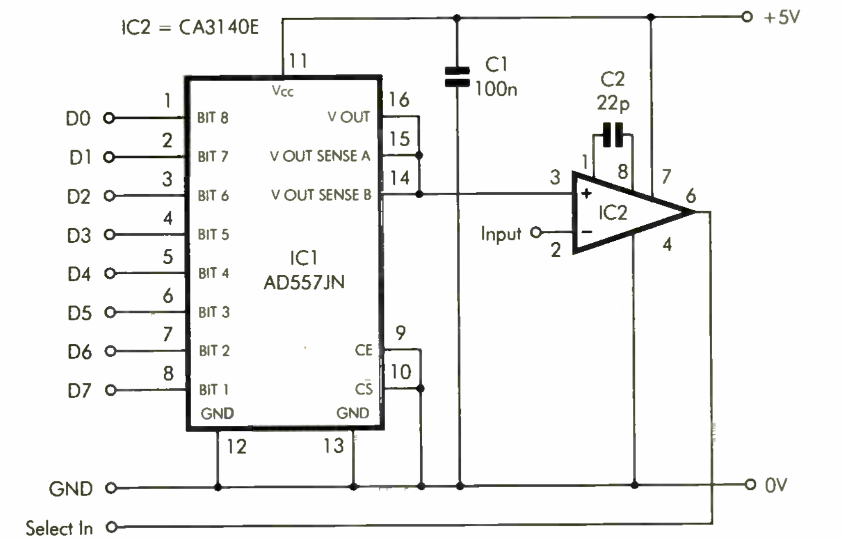


Fig.3. Circuit diagram for the A/D converter. It has a full scale potential of 2·55 volts and a resolution of 10 millivolts

Listing 1

```
Private Sub Command1_Click()

For loopcount = 0 To 255
Out &H378, loopcount
Label1.Caption = loopcount
If (Inp(&H379) And 16) = 16
Then loopcount = 255
Next loopcount

End Sub

Private Sub Form_Load()

End Sub
```

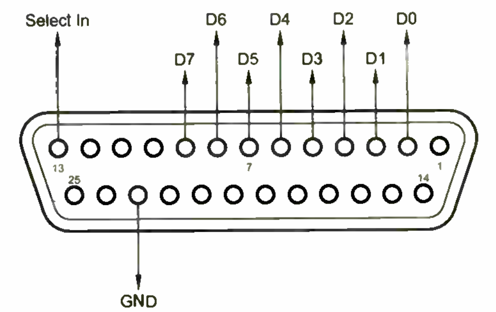


Fig.4. Connections to the printer port are made via a 25-way male D connector. The cable should be no more than about two metres long

which is read at bit 4 of the handshake input register. Some of the handshake lines have built-in inverters, but the Select In line is not inverted. Therefore, bit 4 of the handshake input register going high indicates that the converter has reached the appropriate input value.

The CA3130E does not have an internal compensation capacitor. Discrete capacitor C2 is therefore included in order to ensure that IC2 provides stable operation.

Both the AD557JN and the CA3130E are MOS devices, and the standard anti-static handling precautions should therefore be observed when dealing with these components. Few op. amps have the characteristics required for use in this circuit, so the use of alternative types for IC2 is ***not*** recommended. Most op. amps will not work at all in this circuit. The connections to the printer port are made via a 25-way male D connector (Fig.4).

Software

A routine to take and print readings can be very simple indeed. The sample program in Listing 1, which utilises **Inpout32.dll**, requires a form equipped with a button (Command1) and a label (Label1). The label should have a suitably large text size set via the Font property.

Operating the button starts a For.....Next loop that increments the variable "loopcount" from 0 to 255. On each loop, the current value stored in this variable is output to the base address of the printer port (&H378). This provides rising output potential from the D/A converter.

An If instruction tests the state of the Select In line at address &H379, and uses a bitwise And instruction to mask the other seven bits of this register. The loop continues normally until the Select In line goes high, and a value of 16 is returned. Variable "loopcount" is then set at a value of 255, bringing the looping action to a halt. This line is preceded by one that writes the "loopcount" value to the label component, so the final value of this variable is displayed when the routine stops.

In theory, the value on the label is incremented each time the routine goes through a loop. Of course, in practice the looping is so rapid that only the final value is actually displayed. Fig.5 shows the program after a reading has been taken. The full scale voltage and resolution of the circuit are the same as those of the D/A converter chip, or 2·55V and 10mV in other words.

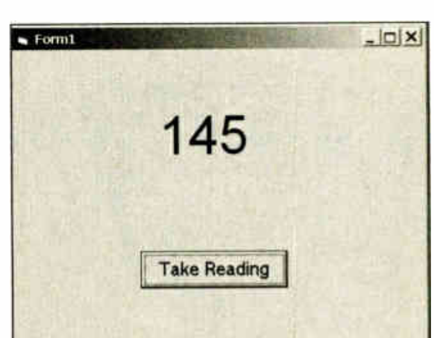


Fig.5. Test program displaying a reading

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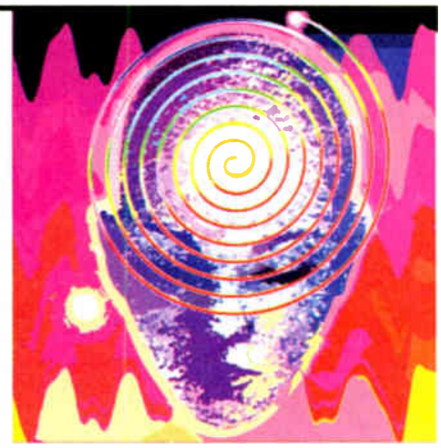


Pain Monitor

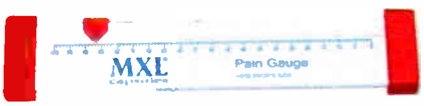
John Becker

A patient welfare logger that also has applications for other occasional event logging requirements, as in sailing, golfing or wildlife watching, for example.

RECENTLY, Dr. Mark Piper, Consultant Anaesthetist at Wansbeck General Hospital, Ashington, Northumberland, emailed Editor Mike:

There is a need for a "pain meter" in modern hospital practice. This meter needs to prompt the patient to record an assessment of their pain and store this information for downloading. This would help in research into pain relief after surgery.

There are many "pain scales" used. A common one is the visual analogue score. This is a 100mm line, one end represents no pain, the other end represents the "worst pain imaginable". The patient is expected to mark along this line where their pain severity is, for example:



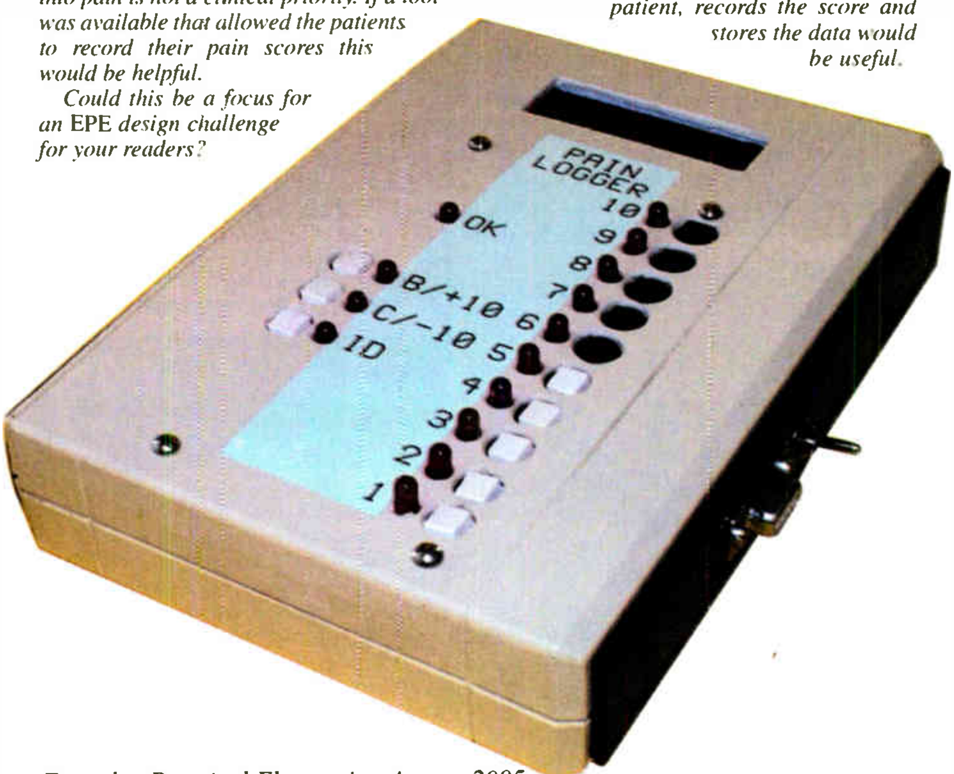
The NHS does not have the adequate nursing resources, and research and audit into pain is not a clinical priority. If a tool was available that allowed the patients to record their pain scores this would be helpful.

Could this be a focus for an EPE design challenge for your readers?

Talking with Mike, the author felt that it was an idea that he would like to explore further. Pain is a subjective experience and its perception will vary from patient to patient. Consequently, Mark was asked if there are any electrical waves the body generates when experiencing pain and which could be electronically monitored? To which Mark replied:

You have hit on the problem that underpins all research into pain. It is subjective. Pain in humans is difficult to measure. However, it is still important to measure. The type of pain scores are visual analogue scoring (previously described), using verbal descriptor ratings (No, Mild, Moderate, Severe Pain). All scoring systems are ways of asking the question "How bad is the pain?" and finding some way to statistically analyse the data.

There are conventional pain measures in clinical research. To make data between patients comparable, the data set needs to be similar. A device that prompts the patient, records the score and stores the data would be useful.



SPECIFICATIONS

- Line of 10 pushbutton switches representing and recording pain threshold values
- Two pushbutton switches to record presence or absence of other patient conditions, such as nausea or itch
- 13 l.e.d.s to visually indicate conditions selected
- Additional general purpose l.e.d.
- PIC microcontroller controlled
- Real-time clock chip, non-volatile
- Serial EEPROM (non-volatile memory), with 32K byte storage
- Serial interface to PC (any current Windows platform) via RS232 device
- PC file generated to suit viewing and analysis via Windows Excel
- PIC monitors switch presses, records which switch and the time pressed
- Provision for monitoring up to 99 patients on the same unit
- L.C.D. displays latest recorded patient data
- Unit can be switched off without memory loss
- Battery powered
- Optional audio output via buzzer

Design Criteria

Further discussions with Mark led to the formulation of the design criteria shown in the Specifications table.

Sketching out a block diagram, it was found that there was a need for PIC monitoring and control of the following:

- switches, 13 pins
- l.e.d.s, 14 pins
- serial EEPROM, 2 pins
- RS232 interface, 2 pins
- real-time clock (RTC), 2 pins
- l.c.d., 6 pins

A total of 39 pins, but as the RTC and EEPROM can be multiplexed readily, using their in-built selection via dedicated

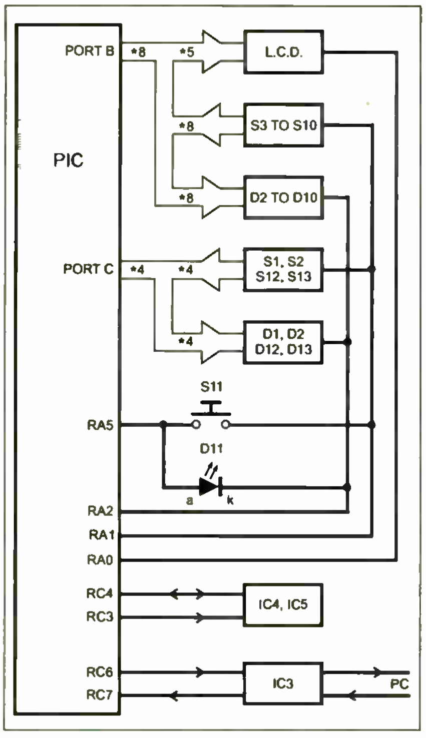


Fig.1. Pain Monitor block diagram

transmission addresses, that brought the count down to 37 PIC I/O (input/output) pins needed.

It was obvious that a PIC16F877 device, having 33 usable I/O pins, could do the job if a minor bit of multiplexing was used. However, on further consideration, it became apparent that the smaller PIC16F876, having 22 I/O pins, could be coaxed into service if more sophisticated multiplexing techniques were used, and having several devices accessed by the same pins. See block diagram Fig.1.

Circuit Diagram

The resulting complete circuit diagram for the Pain Monitor is shown in Fig.2.

The PIC16F876 microcontroller is notated as IC2, and is run at 4MHz as set by crystal X1 in conjunction with capacitors C3 and C4. Its I/O pins are used as follows:

Port B pins (RB0 to RB7):
- Outputting data to the l.c.d. (X2)
- Monitoring eight switches (S3 to S10), biased normally-high by Port B internal pull-ups
- Controlling eight l.e.d.s (D3 to D10)

Port C (RC0 to RC2, RC5):
- Monitoring four switches (S1, S2, S12, S13), biased normally-high by R1 to R4
- Controlling four l.e.d.s (D1, D2, D12, D13)

Port C (RC3, RC4):
- Data exchange with EEPROM (IC4) and RTC (IC5) (multiplexed by software address)

Port C (RC6, RC7):
- Data exchange with RS232 serial I/0 controller IC3

Port A (RA0 to RA2):
Multiplex selection of l.c.d., switches and l.e.d.s (excluding S11, D11, D14) is controlled by Port A:
- RA0 controls the E pin (enable write) of the l.c.d. when data is written to it
- RA1 controls the bank selection of l.e.d.s D1 to D13 through their commoned cathodes, buffered by resistor R5
- RA2 controls the bank selection of switches S1 to S13

Port A (RA3 to RA5):
- RA3 activates optional buzzer WD1
- RA4 controls general purpose l.e.d. D14, buffered by R7
- RA5 monitors S11, biased normally-high by R10, and controls l.e.d. D11

Switches S1 to S10, S12, S13 all have dual roles, selected via S11. They normally monitor the patient's perceived welfare, but when their second role is activated via S11, they are used to select the ID number allocated to the patient, from 1 to 99.

In Fig.2 the l.e.d.s and switches are represented in a block outline, the internal logic of which is illustrated in Fig.3.

Port A Control Logic

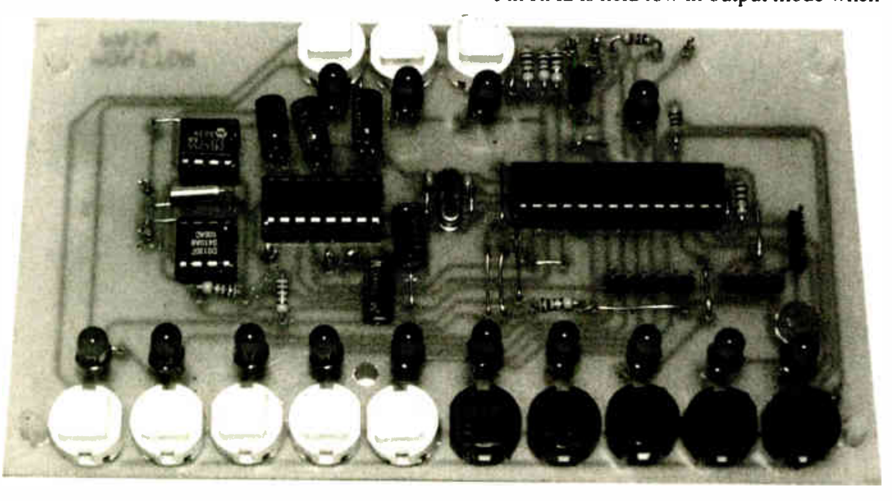
Pin RA0 is always used in output mode. It is normally held low to prevent the l.c.d. from accepting Port B data generated in response to switch and l.e.d. requirements. It is toggled as usual when required to send data to the l.c.d.

Pin RA1 is held low in output mode when data is to be sent to l.e.d.s. D1 to D13. It is set to input mode (high impedance) when data is being sent to the l.c.d. and when the switches are being read.

Pin RA2 is held low in output mode when data is being read from the switches. It is set to input mode (high impedance) when data is being sent to l.e.d.s. D1 to D13.

Pin RA3 is always set to output mode, normally low, going high when the optional buzzer WD1 is to be sounded.

Pin RA4 is always set to output mode, normally high, going low when l.e.d. D14 is to be turned on.



COMPONENTS

Resistors

R1 to R4	10k (7 off)
R8 to R10	
R5, R7	470Ω (2 off)
R6	1k

See SHOP TALK page

Potentiometer

VR1	10k min cermet round preset

Capacitors

C1, C2	100n ceramic disc, 5mm pitch (2 off)
C3, C4	10p ceramic disc, 5mm pitch (2 off)
C5 to C9	1µ radial elec. 16V (5 off)

Semiconductors

D1 to D14	red l.e.d., high brightness (14 off)
D15	1N4148 signal diode
IC1	78L05 +5V 100mA regulator
IC2	PIC16F876 microcontroller, preprogrammed (see text)
IC3	MAX232 RS232 interface
IC4	24LC256 serial EEPROM
IC5	DS1307 serial I²C real-time clock

Miscellaneous

B1	9V PP3 type battery
B2	3V Lithium battery, p.c.b. mounting
S1 to S13	push-to-make switch, high profile, round top, p.c.b. mounting (13 off) (see text)
S14	min. s.p.s.t. toggle switch
SK1	9-pin serial connector, female, panel mounting
WD1	piezo sounder (optional)
X1	4MHz crystal, low profile
X2	alphanumeric l.c.d. module, 2-line x 16-character (per line)
X3	32.768kHz crystal, capacitance 12.5p

Printed circuit board, available from the *EPE PCB Service*, code 519; 8-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; 28-pin d.i.l. socket; PP3 battery clip; plastic case 204mm × 150mm × 40mm; connecting wire; solder, etc.

Approx. Cost Guidance Only **£45** *excl meter & batts*

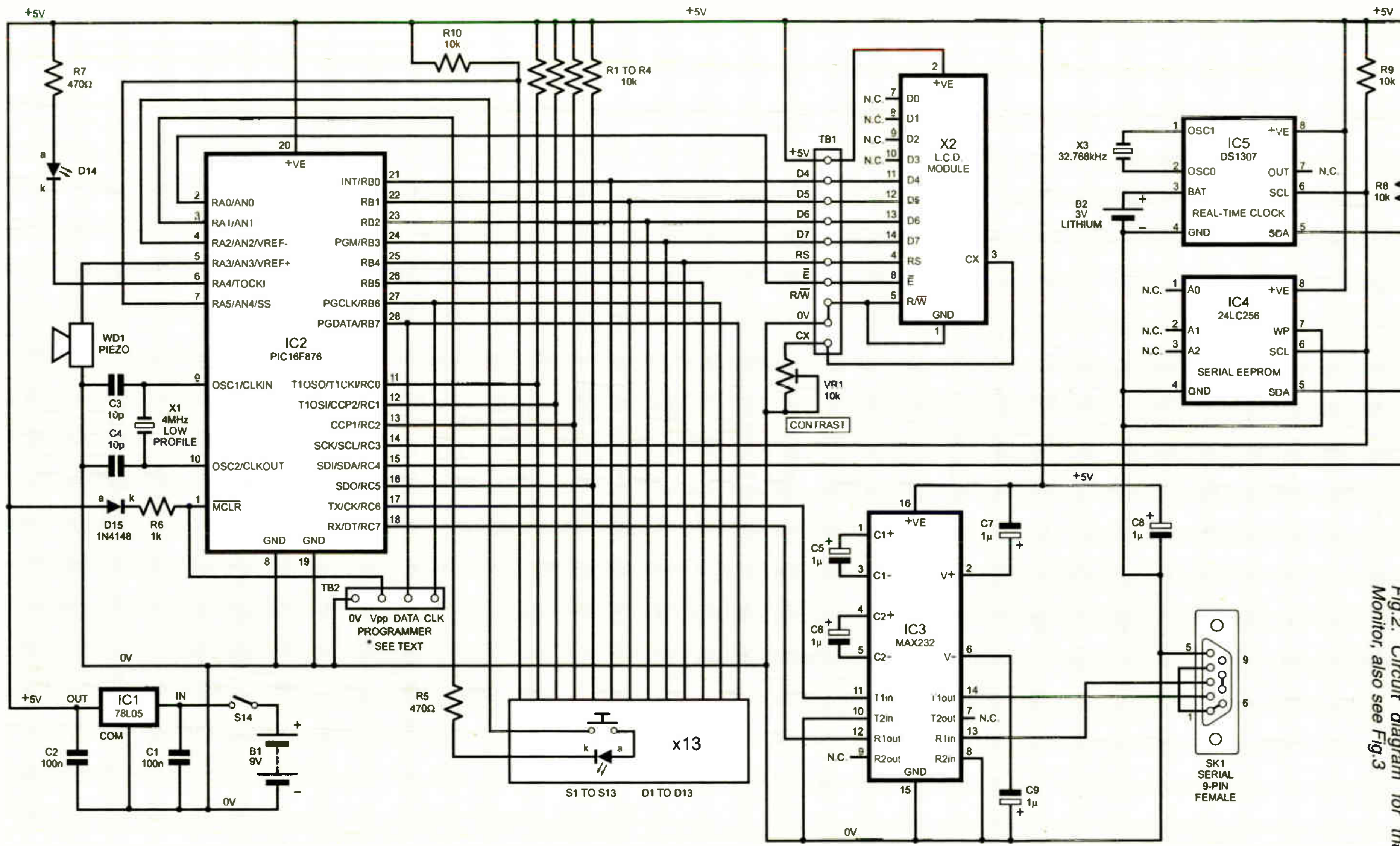


Fig.2. Circuit diagram for the Pain Monitor, also see Fig.3

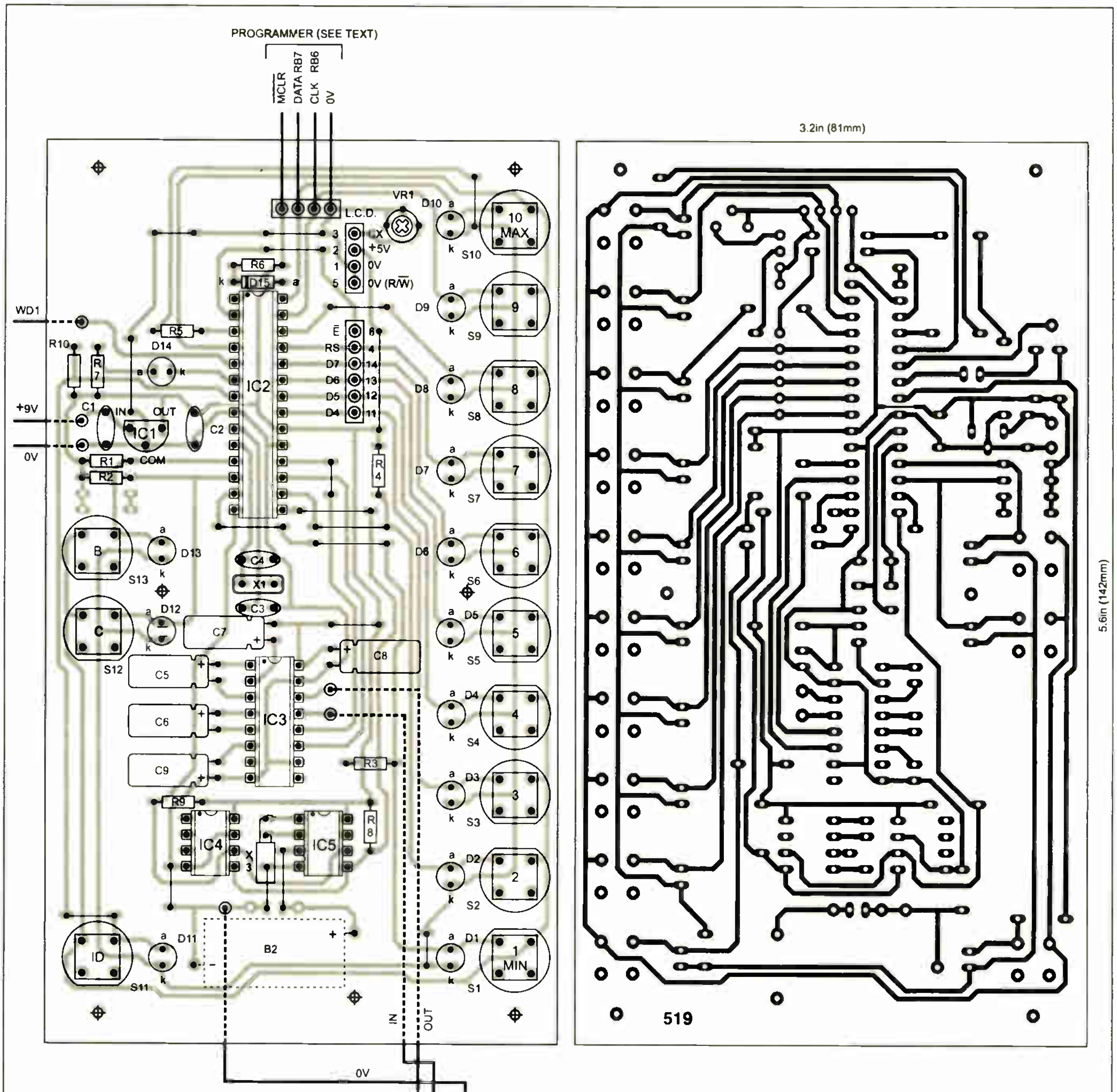


Fig.4. Printed circuit board component and track layouts

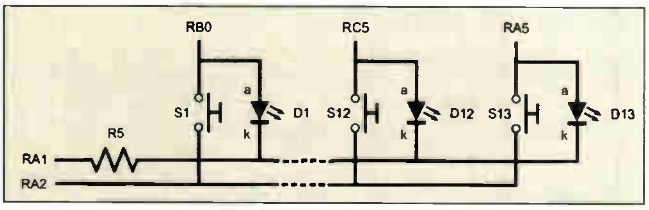


Fig.3. Switch multiplexing logic

Pin RA5 is normally held in input mode (high impedance), but set low in output mode when the switches are read.

The outputs at pins RA4 and RA5 are always changed at the same time as each other (except during data exchange with PC). Thus the buzzer is normally always activated when l.e.d. D14 is turned on.

Other Components

The remaining components in Fig.2 have the following functions:

Resistors R8 and R9 bias high the clock and data pins of the EEPROM and RTC devices. Capacitors C5 to C9 are associated with the ±10V biasing of the PC interface connections of the RS232 chip, IC3. This communicates with a PC via socket SK1 and a standard serial interface cable connected to the PC's COM1 or COM2 port.

IC1 regulates the 9V d.c. primary power supply (e.g. PP3 battery, B1) down to +5V. Capacitors C1 and C2 provide +5V line decoupling. Switch S14 turns on the 9V supply. Current consumption is about 17.5mA with no l.e.d.s on, rising to about 30mA with two l.e.d.s on.

Diode D15 and R6 protect the +5V line if the PIC is programmed in situ from a dedicated PIC programmer via connector TB2. Preset VR1 sets the l.c.d. screen contrast.

IC4 is the serial EEPROM which records the monitored data. It is a 256K-bit (32K byte) device as featured in many *EPE* data logging designs. It is accessed under 2-line I²C protocol.

The RTC device, IC5, is also accessed under I²C protocol. It is controlled by its own oscillator, activated by crystal X3, which is specified as a 32.768kHz, 12.5pF device. The RTC is powered by its own dedicated 3V Lithium battery, which can typically power it for around 10 years, roughly the same as the shelf life of such batteries. This means that the RTC is not turned off when the main 9V supply is switched off.

Consequently, the RTC continually generates real-time clock and calendar data throughout its battery life. This data is immediately accessible to the PIC once the main supply has been switched on.

The initial clock and calendar data is set into the RTC from the PC's own real-time clock when such a link is established via SK1. The RTC does not become active until this data has been sent for the first time following the unit's assembly.

Construction

The component and track layout details for the Pain Monitor's printed circuit board are shown in Fig.4. This board is available from the *EPE PCB Service*, code 519.

Assemble the board in ascending order of component size, starting with the link wires and d.i.l. sockets for IC2 to IC5.

Two initial points to note – the board must maintain a low profile to allow the l.e.d.s and switches to protrude through the case when the board is mounted behind it. This means that the electrolytic capacitors and crystal X3 need to be positioned with their bodies horizontal to the board. Additionally, crystal X1 must be a low-profile type. Ensure the top of regulator IC1 is set low, or even position this device horizontally too.

Conversely, the switches should be chosen so that their push-tops are high-profile and are well above the tops of the d.i.l. i.c.s. Get the type which have rounded tops to make hole drilling simpler. Those used in the prototype, which should be avoided if possible, have square tops requiring either a square cut-out, or a round hole of at least 11mm diameter.

The l.e.d.s should be positioned so that their tops will be about 5mm above the case. Initially, mount them somewhat higher, and then desolder and lower them once the board is mounted in the case, allowing them to be more accurately aligned before resoldering.

All the wired connections to the off-board components should be made on the trackside of the board. Pin connections for standard l.c.d.s are shown in Fig.5.

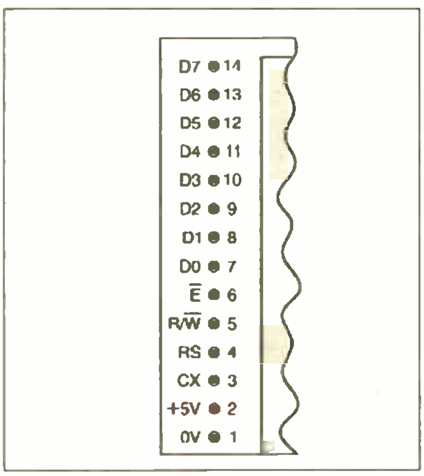
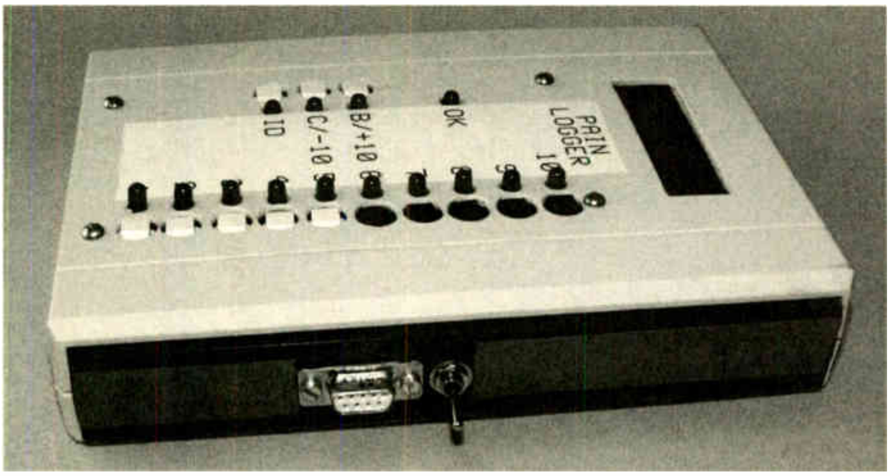


Fig.5. Pin connections for standard l.c.d. module

Battery B2 for the RTC has p.c.b. mounting tabs and should be soldered to the rear of the board. Do not short the battery's terminals together when doing so!



Enclosure

The case used to house the prototype is plastic and measures 204mm × 150mm × 40mm. Its hole drilling positions can be marked on it using a photocopy of Fig.4 as a template. The holes should allow the switches to be pressed without friction.

The l.c.d. slot can be cut by first drilling a perimeter of small holes, then cutting with a craft knife and smoothing with a file. Socket SK1 and switch S14 should be mounted in one side of the case.

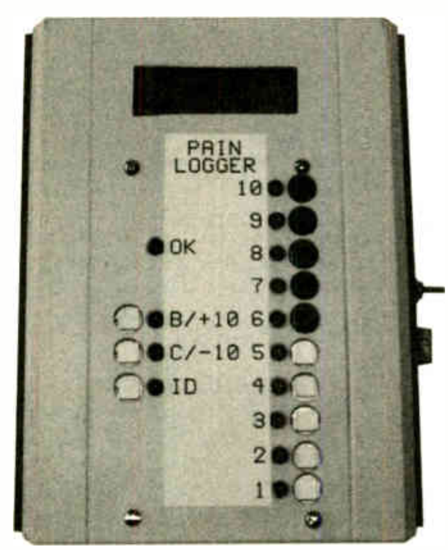
Testing

Before inserting the d.i.l. i.c.s and connecting the l.c.d., or connecting power from battery B1, thoroughly check the board for soldering and component positioning errors. Connect and switch on battery B1, then check that +5V (within a few millivolts) is present at the output of regulator IC1. Always switch off B1 before making any changes to the board (beware that B2 is always connected to the RTC's B2 power pins 3 and 4).

When satisfied, plug in the preprogrammed PIC (see later) and connect the l.c.d. Check the 5V supply line again.

On power-up, the l.c.d. should initialise into its 2-line 4-bit control mode, and display information similar to:

```
ID NO 1 EVENTA 0
B 0 C 0 00:00:00
```



Line 1 shows the ID NO (patient number), and Event A (pain) value. Line 2 shows the values for Events B and C (allocated to whatever condition you wish – e.g. itch or nausea as Mark suggests). The clock display at the right of line 2 will remain at 00:00:00 until the RTC has been initialised via the PC. It may be necessary to adjust preset VR1 to improve the l.c.d. screen display contrast.

Press one of the 10 in-line switches; l.e.d. D14 should turn on as an acknowledgement of the press. When the switch is released its associated l.e.d. will come on, the Event A value on the l.c.d. will change to match the switch number pressed and D14 will be turned off. Try the test with the other switches, excluding S11 at this time. Each time a switch is pressed and held pressed, any turned on l.e.d.s, apart from D14, will be turned off.

Switch S11 is the one that controls the ID number selection mode. Press and release it. Having released it l.c.d. line 2 will display a message similar to:

```
ID NO 1 EVENTA 3
SET NO^
```

Note the small arrow indicating the value which can be changed.

Now pressing any of the 10 in-line switches causes the ID number to change and match the switch number. If you now press S13 (B/+) the value of 10 will be added to the displayed value. Pressing S13 again adds a further 10. The maximum is 99. Similarly, pressing S12 (C/–) deducts 10 from the displayed value, to a minimum limit of one.

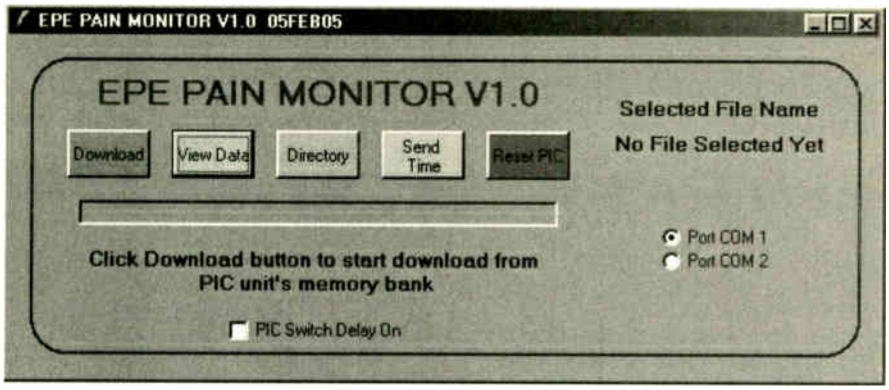
The number-changing switches may be pressed as often as required. But note that pressing S1 to S10 will always set the ID number to that switch number.

Having changed the ID number to that required, press S11 again. On releasing it the new ID number is now active, and patient welfare recording resumes, for this new patient.

When the ID is changed, the recorded Events data for the new ID replaces the previous Events data (as held in the last 512 bytes of the EEPROM).

Recording Data

The switch information relating to patient welfare is recorded to the EEPROM on each successful release of the relevant switch. This data can later be downloaded to a PC for viewing.



The main screen for the Pain Monitor's PC program

Downloading will be discussed presently, but first install the remaining chips, RTC, EEPROM and RS232, then check the +5V power line again.

The EEPROM will record data in response to each successful keypress. Data is recorded in order of ID number, year, month, day (date), hours, minutes, seconds, Events A, B and C values. Eight bytes in all, as the Event values are combined into one byte. With B and C it is only the act of pressing the switch that is recorded, not the number of times it has been pressed (the l.c.d. shows a cumulative count for the B and C values).

Event A can be a value of between 1 and 10 (bits 0 to 3), B and C are allocated 0 if unpressed, or 16 or 32 (bits 4 and 5) respectively if pressed, so fitting all three values into six bits of a byte.

After each 8-byte batch is recorded the memory address counter is advanced by eight places. A message stating RECORD COUNT is shown on l.c.d. line 2, followed by a number. The number is the EEPROM memory address divided by eight, thus representing a batch (eight bytes) count of the events recorded. The count is displayed for about two seconds before the screen reverts to its normal monitoring mode.

The maximum count should not be allowed to exceed 4032 otherwise the counter rolls over to zero, and starts again, overwriting previous data. (Essential program "housekeeping" data is held in the last 512 bytes of the EEPROM and these 64 blocks are not available for other data storage.) It is recommended that the data should be downloaded to the PC before the maximum is reached, and the EEPROM then erased (see later).

PC Interface

Having recorded a few events, the EEPROM contents can be downloaded to the PC. First, though, the PC must run its specially written program. Details for obtaining and copying this software to your PC are given in the Resources section later.

The program has been written in Visual Basic 6 (VB6) and its purpose is to download data from the unit's EEPROM, clear the EEPROM when required, set the RTC clock and calendar real-time values, and to produce data files suited to examination via Excel or a text editor such as Notepad or Wordpad etc. The program does not offer any graphics display or other data analysis.

An example of a typical VB6 display of the program's main screen is shown above.

The program can be run in one of two ways, either through its source code if you have VB6 installed, or via a standalone facility if you do not. The source code will not be discussed, but running the standalone version is as follows.

Having copied the files to your PC (see later), click on the **PainMonitor.exe** file icon (a lightening flash) to launch the program.

Connect the serial cable between the Pain Monitor and one of your PC's serial ports, e.g. COM1 or COM2. The unit cannot be used with a USB port. The cable should be one of the "standard" (straight through) types, such as used with external modems.

On the screen at the right are two "radio" buttons, marked COM1 and COM2. Click on the one that matches the port into which you have plugged the cable. This information is recorded to disk and recalled each time the program is run. It may be changed by the same buttons whenever you wish.

Setting Calendar and Time

The first thing to do now is set the current calendar and time data into the PIC. Click on the Send Time button. This causes the PC's current calendar and time values to be sent to the PIC, which then installs them into the RTC chip. They should never need to be sent again, for the life time of the RTC battery, B2. The RTC device even keeps track of leap year facts.

However, it is believed that the RTC does not update itself for winter/summer daylight saving changes. These, though, are known to the PC for the country selected (this will normally be your own country unless the PC settings have been changed). Consequently, following a daylight saving change (e.g. GMT or BST for the UK), the revised time can be sent to the PIC via the Send Time button.

Handshakes

The PC software expects handshakes when exchanging data with the PIC. If these are not received in approximately five seconds, a time-out occurs and a screen message informs you of the fact, advising you to check your serial cable and power supply connections (the PIC unit must have its main battery switched on).

Switch Response Delay

The Send Time button also allows a switch response delay to be turned on or off. The function is set via the Delay On tick box at the bottom of the screen. Click on it to toggle between the settings. A tick means that the delay will be active. Click the Send Time button to send the currently required setting, as well as the time and date. The default for the unit following its assembly is delay off.

With the delay turned off the PIC responds almost immediately to any switch press, as you will have found already. With the delay on, when any switch is pressed there is a delay of about three seconds before the PIC accepts the press as valid. At the moment of the switch press, the l.c.d. displays a message on line 2, WAIT FOR LIGHT, indicating that the switch must remain pressed until the delay has ended.

The end of the delay is indicated by the l.e.d. D14 being turned on and screen line 2 showing OK. The switch can now be released, on which D14 will go out again and the l.c.d. will show new data on line 2. If the three seconds delay is active and a switch is not pressed for long enough, all l.e.d.s will remain off until one of them is correctly activated.

EEPROM Clearance

Next, the unit's EEPROM should be cleared, all values being reset to zero. Click on the PC screen's Reset PIC button to start this process. It is a fairly slow process to clear all 32768 EEPROM bytes, taking about two and half minutes to complete. This is due to the various delays required within the PIC software for the procedure to perform correctly.

During the clearance time, a bargraph on the PC screen tracks the progress. The l.c.d. also displays a tracking message, for example:

On completion, the l.c.d. screen reverts to the normal monitoring display, and the PC screen reverts to standby mode.

The EEPROM clearance can also be done from the unit itself. With the unit switched off, press switch S11 and hold it pressed. Switch on the power, wait a moment for the unit to initialise and display the message that the EEPROM is being cleared. Switch S11 can now be released.

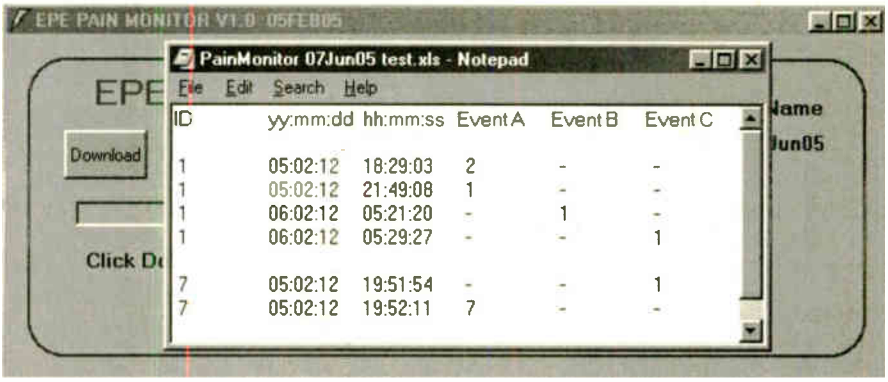
Downloading to PC

Having cleared the EEPROM, press any switches you wish on the Pain Monitor to record example data. Then switch off the unit until you are ready to download the data.

When ready to download, switch on the unit, click on the PC screen Download button to start the data download from all 32K bytes of the EEPROM. Again a bargraph tracks the progress. The l.c.d. screen simply shows the one-line message:

The downloading does not change the contents of the EEPROM, and once it is complete, further data recording starts from the last available address before downloading started.

On completion of the download, the l.c.d. screen again reverts to the normal display. The PC, though, now takes the downloaded



Simulated example of monitored data after download and shown through Windows Notepad

data, formats it suitably for viewing via Excel etc., and sorts it into order.

The sorting process groups data in priority order of ID number, date in relation to YY:MM:DD, and time in relation to HH:MM:SS, followed by the values for Events A, B and C. Blank lines are placed between each ID number group for ease of viewing.

Having completed the sort, the data is output to a file having a name prefix of PainMonitor plus the date and time of the download, followed by the extension .XLS. For example:

PainMonitor 26JAN05 23-32-29.XLS

When the file has been saved, it is immediately opened for viewing as a text file, through Windows Notepad or Wordpad, depending on its size.

Click the text screen's normal X button to close it. The file can be recalled by clicking on the View Data button.

The Directory button allows you to select any previously recorded Pain Monitor file for viewing. The facility has a variety of functions which allow the folder path in which the files are stored to be selected. The one you need to select is that for the folder in which you placed the Pain Monitor VB6 software.

There is a Notes button on the screen which causes detailed notes about the Directory screen options to be displayed.

Other applications

As stated in this article's sub-title, the Pain Monitor can be used for other applications. Three such come to mind and no doubt you will think of others.

One possible use is for recording moderately-slow sports events which allow time for the ID number to be set, such as sailing (but probably not motor racing!).

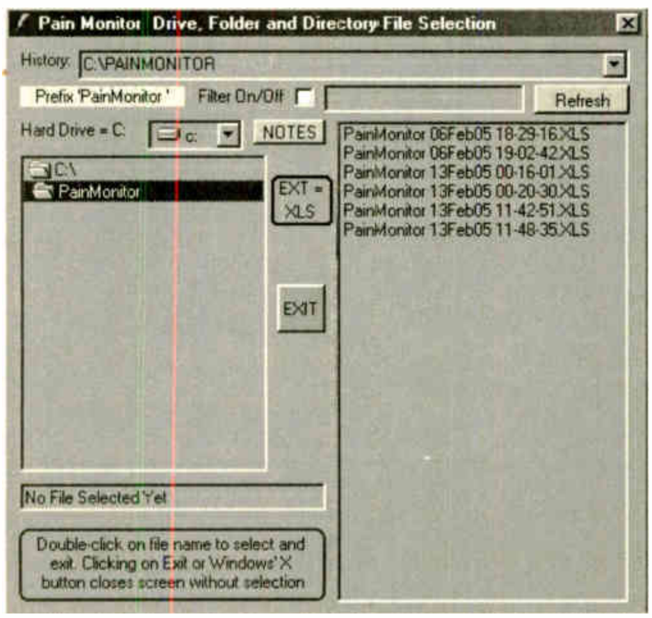
With sailing, for example, the ID number could be that of a particular craft. Switch S13 (Event B) being pressed to record the time of the start of a race. S12 (Event C) could record its completion time. Switches S1 to S10 (Event A) could be pressed at various stages during a race to record the progress, e.g. the time at which a particular buoy is passed. Mike says that craft handicaps could be calculated from such recorded data.

Golfers might also find the unit useful to record their scores at various holes.

Another is for the unit to be used as a wildlife monitor. You could, for instance, regard the ID number as representing a particular bird or animal, e.g. 1 for heron, 2 for cormorant, etc. Having seen the creature, select its allocated ID number, then press the appropriate switch S1 to S10 to record the quantity seen and the time of the sighting.

Conclusion

The Pain Monitor is currently being field tested by Mark Piper and a commercial role for it is under consideration.



Simulated example of the directory screen

It has been a challenge to the author to achieve realisation of this design, but also a satisfaction in the knowledge that he has been able to design something that has potentially wider social benefits. Should you have ideas for other such beneficial designs, let the author know via *EPE*, **john.becker@wimborne.co.uk**

Resources

Software, including source code files, for the PIC unit and PC interface is available on 3·5inch disk from the Editorial office (a small handling charge applies – see the *EPE PCB Service* page) or it can be downloaded *free* from the *EPE* Downloads site, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under Pain Monitor. Download all the files within that folder.

This month's *Shoptalk* provides information about obtaining pre-programmed PICs.

The PIC program source code (ASM) was written using *EPE Toolkit TK3* software (also available via the Downloads site) and a variant of the TASM dialect. It may be translated to MPASM via *TK3* if preferred. The run-time assembly is supplied as an MPASM HEX file, which has configurations embedded in it (crystal XS, WDT off, POR on, all other values off). If you wish to program the PIC yourself, simply load this HEX file into the PIC using your own PIC programming software and hardware.

The PC interface software was written under Visual Basic 6 (VB6), but you do not need VB6 to be installed on your PC in order to run it.

Whether or not VB6 is installed, copy *all* of the Pain Monitor files (except the PIC files if you prefer) into a new folder called C:\Pain Monitor, or any name of your choosing, on Drive C (the usual hard drive letter).

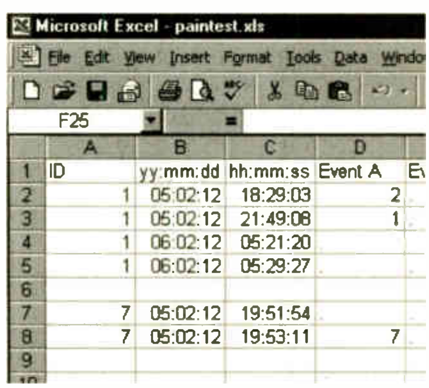
If you do not have VB6, you also may need three other files, **comdlg32.ocx, Mscommctl.ocx** and **Msvbm60.dll**, held on our 3·5inch disk named Interface Disk 1, and in the Interface folder on our Downloads page (they are also included with the *TK3* software, in Disk 2). These files must be copied into the same folder as the other Pain Monitor files.

These three files are not supplied with the Pain Monitor software as they are common to several *EPE* VB6 projects and amount to about 1MB of data.

Additionally, the VB6 source code makes use of Joe Farr's excellent *Serial Interface for PICs* (Oct '03) software. In order to access (and perhaps modify for your own purposes) the Pain Monitor VB6 source code files, you need to have Joe's software installed on your PC as well (see his published text). This is also available via our Downloads site.

Without Joe's software installed, if you try to access the Pain Monitor VB6 source code, it will crash.

Note that you should not attempt to "install" the Pain Monitor VB6 files via Explorer or other similar PC facility. Use Windows' own normal Copy facility. □



Example of a section of Windows Excel showing some of a downloaded data file

Net Work

Alan Winstanley

Let There Be Delight

This month has been a very special one in the history of this Internet column (which itself started life in October, 1996). After well over a decade of chomping at the bit, watching enviously as the rest of country surfed the Internet at ever-increasing speeds, and being brushed off by an intransigent British Telecom and their cruel "trigger levels", against all the former odds ADSL finally arrived with a bang at the author's worklab.

Joyful was the day on 25 May 2005 when I could finally hit the Upgrade button on the Tiscali web site and – at long last – order broadband services for my fax number.

The entire process went extremely smoothly (once I remembered my web site log-in password!). Tiscali is to be congratulated on providing a very efficient and informative upgrade process, in which regular updates were emailed out, the documentation arrived within 48 hours and a conversion date was duly set for two weeks hence. In fact, as a pleasant surprise, ADSL was enabled within the week: I know this because Tiscali sent another email out of the blue advising that the broadband service had now been switched on, and when I looked under the desk at the newly-installed router, the ADSL l.e.d. had suddenly illuminated!

Tiscali's free ADSL modem and two free microfilters arrived in plenty of time as well, in a packet that fitted conveniently through the letterbox. Tiscali's entire upgrade process could not be faulted, which I suppose is one of the benefits of being a late adopter – the rest of the country having been the guinea pigs for the UK's ADSL rollout programme. To start with, Tiscali 512k has been chosen, which has a 30GB per month limit that is more than enough for the time being. Higher speeds have tighter restrictions, and an attractive piece of software that helps you monitor usage totals is the DU Meter from **www.dumeter.com**. A 30 day trial can be downloaded.

Since the writer has a small network, a somewhat overpowered but futureproof ADSL2+ gateway has been used to connect the network to the phone socket. Of course, a microfilter (supplied) is needed to separate out the lower frequency signals for the fax machine, and any other telephones or fax machines connected to extensions on the same ADSL-enabled line each need their own microfilters.

On Guard

Compared with the frustrations of dialup, having ADSL always-on Internet access has been a surreal experience. Mail is checked and filtered immediately. Web sites that were beyond reach due to bandwidth constraints now spring into life. Machines can be left to look after themselves without worrying about time-outs. For someone working in today's knowledge-based economy, broadband Internet access is life transforming.

Always-on access brings its own risks, of course, including viruses, snooping, hijacking, keylogging Trojans and other spyware. There comes a point where it is more cost effective to leave some aspects to experts, especially concerning networking and security. Working on the principle that I know my limits and life is too short to fight with IT equipment, for the sake of one hour's labour a network professional has configured properly the router, the network and the security settings. It is money well spent, and having a robust network sheltering behind a router brings with it peace of mind and some added security benefits.

For single PC users having an ADSL modem, ensure that Windows Firewall (XP) is on. One must be even more vigilant though and ensure that anti-virus software is updated and that spyware is constantly dealt with. I will be looking into these issues in forthcoming columns. I am also happy to report that Tiscali does not have a problem with sending own domain mail either, unlike BT. (This is a real headache for some users and I will be suggesting some workarounds in future articles.)

Net More Benefits

Not all ISP's tariffs permit more than one PC to share a single ADSL port, but for the writer the next question is how to connect other computers and a laptop to the same network. A Linksys 802.11b wireless access point was hooked up to the gateway, and USB WiFi dongles were used on the laptop and on another PC in the building, to connect them to the Internet. The Linksys equipment is neat and stackable, and I am sticking with a pile of separate Linksys devices, even though newer combined units are now available.

Forget any idea of instantly "going wireless" and the entire building coming alive with powerful WiFi internet access. It must be said that WiFi may not be the most reliable method of hooking to a network, so expect some debugging and trial and error. In the writer's case, having four brick walls and a large copper water heating tank in the way did nothing to help with signal strength. Wireless network reliability depends enormously on bricks, people, concrete, pipework, radiators, water tanks and the odd steel-cased PC or filing cabinet not getting in the way. Near line of sight transmission is preferable.

The aerial location and r.f. transmission pattern can also play a part; perhaps consider using an internal antenna on the wireless access point if necessary. Helped along by an unofficially-long USB extension lead, a USB dongle was Blu-tacked to the wall, in near line-of-sight of the WAP, and effective links were finally established with another PC. Another machine uses a PCI 802.11g card successfully. Meanwhile, the laptop works fine on WiFi with its USB dongle, even at the bottom of the garden.

Again, rather than spend a lot of time struggling to re-invent the wheel, consider leaving this to a reputable networking professional who will also (absolutely critically) configure the security for your wireless system that will prevent any wireless-enabled neighbours from thieving your bandwidth or snooping on your machines.

Homeplug: Networks For Live Wires

If wireless networking isn't for you, then more recently networking through the mains electricity supply has started to take off, applying the new Homeplug standard (see **www.homeplug.org**). In effect, Ethernet can be fed into the ring mains and special mains adaptors act as Ethernet ports for network clients such as PCs, Homeplug-capable DVD and HDTV. One Homeplug adaptor product claims a range of 500 metres at 14Mbps.

An excellent source of network components, WiFi, antenna, Homeplug adaptors and interesting information is available from Solwise of Hull (**www.solwise.co.uk**), well worth browsing and bookmarking. The same web site explains remarkably well why faster is not always better or more reliable, especially comparing wireless 802.11g with its slower stablemate 802.11b, as used on the author's wireless access point.

Needless to say, readers, there are many exciting and interesting times ahead, and I'll be sharing useful hints, tips and pointers in future editions of *Net Work* – The Internet column.

You can email me at **alan@epemag.demon.co.uk**

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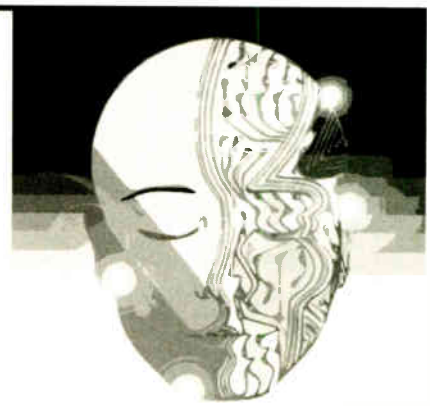

Ingenuity Unlimited

Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must not have been published or submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and include a full circuit diagram showing all component values. **Please draw all circuit schematics as clearly as possible.** Send your circuit ideas to: *Ingenuity Unlimited,* Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. (We **do not** accept submissions for IU via email). Your ideas could earn you some cash **and a prize!**

Helix Thermostat *Spiralling Into Control*

THE Seebeck effect will be familiar to most *EPE* readers – when heat or cold is applied to one of the junctions of a circuit composed of two different metals, a small amount of electricity is generated. Less familiar, however, is that a thermoelectric effect may occur in a circuit composed of a single metal. For this, one only needs to twist a wire into a helix, and to heat it to one side of the helix.

For the circuit described here, the author created such a sensor, or "thermistor", using seven turns of 24s.w.g. (0·56mm diameter) copper wire wound on a 10mm diameter former. At one side of the helix, he twisted the wire into a small, flat zigzag "pad" measuring about 10mm by 10mm, to maximise the area affected by the heat of a candle flame. This "pad" was situated at the base of the helix.

Using a single candle flame, this generated nearly 1mV and 0·5μA, which in terms of modern electronics is a very useful amount. In fact a candle flame is not required, since the circuit shown in Fig.1 may be triggered with a mere ten degrees change in temperature.

Circuit Details

Referring to Fig.1, IC1 represents a simple comparator. The thermistor "pad" is wired to IC1's inverting input pin 2, and the thermistor helix is wired to non-inverting input pin 3. Resistors R1 and R2 are not strictly necessary in the circuit, but add stability, particularly where mains wiring is present in the vicinity, otherwise the wire helix may act as a pick-up coil.

Multiturn preset VR1 is used to take advantage of IC1's offset adjustment feature, and is used to adjust the thermostat. Resistor R3 and transistor TR1 represent a simple current amplifier to switch relay RLA.

When the circuit is first powered up, VR1 needs to be adjusted so that l.e.d. D1 just extinguishes. When heat is applied to the thermistor's "pad", a potential difference is generated across the inverting and non-inverting inputs of IC1, and the output of IC1 switches high, thus triggering the relay via TR1.

It needs to be borne in mind that the "thermistor", unlike a standard thermistor, measures relative changes in temperature. It therefore effectively compares the temperature between the "pad" and the helix.

Hot Property

One may wonder what the usefulness of such a circuit might be. Three possibilities immediately present themselves in their characteristics. The "thermistor" effectively has zero resistance, it generates a small voltage when heated, and it is "quiescent" when the temperature equalises across its length.

These characteristics might find special applications. An obvious advantage is that a sensor made of copper may withstand temperatures up to 1083°C. In fact if platinum wire were used, this would increase to 1755°C. A further advantage is that, since the thermistor measures *relative* temperature, it would be ideal, if suitably arranged, for sensing rising heat in a room. Thus it would serve as a very cheap and effective fire alarm system. With the thermistor reversed, the circuit would of course detect falling temperature.

Thomas Scarborough, South Africa

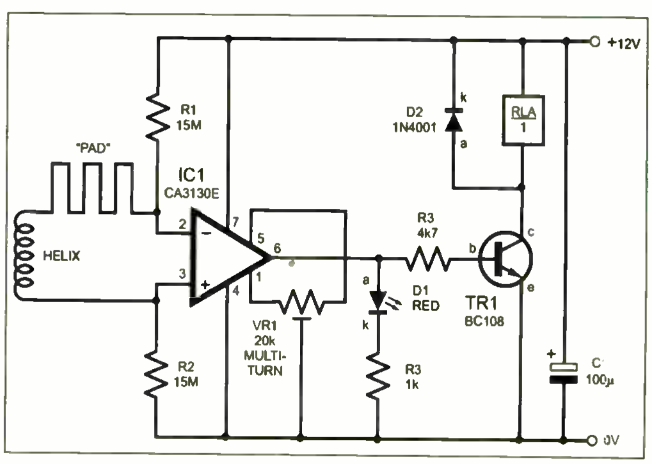

Fig.1. Circuit diagram for the Helix Thermostat. The helix thermistor is wound using 7 turns of 24s.w.g. copper wire

Meter Identifier *Measuring Up To It*

THE circuit diagram shown in Fig.2 is for a device I was asked to build for a friend who, when walking around radio rallies etc, trying to find a 100μA meter, had trouble locating one. Firstly because some meters are not marked with the f.s.d. (full scale deflection), secondly because some meters have special scales like °C or volts.

Switch S2, when in position G (green) puts 33 kilohms (33kΩ) into circuit, limiting the maximum current that can be drawn to about 40μA. This will give over three-quarters f.s.d. on a 50μA meter. It is important that the meter needle should not go "hard over" to f.s.d. in case this damages it and prevents the true f.s.d. from being seen.

On range G the meter will give just below half f.s.d. for 100μA meters. On range Y (yellow) the meter will give just below 400μA for a 500μA meter or just below half f.s.d. for 1mA. On range R (red) it will give 8mA for 10mA or 100mA movements. The range names refer to the colour codes used for the prototype's S2 switch positions.

Pushbutton switch S3 operates on red and will give current limited by the lamp (LP1) for 1A upwards for continuity checks. The red range and S3 also serve as a battery test point.

Extra or different ranges can be added as felt necessary. When using the unit, start at range G the lowest current.

You must ask the stall holders permission before testing any meters!

Jim Littler G4HPH,
Wigan, Lancs

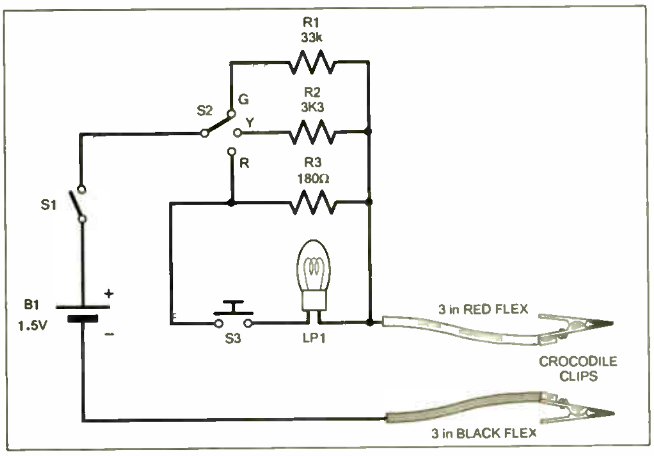

Fig.2. Circuit diagram for a simple Meter Identifier

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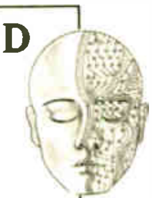

The Terminator *Arnie's Aid?*

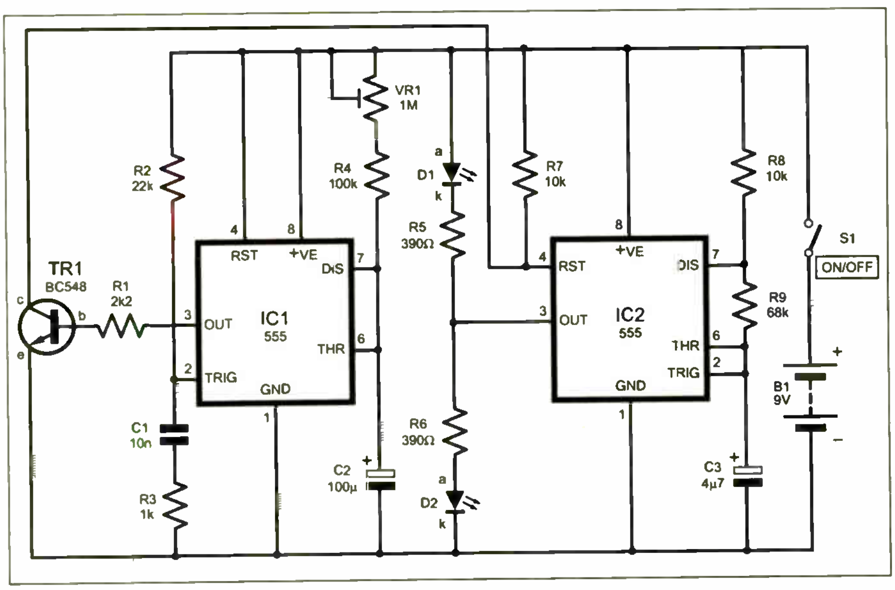

Fig.3. The Terminator speech timer circuit diagram

A FRIEND who organises guest speakers for his Probus Club sought my help. Apparently many of the speakers tend to ramble on and exceed the time scheduled for their talk. Could I design an instrument that he could operate from his seat at the back of the room which would discreetly signal the speaker to draw their talk to a close? The terminator circuit shown in Fig.3 is the result!

When power is applied, two events are set in motion. A five minute delay period is initiated and an ultrabright l.e.d., D1, begins to glow. The appearance of the light warns the speaker that he/she is nearing the end of the allotted time.

After a lapse of approximately five minutes, the l.e.d. starts to flash alternately with a second ultrabright l.e.d., D2, in a hard-to-ignore manner. This indicates the termination of the speaker's segment.

The prototype comprised two LM/NE555 timers, IC1 and IC2, although a dual NE556 timer could be used instead. IC1 is configured as a conventional timer and IC2 as a slow-running oscillator. When power is applied via switch S1, trigger pin 2 of the timer is momentarily taken to ground via C1 and R3, which triggers the timer. Capacitor C2, resistor R4 and preset VR1 determine the delay period.

Transistor TR1 is now switched on by IC1's output, pin 3, which temporarily disables the oscillator, IC2, by taking its reset pin 4 to 0V.

During the delay D1 glows continuously, while D2 remains off. At the end of the timing sequence, IC1 pin 3 goes low, turning off TR1, thus enabling the oscillator, allowing both l.e.d.s to flash alternately. The combination of R8, R9 and C3 provide a fairly symmetrical flash rate but their values are not critical.

Tony Lee,
Old Reynella, S. Australia

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ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

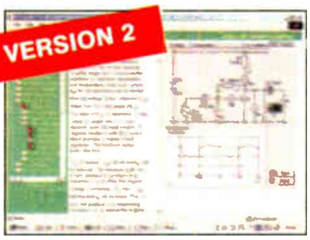
Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

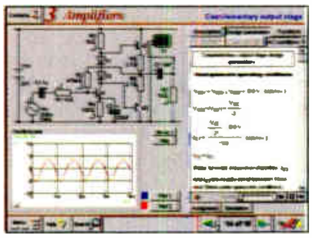
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS



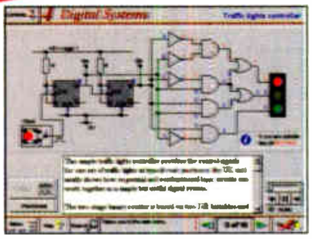
Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

VERSION 2

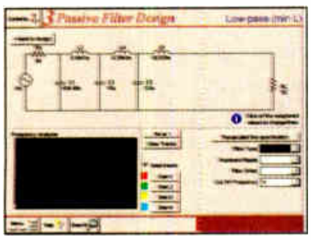


Virtual laboratory – Traffic Lights

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

Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers, A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

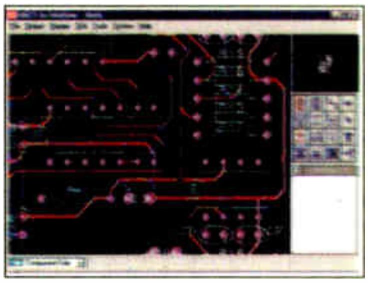
ANALOGUE FILTERS



Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev

ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
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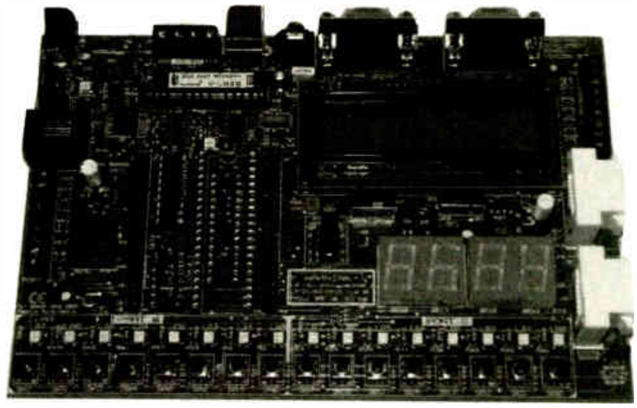

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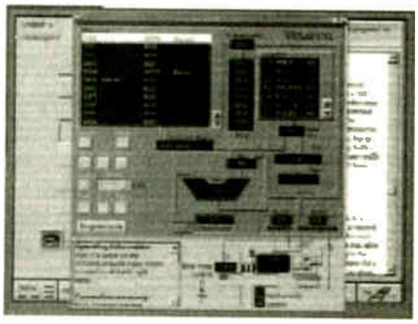
● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.



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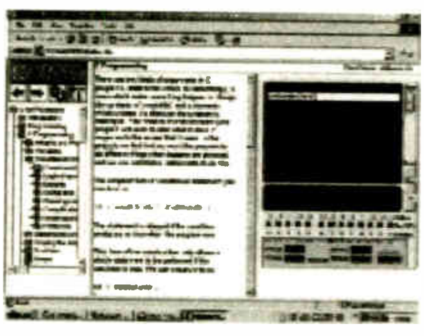
● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



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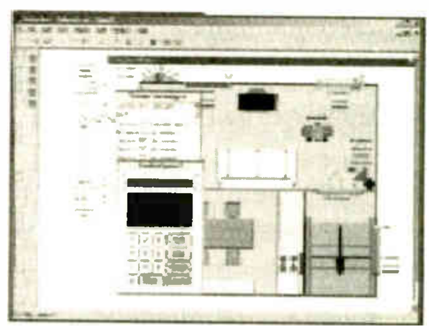

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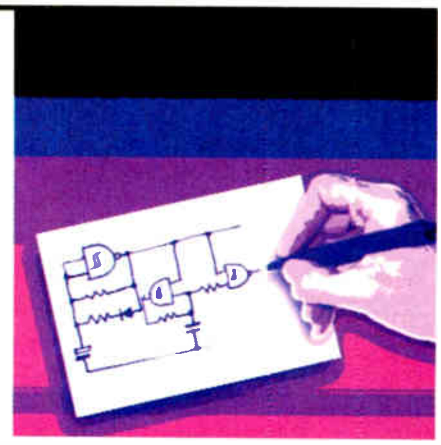
Back to Basics – CMOS Logic Devices



Bart Trepak

Part 5 – Kitchen Timer and Room Thermometer

This short series of articles illustrates how useful circuits can be designed simply using CMOS logic devices as the active components

THERE are many simple operations in a kitchen which require short timing intervals without constant attention, and simply needing a signal to alert the user that the operation has been completed. Such devices are available in the shops, including electronic timers featuring crystal controlled timing with l.c.d. displays. But if such sophistication is not really needed, it can still be almost as cheap to build your own, and much more fun!

The timer described here can be set for periods of up to nine minutes in one minute increments, but a simple component change can result in, say, a 4·5 minute period in 30 second increments, or 18 minutes in two minute increments. Longer periods are impractical unless the timing is repeated or the clock oscillator redesigned. The elapsed time is displayed to the nearest minute and an alarm indicates the end of the period.

Basic Operation

This design is based on a 4017 decade counter. To make a simple timer using it, all that is required is an oscillator to pulse the clock input once every 30 seconds or every minute, causing the outputs to be triggered high in sequence at this rate. Connecting l.e.d.s to each output will thus show the state of the counter, indicating the number of periods elapsed and the number still left to run. A block diagram of the circuit is shown in Fig.5.1.

The counter can be set for the delay required by advancing the count manually by a pushbutton switch connected to the Inhibit pin 13 (assuming that the logic levels at the CLK pin is in its correct state). This also starts the timer which will continue to run from the set position. When the counter rolls over to its zero position, the clock oscillator is disabled and an oscillator driving a piezo sounder is switched on via a monostable to briefly indicate the end of the timing period.

Since the l.e.d.s remain off following the end of the timing period, the circuit draws virtually no current in the stand-by condition and therefore no on/off switch is provided.

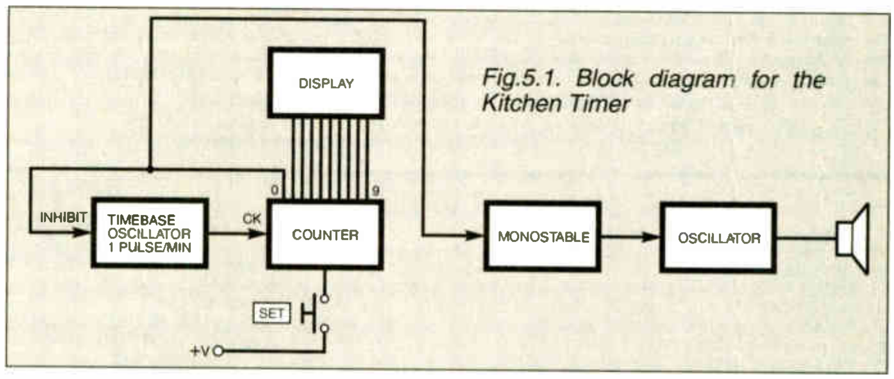


Fig.5.1. Block diagram for the Kitchen Timer

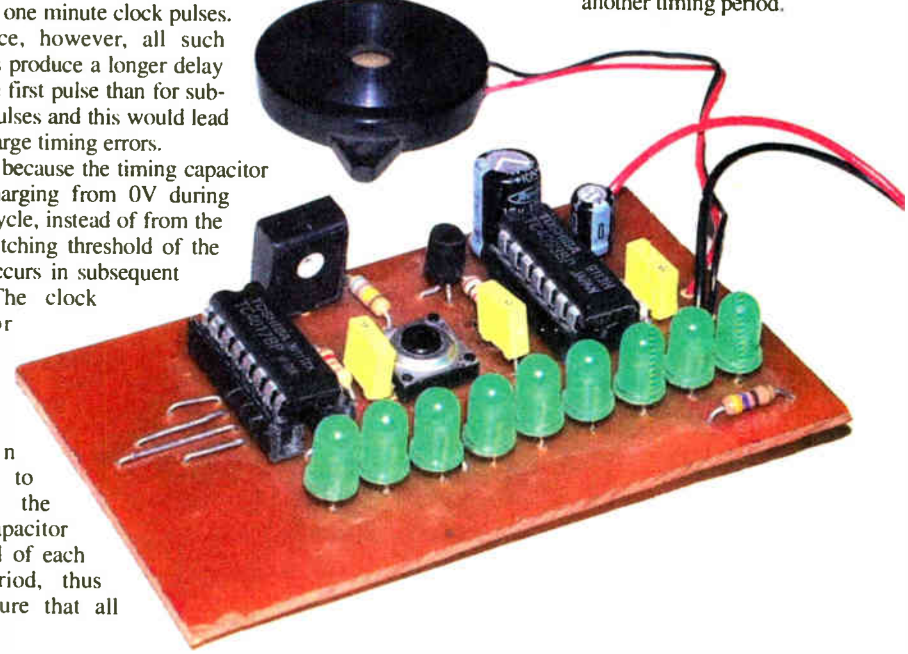
Circuit Diagram

The complete circuit diagram for the Kitchen Timer is shown in Fig.5.2. The decade counter is shown as IC2. At switch on, assuming IC2 is reset, its Q0 output will go high and the alarm may sound briefly. All of the l.e.d.s. will be off and timing capacitor C1 will be uncharged.

In principle, a clock oscillator based on a Schmitt NAND gate (as built around IC1c and used to sound the alarm in this project) could be used with suitable values of resistor and capacitor to provide the 30 second or one minute clock pulses. In practice, however, all such oscillators produce a longer delay before the first pulse than for subsequent pulses and this would lead to fairly large timing errors.

This is because the timing capacitor begins charging from 0V during the first cycle, instead of from the lower switching threshold of the gate as occurs in subsequent cycles. The clock oscillator in this project has therefore been designed to discharge the timing capacitor at the end of each clock period, thus making sure that all pulses occur at approximately equal time intervals.

When Start/Set switch S1 is pressed and released, the counter is advanced from output Q0 to Q1, turning on l.e.d. D1. With Q0 now low, capacitor C1 starts to charge, causing the voltage at IC1a input pin 2 to fall. When the lower logic threshold of this input is reached, the monostable formed by IC1a and IC1b is triggered and IC1b output pin 4 goes low for a short period, defined by capacitor C2 and resistor R3. This switches on transistor TR1, discharging C1 ready for another timing period.



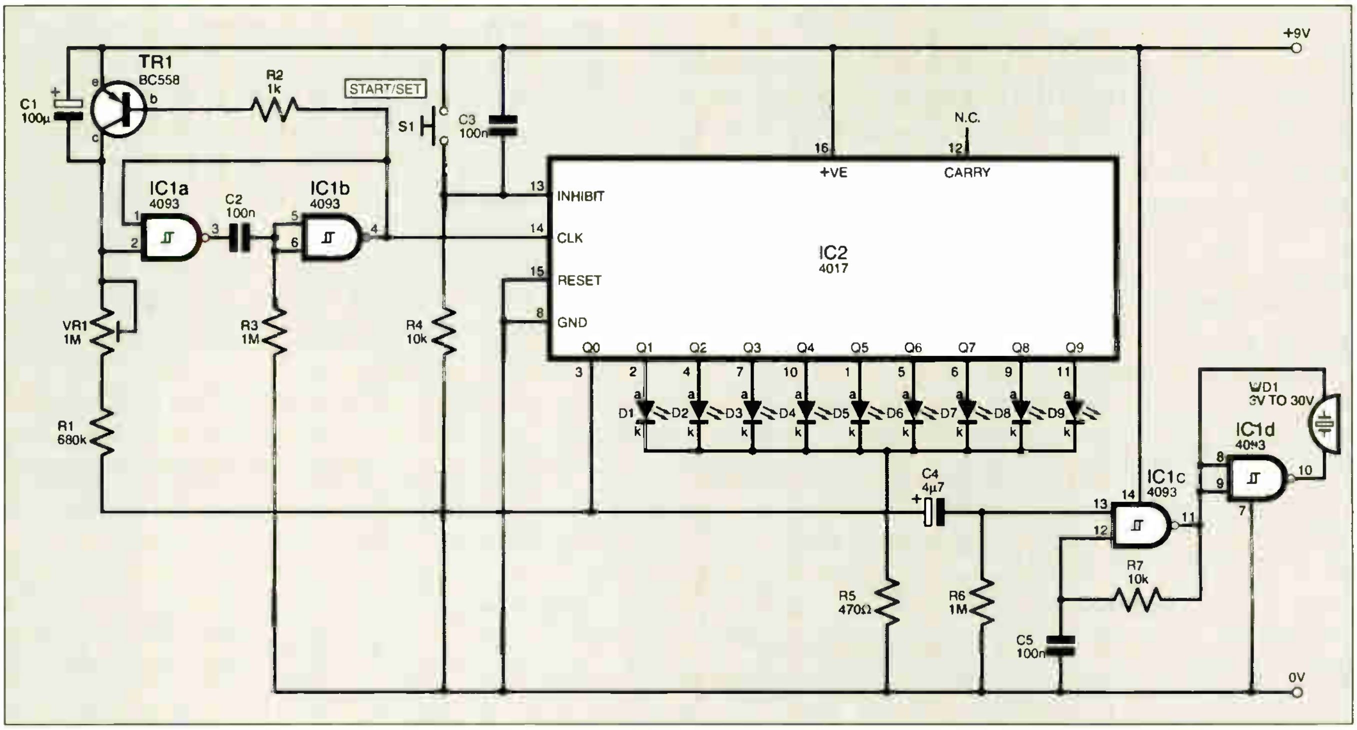


Fig.5.2. Full circuit diagram for the Kitchen Timer

In principle, a diode from the output of IC1a, which goes high for the C2/R3 period, could be used to discharge C1, but there would still be a residual charge on C1 because of the 0·6V forward voltage drop of the diode. Since the voltage across a saturated transistor is only about 0·1V this will discharge C1 more fully, resulting in a much smaller timing error.

When the output of IC1b returns to its high state, the counter is advanced by one count and transistor TR1 is switched off, allowing C1 to begin charging again. As the Q0 output of IC2 remains low until the counter has cycled through all outputs Q1 to Q9 and back to Q0, the clock circuit will continue to produce pulses and the l.e.d.s light up in turn.

When the count again reaches Q0 and this output goes high, the oscillator will stop as C1 will no longer charge via R1/VR1 and will discharge fully to be ready for another timing cycle. Output Q0 going high creates a pulse across capacitor C4, causing IC1c input pin 13 to go high for about five seconds, determined by the C4/R6 values.

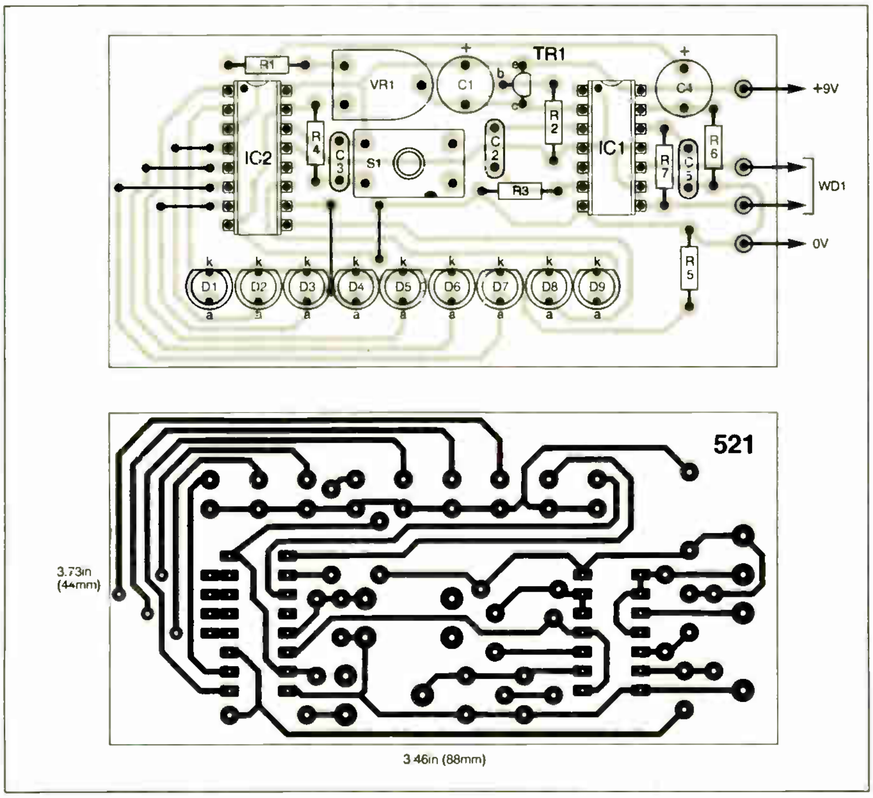


Fig.5.3. Kitchen Timer printed circuit board component layout, wiring details and full-size underside copper foil track master

COMPONENTS

KITCHEN TIMER

Resistors

R1	680k	**See SHOP TALK page**
R2	1k	
R3, R6	1M (2 off)	
R4, R7	10k (2 off)	
R5	470Ω	

All 0·25W 5% carbon film

Potentiometer

VR1	1M skeleton preset

Capacitors

C1	100µ radial elect. 16V
C2, C3, C5	100n ceramic disc, 5mm pitch (3 off)
C4	4µ7 radial elect. 16V

Semiconductors

D1 to D9	red l.e.d. (9 off)
TR1	BC558 *pnp* transistor
IC1	4093 hex Schmitt trigger inverter
IC2	4017 decade counter

Miscellaneous

S1	min. push-to-make switch
WD1	passive piezo sounder element

Printed circuit board, available from the *EPE PCB Service*, code 521;14-pin d.i.l. socket; 16-pin d.i.l. socket; 9V battery and connector; case to suit; connecting wire; solder, etc

Approx. Cost Guidance Only **£12** *excl case & batts*

The positive-going pulse enables the oscillator formed around IC1c to briefly sound the alarm, WD1, via IC1d, signifying the end of the timed period. Capacitor C5 and resistor R7 set the alarm tone frequency. IC1d is used as an inverter to drive the piezo sounder in anti-phase, thus producing a louder sound.

When the pulse from C4 ends and IC1c pin 13 is again held low via resisitor R6, the oscillator stops and the current drain of the circuit falls to just a few microamps.

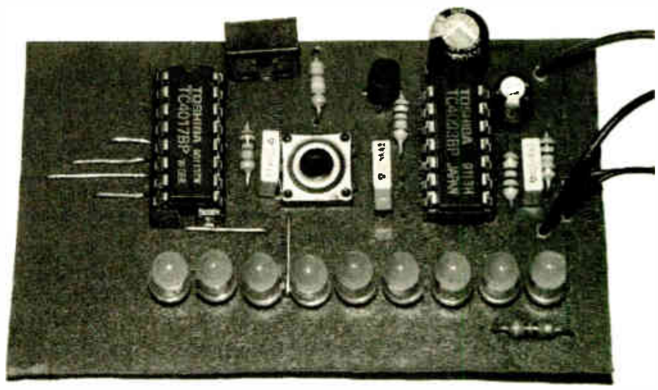
Construction

Printed circuit board component and track layout details for the Kitchen Timer are shown in Fig.5.3. This board is available from the *EPE PCB Service*, code 521.

Care should be taken to ensure that all l.e.d.s and electrolytic capacitors are inserted the correct way around and normal precautions are taken when handling CMOS devices, as discussed in Part 1. The board is designed to accommodate all of the components with the exception of the piezo sounder and the battery. These components should be connected to the circuit using flying leads.

Note that WD1 is simply a piezo element which does not contain any internal driving circuitry and as such it may be connected to the circuit either way around. There are also six wire links required on the board to complete the circuit and these may be made from discarded component leads.

The choice of case for this unit is left to the user.



Completed prototype timer circuit board

Set-Up and Use

Setting up consists of adjusting the value of the timing resistance, using preset VR1, to give a period of one minute between pulses. Other timing ranges, e.g. 30 seconds could be accommodated by altering the value of C1 or by switching in other values of resistor.

Because of the difficulty in calibrating very long periods, partly due to the problems associated with very large values of capacitance and/or resistance, this circuit is *not* suited for oscillator cycle periods longer than two or three minutes.

To operate the timer, press the Start/Set switch, on which the l.e.d.s will start to light in turn at the set intervals. Assuming a one minute time base, a maximum time of nine minutes can elapse before the alarm will sound.

To set up a time of five minutes, say, the switch should be pressed repeatedly until l.e.d. D5 is lit and the timer is then allowed to continue from there. After one minute, D4 will light indicating that four minutes of the cycle remain, followed by D3 after another minute and so on. Finally when D1 goes out and output Q0 goes high, the alarm will sound indicating that five minutes have elapsed since S1 was first pressed.

Room Thermometer

ELECTRONIC thermometers have all but replaced the old mercury or alcohol-in-glass types in most applications. The electronic types can usually respond much faster to temperature changes, and also allow the display to be remote from the sensor, allowing greater flexibility in use. They can also be more accurate and, depending on the sensor, can be used over greater temperature ranges.

It has to be said, though, that the thermometer design described here is not the last word either in range or accuracy (perhaps a temperature indicator would be a more apt description), as it is intended to display the temperature of a room where neither of these attributes is particularly important.

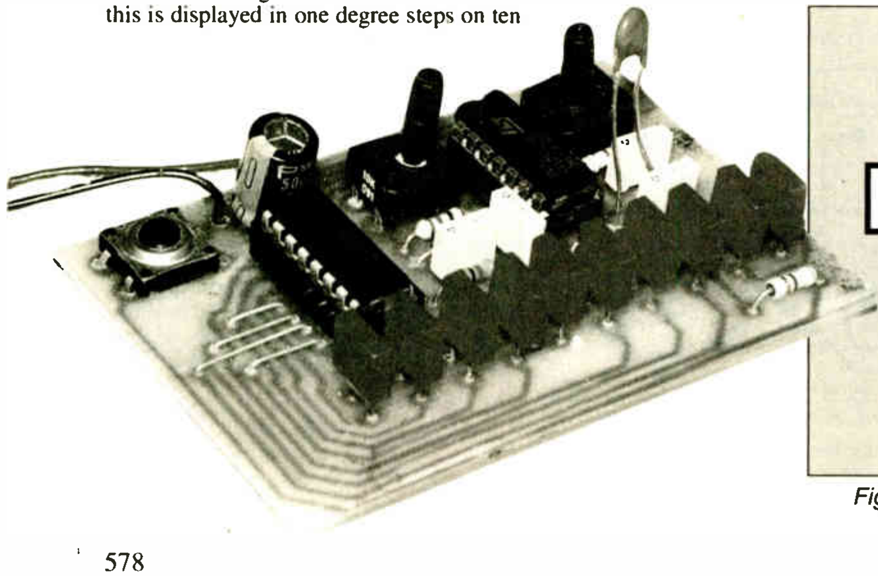
Here the range is limited to 10°C and this is displayed in one degree steps on ten l.e.d.s. These are normally turned off to save power, but may be turned on by means of a pushswitch when a reading is required.

Basic Operation

All electronic thermometers contain a sensor which converts a change in temperature to a change in some electrical property such as resistance, output current etc. In most cases, this is converted to a voltage which is then further processed (amplified, etc.) before being fed to some sort of analogue-to-digital converter (ADC) and output to a digital display.

Of the many different sensors available, a thermistor is used here for simplicity. Thermistors exhibit a relatively large change in resistance with temperature, removing the need for further amplification of the signal before it can be used. Although over a wide range the resistance change is not linear, it is good enough for monitoring temperature over a relatively narrow range, such as in this application where a range of say 14°C to 23°C is adequate.

This simple thermometer is different from most because the changes in resistance of the thermistor are not converted to a voltage but are used directly to alter the period of a monostable. The resultant output pulse, whose length is proportional to temperature, is used to switch on an oscillator forming a simple ADC where the number of pulses produced in a given time depends on the temperature of the thermistor.



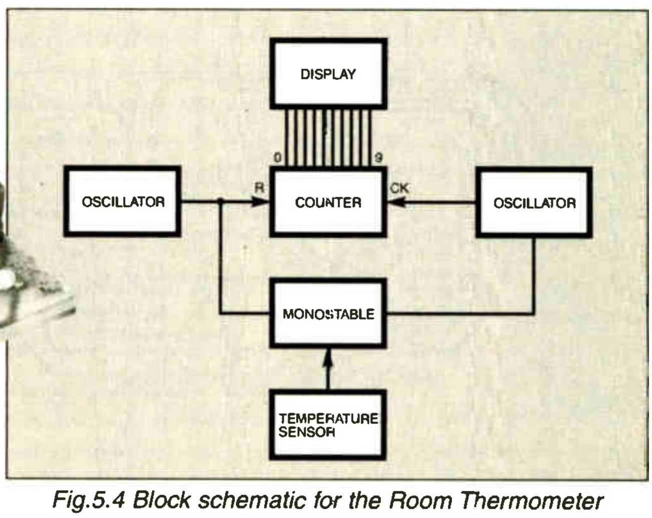


Fig.5.4 Block schematic for the Room Thermometer

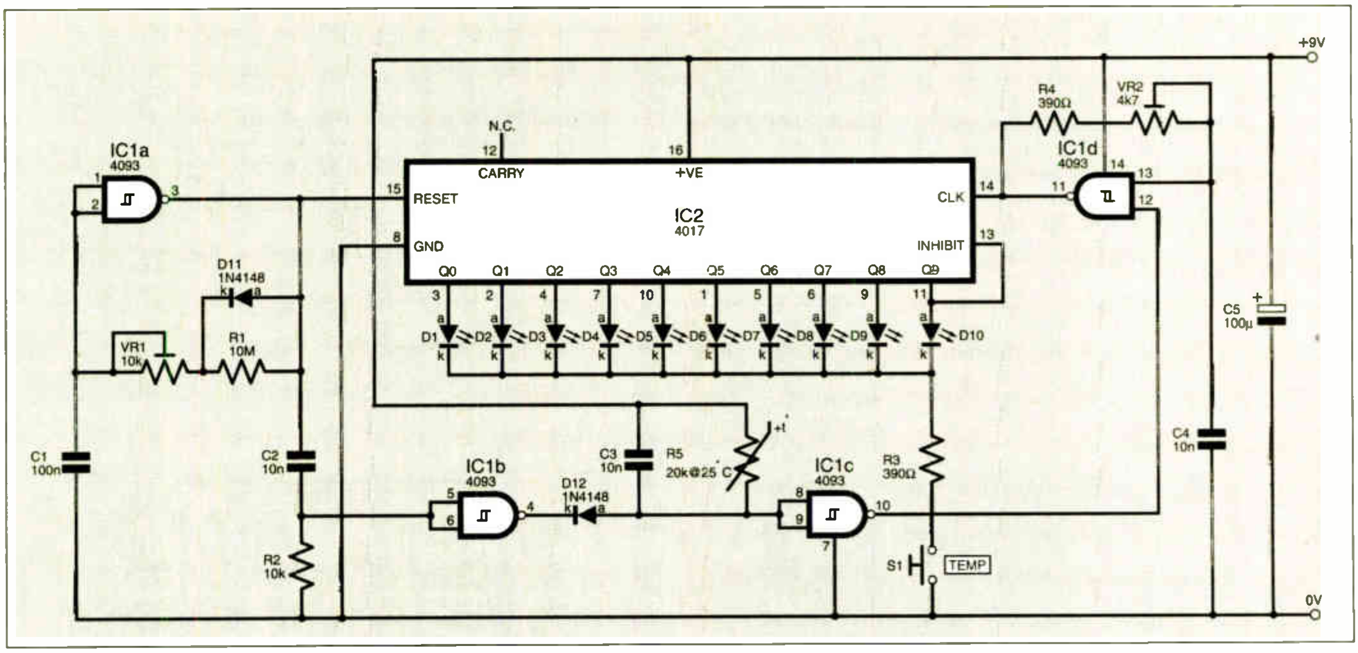


Fig.5.5. Complete circuit diagram for the Room Thermometer

The pulses are then simply counted and the result displayed on a row of ten l.e.d.s. The block diagram in Fig.5.4 shows the main components of the thermometer, a sensor, monostable, oscillator and counter/display.

The circuit operates in two stages. The first measures the temperature by counting pulses from the temperature sensitive oscillator and then displaying the count. A second oscillator controls the rate at which this occurs. The measurement cycle is made very short so that its effect on the display is not noticeable.

Circuit Description

The full circuit diagram for the Room Thermometer is shown in Fig.5.5. It is based around a 4017 decade counter, IC2, which controls the l.e.d. display. The operation of this circuit is probably best understood by referring to the waveforms diagram in Fig.5.6 – but note that it is not to scale as the display period is very much longer compared to the measurement period shown.

Schmitt trigger NAND IC1a is configured as an oscillator which resets the counter when its output goes high, as shown in waveform (a). Diode D11 in combination with resistor R1 and preset VR1 ensures that the high (reset) period is very much shorter than the low period. VR1 is included to enable the reset period to be adjusted.

The rising edge of this waveform is differentiated by capacitor C2 and resistor R2 to create a short positive-going pulse at IC1b pins 5 and 6, waveform (b). IC1b is used as an inverter and its output at pin 4 goes low in response to the pulse, waveform (c), quickly charging C3 via diode D12, waveform (d).

This causes the input of inverter IC1c to go high, waveform (e), thus enabling IC1d to oscillate at a frequency determined by C4 and R4/VR2, waveform (f).

Capacitor C3 now discharges via the thermistor R5 until the upper threshold of gate IC1c is reached, indicated by the dotted line in waveform (d). At this point, the output of IC1c goes low, switching off IC1d. The length of time for which IC1c output remains high depends on the resistance of the thermistor, which in turn determines how many clock pulses are produced by IC1d.

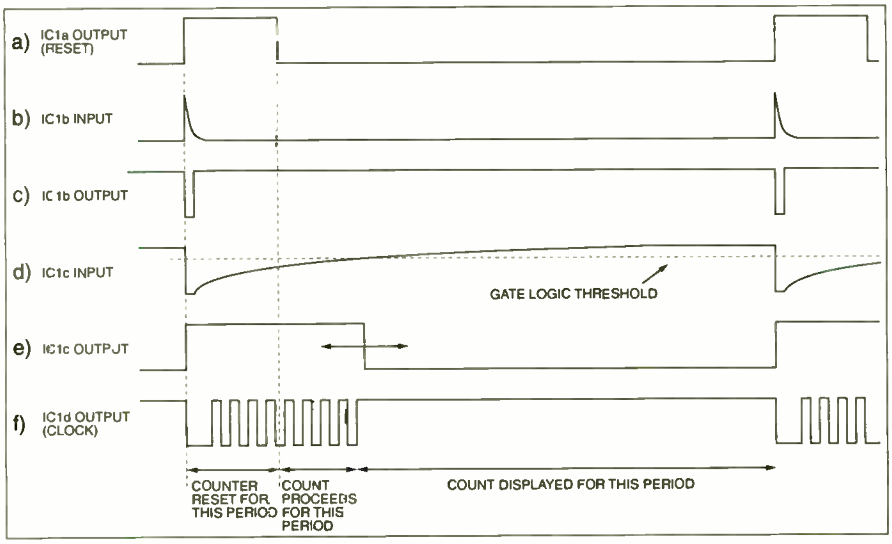


Fig.5.6. Room themometer circuit waveforms

COMPONENTS

ROOM THERMOMETER

See SHOP TALK page

Resistors

R1	10M	
R2	10k	
R3, R4	390Ω (2 off)	
R5	n.t.c. thermistor, 20k at 25°C	

All 0·25W 5% carbon film or better, except R5

Potentiometers

VR1	10k skeleton preset
VR2	4k7 skeleton preset

Capacitors

C1	100n ceramic disc, 5mm pitch
C2 to C4	10n ceramic disc, 5mm pitch (3 off)
C5	100µ radial elect. 16V

Semiconductors

D1 to D10	red l.e.d. (10 off)
D11, D12	1N4148 signal diode (2 off)
IC1	4093 quad Schmitt inverter
IC2	4017 decade counter

Miscellaneous

S1	min. push-to-make switch

Printed circuit board, available from the *EPE PCB Service*, code 522; 14-pin d.i.l. socket; 16-pin d.i.l. socket; 9V battery and connector; case to suit; connecting wire; solder, etc.

Approx. Cost Guidance Only **£10** *excl case and batts*

The thermistor specified has a negative temperature coefficient which means that as its temperature rises, its resistance falls. This causes IC1c to remain high for a shorter time as the temperature increases, leading to fewer clock pulses and thus a lower count. This is slightly unusual but with the form of display chosen, it is not a problem as it simply means that l.e.d. D1 indicates the highest temperature and l.e.d. D10 the lowest.

It should also be noted that, although IC1d starts producing clock pulses as soon as IC1c output goes high (at the beginning of the reset pulse), many of these are not counted as the counter remains reset until the output of IC1a goes low. The counter then advances on each positive clock transition so that, in the example shown in Fig.5.6, although a total nine low to high clock transitions are produced, only five of these are counted, causing output Q6 to go high.

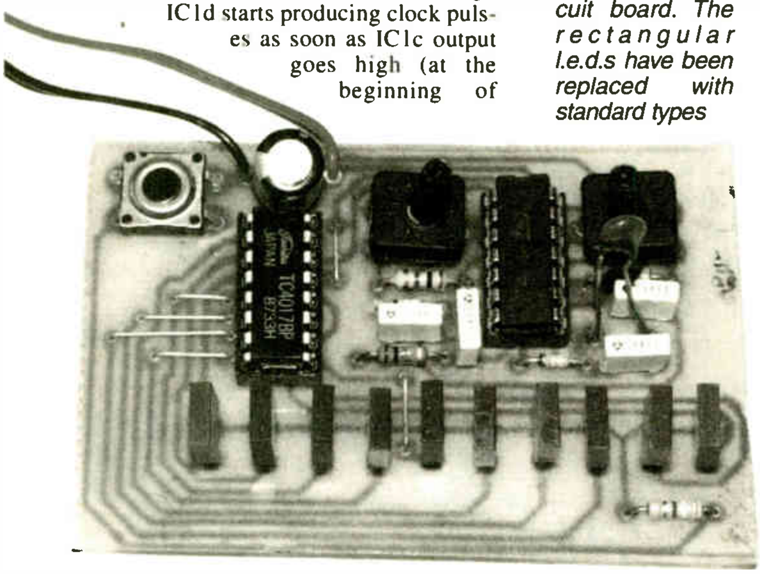
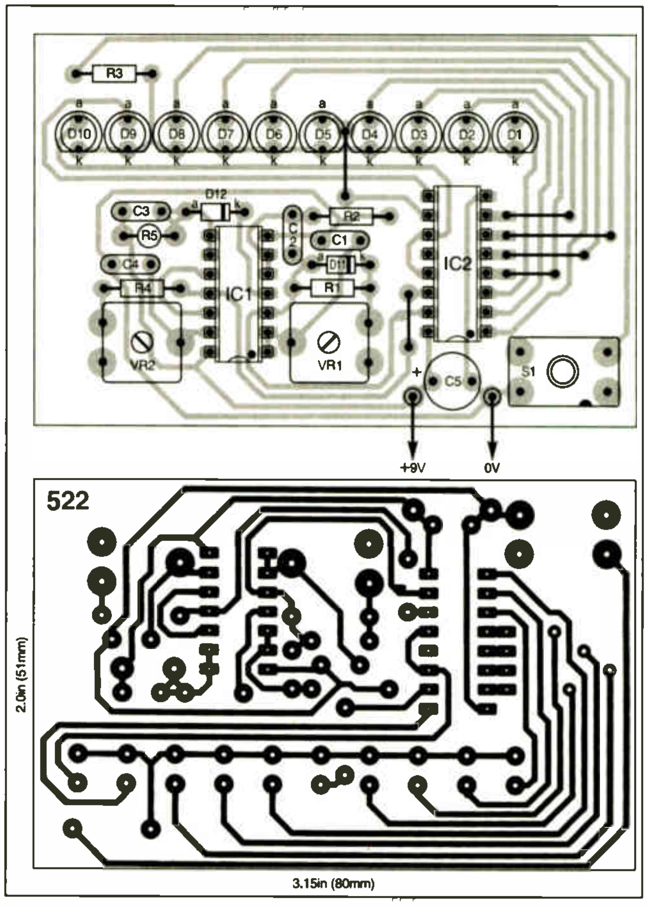


Fig.5.7. Printed circuit board component layout and full-size underside copper foil master pattern for the Room Thermometer.



(below) Prototype Thermometer circuit board. The rectangular l.e.d.s have been replaced with standard types

Outputs Q0 to Q5 will also go high briefly, but this is for such a short time that the eye does not normally respond to their l.e.d.s turning on. However, in low ambient light, this may be noticed as a slight flicker of the display, but to the casual observer only one l.e.d. will appear to be on at any time.

The thermistor has a quoted resistance of 20 kilohms (20kΩ) at 25°C, but as with all electronic components this is subject to a certain tolerance. The device used in the prototype had a resistance of 19·6kΩ rising to about 30kΩ at 16°C (i.e. roughly 1kΩ per °C).

To enable the circuit to be calibrated easily and for variations in thermistor resistance to be accommodated, both the clock oscillator frequency and the start of the count period are made adjustable, by presets VR2 and VR1 respectively.

Preset VR1 is adjusted so that at the highest temperature (say 23°C) the reset period is just greater than monostable IC1c's output period, so that no clock pulses are counted and only Q0 goes high. At the lowest temperature (14°C), when IC1c's output stays high for the longest period, the clock frequency is adjusted by means of VR2 to provide nine positive going clock transitions during this counting period.

If the resistance of the thermistor should fall below this minimum, more clock pulses will be produced and the counter would "wrap around" to display a high temperature again. Output Q9 is therefore connected to IC2's Inhibit pin 13 to prevent further counting in this case. The two extreme l.e.d.s in the display should therefore be regarded as 14°C or lower and 23°C or higher.

The circuit may be powered by a 9V battery. To save battery power, the l.e.d.s are only allowed to light when switch S1 is pressed. If a continuous display is required, the switch can be replaced by a wire link. In this case a 9V d.c. supply from a mains adaptor would be preferable.

Limitations

A simple circuit of this sort obviously lacks the accuracy, resolution or stability of many alternative designs but it should be adequate for this uncritical application. One source of error is the basic non-linearity of the thermistor resistance with changes in temperature although, as mentioned earlier, over small temperature ranges/changes the non-linearity is not too pronounced.

Another problem is the exponential nature of the voltage ramp across capacitor C3 due to it being discharged by a resistor.

There are ways round these problems in a more sophisticated design, but such techniques are beyond the scope of this article.

Construction

The printed circuit board component and copper track layout details for the Room Thermometer are shown in Fig.5.7. This board is available from the *EPE PCB Service*, code 522.

Assemble with the same care and attention as advised for previous designs in this series. Normal precautions for handling CMOS and other components should be followed. The thermistor can be soldered to the board either way around.

To calibrate the unit, turn preset VR1 fully clockwise and check that l.e.d. D10 and some of the adjacent l.e.d.s can be turned on by varying VR2. If this is not possible, back off VR1 slightly.

Place the thermistor in a place that is about one degree higher than the lowest temperature to be monitored and adjust VR2 so that l.e.d. D9 lights. An ordinary thermometer will be of help here. With the thermistor at a temperature one degree below the maximum, adjust VR1 until l.e.d. D2 is lit. Repeat the last two steps readjusting VR1 and VR2 if necessary until D2 and D9 light when required.

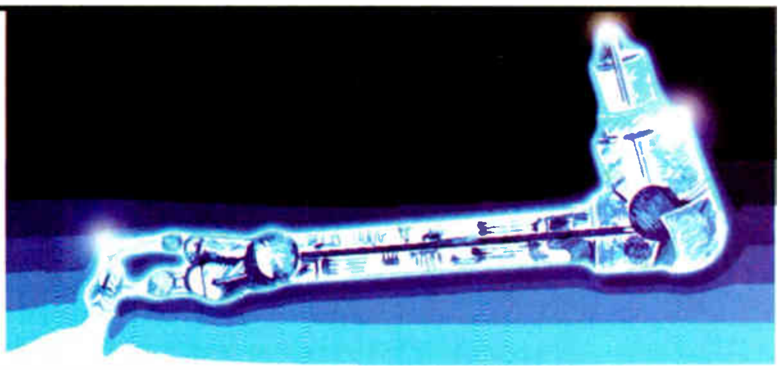
In practice it may be easier to measure the thermistor resistance at the two extreme temperatures and substitute resistors of this value for the thermistor when calibrating the unit. The thermistor used in the prototype had a resistance range of 19·6kΩ and 28·6kΩ at the temperature extremes chosen.

With the test model, a 22kΩ preset potentiometer set for 19·6kΩ, together with nine 1kΩ resistors connected in series was therefore used to simulate the resistance of the thermistor at various temperatures in the range. For calibration purposes, it will also be found useful to short out pushswitch S1 so that the display is permanently on.

Next Month

Daily Reminder and a Whistle Switch.

Circuit Surgery



Alan Winstanley and Ian Bell

We continue with our primer on CompactFlash (CF) cards, with more pointers and snippets of code intended for experienced microcontroller enthusiasts

Back in a CompactFlash

In last month's *Circuit Surgery* we outlined some of the software aspects of using a CompactFlash (CF) memory card with a PIC or similar microcontroller. Some of the various commands and registers which are used to control the card were explained. This month we will cover some of the techniques of actually reading and writing data, sketching some PIC code that could be used to read and write a CompactFlash card.

A CompactFlash card is a semiconductor memory device, but from the user's perspective it is designed to behave like a disk drive. This means that data is read and written one sector at a time rather than as individual bytes. This is relatively easy to cope with in software. It also means that the card may be formatted by a PC using a file system. If you want to use, or even simply avoid damaging, a PC file system then you may be faced with a demanding programming task. We will return to this point later.

Last month we introduced the Identify Device command (EC hex) and gave an example of some typical PIC assembly code to use this command. Reading data after issuing the Identify Device command will provide you with a byte sequence similar to that shown in Table 1. This was obtained from a 32MByte Fuji branded CompactFlash card. Your software can work out the size of the card from the four bytes in Words 7 and 8 which give the number of sectors.

In this case there are 0000F600 hex sectors, which is 62976 in decimal. Multiplying this value by the number of bytes per sector, which is 512, gives 32243712 bytes (roughly 32MBytes), which obviously matches the specification of our card in this example. Note that Word 5 contains the number of bytes per sector, but the CompactFlash specification document indicates this value is obsolete. The specification also explicitly states that the host reads 512 bytes from the buffer after issuing the Read Sector command. Assuming a sector size of 512 should be OK for most cards.

Before reading to or writing from the card, we have to set up the address of the first sector we want to write to. To do this we write to the appropriate card registers. We need to set the Select Card/Head (address 6), Cylinder High (address 5), Cylinder Low (address 4), Sector Number (address 3) and Sector Count (address 2) registers.

Table 1. Card identify information from a 32MByte CompactFlash card

Word no	Hex Bytes	Meaning
0	84 8A	848A Signature
1	01 EC	1EC hex = 492 cylinders
2	00 00	Reserved
3	00 04	0004 heads
4	00 00	Obsolete
5	02 00	0200 hex = 512 bytes per sector (obsolete)
6	00 20	0020 hex = 32 sectors per track
7-8	00 00	F600 hex = 62976 sectors per card
	F6 00	
9	00 00	Obsolete
10-19	30 30	Serial number 00000000002011600087
	30 30	
	30 30	
	30 30	
	30 30	
	32 30	
	31 31	
	36 30	
	30 30	
	38 37	
20	00 00	Obsolete
21	00 02	Obsolete
22	00 04	0004 ECC bytes passed on Read/Write Long commands
23-26	52 65	"Rev 1.15" Firmware revision in ASCII
	76 20	
	31 2E	
	35 31	
27-46	53 41	"SAMSUNG CF/ATA" Model number in ASCII
	4D 53	
	55 4E	
	47 20	
	43 46	
	2F 41	
	54 41	
	20 20	(remaining bytes are space character)

The Select Card/Head Register controls the mode in which the card is addressed. This can be either Cylinder/Head/Sector (CSH) Mode or Logical Block Addressing (LBA) Mode. It is probably easier to use Logical Block Addressing in which the card sectors are addressed by a 28-bit value. This potentially gives access to a maximum of 137GBytes with sectors of size 512 bytes, but most currently available cards are smaller than this, so the upper address bits will always be zero.

Setting bit 6 of the Select Card/Head Register to 1 selects LBA mode. Bits 5 and 7 should be set to 1 for backward compatibility reasons. Bit 4 is the drive number and would usually be 0. So the top four bits of the Card/Head Register should be set to

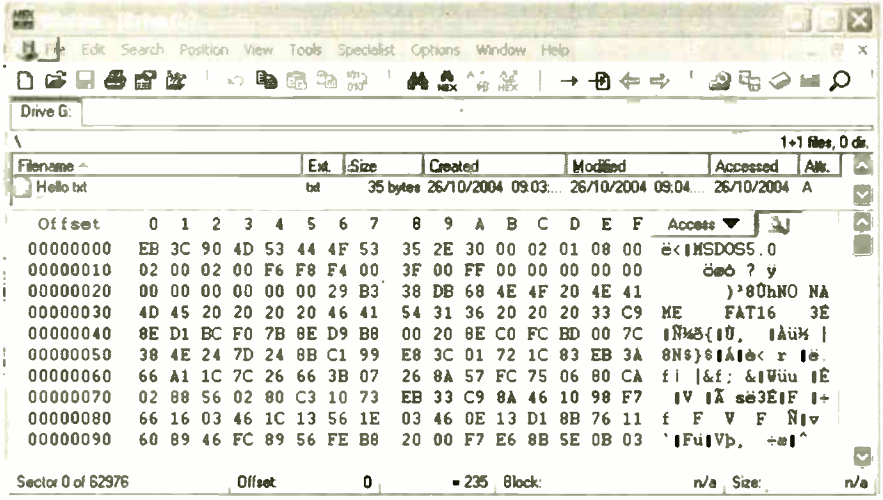


Fig.1. Screen shot from WinHex looking at the raw byte data on a CompactFlash

1110 (E in hexadecimal) for LBA operation. The lower four bits are bits 27 to 24 of the 28 bit LBA sector address, and unless the card is very large these will be zero. In Listing 1A the code sets up LBA mode and sets the upper four address bits to 0.

The value of CF_ADDR (the Card/Head Register address) is defined to be 0x06 as discussed last month. Assuming the CF_WRITE subroutine simply pulses the card's write line (WE) low with appropriate timing. The example of code given last month included this operation in an in-line rather than a subroutine form.

Next we need to set the remaining 24 bits of the sector address. This requires three bytes. A useful way to do this is to store the address in three registers (here we have named them CFADDR23TO16, CFADDR15TO8, and CFADDR7TO0). The values in these registers are then written to the Cylinder High, Cylinder Low, and Sector Number registers respectively. Again we have predefined values for the register addresses (0x05, 0x04 and 0x03 respectively), as discussed last month. The code in listing 1B thus sets up the sector address.

We can read or write up to 255 consecutive sectors at a time. The number of sectors to be accessed by it is written to the Sector Control Register. Assuming we have previously stored this value in a register named NUMOFSECS and defined the address (0x02) of the register as SEC_CNT_REG we can continue as in Listing 1C, using the same pattern of code as above.

Get Ready to Write

We are nearly ready to read data from or write data to the card, but first we need to issue a Write Sector or Read Sector command as appropriate. This follows the same pattern as issuing the Identify Device command, for which we gave some sample code last month. Once the command is written we need to set the card's address bus to the address of the data register (0x00) ready for the actual read or write operations. For example, to issue the write command (0x30), assuming this is defined as WRITE_SEC and that the command register address (0x07) is defined as COMMAND_REG we would use the code shown in Listing 1D.

To write the data each byte is placed on the data bus and the card's Write Enable (WE) line is pulsed low for sufficient time. The write operation must be performed 512 times the value written to the Sector Control Register, so your code will need a loop set up to do this. If the Sector Control value is 0x00 256 sectors should be written.

Reading follows the same pattern except, of course, the Read Sector command (0x20) is issued, the value on the data bus is read and not written, and the card's Output Enable (OE) line is pulsed low rather than WE. To do the reading the data bus port direction must be changed to input (it was an output during the sector address and command writing operations). This is accomplished using the PIC's data direction register (TRISx), as in Listing 1E.

Do not forget to return the data bus port direction to output before issuing further commands, performing a write, or changing the sector address.

Experimenting

As mentioned earlier, CompactFlash cards can be formatted when used with a PC. Experimenting with using a card with a PIC may destroy this formatting and prevent you from accessing files on the card. You are therefore advised to experiment with a blank card until you are confident about the way the card works and have developed reliable code.

If you simply want to use the card as a large memory for a PIC and will never try to access the card with a PC, you don't have to worry about formatting. If you want to be able to still use the card with a PC or other device, then things get trickier.

Listing 1A

```
movlw    0xE0            ;Value to select LBA and set upper address bits to 0
movwf    CF_DATA         ; Put the value on the data bus
movf     HEAD_REG,0      ; Card/Head Register Address
movwf    CF_ADDR         ; Put address onto the bus
call     CF_WRITE        ; Do the write.
```

Listing 1B

```
movf     CFADDR23TO16,0  ; Sector address bits 23 to 16
movwf    CF_DATA         ; Put on data bus
movf     CYL_HI_REG,0    ; Cylinder High Register address (0x05)
movwf    CF_ADDR         ; Put on address bus
call     CF_WRITE        ; Write the value to the CF card

movf     CFADDR15TO8,0   ; Address bits 15 to 8 to Cylinder Low Register
movwf    CF_DATA
movf     CYL_LO_REG,0
movwf    CF_ADDR
call     CF_WRITE

movf     CFADDR7TO0,0    ; Address bits 7 to 0 to Sector No. Register
movwf    CF_DATA
movf     SEC_NUM_REG,0
movwf    CF_ADDR
call     CF_WRITE
```

Listing 1C

```
movf     NUMOFSECS,0     ; Write no. of sectors to Sector Control Register
movwf    CF_DATA
movf     SEC_CNT_REG,0
movwf    CF_ADDR
call     CF_WRITE
```

Listing 1D

```
movf     WRITE_SEC,0     ; Sector write command on data bus
movwf    CF_DATA
movf     COMMAND_REG,0   ; Command Register address on address bus
movwf    CF_ADDR
call     CF_WRITE
movf     DATA_REG,0      ; Data Register address on address bus ready for write
movwf    CF_ADDR
```

Listing 1E

```
movlw    0xFF            ; Set data PIC lines to input
movwf    TRISx           ; x is port letter of data bus port
```

Your PC will probably format the card with a FAT16 file system; this is fully publicly documented and is beyond the scope of this article, so if necessary you can research exactly how all the files are arranged on the card. It must be added that it is not simple because files are not necessarily stored in contiguous portions of the memory, so you have to use the File allocation Table (FAT) to find which clusters (groups of sectors) the file occupies.

A formatted but otherwise empty card will contain formatting data in the first sectors of the card. Writing to this area with your PIC code will destroy the formatting. If you avoid the first few hundred sectors (say start at sector 5000 or 10000 to be safe) you can write to the card, hopefully without corrupting the formatting. However the PC will not see the data you write as a file and will happily overwrite it if it chooses to create a file in that part of the card's memory. If the card is not empty, then writing to a random location beyond the initial sectors with your PIC code may corrupt files on the card.

One cheat that may provide a workaround without the need to fully decode the file system is to create a file (or files) on a blank card of the size you need for the data for your PIC program. Hopefully this file will be contiguous if the card is empty.

The file can be created with dummy data in it (e.g. a text file containing a large number of space characters). If you know the starting address, size and format of the file you can overwrite it with the PIC program without corrupting the file system. As long as the file is not relocated by the operating system (e.g. by a defragging operation) you should be able to access it using Windows programs and create and use other files on the card, but this approach will never be 100% guaranteed.

Debugging

It is useful to be able to look at the raw data on a CompactFlash card with your PC if you are trying to debug PIC software that should have written particular values to known locations in the card's memory. It is also useful to see the raw data if you are trying to decode and understand the file system formatting information.

There are a number of software applications which enable you to do this, one example being WinHex (**www.x-ways .net/winhex/index-m.html**).

A typical screen shot from WinHex is shown in Fig.1, in this case looking at the Microsoft FAT16 formatting information in the first bytes on the card (the card is being read via a standard USB multiformat card reader). WinHex can search for strings or byes sequences on the card, which is useful for locating the address of files or data in the card's memory space.

As will be seen, using CF cards is not very straightforward or trivial but there are various modes in which they can be utilised without incurring too many technical setbacks.

We hope you find this introduction to CompactFlash cards useful. If you wish to experiment further, in the June '05 issue we reproduced a p.c.b. design which is available from the *EPE PCB Service*. Let us know how you get on! *I.M.B.*

SHOP TALK
with David Barrington

Pain Monitor

As previously, we have found only two listings for the 24LC256 256 kilobit serial EEPROM memory chip, used in the *Pain Monitor* project. This was from **Jaycar Electronics** ***(see their ad on back cover)***, code ZZ8485 and **Farnell** ***(☎ 0870 1200 100*** or ***www.farnellinone.co.uk)***, code 300-1696.

The Dallas/Maxim DS1307 serial I^{2}C realtime clock (RTC) chip is currently listed by **Rapid Electronics** ***(☎ 01206 751166*** or ***www.rapidelectronics.co.uk)***, code 82-0566. For datasheet details you could log-on to ***www.maxim-ic.com***.

Paperwork for the Monitor shows that the RTC battery is a Saft LS14250, 1/2AA, 3·5V 950mAh and measures just 25mm long by about 12mm wide (1in × 0.5in). It was purchased (**credit card only**) from **RS Components** ***(☎ 01536 44079*** or ***rswww.com)***, code 203-3894. Other batteries from 2V to 3·6V could also be used. They also supplied the specified 32·768kHz low-profile crystal, code 226-1443.

The MAX232 RS232 series interface i.c. is one of the more popular interface devices and most components advertisers should have stocks. The same applies to the "click-effect" or "tactile" pushbutton switches. It is the extended plunger type that is required. Note that although they have four connecting pins, each switch contact is joined to two pins so they must be inserted correctly on the p.c.b.

For those readers unable to program their own PICs, fully programmed PIC16F876 microcontrollers can be purchased from **Magenta Electronics** ***(☎ 02083 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £10 each (overseas add £1 for p&p). The software, including source code files, is available on a 3·5in. PC-compatible disk (Disk 8) from the *EPE Editorial Office* for a sum of £3 each (UK), to cover admin costs (for overseas charges see page 589). The software is also available for free download via the Downloads link on our UK website at **www.epemag.co.uk**.

The printed circuit board is available from the *EPE PCB Service*, code 519 (see page 589). The 2-line 16-character (per line) alphanumeric display is a standard l.c.d. module and most of our components advertisers should be able to offer a suitable device.

Audio System – Communications

Practically all the components required for the three circuits that make up the *Audio System – Communications* project should be readily available from our component advertisers.

Most suppliers should be able to suggest a suitable meter for the optional signal strength meter facility. However, do heed the remarks regarding selecting a meter.

Another item that should be easy to locate is the miniature omni-directional electret microphone insert. Certainly try **Sherwood Electronics** (***see ad on page 592***) and **Cricklewood Electronics** ***(☎ 020 8452 0161*** or ***www.cricklewoodelectronics.com)***.

Small quantities of enamelled copper wire, in 50g (2oz) reels, for the Power Amplifier inductor coil, is obtainable from **JAB Electronic Components** ***(☎ 0121 682 7045*** or ***www.jabdog.com)*** mail order only. You will, of course, need to specify the wire gauge size.

The three printed circuit boards are available from the *EPE PCB Service*, codes 516 (Preamp), 517 (Electret Mic) and 518 (Power Amp) – see page 589.

Back to Basics – Kitchen Timer/Room Thermometer

No component buying problems should arise when shopping for parts for the *Kitchen Timer* and *Room themometer*, this month's two *Back to Basics* projects. When ordering the piezoelectric sounder for the Kitchen Timer, make sure it is a "passive" element only type – one without any internal driver/oscillator circuit.

It is likely that suppliers will offer a choice of negative temperature coefficient thermistors varying slightly from the specified 20kΩ at 25°C in the article. As we are only measuring room temperature changes, and a certain amount of tolerance is acceptable, they should be OK for this circuit. The disc thermistor used in the prototype came from **Rapid Electronics** ***(☎ 01206 751166*** or ***www.rapidelectronics.co.uk)***, code 61-0415.

The two printed circuit boards are obtained from the EPE PCB Service, codes 521 (Kitchen) and 522 (Room Therm) – see page 589.

Motor Amplifier

The SIOV-S14K25 31V d.c. varistor for the *Motor Amplifier* project was purchased form **Farnell** ***(☎ 0870 1200 100*** or ***www.farnellinone.co.uk)***, code 580-168. The 450mA 30V *positive* temperature coefficient thermistor also came from the same source, code 606-911.

We have a problem with the 24V d.c. power relay used by the author in his unit. This heavy-duty relay is marked as an RS Component part and carries the stock code 348-425, which unfortunately is now obsolete. The technical details show it as having: 24V d.c. 277 ohm coil, with double-pole changeover contacts rated at 20A. Readers will need to select a relay, possibly an automotive type, with contacts rated to suit their own particular application. We see from the **Display Electronics** ad on page 522 the they "hold" over 100,000 relays/contactors, so they may be able to help here.

Other items sourced from Farnell – see above – include the 40EPS08 40A power diode, code 646-179; the *n*-channel power MOSFET STW60NE10 60A, code 364-1351 and the FQA70N10 70A, code 394-4414. Note the STW60NE10 is no longer produced but they have stocks. The FQA device is the recommended alternative.

The two opto-isolators types SFH618A d.c. and TLP620 a.c. are both listed by **Rapid Electronics** ***(☎ 01206 751166*** or ***www.rapidelectronics .co.uk)***, codes 58-0514 (d.c.) and 58-0524 (a.c.) respectively. The printed circuit board is available from the *EPE PCB Service*, code 520.

You need two 12V gel-cell batteries connected in series to give a good low impedance source for the main 24V supply. These are fairly expensive items and you need 15Ah cells or better. Readers may be interested in a "flyer" from **WCN Supplies** ***(☎ 023 8066 0700*** or ***www.wcnsupplies.net)*** offering 12V 24Ah gel type for £19.95 each.

PLEASE TAKE NOTE

Crossword Solver *(May 05)*

Page 317 Fig.1 and page 318 Fig.2. The author advises that a 4.7kΩ resistor be connected between IC1 pin6 (RA4) of the PIC to the +5V line.

Cybervox *(July '05)*

Page 464 Fig.6. The capacitor at the top-centre of the p.c.b. marked C19 should be annotated **C13**

Toolkit TK3 V3.05

The latest version of the TK3 software is now available on our Downloads site (via **www.epemag.co.uk**) and on CD from the Editorial Office (see *EPE PCB Service* page). The principal differences from the version V3.00 is that the PIC18F programming routine has been considerably speeded.

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THEORY AND REFERENCE

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The first transistor radios began to appear in the second half of the 1950s and in this new edition, this rather neglected area has been fully covered by a section all of it's own which includes a directory listing of nearly 3,000 different transistor models. The book finishes after the 1960s, by which time our long established and once great radio industry had all but been destroyed by foreign imports.

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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

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Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

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MUSIC, AUDIO AND VIDEO

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ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold

This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

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R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit. ~~£10.95~~

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His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first electronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

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VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

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There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

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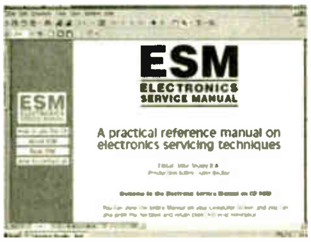

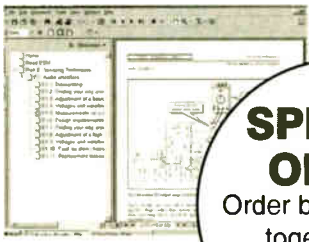

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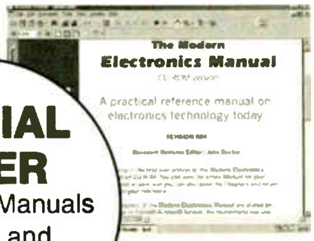

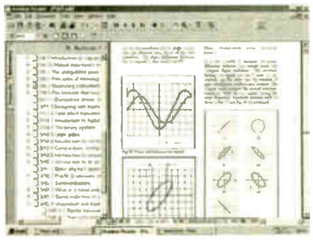

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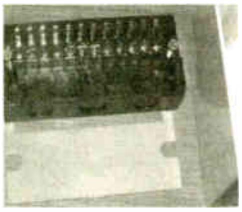

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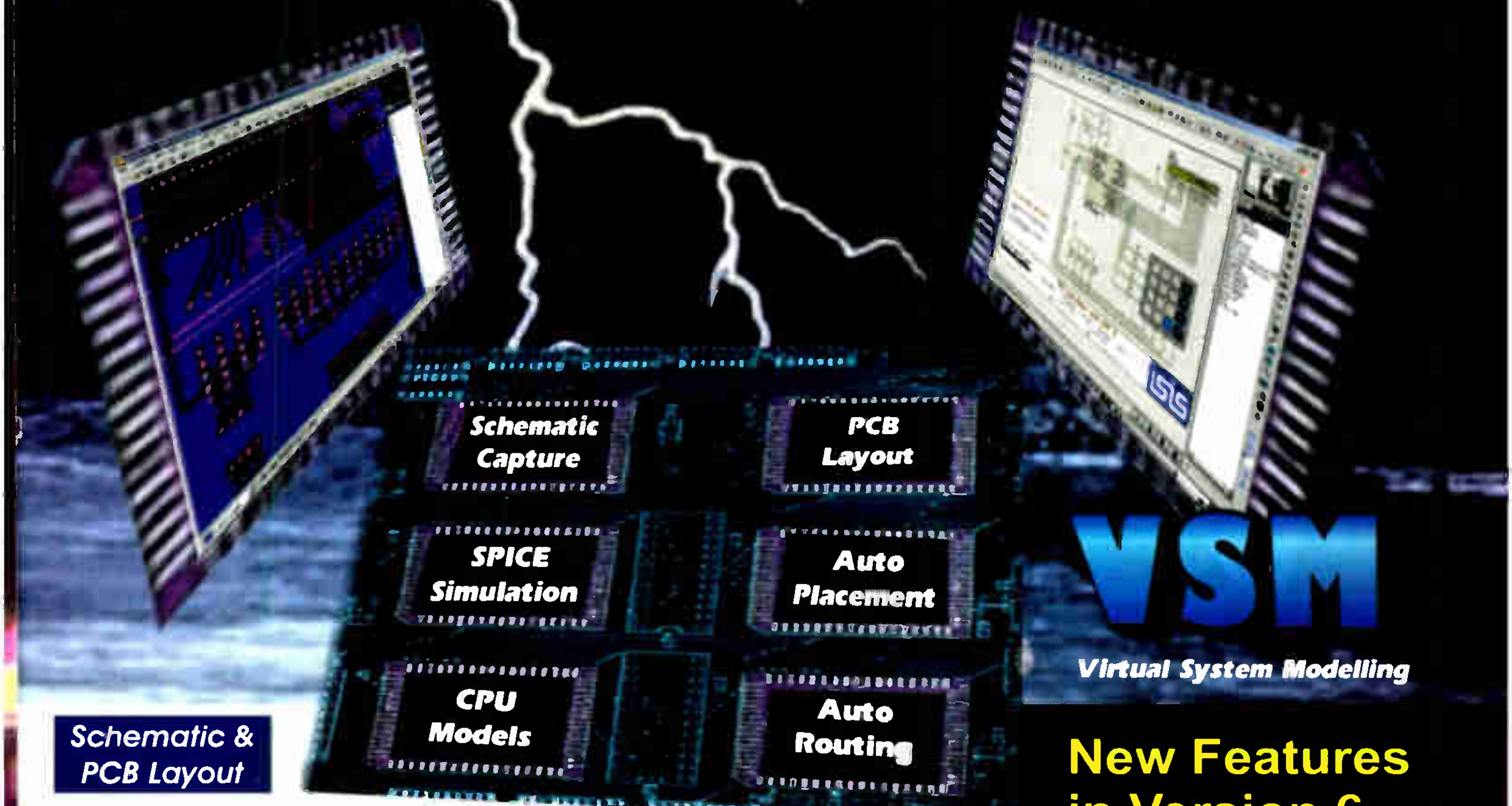

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