

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY

SEPTEMBER 2005

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PIC-based electronic aid and display



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ALL-BAND RADIO

Simple set covering the long wave to 41m bands

PLUS

BACK TO BASICS - 6

Daily Reminder
Whistle Switch



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Colour CCTV camera, 8mm lens, 12vdc200ma 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 aenal, 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 picr002 crossbow with metal body. Selfcocking for precise stng 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" stng 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 FF11



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 diaphragms 12vdc 400ma Built in light level sensor. £108.90 Ref EE13



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



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



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



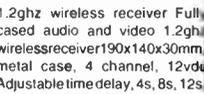
Complete wireless CCTV system with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4ghz 3lux 6-12vdc manual tuning. Available in two versions, pinhole and standard. £79 (pinhole) Ref EE17, £86.90 (standard) Ref EE18



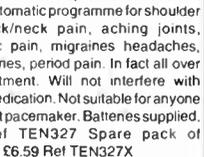
GASTON SEALED LEAD ACID BATTERIES 1.3AH 12V @ £5.50 GT1213 3.4AH 12V @ £8.80 GT1234 7AH 12V @ £8.80 GT127 17AH 12V @ £19.80 GT1217 All new and boxed, bargain prices. Good quality sealed lead acid batteries



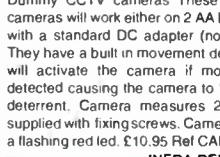
1.2ghz wireless receiver Full-cased audio and video 1.2ghz wireless receiver 190x140x30mm metal case, 4 channel, 12vdc Adjustable time delay, 4s, 8s, 12s 16s £49.50 Ref EE20



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



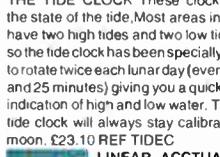
The TENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart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



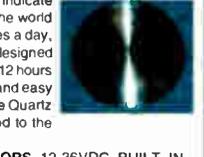
Dummy CCTV cameras These motosed cameras will work either on 2 AA batteries or with a standard DC adapter (not supplied) They have a built in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with fixing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



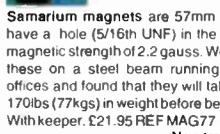
INFRARED FILM 6" square piece of flexible infra red film that will only allow IR light through Perfect for converting ordinary torches, lights headlights etc to infrared output using standard light bulbs Easily cut to shape. 6" square £16.50 ref IRF2 or a 12" sq for £34.07 IRF2A



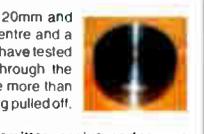
THE TIDE CLOCK These clocks indicate the state of the tide. Most areas in the world have two high tides and two low tides a day, so the tide clock has been specially designed to rotate twice each lunar day (every 12 hours and 25 minutes) giving you a quick and easy indication of high and low water. The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



LINEAR ACTUATORS 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,



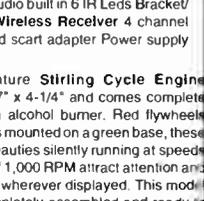
Samarium magnets are 57mm x 20mm and have a hole (5/16th UNF) in the centre and a magnetic strength of 2.2 gauss. We have tested these on a steel beam running through the offices and found that they will take more than 170lbs (77kgs) in weight before being pulled off. With keeper. £21.95 REF MAG77



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) Built in 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 Antireflection 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 165w 24v 1575x826x46mm £652.30

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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' Gen2+ 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 INFRARED TORCHES Searchguard 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 sgard 1. Also available, 70 watt @ £59, 100 watt @ £79, 200 watt @ £99.



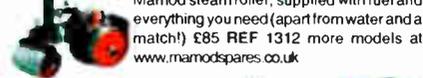
AIR RIFLES FROM £24.70
B2 AIR RIFLE Available in .177 and .22* 19" Tapered Rifled Barrel* Adjustable Rear Sight* Full Length Wooden Stock* Overall Length 43" approx Barrel Locking Lever * Also available in CARBINE Grooved for Telescopic Sight model with 14" barrel - no front sight for use with scope. 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 upto £250 www.airpistol.co.uk



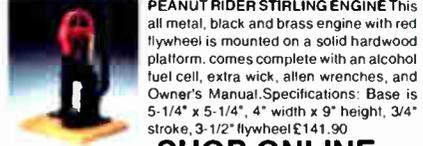
12V SOLAR PANELS AND REGULATORS 9WATT £58.75 15WATT £84.25 22WATT £126.70 Regulator up to 60 watt £21.25 Regulators up to 135 watt £38.25 The combination of multi-crystal cells and a high-reliability module structure make this series of solar panels the ideal solar module. For large-scale power generation 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.



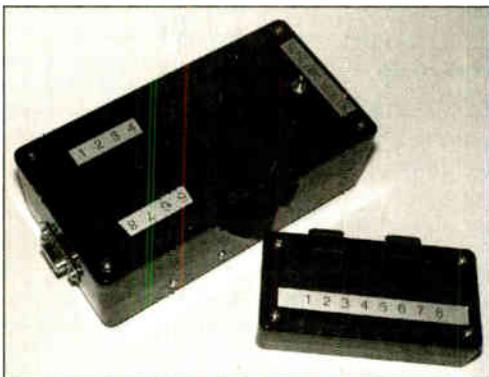
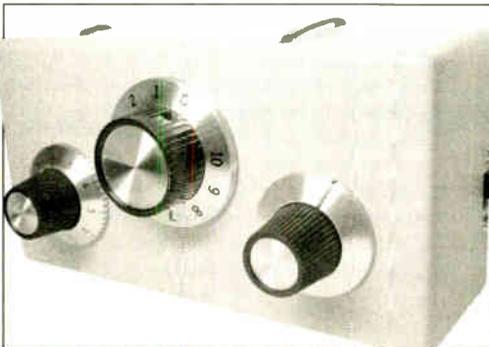
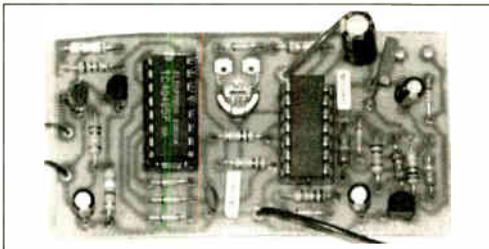
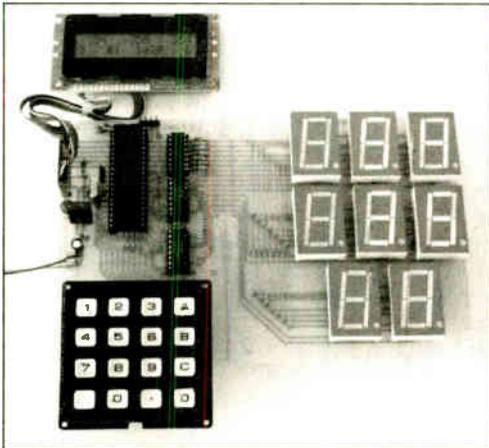
LOCK PICK SETS 16, 32 AND 60 PIECE SETS
This set is deluxe in every way! It includes a nice assortment of balls, rakes, hooks, diamonds, two double ended picks, a broken key extractor, and three tension wrenches. And just how do you top off a set like this? Package it in a top grain leather zippered 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 you want to 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



Marmod steam roller, supplied with fuel and everything you need (apart from water and a match!) £85 REF 1312 more models at www.marmodspares.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 October 2005 issue will be published on Thursday, 8 September 2005. See page 595 for details

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How to conveniently check lengthy multicore cables
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Low-cost RS232 Interface; TV Audio Coupler; PIC-Based Noise Generator
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Simple, easy-to-build circuits based on one or two CMOS logic chips

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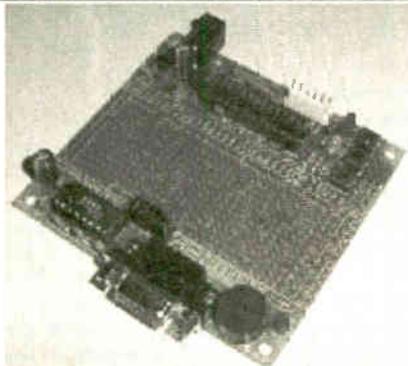
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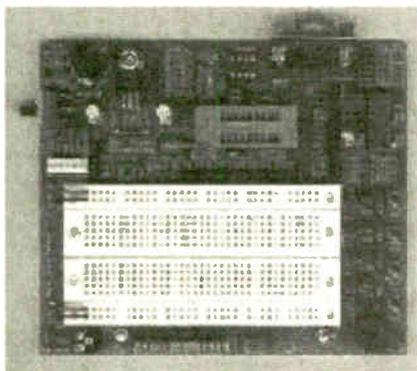
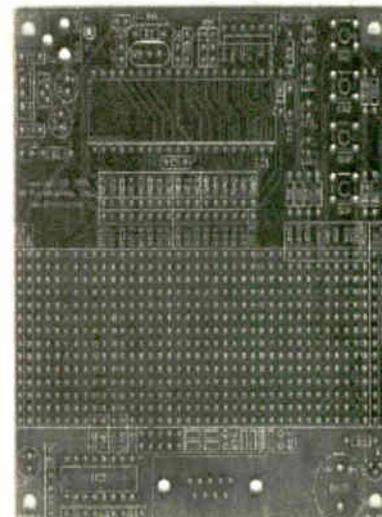
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New PIC Products from Forest Electronics Low Cost Development Boards, New Programmer, Lite version of our C Compiler



A range of New PIC development boards priced from just £4.00 !

We have a range of 5 new PIC project boards - all available as bare PCB's or as pre-built boards with components. They all have space for the PIC microcontroller, (from 8 to 40 pins). Support circuitry includes the 5V power regulator, decoupling components, reset circuitry and a crystal oscillator. Included are basic I/O components including, LEDs, push-buttons, and a piezo buzzer plus RS232 drivers and DB9F serial connectors. All boards have a large circuit prototyping areas for your designs. The boards all feature a compatible 6 pin in circuit programming connector.

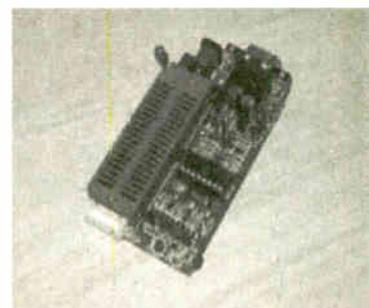


The most comprehensive board (lower left) offers a ZIF socket and breadboard area, plus LCD connection which is ideal for experimental and educational users.

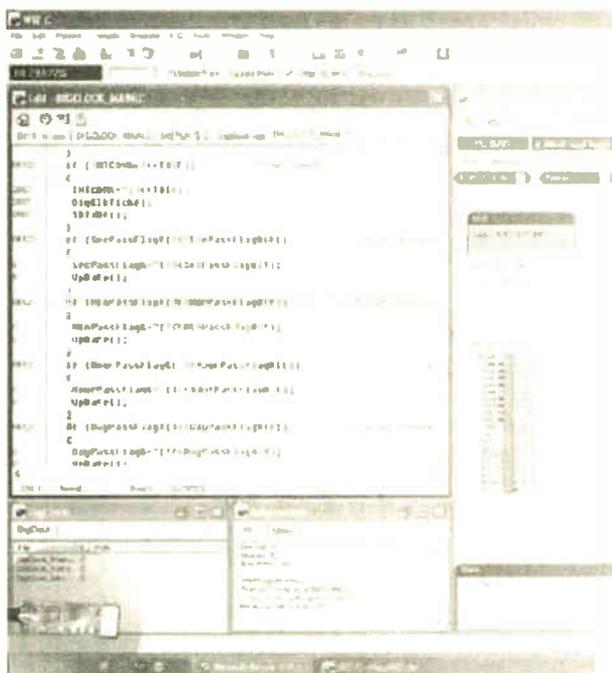
Ideal for use with WIZ-C Lite (below).

See www.fored.co.uk for further details

Serial+ Programmer (Right). New programmer handles 12C, 12F, 16C, 16F, 18F devices from 8 to 40 pins includes In Circuit Serial Programming connector and In Circuit Debugger function. Fully built and tested at just £35.00



WIZ-C Lite – complete ANSI C Compiler for the PIC together with RAD front end Lighting fast C development at an affordable price



- WIZ-C is more than a C Compiler for the PIC – it is a complete development environment with rapid access to library components with point and click set up.
- Ideal for beginners, includes full tutorial manuals and an introductory manual to the C language
- Syntax highlighting editor.
- Full ANSI C Compiler
- Large libraries included for displays, ports, data transfer, keypads, graphics, bootloader and C standard functions.
- Extensive simulation capabilities, very rapid program execution, includes simulation of LCD, LED switches, I2C, RS232 terminals etc. Inspect C variables in C format
- Logic analyser can display waveforms of PIC pins and internal registers simplifying debugging.
- Includes assembler to allow you to develop assembler projects in their own right, or as part of C projects
- LITE version supports the most popular PIC devices – academic users may choose these types.
- UK written and supported.
- **LITE Version available for only £35.00**

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NEXT MONTH

PIC-BASED USB INTERFACE

Are you ready to jump on the Universal Serial Bus (USB) bandwagon? Maybe you have an existing embedded application or a PIC design you would like to update or develop to use USB. In this article we explore the basics of an easy way of getting data into and out of a PIC18F2455 microcontroller using its USB interface.

This design allows existing RS232 devices to be controlled by a Windows 2000/XP USB connection. Although the design is simple, it illustrates the process of getting data into and out of the PIC over a USB connection. The "easy way" approach to USB makes maximum use of existing free software and Windows drivers.

PHOTIC PHONE

The Photic Phone slices up the human voice into forty-thousand binary segments a second, transmits it over a light-beam, then re-integrates it at the other side. That is, it applies pulse width modulation (p.w.m.) to the voice, to create a binary transmission. This has the advantage of always transmitting at full intensity, meaning that even the weakest nuances of a voice will reach the receiver as strongly as the rest.

The circuit typically has a range five times greater than similar analogue circuits. Without the use of lenses, the prototype achieved a range of four metres. With a single lens at the transmitter, it achieved a range of fifteen metres. With the use of two lenses, it should achieve a range of fifty metres using a single cheap, ultrabright l.e.d. It is all but impossible for anyone to eavesdrop on a transmission.

PLUS BACK TO BASICS – 7

● Parking Radar

Avoid expensive mishaps to that car behind you.

● Telephone Switch

Phone home and remotely control an electric appliance while you're away.



HALLOWEEN HOWLER

Halloween's coming – why not give your "trick or treat" visitors a scare?! Picture a pumpkin head, eyes lighting up red and emitting an eerie howl when someone walks past it!

Although intended to help generate a bit of fun over Halloween this project also serves to demonstrate just how easy (and cheap) it can be to output audio in an electronics project. The sound comes from a pre recorded computer "WAV" file stored in a small EEPROM memory. WAV files can be downloaded from the internet, extracted from music CDs and even recorded by yourself on a PC using software supplied with most operating systems.

The circuit described can be configured into one of two modes of operation: Halloween Howler, which includes a light sensor to detect moving objects, and a generic 3-input design that allows one of three stored sound samples to be played when an input is asserted. This second setup provides a more general purpose sound generator that can have a number of uses.

NO ONE DOES IT BETTER

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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

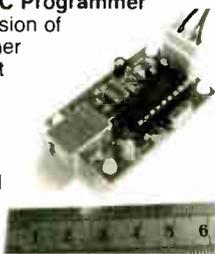
USB/Serial connection. Header cable for ICSP. Free Windows software. See website for PICs supported. ZIF Socket and USB Plug A-B lead extra. 18VDC.

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 i.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. Includes one DS1820 sensor and four header cables.

Kit Order Code: 3145KT - £16.95

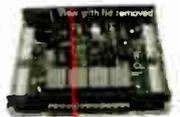
Assembled Order Code: AS3145 - £23.95

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

Monitor and log a mixture of analogue and digital inputs and control external devices via the analogue and digital outputs. Monitor pressure, temperature, light intensity, weight, switch state, movement, relays, etc. with the appropriate sensors (not supplied). Data can be processed, stored and the results used to control devices such as motors, sirens, relays, servo motors (up to 11) and two stepper motors.



Features

- 11 Analogue Inputs - 0-5V, 10 bit (5mV/step)
- 16 Digital Inputs - 20V max. Protection 1K in series, 5-1V Zener
- 1 Analogue Output - 0-2.5V or 0-10V. 8 bit (20mV/step)
- 8 Digital Outputs - Open collector, 500mA, 33V max
- Custom box (140 x 110 x 35mm) with printed front & rear panels
- Windows software utilities (3.1 to XP) and programming examples
- Supply: 12V DC (Order Code PSU203)

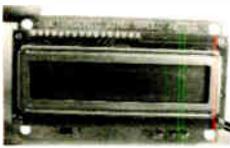
Kit Order Code: 3093KT - £64.95

Assembled Order Code: AS3093 - £94.95

Hot New Kits This Summer!

Here are a few of the most recent kits added to our range. See website or join our email Newsletter for all the latest news.

NEW! EPE Ultrasonic Wind Speed Meter



Solid-state design wind speed meter (anemometer) that uses ultrasonic techniques and has no moving parts and does not need

calibrating. It is intended for sports-type activities, such as track events, sailing, hang-gliding, kites and model aircraft flying, to name but a few. It can even be used to monitor conditions in your garden. The probe is pointed in the direction from which the wind is blowing and the speed is displayed on an LCD display.

Specifications

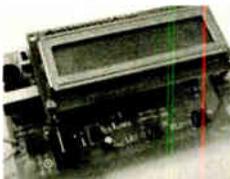
- Units of display: metres per second, feet per second, kilometres per hour and miles per hour
- Resolution: Nearest tenth of a metre
- Range: Zero to 50mph approx.

Based on the project published in Everyday Practical Electronics, Jan 2003. We have made a few minor design changes (see website for full details). Power: 9VDC (PP3 battery or Order Code PSU345).

Main PCB: 50 x 83mm.

Kit Order Code: 3168KT – £34.95

NEW! Audio DTMF Decoder and Display



Detects DTMF tones via an on-board electret microphone or direct from the phone lines through the onboard audio transformer. The

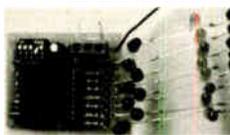
numbers are displayed on a 16-character, single line display as they are received. Up to 32 numbers can be displayed by scrolling the display left and right. There is also a serial output for sending the detected tones to a PC via the serial port. The unit will not detect numbers dialled using pulse dialling. Circuit is microcontroller based.

Supply: 9-12V DC (Order Code PSU345). Main PCB: 55 x 95mm.

Kit Order Code: 3153KT – £17.95

Assembled Order Code: AS3153 – £29.95

NEW! EPE PIC Controlled LED Flasher



This versatile PIC-based LED or filament bulb flasher can be used to flash from 1 to 160

LEDs. The user arranges the LEDs in any pattern they wish. The kit comes with 8 superbright red LEDs and 8 green LEDs. Based on the Versatile PIC Flasher by Steve Challinor, EPE Magazine Dec '02. See website for full details. Board Supply: 9-12V DC. LED supply: 9-45V DC (depending on number of LED used). PCB: 43 x 54mm. Kit Order Code: 3169KT – £11.95

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

FM Bugs & Transmitters

Our extensive range goes from discreet surveillance bugs to powerful FM broadcast transmitters. Here are a few examples. All can be received on a standard FM radio and have adjustable transmitting frequency.

MMTX' Micro-Miniature 9V FM Room Bug



Our best selling bug! Good performance. Just 25 x 15mm. Sold to detective agencies worldwide. Small enough to hide just about anywhere.

Operates at the 'less busy' top end of the commercial FM waveband and also up into the more private Air band.

Range: 500m. Supply: PP3 battery.

Kit Order Code: 3051KT – £8.95

Assembled Order Code: AS3051 – £14.95

HPTX' High Power FM Room Bug

Our most powerful room bug.

Very Impressive

performance. Clear and stable output signal thanks to the extra circuitry employed.

Range: 1000m @ 9V. Supply: 6-12V DC (9V PP3 battery clip supplied). 70 x 15mm.

Kit Order Code: 3032KT – £9.95

Assembled Order Code: AS3032 – £17.95

MMTX' Miniature Telephone Transmitter



Attach anywhere along phone line.

Tune a radio into the signal and hear

exactly what both parties are saying.

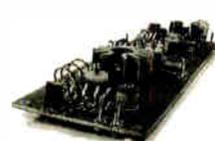
Transmits only when phone is used. Clear, stable signal. Powered from phone line so completely maintenance free once installed.

Requires no aerial wire – uses phone line as antenna. Suitable for any phone system worldwide. Range: 300m. 20 x 45mm.

Kit Order Code: 3016KT – £7.95

Assembled Order Code: AS3016 – £13.95

3 Watt FM Transmitter



Small, powerful FM transmitter. Audio preamp stage and three RF stages deliver 3 watts of RF power. Can be used with the electret

microphone supplied or any line level audio source (e.g. CD or tape OUT, mixer, sound card, etc). Aerial can be an open dipole or Ground Plane. Ideal project for the novice wishing to get started in the fascinating world of FM broadcasting. 45 x 145mm.

Kit Order Code: 1028KT – £23.95

Assembled Order Code: AS1028 – £31.95

25 Watt FM Transmitter

Four transistor based stages with a Philips BLY89 (or equivalent) in the final stage. Delivers a mighty 25 Watts of RF power.

Accepts any line level audio source (input sensitivity is adjustable). Antenna can be an open dipole, ground plane, 5/8, J, or YAGI configuration. Supply 12-14V DC, 5A. Supplied fully assembled and aligned – just connect the aerial, power and audio input. 70 x 220mm.

Order Code: AS1031 – £134.95



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30, 130, 200 and 300-in-1 project labs also available – see website for details.



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With over 300 projects in our range we are the UK's number 1 electronic kit specialist. Here are a few other kits from our range.

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- No ground effect, works in seawater



- Detects gold, silver, ferrous & non-ferrous metals

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- Full kit with headphones & all hardware

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- DUAL OPTION



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KIT 856.....£28.00

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Magenta have prepared a FULL KIT for this, excellent new project. All components, PCB, hardware and electrodes are included. Designed for simple assembly and testing and providing high level dual output drive.

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Full set of top quality NEW components for this educational series. All parts as specified by EPE. Kit includes breadboard, wire, croc clips, pins and all components for experiments, as listed in introduction to Part 1.

*Batteries and tools not included.

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- UP TO 4 METRES RANGE
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Includes PIC16F84 chip disk, lead, plug, p.c.b., all components and instructions

Extra 16F84 chips £3.84 Power Supply £3.99

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16 Character x 2 Line display, pcb, programmed PIC16F84, software disk and all components to experiment with standard intelligent alphanumeric displays. Includes full PIC source code which can be changed to match your application.

KIT 860.....£19.99

- Learn how to drive the display and write your own code.
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- Top quality display with industry standard driver, data and instructions

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Use this project to develop your own applications. PCB allows 'simple PIC programmer' 'SEND' software to be used to reprogram chip.

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From Aug/Sept. '99 EPE. Featuring 8 analogue inputs and serial data transfer to PC. Magenta redesigned PCB - LCD plugs directly onto board. Use as Data Logger or as a test bed for developing other PIC16F877 projects. Kit includes lcd, prog. chip, PCB, Case, all parts and 8 x 256k EEPROMs

KIT 877.....£49.95

PIC16F84 MAINS POWER CONTROLLER & 4 CHANNEL LIGHT CHASER / DIMMER

- Zero Volt Switching
- Opto-Isolated 5 Amp HARD FIRED TRIACS
- 12 Way keypad Control

- With program source code disk.
- Chase Speed and dimming potentiometer controls.
- Reprogram for other applications

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PIC TUTOR 1 EPE MARCH APRIL MAY '98 PIC16F84 STARTER SERIES

The original PIC16F84 series by John Becker. Magenta's Tutor board has individual switches and leds on all portA and PortB lines, plus connectors for optional 4 digit seven segment led display, and 16 x 2 intelligent lcd. Written for newcomers to PICs this series. Disk has over 20 tutorial programs. Connect to a PC parallel port, send, run, and experiment by modifying test programs - Then Write and Program your Own

KIT 870... £27.95, Built...£42.95

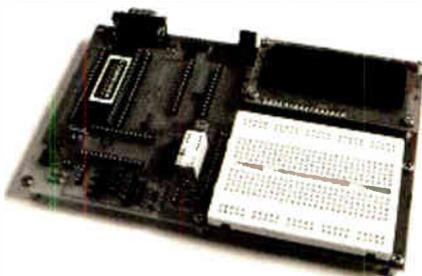
16x2 LCD..£7.99. LED display..£6.99. 12VPSU..£3.99

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KIT 862... £29.99 Power Supply £3.99

ICEBREAKER



PIC Real Time In-Circuit Emulator

- ICEbreaker uses PIC16F877 in-circuit debugger.
- Links to standard PC Serial port (lead supplied).
- Windows (95 to XP) Software included
- Works with MPASM assembler
- 16 x 2 LCD display, Breadboard, Relay, I/O devices and patch leads.

Featured in EPE Mar'00 Ideal for beginners & experienced users.

Programs can be written, downloaded, and then tested by single-stepping, running to breakpoints, or free run at up to 20Mhz.

Full emulation means that all ports respond immediately - reading and driving external hardware.

Features include: Run; set Breakpoint; View & change registers, EEPROM, and program memory; load program; 'watch window' registers.

KIT 900...£34.99 With serial lead & software disk, PCB, Breadboard, PIC16F877, LCD, all components and patch leads.

POWER SUPPLY - £3.99 STEPPING MOTOR 100 Step £9.99

20W Amp. Module

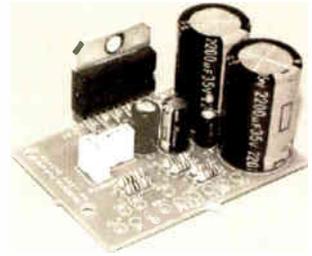
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Stable Reliable design

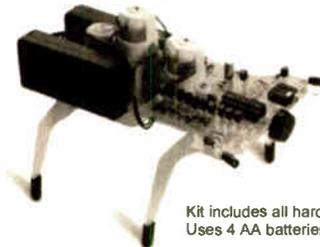
Latest Technology IC with local feedback gives very high performance.



KIT 914 (all parts & heatsink for stereo or mono) **£11.90**

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CD contains illustrated constructional details, operating principles, circuits and a superb Educational Programming Tutorial.

Test routines give real-time 'scope traces of sensor and motor signals. Connects to PC via SERIAL port with the lead supplied.

Kit includes all hardware, components, 3 motor/gearboxes. Uses 4 AA batteries (not supplied). An Ideal Present!

KIT 912 Complete Kit with CD rom & serial lead **£49.99**

KIT 913 As 912 but built & tested circuit board **£58.95**

EPE PIC Tutorial

EPE Apr/May/Jun '03 and PIC Resources CD

- Follow John Becker's excellent PIC toolkit 3 series.
- Magenta Designed Toolkit 3 board with printed component layout, green solder mask, places for 8,18, 28 (wide and slim), and 40 pin PICs. and Magenta extras.
- 16 x 2 LCD, PIC chip all components and sockets included.

KIT 880 (with 16F84) **£34.99**, built & tested **£49.99**

KIT 880 (with 16F877) **£39.99**, built & tested **£55.99**

EPE TEACH-IN 2004

THE LATEST NOV 03 SERIES All parts to follow this new Educational Electronics Course. Inc. Breadboard, and wire, as listed on p752 Nov. Issue.

Additional Parts as listed in 'misc.' Section (less RF modules, Lock, and Motor/g.box)

Reprints: £1.00 per part.

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KIT921.....£12.99

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- As featured in EPE Feb '03 (KIT 910)
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160 x 233mm Board £1.02
220 x 233mm Board £1.40
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100 x 220mm Single £1.25
160 x 233mm Single £2.29
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840 175 x 67mm 2 £4.86
740 175 x 55mm 1 £4.03
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HSS parallel shank bits available in sizes from 0.3mm to 2.0mm
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Expo reformat 12V drill, 3.8mm capacity, 8400rpm £12.78

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Model EPE270-390
Normal price £48.51



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PCB Production - Chemicals

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6 x 12"	£4.20	£5.04	£5.60	£6.23
9 x 12"	£6.30	£7.70	£8.40	£9.38
10 x 12"	£8.19	£10.01	£10.78	£11.83
12 x 12"	£8.26	£10.08	£10.99	£12.25
100 x 160mm			£2.38	£2.66
203 x 114mm			£3.01	£3.43
220 x 100mm			£3.08	£3.71
233 x 160mm			£4.83	£5.32
233 x 220mm			£6.83	£7.70

PCB Production - Chemicals

100ml	Aerosol Photoresist spray, covers 2m ²	£4.25
50g	Powder developer, makes 1l	£1.09
500g	Powder developer, makes 10l	£7.08
250g	Ferric Chloride Pellets, makes 500ml	£1.68
500g	Ferric Chloride Pellets, makes 1l	£3.04
2.5kg	Ferric Chloride Pellets, makes 5l	£9.84
1.1kg	Clear Fine etch crystals, makes 5l	£17.58
90g	Tin Plating Powder, makes 1l	£11.58
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110ml	Aerosol PCB Laquer spray	£3.63

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Range	Int £	All meters £5.89 each	6V Lamps £1.23 / pair
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0-100uA	1k0		
0-500uA	430Ω		
0-1mA	200Ω		
0-10mA	2k26		
0-50mA	1k22		
0-100mA	0k265		
0-500mA	0k212		
0-1A	60mΩ		
0-5A	20mΩ		
0-5A	12mΩ		
0-15A	4mΩ		
0-10V	10k		
0-15V	15k		
0-30V	30k		
±50uA	1k9		



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DC current 2mA - 20A (±1.2%)
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Video Output: 1 Vpp, 75Ω
Dims: 35 x 35 x 28mm 20g **£16.60**



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Video System: PAL
Pixels: 628 x 582
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Video Output: 1 Vpp, 75Ω
Dims: 28 x 28 x 28mm 20g **£36.33**



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The Wonders of Technology

I'm sat by a swimming pool outside of a four star hotel in Cape Town, courtesy of South African Airways, writing this. I met our regular contributor Thomas Scarborough, who lives in Cape Town, a couple of days ago following a sports tour I had been on with my wife, who coaches netball, and 21 netball and hockey players. Our flight home was cancelled due to an on-going strike by South African Airways staff. Technology has allowed us to stay in touch with home and office during the tour and also allowed me to write this and zoom it around the world to be in print a few days later.

The problem is that, with all SAA International flights cancelled, we have no way of getting everyone home for a few days until there is space on a BA flight. I guess what we need is a teleport system but even if such a thing were possible it could still be defeated by an operator's strike!

Problems

The problems are further compounded by system overload when everyone wants to use their mobile phones or the Internet. Technology is great when everything is fine but I don't think we have yet got the systems we need when unusual circumstances result in exceptional use. And no doubt we will always be in the hands of workers who might strike for better pay or conditions.

Meeting Thomas in Cape Town was a bonus of the tour, he presented me with an unusual project for future publication and also demonstrated a prototype magnetic field detector which he is presently working on. I also met his son Matthew who is responsible for many of the ideas Thomas turns into working projects.

EPE is truly international, not only in sales but also with contributors like the Reverend Thomas that provide the wide variety of unusual projects that make *EPE* what it is today.

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All-Band Radio

Thomas Scarborough

A no frills, low budget, easy-build, sensitive radio with excellent reception

ONE might call this a “dog” of a radio. It doesn’t pretend to any finesse. 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, South Africa, the prototype All-Band Radio 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.

Regeneration

Despite its simplicity, this regenerative set 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.

A regenerative radio is interesting to work with. It might be compared with a manual car as opposed to an automatic. In addition to the customary Volume control and Tuning dial, it has a third Regeneration dial to control regeneration. Regeneration “regenerates” the received signal, much as a child on a swing increases the energy of the swing with modest kicks of its legs. This type of radio was invented by Major Armstrong in 1912, bringing about a vast improvement in radio receivers at that time.

At first it was thought that the set’s maximum frequency would lie around 5MHz – that is, the shortwave 60 metre band. In practice, however, it picked up radio stations above 7MHz. Therefore it has the potential to tune in the following bands:

<i>Long Wave</i>	
<i>Medium Wave</i>	
<i>Marine Band</i>	<i>120 metres</i>
	<i>90 metres</i>
	<i>75 metres</i>
	<i>60 metres</i>
	<i>49 metres</i>
<i>Short Wave</i>	<i>41 metres</i>

Mini Radio

At the heart of this radio circuit is the 4069UB (unbuffered) hex inverter i.c. which is able to provide a powerful signal into a crystal earpiece. Therefore, the circuit obviously has the potential for miniaturisation. With this in mind, the author further designed a p.c.b. layout for a miniature radio (see Fig.4), and it remains to the ingenuity of the constructor to fit this into a suitably small plastic case.

Circuit Description

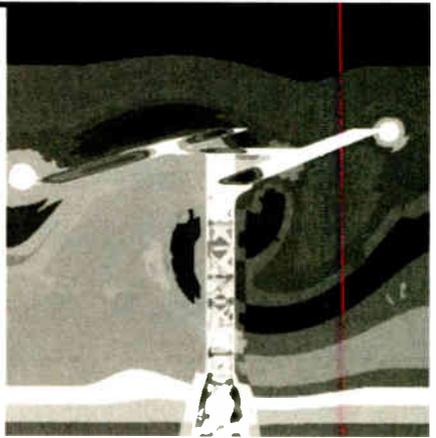
As mentioned above, the heart of the circuit is represented by inverting buffer IC1a (see Fig.1). Although this is classed as a digital device, it may in some situations serve as an analogue amplifier up to several megahertz, albeit without the same quality of reproduction as a dedicated analogue amplifier i.c.

The full circuit diagram for the All-Band Radio is shown in Fig.1. When a station is tuned in, variable capacitor VC1 and coil L1 resonate at the tuned frequency. In other words, they present a minuscule alternating voltage to the input of IC1a through d.c. blocking capacitor C1. Therefore any activity in the tuned circuit unsettles both the input and the output of IC1a, sending ripples down the chain IC1a to IC1f, which are amplified and demodulated as they go.

To bring about regeneration, the tuned circuit is inserted in the feedback path of IC1a, while resistor R1 and potentiometer VR1 serve to balance IC1a at roughly half the supply voltage. The higher the value of VR1, the greater IC1a’s potential for being unsettled, and the greater the regeneration as the amplified signal at input pin 1 is passed back through the tuned circuit via output pin 2.

The purpose of regeneration is to reinforce the r.f. signal through positive feedback. Not only does this make the signal louder, but it also sharpens it a great deal. As a matter of interest, Fig.2 shows how this circuit might have looked if a more standard tuned radio frequency (t.r.f.) configuration had been used, and it would be instructive to try this out. The result is much vaguer tuning, and reduced volume.

When using the radio, regeneration needs to be held as high as possible without introducing instability to the circuit.



Front panel controls for the full version of the All-Band Radio

Such instability is manifested either through "shrieks" or "juddering" in the loudspeaker or earpiece. Generally speaking, however, it will be possible most of the time to turn up regeneration to the maximum without this occurring. Regeneration will be needed particularly if a longer aerial is employed.

It is possible, with a small modification to the circuit, to introduce the most radical regeneration, and therefore very sharp tuning (that is, high selectivity). This is done by wiring a 10 megohm resistor between IC1a pin 1 and IC1b pin 4. However, while this would take the All-Band Radio to its full potential, it would also make it tricky to use in practice. In this case, R1 and VR1 would best need to be tweaked for greater ease of use.

Inverter IC1b serves to amplify the radio frequency (r.f.) signal, while diode D1 provides demodulation (that is, it extracts the audio signal). A common disadvantage of using a simple diode for demodulation is that this may kill weaker signals through its voltage drop; hence the choice of a germanium type. Therefore before demodulation is applied to this circuit, r.f. amplifier stage IC1b is added. Diode D1 thus demodulates a far stronger r.f. signal, and far fewer stations are lost in the process.

Tuning-In

One of the particular advantages of this design is that virtually any tuned circuit may be tried for VC1 and L1, on condition that this is tuned to less than about 8MHz. So, for instance, various coils and a.m. tuners (tuning capacitors) may be pulled out of junked radio circuits, and the majority would be likely to work, possibly with interesting results.

The most commonly available a.m. tuning capacitors typically have two separate sections (that is, two variable capacitors with one common terminal - ask your component shop to identify the terminal pins). A tuned circuit for the medium waves could use such a tuner with its two separate sections wired in parallel, together with L1 which would be about eighty to a hundred turns of 30s.w.g. (0.15mm)

enamelled copper wire close-wound on a 10mm diameter ferrite rod. This does not, however, represent an ideal Q for the tuned circuit - more later.

In order to access higher frequencies, thicker gauges of wire would be used, with fewer turns, spaced out more widely on the ferrite rod, or even being air-spaced. The author accessed the 41 metre shortwave band with an air-spaced coil which was wound on a 25mm diameter former, with 10 turns of 24s.w.g. (0.56mm) enamelled copper wire. This was then stretched out to 25mm from end to end.

Don't hesitate to wire up different coils and a.m. tuning capacitors to see what the circuit does with them. Also, try experimenting with different aerials, which could greatly increase the range of the radio. The author picked up many distant stations by winding a length of enamelled copper wire a few times round his work room. Even a tree may serve well as an aerial. In the case of the tree, the connection is made by sticking a pin through the bark.

As a matter of interest, Raymond Haigh's, series *Practical Radio Circuits* (EPE Sept '03 P646) gives some examples of coils which could be tried to bring in different frequencies. Note also that since

inductance drops when inductors are wired in parallel, the frequency of the radio could be raised simply by wiring coils in parallel with the existing coil. Although this is not ideal, it is an easy way to experiment.

Going Miniature

If the miniature version of the Radio should be built, coil L1 may be compressed by using a short stub of 10mm diameter ferrite rod, pile-winding eighty to a hundred turns of 30s.w.g. (0.315mm) enamelled copper wire on the stub. The a.m. tuning capacitor may further be miniaturised by wiring a trimmer capacitor, in series with a small fixed value capacitor, in its place. The fixed value would need to be chosen experimentally so as to pick up one's chosen radio station or stations, since the tuning range would be reduced in this case.

Theoretically, the tuner may be no more than two metal plates with a dielectric (e.g. a sheet of plastic). Many years ago, the author bought the Soviet Astrad Orion, which was possibly the smallest radio ever to have become widely available. Out of curiosity, it was opened up to examine the tuning capacitor, and a single metal plate fell out. This, together with a plate on the front of the case, formed the tuning capacitor.

Q-Factor

In order to experiment intelligently with the All-Band Radio, one should best have some understanding of the Q -factor. The radio as shown (Fig.1) has been designed for a relatively high Q , although it does not depend on this to work reasonably well.

A common definition of Q is "the ratio of the reactance of an inductor (in this case coil L1) to its effective series resistance at a given frequency". However, a simple way of putting this is that Q represents the "power" with which the tuned circuit resonates at a given frequency. As in many situations, it is one thing to get something to work - it is another to get it to work efficiently.

The formulae for calculating the ideal Q are relatively complex, but two factors are especially important for obtaining a good Q .

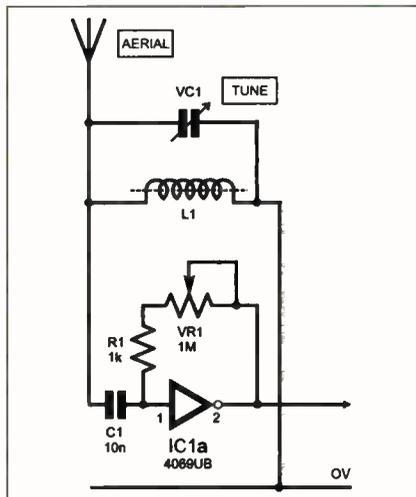


Fig.2. Standard t.r.f. configuration

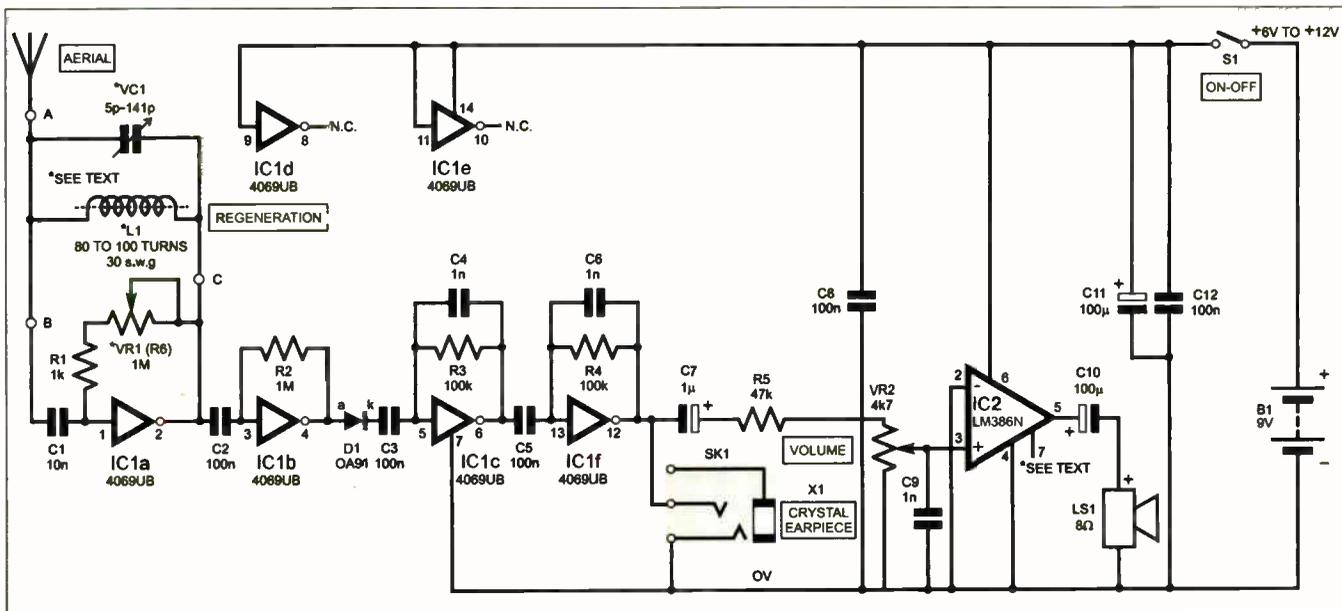


Fig.1. Complete circuit diagram for the "full version" of the All-Band Radio

COMPONENTS

Resistors

R1	1k
R2	1M
R3,R4	100k (2 off)
R5	47k
R6	1M (see text)

All 0.25W 5% carbon film

Potentiometers

VR1	1M min. carbon track or conductive plastic, 5mm pitch
VR2	4k7 min. carbon track or conductive plastic, 5mm pitch

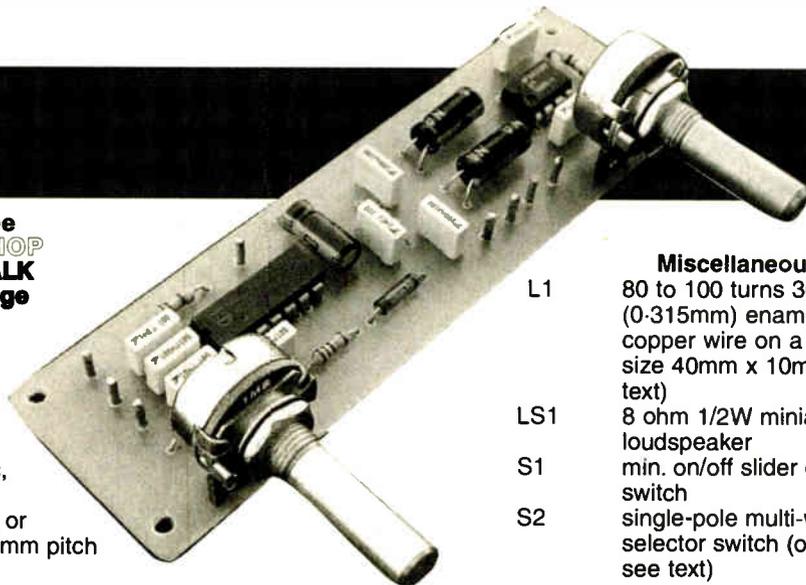
Capacitors

C1	10n polyester or ceramic
C2,C3,C5,	
C8,C12	100n polyester or ceramic (5 off)
C4,C6,C9	1n polyester or ceramic (3 off)
C7	1 μ radial elect. 16V
C10,C11	100 μ radial elect. 16V (2 off)
VC1	126p, 141p a.m. variable, with trimmers (see text)

Semiconductors

D1	OA91 or similar germanium diode
IC1	4069UB (unbuffered) CMOS hex inverting buffer i.c.
IC2	LM386N-1 audio amplifier i.c.

See
SHOP
TALK
page



Miscellaneous

L1	80 to 100 turns 30s.w.g. (0.315mm) enamelled copper wire on a ferrite rod, size 40mm x 10mm (see text)
LS1	8 ohm 1/2W miniature loudspeaker
S1	min. on/off slider or toggle switch
S2	single-pole multi-way Band selector switch (optional – see text)
SK1	2.5mm or 3.5mm mono jack socket, chassis mounting (optional)
X1	crystal earpiece optional – see text)
B1	9V battery (PP3 type), with clips

Printed circuit boards available from the *EPE PCB Service*, codes 523(Full) and 524(Mini); case, size 130mm x 70mm x 40mm approx. (or to suit Mini version); 8-pin d.i.l. socket; 14-pin d.i.l. socket; plastic knob (3 off); aerial wire; screened microphone cable (about 30cm); cable ties; solder tag; solder pins; solder etc.

Approx. Cost
Guidance Only

£16

excl case and batts

The first is that fine wire should be used for coil L1, or more exactly that skin effect should be avoided – a complaint that applies to thicker wire gauges, and raises the effective (a.c.) resistance of the coil. Often, therefore, a coil is wound with several strands of fine wire twisted together but insulated from each other, being equivalent in their total cross-sectional area to the wires they replace.

A second factor is to maximise the influence of coil L1 on the tuned circuit, and to minimise capacitance and resistance. This is done by minimising the value of variable capacitor VC1, and by maximising the value of coil L1 – as well as minimising any resistance in the tuned circuit.

Described from a practical point of view, some tuned circuits will cause the All-Band Radio to pick up stations at full volume, while others will cause it to pick them up more quietly. Therefore if you should decide to recycle a tuned circuit from another radio, it might be worth taking it out of a full-sized radio set to obtain good *Q*, and to choose a case for the All-Band Radio that is able to accommodate this. This will ensure a reasonably strong sound input to the loudspeaker.

It is known that the *Q*-factor suffers especially when miniaturising the tuned circuit, and for this purpose, it is possible to increase the amplification of the All-Band Radio. Resistor R2 may be increased up to about 4M7, R3 may likewise be increased up to about 4M7, and R4 may be increased a little (say to 220k Ω).

Audio Circuit

Two preamplifier stages (IC1c and IC1d) follow after the r.f. section. Their gain is set through resistors R3 and R4. Each of these

stages filters out high frequencies (including radio frequencies) with the use of a small feedback capacitor (C4 and C6). A reduction of the values of these capacitors gives a “sharper” sound, arguably increasing the clarity of reception. However, this also increases hiss. The two spare inverter gates IC1d and IC1e (IC1 pins 9 and 11) are “tied high” to prevent any instability.

Note that because this circuit is based on a cheap CMOS 4000-series i.c. instead of dedicated radio and audio i.c.s, its sound quality suffers somewhat, in particular through the introduction of hiss. However, for everyday listening, the quality is quite adequate.

The two preamplifier stages are followed by a Volume control (VR2) and a low-pass filter (C9). A basic hazard of radio circuits is that the audio amplifier might be fed with radio frequencies (r.f.) that have slipped through the preceding stages, thus overloading the amplifier. The amplifier thus works too hard with signals that the listener is unable to hear. Therefore adequate filtering is important. Notice also the decoupling capacitors C8, C11, and C12, which are not used merely for “good practice”, but make a noticeable difference to sound quality.

Using the popular LM386 audio amplifier i.c., IC2 is capable of providing up to about 1/2W r.m.s. at 9V into an 8 ohm loudspeaker. If desired, its gain may be increased by wiring a capacitor between pins 1 and 8 of IC2, the value of which may be between about 100nF and 10 μ F. The capacitor’s positive terminal is wired to pin 1.

The usual Zobel network at the output is omitted for the sake of simplicity. The small measure of protection which a Zobel

network would afford IC2’s internal transistors ought not to be missed here, although constructors of a more nervous disposition might wish to wire a 10 Ω resistor and a 100nF capacitor in series from IC2 output pin 5 to the 0V line.

For the miniature version of the Radio, IC2 is completely omitted, leaving a powerful “crystal” set which feeds a crystal earpiece (X1), via jack socket SK1, wired from IC1f output pin 12 to 0V – or an inductive earpiece may be used if it is wired in series with a 1 μ F capacitor.

The All-Band Radio’s quiescent current consumption is relatively high. The miniature version of the radio draws about 30mA at 9V, while the fully built version with amplifier and speaker will consume upwards of 50mA, depending on the volume. This means that an alkaline PP3 type 9V battery might last ten or fifteen hours for the miniature version, and five or eight hours for the fully built version.

For regular use, therefore, a regulated mains-to-d.c. power supply (mains adaptor) might be considered. If there should be any hum as a result of using a power supply, a 10 μ F capacitor may be wired from IC2 pin 7 to 0V, and this is likely to improve matters significantly. Alternatively, a better quality supply might need to be used.

Construction – Full Version

Since this is a radio circuit, it is of prime importance that connections to off-board components should be made with screened microphone cable. The screen is always taken to 0V where this applies. The wires from L1 and the battery may be excepted on condition that these are kept as short as reasonable.

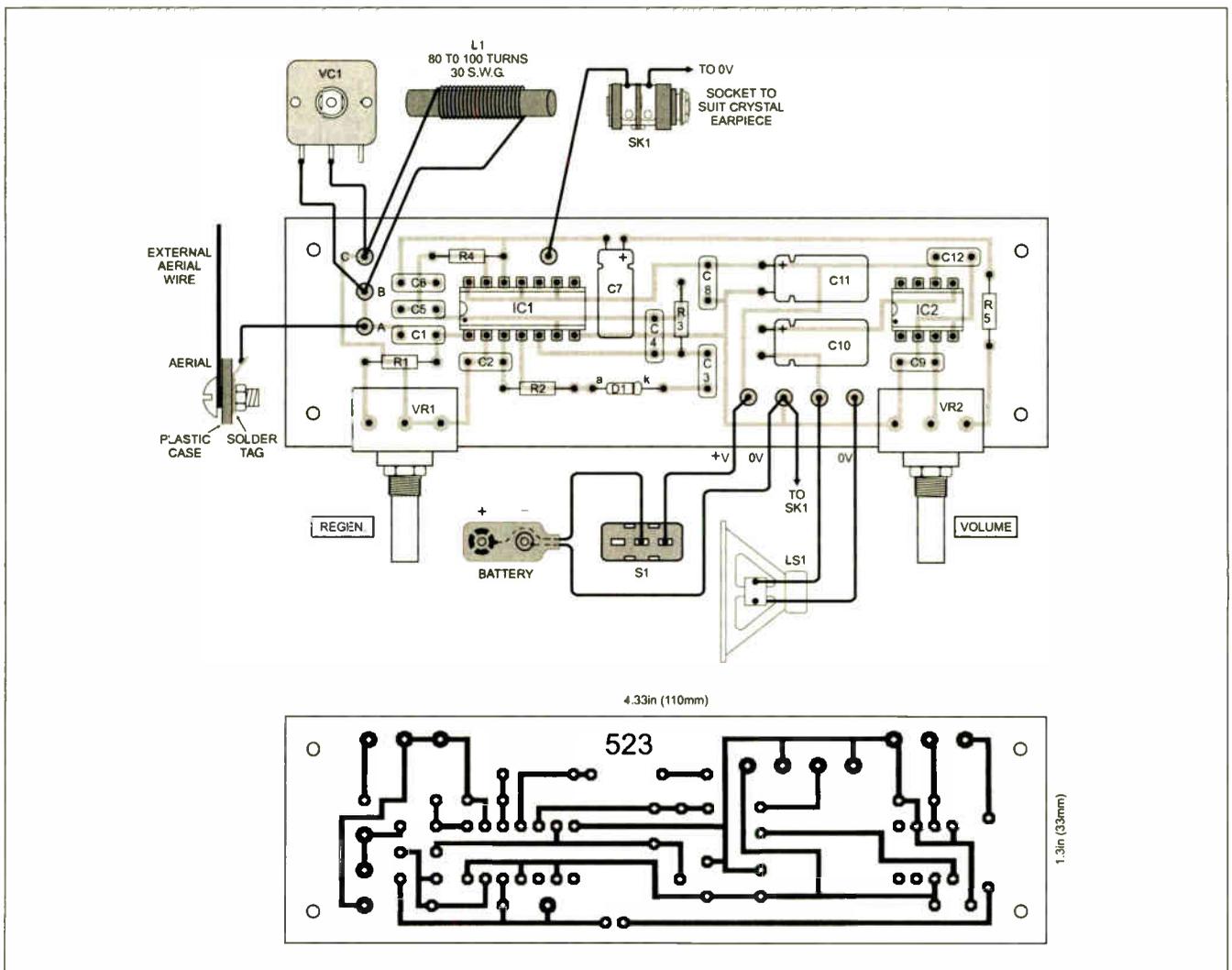


Fig.3. Printed circuit board component layout, full-size copper foil master and off-board wiring details for the full version of the All-Band Radio

The printed circuit board (p.c.b.) for the fully built version measures 110mm x 33mm, and the component layout, full-size copper foil master and wiring details are shown in Fig.3. This board is available from the *EPE PCB Service*, code 523 (Full).

Begin construction by soldering in position the eight solder pins, five resistors and twelve capacitors, taking note of the polarity of the electrolytics. Insert and solder potentiometers VR1 and VR2 on the p.c.b.

Lastly, solder the germanium diode D1 and the two i.c.s – observing anti-static precautions for both (ensure that your body has been discharged to earth). The author soldered the i.c.s directly to the p.c.b., for the reason that this is a sensitive radio circuit, however readers can, if they wish, use dual-in-line (d.i.l.) sockets.

Attach the loudspeaker LS1 and tuning capacitor VC1 to the p.c.b. with suitable lengths of microphone cable. Attach the battery clip and on-off switch S1 as shown. Solder the leads of coil L1 to the p.c.b., keeping these as short as possible.

Casing-Up

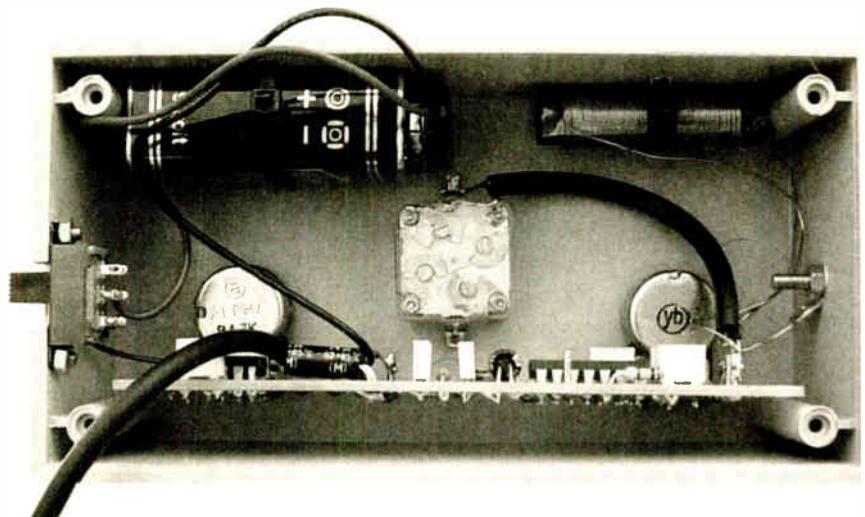
An ABS plastic case of approximately 130mm x 70mm x 40mm was used to house the prototype p.c.b. Drill three holes in the front (bottom) of the case for VR1, VR2 and VC1. Drill a series of "sound"

holes in the lid (rear) for the small loudspeaker and then attach it to the rear of the lid (or elsewhere, if a larger case is used). Make sure there is plenty of room between the rear of the speaker and the circuit board.

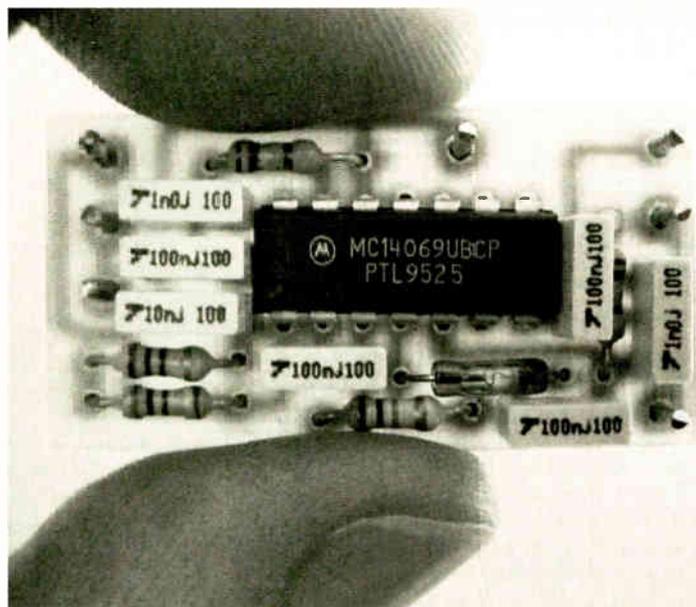
Prepare a hole in one side wall for the on-off switch S1. Drill a hole and bolt a solder tag to the other side wall of the case, taking a short length of wire from

the tag to the p.c.b. This is used later to attach an aerial if desired. The author held the battery and ferrite coil L1 in place inside the case with cable ties, see photograph below.

If desired, a number of different coils for L1 may be switched in and out of use, so as to access the different bands. For this purpose, a single-pole multi-way rotary switch would be used.



Internal component layout of the radio showing the battery and ferrite coil held in position with cable ties.



Completed Mini Radio circuit board

Construction – Mini Version

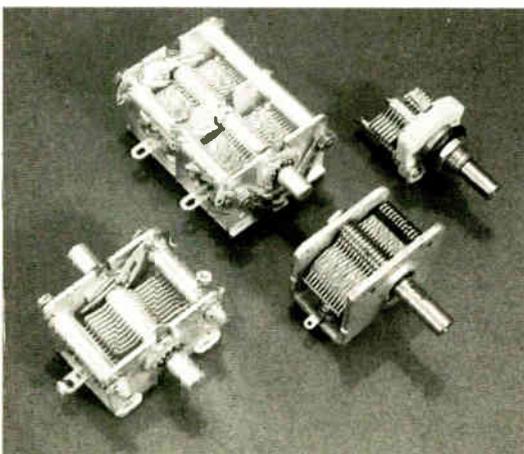
The p.c.b. component layout and full-size copper foil master for the miniature version of the Radio, which measures a mere 44mm x 23mm, is shown in Fig.4. This board is also available from the *EPE PCB Service*, code 524 (Mini).

The mini version has potentially the same performance as the fully built version, except that it uses an earpiece instead of a loudspeaker. A jack socket SK1 may be used for the earpiece X1, or it may be soldered directly to the p.c.b., with a dab of glue acting as a strain relief for X1's leads.

Commence construction by soldering in position the seven solder pins and five resistors. Note that Regen. control VR1 is replaced on this p.c.b. with a one megohm (1M Ω) fixed value resistor, to conserve space. A 1M Ω potentiometer may by all means be used instead. A 1M Ω fixed value resistor should not cause excessive regeneration unless a particularly generous length of aerial is used.

Next, insert and solder in position the seven capacitors, the germanium diode D1 and IC1, again observing anti-static precautions with the i.c. Coil L1 and tuning capacitor VC1 may be miniaturised as described earlier.

Finally, a suitable miniature slider or toggle type switch is wired up, together with a battery or batteries. Bear in mind that current consumption is relatively high, and some smaller batteries might only last



Group of air-spaced variable capacitors

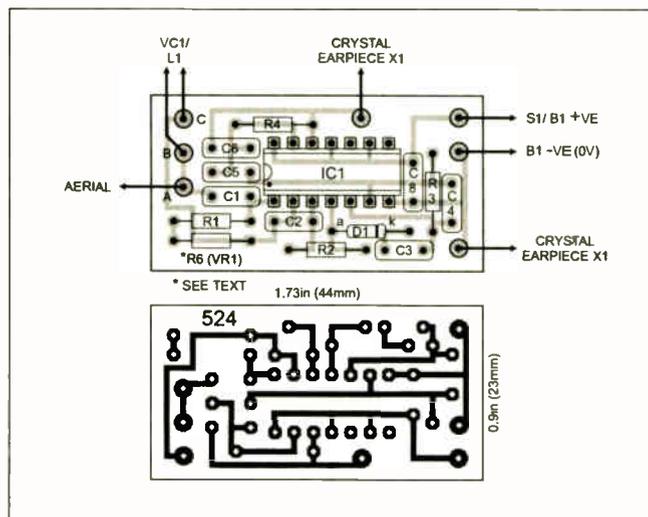


Fig.4. Mini version p.c.b. component layout, wiring and copper foil master

an hour or so. Any batteries from 6V to 12V may be used. A possible choice would be a standard small keyfob battery, the MN21 or A23.

Set-Up and Use

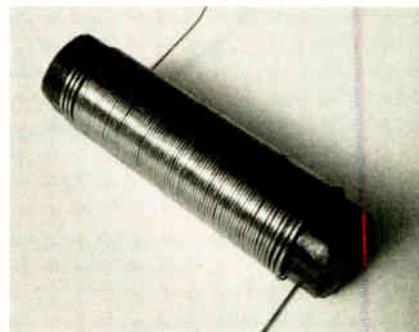
Begin the setting up procedure by turning the Regeneration control (VR1) fully clockwise. Turn up the Volume control (VR2) to about half. Switch on – then turn the tuning dial (VC1) until a station is tuned in.

On the medium waves in Europe or North America, there should be no shortage of stations even without an external aerial. However, in Southern Africa or Australia, stations may be relatively few and far between – perhaps just one or two until night falls and an aerial is attached. As with all medium and short wave sets, reception is very much improved at night, particularly as one approaches midnight.

If without an external aerial nothing at all is tuned in on the medium waves, try re-orientating coil L1 for better reception. Alternatively, L1 and tuning capacitor VC1 may not be covering the desired frequencies, and another coil might be required.

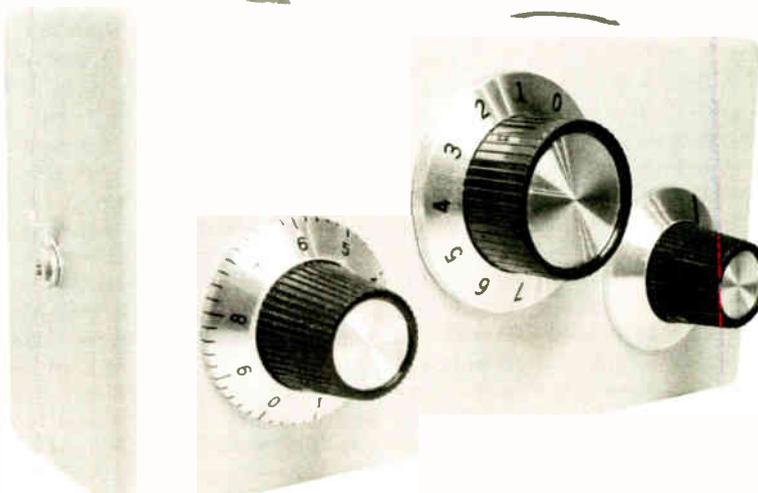
If, even with an aerial, nothing at all is tuned in, check that all components are correctly placed on the p.c.b., and that there are no solder bridges or dry solder joints. Since this is a sensitive radio circuit, it might be worth briefly melting each joint again with the soldering iron. Inadequate joints are seldom visible to the eye.

If there is excessive regeneration or instability in the form of "shrieks" or "judging", first try turning down the volume (VR2). If this does not restore stability, reduce regeneration by slowly turning back VR1. Once stability returns, the volume may be turned up again. Regeneration needs to be kept as high as possible, so that tuning is as sharp as possible.



Once the All-Band Radio is working satisfactorily, different coils may be substituted for L1, or these may simply be wired in parallel with L1 as described earlier. Avoid attaching coils with crocodile clips, since such clips are bulky, and may lead to stray r.f. and capacitive effects that could kill reception completely. Rather use short leads which are wired directly to the p.c.b., or to solder tags close to the p.c.b.

Happy listening! □





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 **RD Research**

SOUNDS OF THE FUTURE

As conventional audio sales decline, surprising technological alternatives could soon be booming. Barry Fox reports

CONFIDENTIAL trade figures from JEIDA, the Japanese electronics industry trade body, show conventional audio in terminal decline. Sales of multi-speaker systems are flagging. The only hope, Japanese manufacturer Marantz told European press and dealers at a seminar in Italy recently, is for the audio trade to take the Swiss watch industry as a model and completely re-think its business strategy.

Apple has done it with iPod and Bose has done it with direct sales. Marantz will not sell direct and Apple tightly controls the iPod world. The challenge now is to find something for mainstream audio, admits Marantz.

As part of the quest for something new and appealing, Marantz gave the first demonstration of a system called *Opsodis* that was developed by Southampton University to deliver surround effects from three front speakers.

Facts and Figures

The confidential trade figures came from Marantz "Brand Ambassador" Ken Ishiwata. Constrained by copyright, Ishiwata only flashed figures on screen for quick hands to note.

Figures for world TV sales, he says, show "no drastic drop in CRT sales yet", especially in the US where they remain "very significant". China is now the biggest TV market in the world, with 30.4 million TV sets sold in 2004, 31.7m expected in 2005 and 33m anticipated for 2006.

A total of 147m TV sets of all kinds sold in 2004, with 153m expected this year and 190m predicted for 2009. Flat panel displays were at 10.3m for 2004, 18m for 2005 and 28.4 expected for 2006.

Of total TV sales worldwide for 2004, 7% were flat panels in 2004, with 11.7% this year and 17.6% due next year. But in Japan the figures are 32%, 48% and 65% for the same years; while in Western Europe the figures are 11.6%, 18.9% and 26.7%, with the US at 9%, 15.8% and 24.3%.

"The industry trend is towards \$40 per inch for flat panels by the end of the decade" says Ishiwata.

The world market for DVD is still growing, with 85m players sold in 2004, 91.6m selling in 2005 and 97.1 in 2006. VHS is collapsing from 16m last year to 11.5m in 2005 and 8.2m next year, while DVD recorder sales have risen from 8.5m in 2004 to 15.2m this year. There is no breakdown from JEIDA on recorder format sales yet.

Home audio sales are slowing worldwide from 63.7m worldwide to 63m and 62.3m, of which 34.7m, 34.8m and 34.6m are mini/micro systems. Amplifier/receiver sales are stagnant at 5.3m, 5.2m and 5.2m.

Emotions to the Fore

"So what are we going to do to increase audio sales?" asks Ishiwata. "The best lesson is from what happened in the 1970s when the Japanese watch industry killed the Swiss manufacturer's business. The Swiss came back by offering sexy, attractive products that created desire. It was about emotion.

"Music is about emotion, too. You can't buy Swiss watches on the Internet either. It's time for the specialist audio manufacturers to do something like the Swiss watch industry. To make people say - 'I want that'. There has to be a different approach, which people feel something is different. Apple did it with the iPod. They took away Sony's market. I really hope we can see something similar in hi-fi.

"Bose have done a wonderful job from a business point of view. They knew exactly where they were going. They communicated and created brand awareness. They bypassed the distribution and were consistent. They are the most consistent company in audio".

Marantz will not even consider direct sales. "Our dealers are our partners" says Ken Ishiwata. "We have a contract with our European dealers. It was carefully checked with lawyers. B&O have a similar control system. If any dealer sells by mail order, or on the Internet, their contract is terminated.

"But there is nothing we can do if a mail order company buys from an authorised dealer and then sells over the Internet" admits Ishiwata. "They do that so that they can use our name in their lists. They lose money by buying from an authorised dealer and then selling on at below cost, but they make money in the long run by being able to promise all brands."

Cancelling Surrounded

Marantz is now evaluating a new technology called *Opsodis*, a commercial spin-off from Southampton University in the UK. *Opsodis* builds on the well-known crosstalk cancellation principle to create 3D surround from front speakers. Sound from the left channel is reversed in phase and added to the right channel so that it cancels out and the right ear hears only the right channel.

Marantz had given *Opsodis* the opportunity to talk to the press and demonstrate, to get feedback. The *Opsodis* team, including Chief Technical Officer Takashi Takeuchi, clearly surprised Marantz by announcing that Marantz would "launch during next year", that "many AV manufacturers will join this sound revolution", and "Marantz will lead the move".

During a hard-to-understand description of the complex theory behind the system, *Opsodis* claimed "natural sound quality anywhere in a room ... with minimal manipulation" and even quoted a price - Eu 2500 for a "lifestyle" system including a Marantz amplifier with built-in *Opsodis* processor and front speaker units.

Effective Demo - in Part

Demonstrations were given to groups of only five journalists at a time sitting in the room centre, in front of a plasma screen and three bookshelf speakers laying on their sides like small coffins. The centre speaker has two tweeters (left and right) and two mid-range units (left and right); there are two bass drivers in each of two outer cabinets. The walls of the room were damped to show that the system did not rely on wall reflections.

A demonstration recording of frogs at the front and thunder at the rear was remarkably effective, and excerpts from martial arts fantasy *House of Flying Daggers* sent fight and drum effects wafting round the room. But a recording of a car driving away gave an image which was hard to locate. My/our request to hear music through the system was refused. "We have not prepared any music" said Takeuchi.

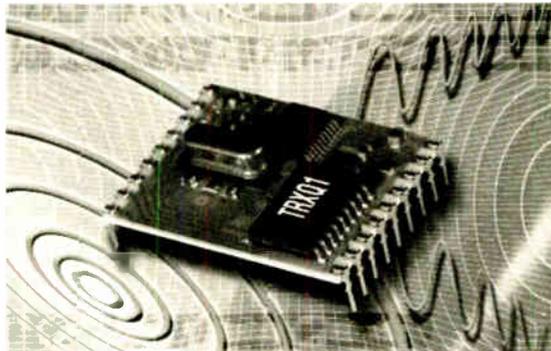
He also explained that the use of eight drivers at a spread of different horizontal positions was necessary because different frequencies should come from different directions. "I would prefer more driver units - ideally an infinite number" said Takeuchi.

Marantz staff said afterwards that they would only be interested in selling the system as a way to create pseudo surround from a lifestyle AV package, with a single small and stylish speaker unit at the front - not three large front boxes that users may well find more intrusive than small satellite speakers around the room. Terrie O'Connell, MD of Marantz Europe, stressed that - despite what *Opsodis* was saying - Marantz is not yet committed to a launch in the form demonstrated.

Smart Radio

RF Solutions have introduced a new intelligent modem FM narrow-band transceiver. TRXQ1 is their latest "Smart Radio" that greatly simplifies the implementation of reliable wireless communications. An RF transceiver-only version, the RXQ1 is also available.

The modules are able to achieve data transfer at up to 20K Baud with a range of up to 200 metres. The TRXQ1 incorporates all the functions of a complete radio modem and simply requires CMOS/TTL data at its transmitting input. A serial data interface with handshake and on-board 190-byte buffer are included. Both modules can operate at either 433-92MHz or 434-33MHz and are crystal controlled. Performance is



also enhanced by excellent interference rejection. They operate at 3V to 5V.

For more information contact RF Solutions, Dept EPE, Unit 21, Cliffe Industrial Estate, South Street, Lewes, E.Sussex BN8 6JL. Tel: 01273 898000. Fax: 01273 480661
Email: sales@rfsolutions.co.uk
Web: www.rfsolutions.co.uk

CONRAD'S COMPONENTS

We are pleased to welcome Conrad-Direct as an advertiser in *EPE*. Conrad offer a wide variety of electronics components and equipment, "from power supplies and components to circuits and accessories".

Max Conrad founded the company in Germany in 1923, aiming to provide his customers with everything they needed to listen to the radio – a newly-introduced feature at that time. Conrad's first catalogue was introduced in 1936.

Conrad-Direct are currently also in Austria, France, Eastern Europe and now the UK. They supply their products to customers in more than 150 countries world-wide.

In Conrad's first advert with us (see elsewhere in this issue), you can obtain a discount of 10% off orders valued at £30 or more. You'll also get the chance to win a Voltcraft Multimeter worth £139 in Conrad's Prize Draw!

To find out more about Conrad, browse www.conrad-direct.co.uk.

'Ear 'Ear!

Well, we really have to agree with the press release we've received from Bim Bam Banana – their Politician's Ear Piece "alarm is probably one of the most ingenious gadgets for people who nap and fall asleep when they are, for example, driving, at a meeting, watching TV/video"!

The alarm sits on your ear and works as a spirit level. When you start nodding, it starts hooting and wakes you up immediately (and presumably those alongside you too – can't be bad!)

For \$36 US, you can buy this astonishing insomnia inducer, and other "latest gadgets, fantastic innovations, funny gizmos and cool novelties" at the e-shop www.bimbabanana.com, or you can find out more by emailing sales@bimbabanana.com (mention *EPE*).

Gi's a Job!

An interesting press release has come in about *CVmailer.com*, "an innovation for finding work in electronics".

CVmailer is said to provide far more benefits at a quarter of the price charged elsewhere. The software is free to download and try, so the job seeker can evaluate the product before making a decision. Just by selecting "Electronics" and a geographical location, the user gets *CVmailer* to compose a fully amendable cover letter, personalised and sent with the CV to a named contact at an agency.

The database lists hundreds of agencies and the job seeker can choose how many they want to contact. Carefully vetted recruiters are added and categorised daily.

CVmailer is easy to use, taking an average of 10 minutes to complete the process. It works on all versions of Microsoft Outlook and Outlook Express.

For more information browse www.CVmailer.com or email enquire@cvmailer.com (mention *EPE*).

Jack Kilby Dies

Jack Kilby, a retired engineer with Texas Instruments who invented the integrated circuit, died on 20 June 2005 in Dallas. He was 81.

Jack St. Clair Kilby invented the first monolithic i.c., which was to become the foundation for modern microelectronics, resulting in the world of miniaturization and integration that we know today. He was awarded the Nobel Prize in Physics in 2000 for his role in the invention of the i.c.

TI chairman Tom Engibous said, "If there was ever a seminal invention that transformed not only our industry but our world, it was Jack's invention of the first integrated circuit."

Kilby joined TI in 1958, and invented the i.c. that year, apparently while many of his colleagues were on holiday! Kilby and

USB PIC Programmer

Microchip has announced its PICkit 2 Starter Kit. This is a PIC development and experimentation module for use with PC's having a USB connection, and operating at full-speed USB 2.0. It does not require a separate power supply.

PICkit 2 comes with a set of easy-to-understand tutorials. In addition, it can easily plug into development boards via ICSP (In Circuit Serial Programming).

For more information browse www.microchip.com/tools.

Rapid's New Products

Rapid Electronics have sent us their *Summer Edition of New Products*. In this edition you will find a wide range of product introductions from leading suppliers such as Weller, Flinder and Varta for instance. Rapid say that "your feedback has helped us to analyse your requirements, removing the products you don't want and introducing the ones you do."

Rapid's product portfolio now extends to well over 32,000 tried and tested lines, which are constantly reviewed, refocused and extended.

For more information contact Rapid Electronics Ltd, Severalls Lane, Colchester, Essex CO4 5JS. Tel: 01206 751166. Fax: 01206 751188. Email: sales@rapidelec.co.uk.

Web: www.rapidelectronics.co.uk.

MERG

The Model Electronic Railway Group (MERG) have written to thank us for our last mention of them, and to send their latest newsletter. We feel it's good to mention MERG again now because of John Waller's *Controlling Model Railway Signals* article in this issue. John actually joined MERG following our telling him about the group.

So if you're into model railways, anywhere in the world, why not find out more about MERG, browsing www.merg.org.uk.

TI officials put the first circuit to the test on 12 September 1958, with success. In 1960, TI announced the first chips for customer evaluation. Two years later, TI won its first major i.c. contract to design and build a family of 22 special circuits for the *Minuteman* missile.

Kilby officially retired from TI in 1983, but he continued to do consulting work with the company. He held more than 60 patents for a variety of electronics inventions. Among them were the handheld electronic calculator and the thermal printer, both of which he co-invented. In addition to the Nobel Prize, he received numerous honours and awards for his contributions to science, technology and the electronics industry.

At the time of writing, a report can be read at www.reed-electronics.com/electronic_news/article/CA609808?nid=2019

Multicore Cable Tester

David Geary

Solving one of life's mysteries – how to conveniently check lengthy multicore cables

THE number of fairly complex multicore cables in the home and the workshop is steadily increasing. The workshop PC brings with it a printer, keyboard, mouse and monitor, possibly a network connection and probably a modem line. All of these items require a dedicated connector and a multicore cable to connect it all together.

Buying commercially-made leads can be expensive, and even then, you may not be able to get exactly what you require and have to manufacture your own; with the attendant doubt that all is wired, and wired correctly! Testing these leads can be confusing, especially if there are several to make up of the same type.

Commercially manufactured leads are just as prone to damage, kinking, and connector failure as those we make ourselves, and if you count up the number of leads that surround us in the home and at work, the result can be quite surprising.

Design Motive

The idea for this Multicore Cable Tester arose from the author's apparent new responsibility for an Ethernet network at his place of work. On changing a network hub, one leg of the network stopped working. All other cables plugged to the new hub worked fine, except for one.

As to be expected, the cable in question ran across a false ceiling, down a riser cupboard, under a raised access floor and into a presentation lecturn; therefore changing it to see if that solved the problem was not to be lightly considered! The cable was 15 metres long and checking with a multimeter was simply not an easy option.

This tester allows easy identification and testing of multicore cables in a variety of situations so long as at least two cores are connected. It offers quicker testing than traditional continuity methods, using I.e.d. indication and sound to check continuity and correct connections in cables. There is

also a "quick check" for crossover wired cables.

The unit is designed to test cables having up to eight cores, with cables having more than eight conductors being split into groups of tests. However, eight cores is sufficient for most, including:

- 1 Ethernet cables
- 1 Audio cables
- 1 SCART leads
- 1 Keyboard and mouse extension leads
- 1 Computer monitor cables
- 1 Modem/serial leads
- 1 USB cables, etc.

The unit will:

- 1 Identify a cable
- 1 Check continuity of all cores
- 1 Identify a "crossover" type cable

All that is required is the right connector for the cable under test.

Cable Types

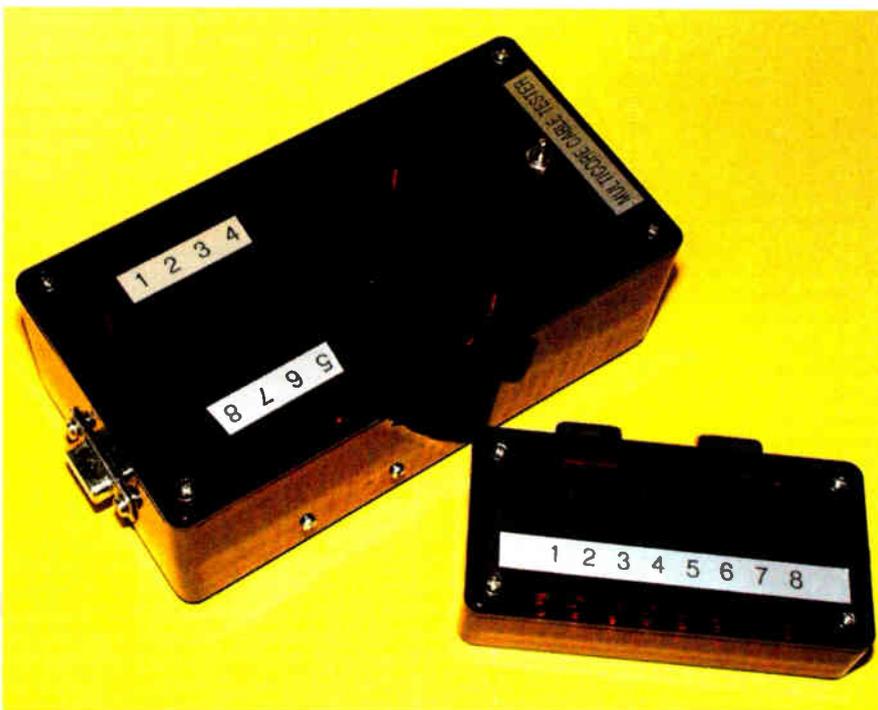
The tester uses relatively low switching rates and employs a software delay to allow settling time from a sharp squarewave test signal and the consequent capacitive delay. There is therefore considerable flexibility in the uses of the device, limited only by the connectors installed by the user.

As an alternative, it is probably easiest and quickest to build the tester and passive/active sockets using 9-pin D-connectors and then make suitable adaptors for each use. Some suggestions are discussed later but there is really no limit to the adaptors that could be made.

Design Overview

Referring to the main Multicore Cable Tester circuit diagram in Fig.1, this design uses a PIC16F84 microcontroller (IC1) for the testing operations and a 74HC164 shift register (IC2) to output the I.e.d. display.

The cable leads to be tested are connected to the PIC's Port B via connector SK1.



The completed Master tester and the small Active/Passive socket that combine to make up the Multicore Cable Tester

COMPONENTS

Resistors

- R1, R3 10k (2 off)
- R2, R4, R13 to R21 1k5 (11 off)
- R5 to R12 10k 8-way commoned s.i.l.

All 0.25W 5% carbon film unless marked

Capacitors

- C1 10n ceramic disc, 5mm pitch
- C2, C3 15p ceramic disc, 5mm pitch (2 off)
- C4 100µF radial elect. 10V

See **SHOP TALK** page

Semiconductors

- D1, D11, D20 to D27 1N4148 signal diode (10 off)
- D2 to D10, D12 to D19 r.e.d. l.e.d., 5mm (17 off)
- TR1 2N3053 *n*pn medium power transistor
- TR2 BC171A *n*pn transistor
- IC1 PIC16F84 micro-controller, preprogrammed (see text)
- IC2 74HC164 shift register
- IC3 78L05 +5V 100mA voltage regulator

Miscellaneous

- S1 min. s.p.s.t. toggle switch
- SK1 9-pin D-type connector, female
- SK2, SK3 9-pin D-type connector, male (2 off)
- WD1 buzzer or sounder, 6V
- B1 9V PP3 type battery with mounting clip
- X1 3.2768MHz crystal

Printed circuit boards, available from the *EPE PCB Service*, codes 525 (Main), 526 (Active); 18-pin d.i.l. socket; 14-pin d.i.l. socket; plastic case, red tinted translucent 150mm x 80mm x 50mm; plastic case, red tinted translucent 100mm x 49mm x 23mm; connecting wire; solder, etc.

Approx. Cost
Guidance Only

£30

excl cases & battery

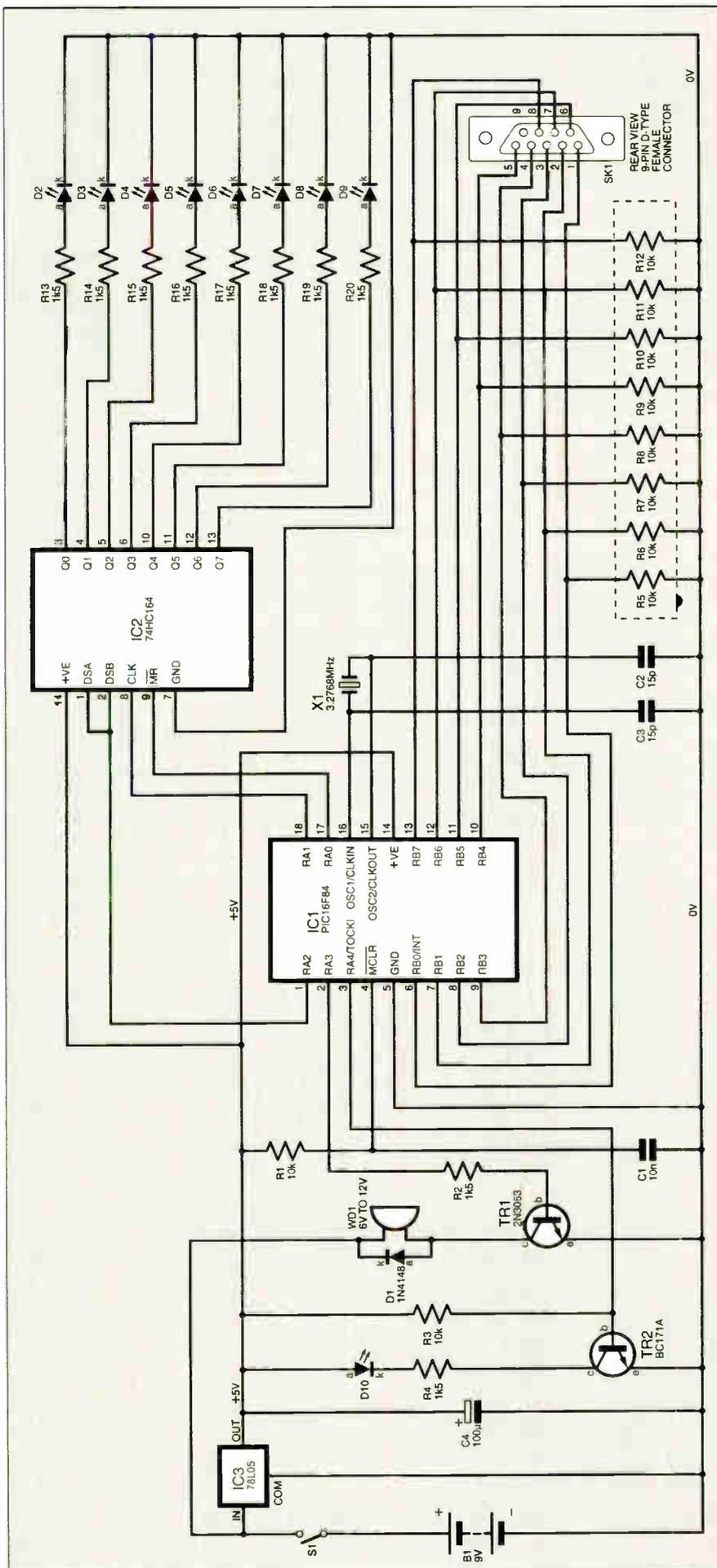


Fig. 1. Master circuit diagram for the Multicore Cable Tester

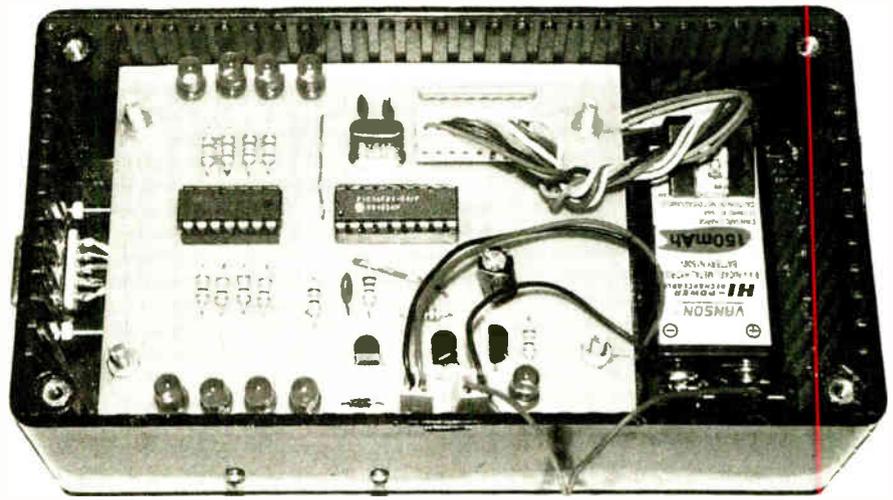
The PIC takes each of the eight cores "high" in turn, in each case configuring the other seven pins on Port B as inputs. A delay is built in to prevent cable capacitance giving erroneous readings. Port B is biased normally-low by resistors R5 to R10, within a s.i.l. (single-in-line) package.

The results of the eight tests are ORed together and the tests re-run to ensure that the results are complete – it is always possible, indeed likely, that a cable could be plugged in halfway through a sequence.

When any combination of connected cores is found, the results are serially fed to the shift register (IC2) by Port A and displayed on eight l.e.d.s, D2 to D9, corresponding to each cable core. A "beep" subroutine then sounds the buzzer WD1 briefly for each digit, extended to a double beep for each logic 1 within the results.

The buzzer uses considerably more current than the PIC could safely drive and therefore transistor TR1 is used in conjunction with back-e.m.f. diode D1, and controlled by PIC pin RA3. The buzzer is a low cost model and the type is not critical. Using TR1 also allows the buzzer to be fed "pre-regulator", from the 9V line.

Finally, a Crossover test routine takes four pins of Port B high and tests the other half. A "go/no go" test here indicates the polarity of the cable and the Port A l.e.d.



General component layout inside the Master unit

D10 is activated accordingly via transistor TR2, which is controlled by PIC pin RA4. Resistor R3 pulls this "open-collector" pin normally high.

The unit is powered by a 9V battery, B1, with regulator IC3 reducing the voltage to 5V to suit IC1 and IC2. The battery type is not critical (the prototype uses a rechargeable PP3-type).

The PIC is crystal controlled (X1). The crystal frequency should not be critical although others have not been tried.

Resistor R1 and capacitor C1 provide power on reset.

Shift register IC2 is specified as an HC type, which has excellent current drive capabilities. Ordinary 5mm red l.e.d.s are used with simple current limiting resistors R13 to R20.

Passive Socket

Both ends of the cable under test must, of course, be connected in some way. The simplest technique is to use a passive "shorting" connector at the far end, such as shown in Fig.2a.

The wiring for the passive socket, though, depends on your final use. If using 9-pin D-type connectors follow Fig.2a. For Ethernet cable testing, however, wire SK2 so that pins 5, 6, 7 and 8 are connected as one group, with pins 1, 2, 3, 4 connected as the other, then connect diode D11 between pin 6 and 3, anode to pin 6.

The principle is to isolate pins into two halves which are reversed with a cross-wired cable, and place the diode between the two halves. Reversing the diode reverses the action of the crosswire i.e.d., D10.

Additional passive sockets can be easily made up using the same principles for other applications.

Active Socket

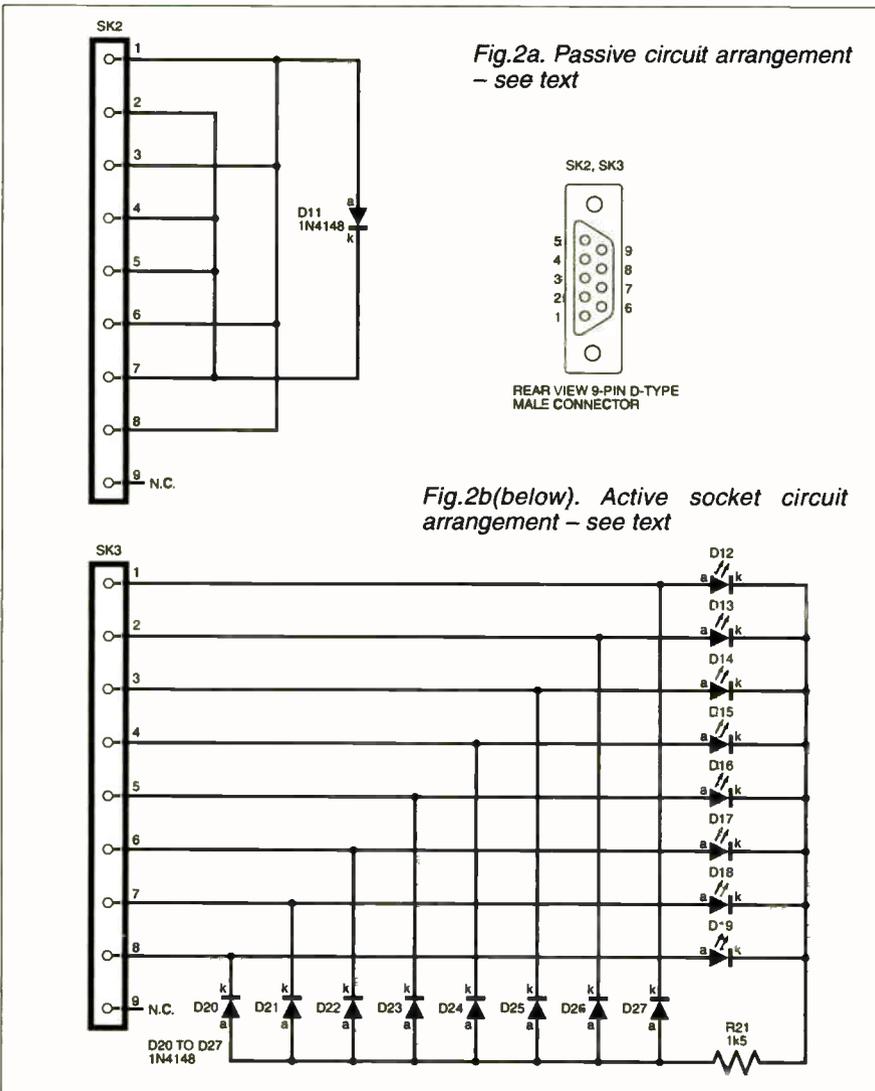
An alternative for the "far end" is to use an "active socket" technique, as shown in Fig.2b. Here additional l.e.d.s (D12 to D19) indicate the status of each core connection, so checking not just that up to eight cores are connected, but also that they are all connected correctly.

Resistor R21 buffers the l.e.d.s, and diode D20 to D27 matrix the circuit to suit the software control.

This unit mirrors the lamp test function so by turning the main tester off and then on again, the sequence of l.e.d.s on both the tester and the active socket should light in order. This clearly identifies incorrect or correct connections, and confirms cross-connected cables.

Construction

Details of the printed circuit board component and track layouts for the Master and Active units are shown in Fig.3 and Fig.4. These boards are available from the EPE PCB Service, codes 525 and 526.



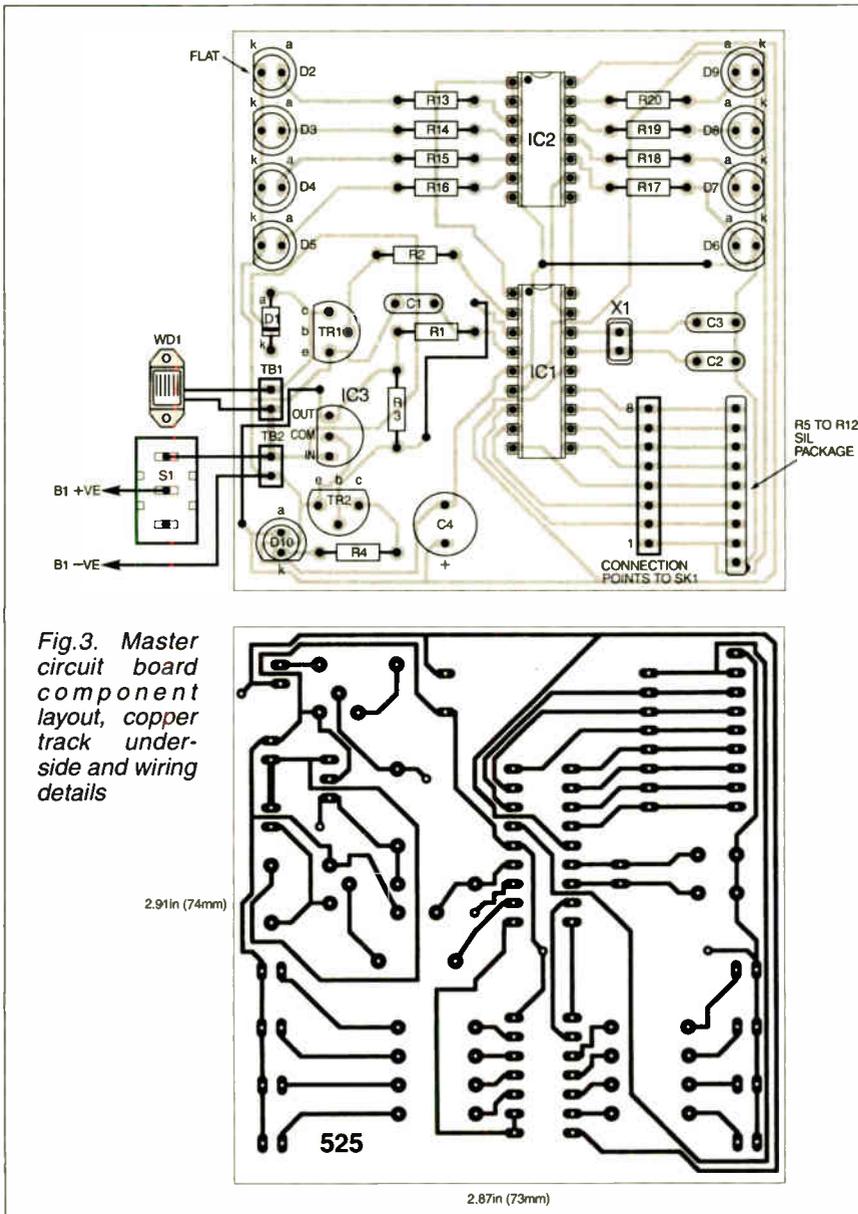


Fig.3. Master circuit board component layout, copper track underside and wiring details

Whilst the circuits are simple, with a project of this nature care is needed with off-board wiring to get correct results from the finished tester. Fit i.c. sockets and connectors first, followed by resistors, then capacitors, then semiconductors. The use of p.c.b. connectors is strongly recommended, although the off-board leads can be hard-wired.

The prototype used small red translucent cases, which allow the l.e.d.s to shine through the case, eliminating the need to drill holes. Take care to make sure that both p.c.b.s are correctly wired to the connectors.

On the cases the l.e.d. positions should be numbered 1 to 8, to correspond with the 9-pin D-type connector pin numbers.

Once the board has been assembled, carefully drill holes for the buzzer, cable connector(s) and switch and wire these to the p.c.b. connectors. Final assembly then becomes a simple case of plugging everything together.

In 9-pin serial leads, pin 9 is not normally used, so the wiring becomes simply pin 1 to pin 1, etc, as marked on the rear of the D-type connectors. Given the possible repeat interwiring of sockets it is useful to adopt a standard colour wiring code throughout the project.

Care is required to ensure that the correct pins from the PIC are connected to the correct pins on the socket, and therefore the cable.

Testing

Without connecting a cable, and after a physical inspection that all is well, switch on. The unit now goes through a self-test routine to check that all l.e.d.s and the internal buzzer are working. The lamp and buzzer test should operate – a moving l.e.d. display and eight beeps. The crossover l.e.d. D10 will light as a power-on indicator. This self-test is later used for checking correct connections in the cable under test.

Prototype Active/Passive socket unit

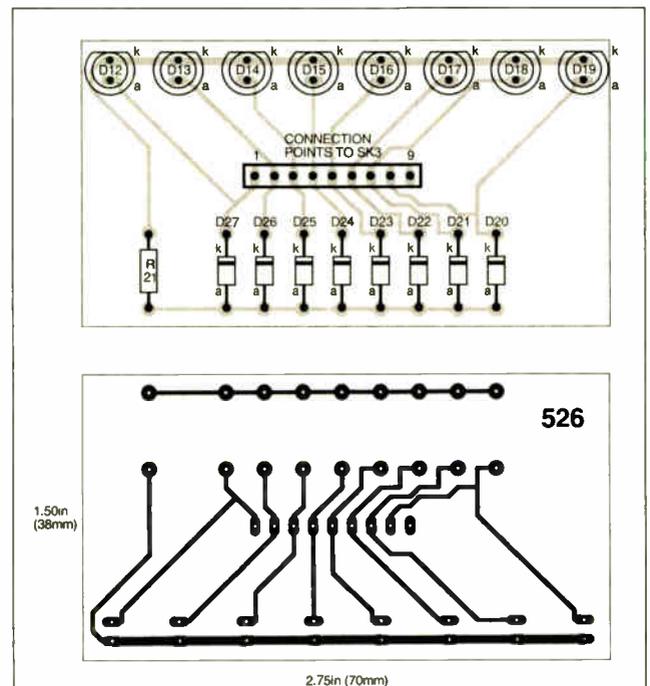
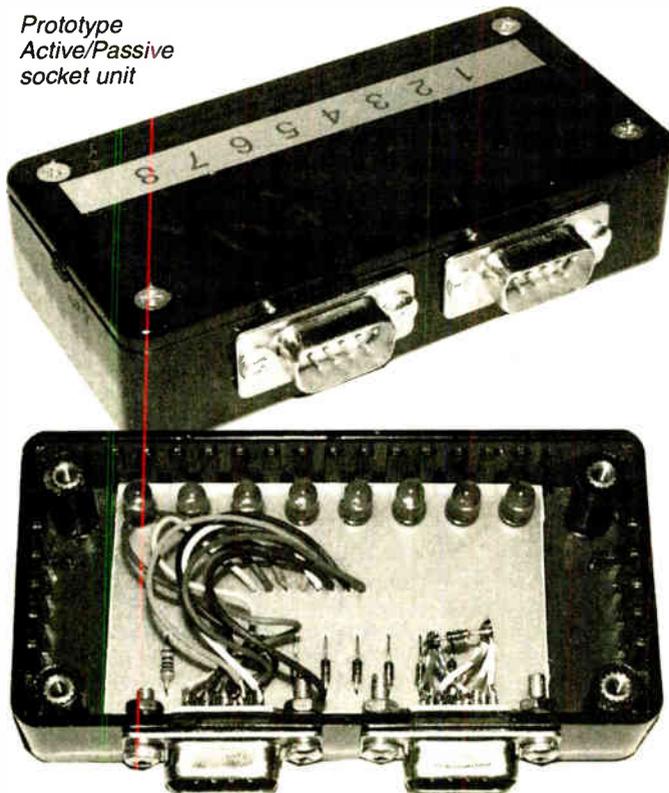


fig.4. Active "socket" printed circuit board details

Plug a straight-through lead into the master unit's socket SK1. Nothing should happen – yet! Plug the other end of the lead into the passive socket, SK2, of the “far end” unit. You should immediately hear a series of eight beeps, a short one for each unconnected core and a long beep for each connected core. An l.e.d. should be lit for each connected core.

Switch off and on again with the cable plugged in for the most accurate and reliable display without plug-to-socket contact bounce.

In Use

In use, one end of the cable is plugged into the master unit, and the other end into the slave (passive) socket. As soon as the cable is connected, the buzzer will sound eight beeps, longer beeps for each connected core. The 8-wide l.e.d. display will turn on a corresponding l.e.d. for each core. The l.e.d. display indicates which cores are connected and which are not in one operation, however, to eliminate the effects of plug-in contact bounce, switch the unit off and then on to retest the cable.

An audible indication is ideal for identifying “which is which” when wiring Ethernet cables or other situations where there are a number of similar cables – plug the end of the cable you are trying to find into the master unit, and (we’ve all been there!), crawl under the desk with the passive socket trying each in turn. When you hear the buzzer, you’ve found it; this is certainly better than the “sharp tug and see if it moves” method!

If the cable is a “crossover” type, a ninth l.e.d. on the main unit (D10) will light after the eight beeps are finished.

Once a cable is detected, unplugging the cable at either end resets the tester to detect another cable so there is no need to switch the tester on and off between operations (other than for contact bounce elimination). The l.e.d. display always shows the last results.

Checking Correct Connections

If the “active” slave socket (SK3) is used, the power on self-test can check the correct connections. The active socket has eight l.e.d.s which can be numbered exactly as for the master unit. On power on, each l.e.d. on the master unit lights and a short beep is heard. Therefore, if a note is made of which l.e.d. lights on the active socket in order, it is simple to establish the connection sequence. For example, testing a modem lead was carried out as follows.

Firstly, the passive socket was connected to one end and the other plugged into the main unit. Switching the tester on, the power up sequence completed in a few seconds, followed by seven of the eight l.e.d.s being lit, with one short beep and seven long beeps. This indicated, correctly, that pin 1 was unused and that the subsequent seven were connected. At the end of the eight beeps, the crossover l.e.d. lit, indicating that this lead was a crossover type.

Secondly, the passive socket was swapped for the active socket. Taking a piece of paper, and numbering from one to eight from top to bottom, the tester was switched off and then on again. Writing down which l.e.d. lit after each beep during the startup sequence gave the following results:

Main	Active
1	None
2	3
3	2
4	6
5	5
6	4
7	8
8	7

Table 1

Pin	Crossover Highlight	A - First Time	A - Rearranged	B - First Time	C - First Time
1		1	2		
2		2	1		
3		3	3		
4		4	4		
5		5	6		
6		6	5		
7		7		1	
8		8		2	
9				3	
10				4	
11				5	
12				6	
13				7	
14				8	
15					1
16					2
17					3
18					4
19			8		
20			7		
21					5

Table 2

Core	A Results - LED Display	Active Socket		Core	Active Socket
1	On (fully wired)	2	rearranging	2	1
2	On (fully wired)	1		1	2
3	On (fully wired)	6		6	3
4	On (fully wired)	4		4	4
5	On (fully wired)	5		5	5
6	On (fully wired)	3		3	6
7	On (fully wired)	8		8	7
8	On (fully wired)	7		7	8
	from Scart diagram	xover lead			xover lead

On self test, LED's on the active socket should light in the order 2,1,6,4,5,3,8,7

Table 3

Core	B Results - LED Display	Active Socket		Core	Active Socket
1	On (fully wired)	1	no rearrange necessary	1	1
2	On (fully wired)	2		2	2
3	On (fully wired)	3		3	3
4	On (fully wired)	4		4	4
5	On (fully wired)	5		5	5
6	On (fully wired)	6		6	6
7	On (fully wired)	7		7	7
8	On (fully wired)	8		8	8
	from Scart diagram	xover lead			xover lead

On self test, LED's on the active socket should light in the order 1,2,3,4,5,6,7,8

Table 4

Core	C Results - LED Display	Active Socket		Core	Active Socket
1	On (fully wired)	1	no rearrange necessary	1	1
2	On (fully wired)	2		2	2
3	On (fully wired)	3		3	3
4	On (fully wired)	4		4	4
5	On (fully wired)	5		5	5
6	On (fully wired)	N/C		N/C	N/C
7	On (fully wired)	N/C		N/C	N/C
8	On (fully wired)	N/C		N/C	N/C
	from Scart diagram	xover lead			xover lead

From this, pin pairs 2/3, 4/6 and 7/8 are swapped but pin 5 remains pin 5 at each end.

Making Up Adaptors

The following information might be useful for those wishing to use the unit for other common cables.

In order to preserve the crossover function it is useful to adopt a procedure for

working out pin connections. There are two groups of pins on D-type connectors:

Group A: 1, 3, 6, 8

Group B: 2, 4, 5, 7

In designing an adaptor for a cable that has a crossover variant, assign either A or B to each group of pins that may get crossed, then substitute the pin numbers above. If there is no crossover variant, or for the pins that are never crossed, the assignment is irrelevant.

The principle is that for crossover detection to work, you must ensure that all pairs of pins that may be crossed have one pin "either side" of the detection diode (D11 in Fig.2a). The following instructions are intended to help design an adaptor for any type of lead, and make interpretation of the results easier.

Referring to Table 1:

1. List down the left hand side of the page the pin numbers in the connector of the cable to be tested

2. Check which pairs would be reversed in a crossover lead, highlighting each pair perhaps in a different colour highlighting pen

3. Using digits in the range 1 to 8, list in the next column the connections you will make to the Multicore Cable Tester

4. Swap the second column around so that for each pair that might be reversed in the lead, one is connected either side of the detection diode, i.e. one core from each group above (A or B) in each pair

When you run the test, you will get different active i.e.d.s on the Main unit and the Active socket if the cable is crosswired. If you "read back" the i.e.d. number on either display from your second column to the first column, you will be able to see which pins are connected in the end of the cable nearest the display you are reading.

SCART

Tables 1 to 5 show how to make a SCART lead tester. Many cheap leads only make the essential connections, which are all within "Adaptor A".

There are 21 pins for a SCART cable, so to fully test it requires three 9-pin D-type connectors – effectively three adaptors in one. Remember you therefore need two SCART connectors and six 9-pin D-type connectors in total (one for the main unit, same again at the slave end). In the tables the three adaptors are labelled A, B, and C.

Tables 2 to 4 calculate the results of power on self-test, and come from examination of a SCART wiring diagram (see web links later).

The crossover version is the one most used. The pins on the SCART connector are already marked, so a suggested wiring table would be that in Table 5.

Crossover indication only works with adaptor A. The active socket will run in sequence, i.e. its i.e.d.s 1 to 8 (D12 to D19) with the main unit's i.e.d.s (D2 to D9) for adaptors B and C, confirming the crossover in the case of adaptor A.

Audio Leads

Testing audio leads is simply a case of assigning pins, as the only crossover (or mirror-image) tends to be with DIN leads.

Table 5
9 pin D connector wiring in each case

SCART	A	B	C
1	2		
2	1		
3	3		
4	4		
5	6		
6	5		
7		1	
8		2	
9		3	
10		4	
11		5	
12		6	
13		7	
14		8	
15			1
16			2
17			3
18			4
19	8		
20	7		
21			5

In the case of a 5-pin DIN connector, use Table 6

Keyboard and Mouse Leads

There are no crossover variants with keyboard and mouse leads, which are typically 6-pin mini DIN. Therefore pin assignments can be simply those in Table 7.

VGA Monitor Leads

There are no crossover variants for VGA monitor leads, which are 15-pin, as shown in Table 8.

USB Leads

Again, there are no crossover variants of USB leads, which are as given in Table 9.

Expansion

For one copy of the prototype, the unit's use was expanded to network cables by installing an RJ45 socket connector in parallel with the 9-pin D-type connector. This enabled the testing of Ethernet cables without a made up adaptor, and still allowed adaptors to be easily and quickly made up to suit other applications. There is no technical reason not to add additional sockets of varying types to the unit, other than the need to keep wiring tidy.

It is remarkably difficult to obtain panel mounting RJ45 sockets, so the prototype used a component which mounts in a conventional-size accessory plate. The RJ45 standard has eight cores, and while getting access to these is easy (thanks to IDC connections on the socket), the layout of these is far from obvious.

The rear connections of the socket used in the prototype relative to the pin connections of the cable, and viewing the socket from behind, the top line order is 7, 8, 5 and 4. For the lower line the order is 6, 3, 2 and 1. The shutter pulls down to this end from above, i.e. the label is below the socket.

Note that RJ45 patch leads for 10mb/s and 100mb/s only need four of the eight cores, but those for 1000mb/s need all eight. Therefore four connected cores may be sufficient – cores 1, 2, 3 and 6.

Conclusion

The tester has become part of the author's armoury, particularly for moving

Table 6

DIN	9 pin D
1	1
2	2
3	3
4	6
5	4

Table 7

6 pin DIN	9 pin D
1	1
2	2
3	3
4	4
5	5
6	6

Table 8

VGA	9 pin D
1	1
2	2
3	3
4	–
5	4
6	5
7	6
8	6 (generally commoned in equipment with pins 6,7)
9	–
10	4 (generally commoned with pin 5)
11	–
12	–
13	7
14	8
15	–

Table 9

USB	9 pin D
1	1
2	2
3	3
4	4
Shield	5

PCs around the work environment, identifying network patch leads from each other and making sure cross-wired cables are easily identified. It is a quick and easy tool to use and can even be used as a "core number" identifier for telephone cables, etc, using just a crocodile clip connection. The possibilities are endless!

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 Cabletest. Download all the files within that folder.

Some useful websites for those making up their own adaptors:

www.netspec.com/helpdesk/wiredoc.html

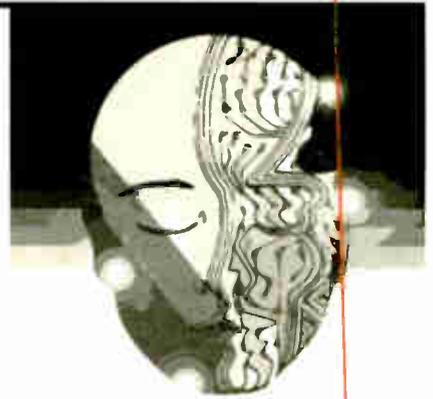
www.ertyu.org/~steven_nikkel/ethernet_cables.html

www.physiol.ox.ac.uk/~trp/pinouts.html

www.leadsdirect.f9.co.uk/scart.htm

http://homepage.ntlworld.com/another_world/scart.htm

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Low-Cost RS232 Interface – *On The Face Of It*

SERIAL PC interfaces are appearing on more and more constructional projects these days, and most will use the ubiquitous MAX232 or similar i.c. to convert between the RS232 and microcontroller voltage levels.

The RS232 requires a voltage of at least +3V for a logic '0' and -3V for a logic '1'. Measuring the output of several PC's, including older desktops and modern laptops shows that the actual output varies enormously, from +/- 5V to +/- 12V.

A microcontroller circuit has no problem generating +3V to +5V since this is often the supply voltage; negative voltages are however not normally available. The simple circuit diagram shown in Fig.1 can be used to "highjack" the required negative supply voltage from the PC's interface, and provide the signal buffer and inversion required.

The circuit relies on the fact that the TX output signal from a PC spends most of its time at the negative voltage level. Although this circuit is not smaller than an equivalent MAX232 the placement of components is not critical so it may be easy to place and route on a p.c.b.

Diode D1 and capacitor C1 implement the negative voltage reference for the circuit, driven by the negative cycles of the TX pin. This allows transistor TR2 to swing between +5V and whatever negative voltage the PC is using.

The logic signals from the microcontroller must be inverted to match RS232 signal polarities, and this is implemented by transistors TR1 and TR2. Diode D2 stops TR1 becoming reversed biased by the TX signal. As TR1 will be saturated when turned on, resistor R4 helps to turn it off quickly on a negative cycle.

Terminal block TB1 connects to the PC's serial port, and TB2 connects to the microcontroller circuit. It can, of course, be intergrated directly onto the project circuit board.

The circuit has been found to work successfully at data rates up to 115200 with a 1.5M cable.

None of the components are critical. Any small signal npn/pnp transistors should do, and the diodes could be replaced with 1N4148s or similar.

The reservoir capacitor C1 could be larger, so long as a working voltage of 35V or greater is used.

*Mike Hibbett,
Chatham, Kent*

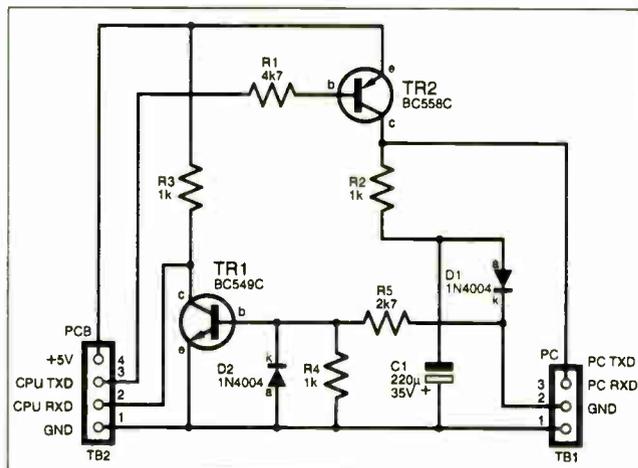


Fig. 1. Circuit diagram for the Low-Cost RS232 Interface

TV Audio Coupler – *Sound Sense*

HAVING recently purchased a new TV with an inbuilt cinema sound decoder, I was disappointed to find that it was configured to only provide the full "Dolby" effect when used with its own extension speakers. I needed a way to use the provided extension speakers at the rear, but derive an audio signal controlled by the TV remote for the front to use my existing Hi-Fi amplifier and speakers. The alternative was yet more speakers (my wife was not impressed) in our room.

The circuit diagram Fig.2 provides a dummy load (R1/R2 and R3/R4) of 9.4 ohms to 20W maximum dissipation. The miniature, specified transformer has a d.c. primary resistance of 660 ohms, which being high compared with the series resistance of R1/R2, R3/R4, will mean that the worst case power dissipation in the transformer primary will be minimal. In practice, the added inductance at audio frequencies will reduce dissipation still further.

The use of a transformer eliminates any possibility of "ground loops" or falling foul of "bridge output" configurations in commercial equipment, where accidentally grounding either side of a loudspeaker output could cause internal damage. The transformer is, of course, an inductive load but so are the loudspeakers that are intended to be used!

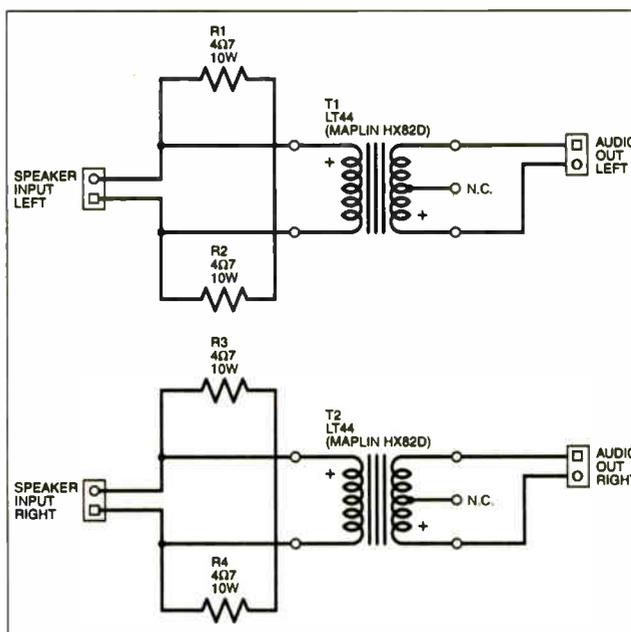


Fig.2. TV Audio Coupler circuit diagram

In practice the centre tap of the secondary was not required, but would provide a 50% attenuation if necessary. This very simple solution appears to work extremely well, fooling the TV electronics into

thinking speakers are connected, and does not require a power supply!

*David Geary,
Blackheath, London.*

PIC-Based Noise Generation – *Logically Inverted Silence*

IN the good old heyday of electronic music and disco sirens, electronics enthusiasts would experiment with different circuits to produce strange hissing sounds, or "white" and "pink" noise, as it became known. Applications included music keyboards, drum machines and even "realistic steam noise" for model railways.

One trick for making "digital noise" involved networks of shift registers and exclusive-OR (XOR) gates. Nowadays, you can do the job much more quickly using a PIC and applications for this technique can be found in many designs, including test equipment, electronic games, encryption and, yes – model railways!

By way of example, here is an 11-line (device independent) PIC routine which produces an 18,23 PRBS (pseudo random binary sequence) of "maximal length". In other words, it simulates a 23-bit shift

register with XOR feedback from outputs Q18 and Q23. For this particular set-up, the pattern of ones and zeros takes over eight million bits before it repeats itself; that's the maximum possible for a 23-bit register. Amazingly, the PIC code does this without using any XOR commands:

The code requires four registers. The output can be taken from any pin of PORTB (which contains bits Q1 to Q8 of the virtual shift register). The other three (user defined) registers are REGB (Q9 to Q16), REGC (Q17 to Q23) and TEMP which is used to perform tests on Q18 and Q23. The carry flag (STATUS,C) is used to link together the individual 8-bit registers which form the long shift register during the RLF (rotate left) operations.

The program loop repeats every 12 program cycles (the GOTO needs two cycles). However, before running the loop you must "seed" the contents of the virtual 23-bit shift register with a non-zero condition.

The code below, when placed in the initialisation routine, puts alternate ones and zeros into the shift register, but you can use any other non-zero seed. You could even use the contents of the PIC's EEPROM to provide a seed value which was stored during a previous use of the program.

```
MOVLW B'01010101' ; non zero seed
MOVWF PORTB
MOVWF REGB
MOVWF REGC
```

You must also set PORTB to output mode by clearing TRISB after using the appropriate bank switches for your type of PIC. (Remember to restore to Bank 0 afterwards.)

Incidentally, if you were wondering why all 24 bits are not used, it's because the maths would require the sampling of four bits from the shift register (instead of two) and this would slow down the routine.

The choice of PIC oscillator frequency will depend upon the application. A 4MHz crystal will produce a "random" output rate of 83k Baud which, when passed through a suitable low-pass filter, gives an audio noise bandwidth of around 4kHz.

If you want to use this code to test your hi-fi you will need to run your PIC at 20MHz. Perhaps you just need a random number generator for a bingo machine or to pick your Lotto numbers. The applications are endless.

*Pete Barrett, High Mickley,
Northumberland*

LOOP	MOVWF REGC,W	;	copy Q17 thru Q23
	MOVWF TEMP	;	into temp register
	BTFSC REGC,6	;	test Q23
	COMF TEMP,F	;	invert TEMP if Q23 = 1
	BCF STATUS,C	;	clear carry flag
	BTFSC TEMP,1	;	test Q18
	BSF STATUS,C	;	set carry if Q18 XOR Q23 = 1
	RLF PORTB,F	;	ripple up
	RLF REGB,F	;	all bits thru
	RLF REGC,F	;	shift reg
	GOTO LOOP		

WHIRLYBLADES

Wind turbines – what’s your opinion of wind harvesting? Mark Nelson describes both the problems and their ingenious solutions.

FEW technologies arouse more passion among normally docile people than wind turbines. The arguments for and against harvesting electricity from the wind are fairly well known but the unforeseen problems the turbines cause demand equal attention.

Wind farms and their turbines are a remarkably emotive subject. The tower clusters seen atop the mountains of Mid Wales for instance are objects of supreme grace and elegance in my view and the fact that they generate electricity for nothing is a fantastic bonus – the classic “win, win” situation.

But that’s only my opinion. A recent report by the Sustainable Development Commission (SDC) notes that although there is widespread support for wind farms from an ecological point of view, there is much local resistance. People argue the noise they make is unbearable, that they spoil the landscape and they may also kill birds.

Simon Clydesdale of Greenpeace is quoted as saying, “People do support wind energy when a survey is put in front of their nose but it’s a question of putting that into practice. We don’t give blanket support for all wind farms, they have to be sensibly sited.”

Nimby Alert

Not in my back yard then. He does, however, agree that wind power is “green”, stating: “Wind power is essential to meet the government’s carbon emission targets and will be one of the cheapest forms of energy out there.”

Renewable energy sources are vital to meeting the government’s Kyoto target of a 12.5 per cent reduction in greenhouse gas emissions from 1990 levels, averaged over 2008 to 2012, meaning the UK must look for cleaner sources of energy. Wind farms could take this figure to 20 per cent by the year 2020.

The towers occupy very little ground space and when situated away from human occupation, any noise issues are irrelevant. The sole issues after that are the capital cost of erecting the towers and dealing with any arguments from the NIMBY brigade over visual intrusion.

There’s no argument that wind farms will indeed alter the British landscape, but so did electricity transmission pylons and motorways – and the economic benefit of these is generally seen to outweigh the visual intrusion. In any case the change to the appearance of the British

countryside is likely to be far less than the dramatic effect of climate change with the shrinking coastline caused by rising sea levels and altered vegetation.

SDC chairman, Jonathon Porritt argues that climate change will have a devastating impact unless urgent action is taken to boost the contribution of renewables, alongside energy efficiency measures. So the issue is merely a matter of public education, right? Well, no. Wind farms pose a serious threat to bird migration and to aircraft radar systems, or at least they did. It’s a serious problem.

Turbulent Times for Turbines

Urgent research is needed into the locations, numbers and movements of birds around our coasts to help us understand the potential impacts, according to the Royal Society for the Protection of Birds. Dr Mark Avery, RSPB Director of Conservation, says the government must do more to avoid major conflicts over the siting of wind farms. And although the RSPB sees climate change as the greatest threat to the world’s wildlife, it does object to any wind farms that seriously threaten important populations of birds and their habitats, calling for some form of legal protection.

Bigger birds have even bigger problems. As *The Business* newspaper reported recently, significant interference is caused to the radar systems that control air traffic by the rotation of the wind turbines’ blades. The radar returns or echoes tend to mimic a light aircraft. To confuse the radar further, says the report, the tip speed (although not that of the whole blade) is just below the speed of sound, much the same as an aircraft.

You might imagine that an object as static as a wind farm would not look anything like an aircraft in flight but apparently it can do. In the same way, several television repeater transmitters built by radio amateurs in the UK have had their licensing held up by the authorities, again because the picture transmissions can fool the very sensitive radar receivers.

The echoes returned by wind turbines appear as transient multiple objects that show up and vanish again. Vast flocks of migrating starlings cause the same effect from time to time and the unpredictable nature of these signals could trigger retaliatory action or the closure of an airport.

Fuzzy Fix

Serious problems call for serious solutions and BAe Systems (the combination of British Aerospace and Marconi Defence Systems) has come up with a solution employing fuzzy logic to minimise or even eliminate the radar interference caused by wind turbines. Fuzzy logic’s approach to problems replicates the way most people come to firm decisions based more on gut feeling than pure logic by balancing out vague, ambiguous or missing input information to still reach a firm conclusion.

In this application fuzzy logic is used to find and analyse data normally hidden in a radar signal to build up a clearer profile of the object that generated the echo. Identified characteristics are then evaluated to calculate its probability of being a wind turbine. If the balance of probabilities is positive, the on-screen image is filtered to remove the object altogether.

Although the current application is for civil airport radars, the technology was first developed for military use, to distinguish aircraft from large waves and flocks of birds. At the time of writing, in-depth tests were scheduled for the end of July, to be held in Wales.

A number of RAF helicopters and Cessna light aircraft would be monitored on a Watchman radar operated by the RAF, noting these signals as well as interference from a number of wind farms in the vicinity. If the filtering software is successful only the aircraft should be visible on the radar screens, with commercial deployment likely some six to 12 months later.

Fears Unfounded

But what fate lies in store for our feathered friends? According to research published in the scientific journal *Biology Letters*, birds are not as stupid as we take them to be. Experts at the Danish National Environmental Research Institute have used radar to monitor bird migration patterns over the Nysted offshore wind farm on the western side of the Baltic Sea.

The verdict is that geese and ducks learn to avoid the blades, with less than one per cent of the birds found to be at risk of collision. Even at night the clever creatures kept their distance from the turbines and flew in the corridors between the structures. Finally this may be the green light for wind farms. I for one will be delighted if it is.

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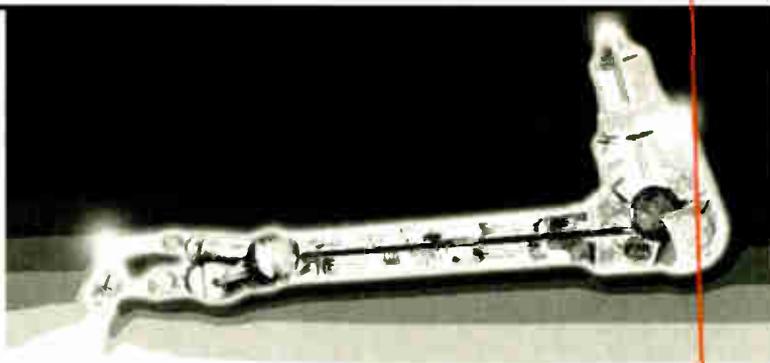
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Circuit Surgery



Alan Winstanley and Ian Bell

Our "surgeons" discuss low frequency amplification, looking at op.amp parameters, and offer a simple low-battery monitor

Low Frequency Amplification

While scanning the *EPE Chat Zone* forum (www.chatzones.co.uk) recently the post "Amplifying <10Hz" from fellow contributor *Thomas Scarborough* caught our eye: "I've done a lot of circuits amplifying audio and radio, but am not as familiar with amplifying very low frequencies. I'm wanting to amplify signals in the region of 0.1Hz to 10Hz. Can you point me to anything to look at, so that I can familiarise myself better?"

Accurately amplifying low frequency signals can be surprisingly difficult, but there are special approaches that can be very effective. One of these – chopper or auto-nulling amplifiers – is this month's *Circuit Surgery* topic. We don't really have enough information about Thomas's situation to know if this would be the best approach for him, but this is an interesting topic that we hope many readers will find useful.

Before we look at the solution, let's look at the problem in more detail. A key issue with low frequency amplifiers is offset, see Fig.1. In simple terms offsets are d.c. errors, but the offsets can drift due to changes in temperature and other factors that influence the circuit. The changing offsets are just like low frequency signals that are amplified along with the signal itself – the offsets act as low frequency noise.

Assuming what we want here is some kind of op.amp with very good low frequency performance, let's look at offsets in the context of op.amps. Ideally with a differential input (the voltage difference between the inverting and non-inverting

inputs) of zero, an op.amp's output should also be zero, but in real op.amps there will typically be a non-zero output. The Input Offset Voltage V_{IO} is defined as the d.c. voltage which must be supplied between the inputs to force the quiescent (zero input signal) open-loop (no feedback resistors) output voltage to zero.

The input offset voltage is defined with respect to the input. The error in the output voltage due to V_{IO} is equal to the circuit gain times V_{IO} (note circuit gain, not op.amp gain). So if the datasheet quoted V_{IO} as 500mV max and your circuit had a gain of 500 you could get a 250mV (0.25V) error on the output. The temperature coefficient of input offset voltage specifies how V_{IO} changes with temperature. The datasheet for an op.amp may also have a graph showing offset variation with temperature.

Bipolar op.amps require bias (base) currents for the transistors connected to their inputs, whilst op.amps with f.e.t. inputs have leakage currents at the inputs. The Input Bias Current I_B tells you how large these currents are, and is defined as the average current into the two inputs with the output at zero volts. This can vary greatly for different types of op.amp.

Bias currents flow in the external components connected to the op.amp and in doing so they cause voltage drops. If these voltage drops are not equal at the op.amp's two inputs, they will be amplified by the op.amp and appear as errors at the output.

A Different Bias

In practice, the bias currents are not equal so we have Input Offset Current (I_{IO}) – the difference between the currents into the two inputs with the output at zero volts. Ideally these currents would be equal, but in practice they are not.

The input currents have to flow through the external circuitry and will cause offsets even if the impedances connected to the two inputs are equal. Of course, bias current and offset both vary with temperature so we have the temperature coefficient of input offset current which specifies how I_{IO} changes

with temperature and curves on the datasheet to show these changes.

We can also look at the problem from a noise-versus-frequency perspective. Random noise may be classed according to the frequency, or range of frequencies present. White noise has the same power throughout the frequency spectrum, whereas $1/f$ noise decreases in proportion to frequency – both types occur in all amplifiers. It is $1/f$ noise that causes problems when amplifying low frequencies.

How noise level varies with frequency for a typical amplifier is shown in Fig.2. At low frequencies the $1/f$ noise dominates, but as frequency is increased we reach a point where noise level flattens out. The point at which this occurs is called the *1/f corner* and the frequencies beyond this are called the *flat band noise area*.

For audio and video amplifiers the $1/f$ noise is not a problem as long as the $1/f$ corner is sufficiently low (say 20Hz for audio). This can be achieved with conventional amplifiers and the unwanted lower frequencies can be blocked by capacitive coupling. From an offset perspective, offsets are simply blocked by capacitive coupling.

Chopper Amplifiers

Chopper amplifiers can achieve lower offsets than conventional amplifiers and – crucially – much lower offset drift (e.g. one device is specified at 0.003 microvolts offset per degree temperature drift). From a noise vs. frequency perspective, choppers have a flat noise area going right down to d.c., at least in theory, completely eliminating the $1/f$ noise (see Fig.2). On the other hand, the chopping process does introduce some extra wideband noise and some of the chopping signal may leak through to the output as indicated by the dashed peak in Fig.2.

There are a number of circuit techniques that fall under the general title of "chopper amplifier" or "auto-nulling amplifier", but Fig.3 gives a good idea of the general approach and is the basis of a number of i.c.s available today. This circuit contains two amplifiers, the main wideband amplifier A1 that handles the signal and the

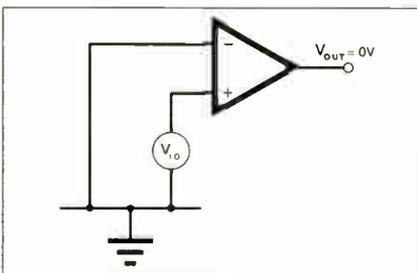


Fig.1. Offset voltage defined

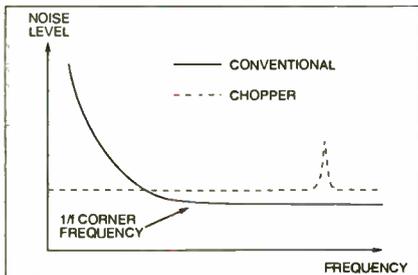


Fig.2. Amplifier noise versus frequency

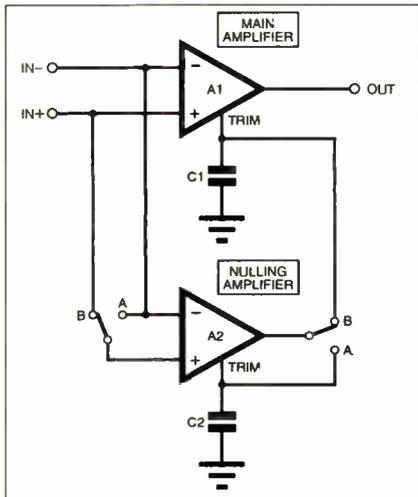


Fig.3. Chopper stabilised amplifier

nulling amplifier A2. Both amplifiers have an offset trimming input which can be used to trim off the offset. The circuit continuously switches between two phases of operation, nulling and output, under the control of a clock signal.

When the switches, which are controlled by the clock, are in the nulling position (position A on Fig.3) the inputs of A2 are shorted together and its output is connected to its own offset trim input forming a feedback loop that will null the offset. The trim voltage required to do this is stored on capacitor C2 so that it can continue to null A2's offset during the next phase. During the nulling phase the trimming voltage for A1 is held on capacitor C1.

During the output phase, the switches are in position B in Fig.3. The voltage across the inputs of the main amplifier is amplified by A2, without offset error by virtue of the trim voltage held on C2, and applied to the trim input of the main amplifier A1. The same input is also amplified directly by the main amplifier. Remember that A1 will be in an external feedback loop (e.g. the gain setting resistors of a standard op.amp amplifier). We have a more complex situation than in the nulling phase, but basically the feedback will adjust the trim voltage applied to A2 to null its offset. This voltage is held on C2 to during the nulling phase, keeping A2's offset trimmed out.

Note that the main amplifier is never switched out of the signal path and is able to continuously amplify the signal. This means that amplifiers of this type can handle quite high frequencies as well as the low frequencies and d.c. that we have been focusing on (i.e. bandwidth is wide).

The main signal is not chopped; the switching action is used simply to take the

error compensation circuit out periodically to fix its own errors. The switching frequency is typically units to tens of kilohertz. There are a number of i.c.s available that are more or less based on this kind of circuit, but often with additional circuitry to compensate for imperfections in the basic approach. Next month I will look at one of those chips. *I.M.B.*

Low Battery Indication

"I run a small piece of self-build kit powered by a 9V battery. I would like some means of measuring when the battery voltage has fallen below some variably preset level, something like 7V. Has anyone got such a circuit with a minimum of components; say something like a resistor or two, a Zener and an l.e.d.? Kind regards, Mike Walker via email."

The simplest way to detect a voltage reduction is probably to use a light-emitting diode that illuminates under normal conditions and fades away as the battery voltage drops. The trade-off is that it consumes a small (often negligible) amount of power that can only have a negative impact on battery life. Never-the-less, a number of battery-operated devices use such a system, including the Philips waterproof radio used in my shower!

A Zener diode, D1, with a series resistor to provide a stable voltage for a small load is shown in Fig.4. The Zener diode operates in reverse-bias mode as shown, in which case the specified Zener voltage will appear across the device when the supply voltage $+V_s$ is sufficient. Series resistor R1 limits the current to a safe value.

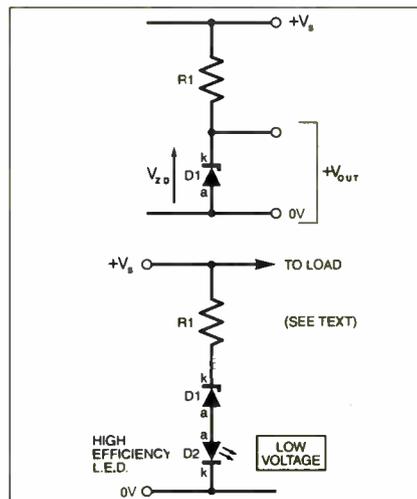


Fig.4. (a) A standard Zener diode arrangement. (b) Adding a series high-efficiency l.e.d. to act as a voltage monitor

It is desirable to have a small Zener current flowing through the device (say, 2mA to 10mA), and the heavier load current passes through the series resistor out to the load. However, when the load current reduces, then the Zener, which is classed as a shunt regulator, will "shunt" or carry the excess current away to 0V.

The operation of Zener diodes was explained in *Circuit Surgery*, November 2004 issue (back issues or reprints are available from the *EPE Online Shop* at www.epemag.co.uk). When calculating

series resistances and Zener diode power ratings, it is best to think of "worst case" conditions, at maximum and minimum loads.

It is easy to use a Zener diode as part of a low-voltage monitor by adding a light-emitting diode (l.e.d.) in series across your power source, see Fig.4b. A high-efficiency l.e.d. is best, as these offer a brighter output under low current conditions. When the supply voltage is higher (say, 9V) the Zener is conductive and current flows through the l.e.d, which glows. As the supply voltage falls, the Zener will gradually cease to conduct and the l.e.d will fade out.

The l.e.d. typically has a forward voltage of +1.8V or more when illuminated, so if you use a series 3V9 Zener diode for example, then assuming a 9V supply this leaves 3.3V to be dropped across the resistor. If we try a 5mA current then using Ohm's Law a series resistor of 3.3V / 0.005A or 660 ohms is needed (680 ohms nearest preferred value). Try a 2.2 kilohm trimmer resistor (preset) in series, set midway.

You'll need to experiment with Zener values (try some junkbox values), and as these have a poor tolerance, don't expect too great an accuracy!

You could replace the Zener with ordinary rectifiers such as the 1N4001, placed in series with the l.e.d. Each rectifier drops about +0.65V when conducting, so a handful of them wired in series will soon produce a useful voltage drop, and it may be possible to lower the current consumption a little as well.

A number of specialist integrated circuits are available that will do a good job warning of over voltage or undervoltage. One place to start is Maxim's web site (www.maxim-ic.com) and search for MAX8211 or MAX8212. Their Application Note 926 shows how to use a MAX8212 to disconnect a load from e.g. a battery when the battery voltage has fallen below a certain level. *A.R.W.*

Hanging up the Gown

Sadly this is the last *Circuit Surgery* column that I will be co-writing. I have enjoyed immensely the challenge of trying to answer your questions in a fun and non-technical way. I hope *Circuit Surgery* has encouraged readers to explore the fast-moving and challenging world of electronics and computer technology in more depth, and to pursue this worthwhile and rewarding hobby as a pastime if not career.

Like electronics technology itself, *Circuit Surgery* moves on – rest assured that this column will remain in good hands, helped along by Ian, and will appear at regular intervals for the foreseeable future. I will still be actively helping with the *EPE* web site, the *EPE Chat Zone*, developing my popular online *Basic Soldering Guide* and, of course, I shall still be writing *Net Work* – the Internet column every month, which reflects my full-time job in the Internet industry.

I have made many interesting contacts and friends along the way. My best wishes to *Circuit Surgery* readers everywhere, especially those from around the world who have been kind enough to contact me with their support and encouragement over the past dozen years. *Alan Winstanley.*

SHOP TALK

with David Barrington

Snooker and Darts Scoreboard

It is most important that when ordering the L293DN 16-pin half-H driver chip (also known as a stepper motor driver i.c.), used in the *Snooker and Darts Scoreboard*, that you emphasize you require one with the DN suffix. The **D** denotes it is a 16-pin device and has diode protection. Do *not* use other L293 device types as they have different characteristics and could be 20-pin versions. The one used in the prototype was purchased from **Rapid Electronics** (☎ 01206 751166 or www.rapid-electronics.co.uk), code 82-0192.

The 7-stage Darlington line driver type ULN2004A was also purchased from **Rapid** (see above), code 82-0622. It is also listed by **RS** (☎ 01536 444079 or rswww.com), code 652-825.

Note that the PIC microcontroller must be the PIC16F877A version. Be aware that the software code is not compatible with the ordinary PIC16F877 device. However, notes at the end of the article show how to adapt it for the standard device.

For those readers unable to program their own PICs, programmed PIC16F877A 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 661). 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 530 (see page 661).

Multicore Cable Tester

No "special" components, apart from the PIC, are called-up in the parts list for the *Multicore Cable Tester* project. If you wish to use the same translucent cases depicted in the article, these came from **Maplin** (☎ 0870 264 6000 or www.maplin.co.uk). You have a choice of Infra-Red or Ice Blue and the code numbers for the "red" versions, used in the models, are N72AL (large) and N69AL (small). Blue codes are N67AL and RN32K respectively.

For those readers unable to program their own PICs, programmed PIC16F84 microcontrollers can be purchased from **Magenta Electronics** (☎ 02083 565435 or www.magenta2000.co.uk) for the inclusive price of £5.90 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 661). The software is also available for free download via the Downloads link on our UK website at www.epemag.co.uk.

The two printed circuit boards are available from the *EPE PCB Service*, codes 525 (Main) and 526 (Active) – see page 661. The 9-way D-type connectors, both male and female, are now stock items from most of our components advertisers. Also, why not visit the web sites given at the end of the article for more info on cable/socket adaptors.

All-Band Radio

Photographs of the All-Band Radio project show that the author used a polyvaricon (polythene dielectric) variable tuning capacitor. The most common "tuning" values listed for the a.m. tuners appears to be around 5pF to 126pF and 5pF to 141pF. They can usually be found listed as "transistor radio" types and are currently stocked by **ESR Components** (☎ 0191 251 4363 or www.esr.co.uk), code 896-110 and **Sherwood Electronics** (see page 664), code CT9.

It is important that readers purchase the unbuffered version of the 4069 CMOS hex inverting buffer i.c. This is indicated by the suffix **UB** after its type number (4069UB).

Small quantities of 30s.w.g. enamelled copper wire can be obtained from **JAB Electronic Components** (☎ 0121 682 7045 or www.jabdog.com), mail order only.

The two printed circuit boards are available from the *EPE PCB Service*, codes 523 (Full) and 524 (Mini).

Model Railway Signal Controller

Stepper motors should be widely available. The stepper motor, incorporating a gearbox, used by the designer in the *Model Railway Signal Controller* project came from **Jameco Electronics of America**, code 28BYJ02A. Their website is www.jameco.com and email address international@jameco.com.

Again, many model shops should be able to offer a suitable trackside semaphore signal tower. The author's came from **Tomar Industries, USA** (www.tomarindustries.com) and is the H-853 (HO scale) signal.

For those readers unable to program their own PICs, programmed PIC16F828 microcontrollers can be purchased from **Magenta Electronics** (☎ 02083 565435 or www.magenta2000.co.uk) for the inclusive price of £4.90 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 661). 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 529 (see page 661).

Back to Basics – Daily Reminder/Whistle Switch

We do not expect any component buying problems to be encountered when shopping for parts for this month's *Back to Basics* projects. Obviously, the choice of relay for the *Whistle Switch* will depend on the rating of the appliance being switched/controlled.

The two printed circuit boards are available from the *EPE PCB Service*, codes 527 (Daily) and 528 (Whistle).

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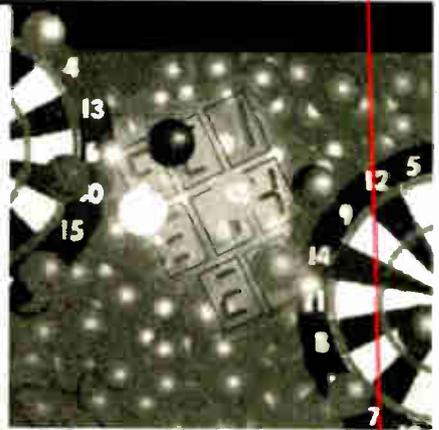
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Snooker and Darts Scoreboard

John Becker

Readily display all the scores at your snooker or darts matches



ONE of the interests of being *EPE's* Tech Ed is that of hearing directly from readers what they would like to see us publish in the way of constructional projects.

This Snooker and Darts Scoreboard resulted from a reader's phone call in which he asked if we had done a snooker scoreboard recently. The last one was about 15 years back – too long ago to recommend for construction now. However, browsing our "library" revealed that old design and it became apparent that it was ripe for updating. Discussing it with Editor Mike, we decided that it was worth doing, and to also add the facilities for darts scoring as well.

Needless to say, perhaps, it was a job ideally suited to a PIC microcontroller, the PIC16F877A in this instance. So, standby your cues and arrows, here it is!

Circuit Diagram

The circuit diagram for the complete Snooker and Darts Scoreboard is shown in Fig.1. Basically, score data is entered via a 4 × 4 matrixed data keypad, S1, processed to suit the game type by the PIC, IC2. The resulting data values are output to a matrixed 8-digit 7-segment l.e.d. array, X1 to X8, and an alphanumeric l.e.d. display module, X10.

The latter is for the benefit of the scorer (adjudicator). It shows, on a 2-line × 16 character per line screen, all current values for the game in progress. Its screen contrast is set by preset VR1.

The l.e.d. array, with its 2-inch (50mm) displays, is ideally suited for viewing by a small audience. Having only eight digits, its displayed data is shown in blocks selected via the keypad, as shown later in Table 1.

Data is entered via the keypad, S1, which is monitored by the PIC via Port C. Pins RC0 to RC3 are used in input mode, biased normally high by resistors R10 to R13, through which keypad column data is read. Pins RC4 to RC7 are used in output mode, being set high for the selected switch row.

The keypad software routine is a variant of that described in the author's *Using PICs With Keypads* of Jan '01. The keypad is read several thousand times a second to see if a key is pressed. When it is, the software jumps to a processing routine appropriate to that key.

Any data resulting from a keypress is stored to the PIC's memory and sent via Port A for display on the allocated section of the l.e.d. module and, as appropriate to the l.e.d. block selected, to that as well.

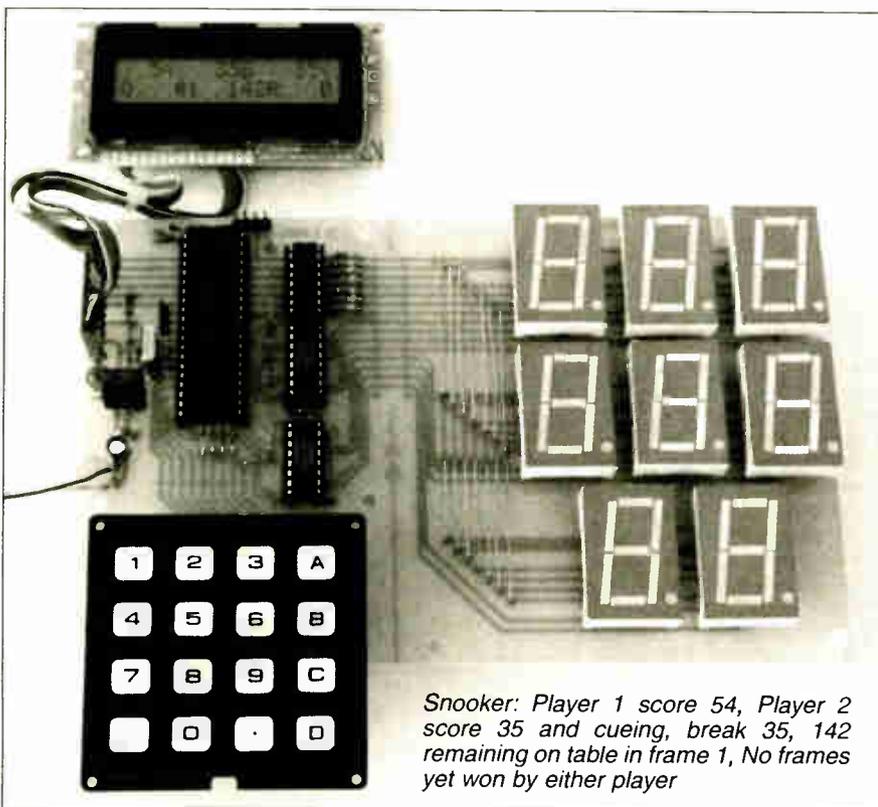
Ports B and D are jointly responsible for controlling the l.e.d. digits. The coded 7-segment data (as discussed in the author's several *PIC Tutorials*) is output from Port B to the voltage level changer and inverting buffer IC3. The buffer's seven output lines are connected via buffer resistors, R3 to R9, to the respective segment cathodes of each l.e.d. The cathodes of each same-lettered segment are commoned (connected together).

Which digit is then turned on is determined by which digit's common anode is powered by drivers IC4 and IC5. Port D controls the digit selection and is synchronised such that the segment code is displayed on the correct digit. The cycle refresh rate is about 100kHz and the eye is oblivious to this rate of cycling (24Hz or 25Hz are the standard frame-change rates used for normal film movies).

Note that only the L293DN (observe the DN suffix) device should be used for IC4 and IC5. There are other L293 devices with different (or no) suffixes, but they have different characteristics and are not suited to this design.

The PIC is run at 4MHz, as set by crystal X9 in association with capacitors C3 and C4.

The PIC can be programmed in situ via connector TB2, whose pins are in the author's standard order. Diode D1 and resistor R1 protect the 5V power line from adverse voltages during programming.



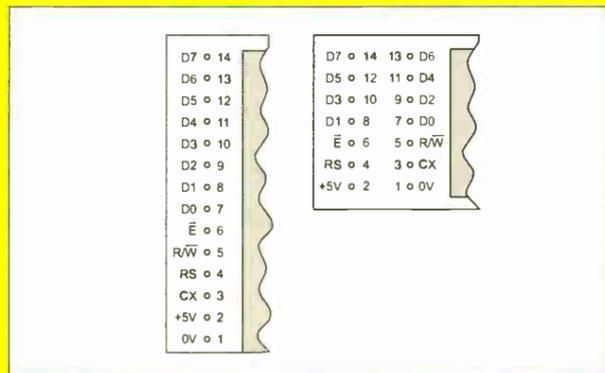
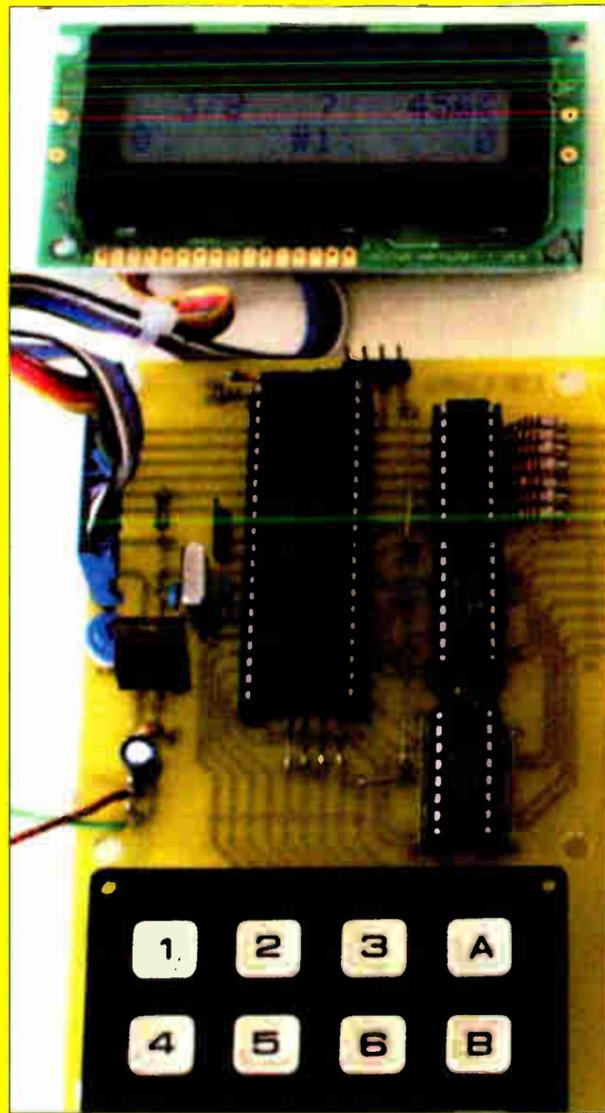


Fig.3. Alternative I.c.d. pinouts

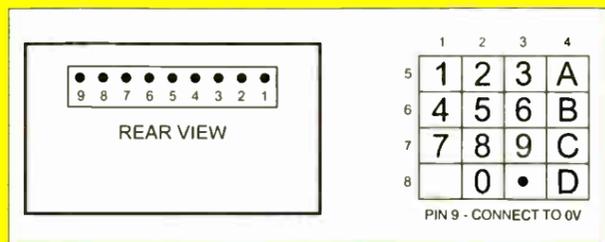


Fig.4. Keypad connection details

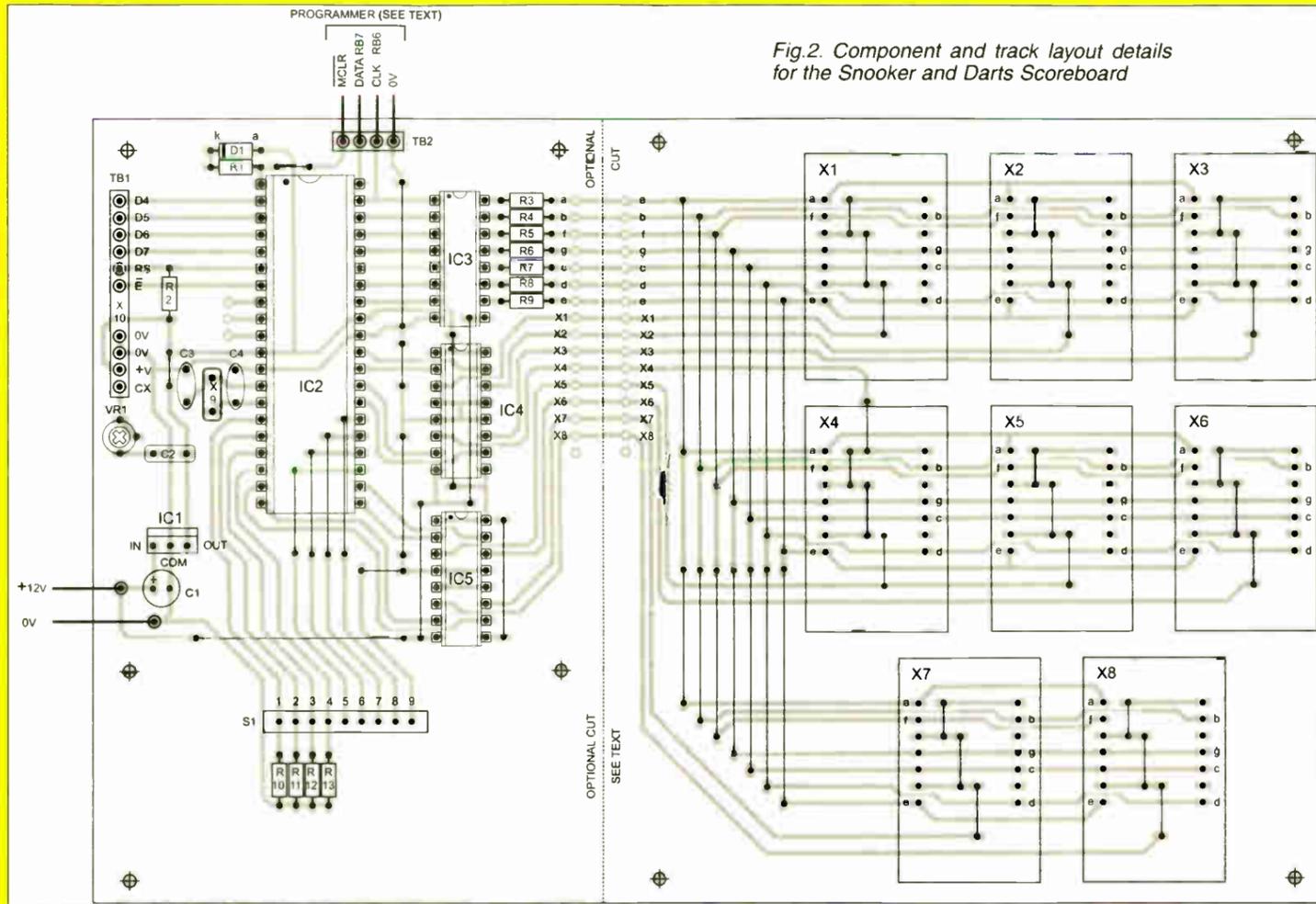
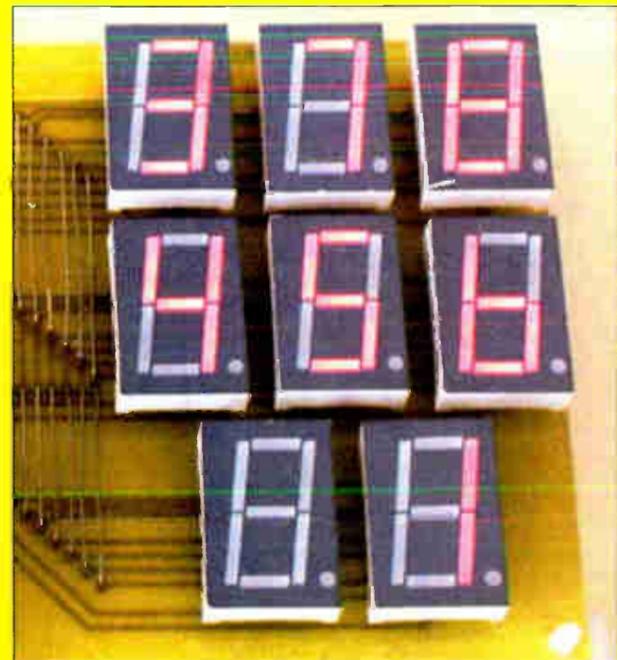
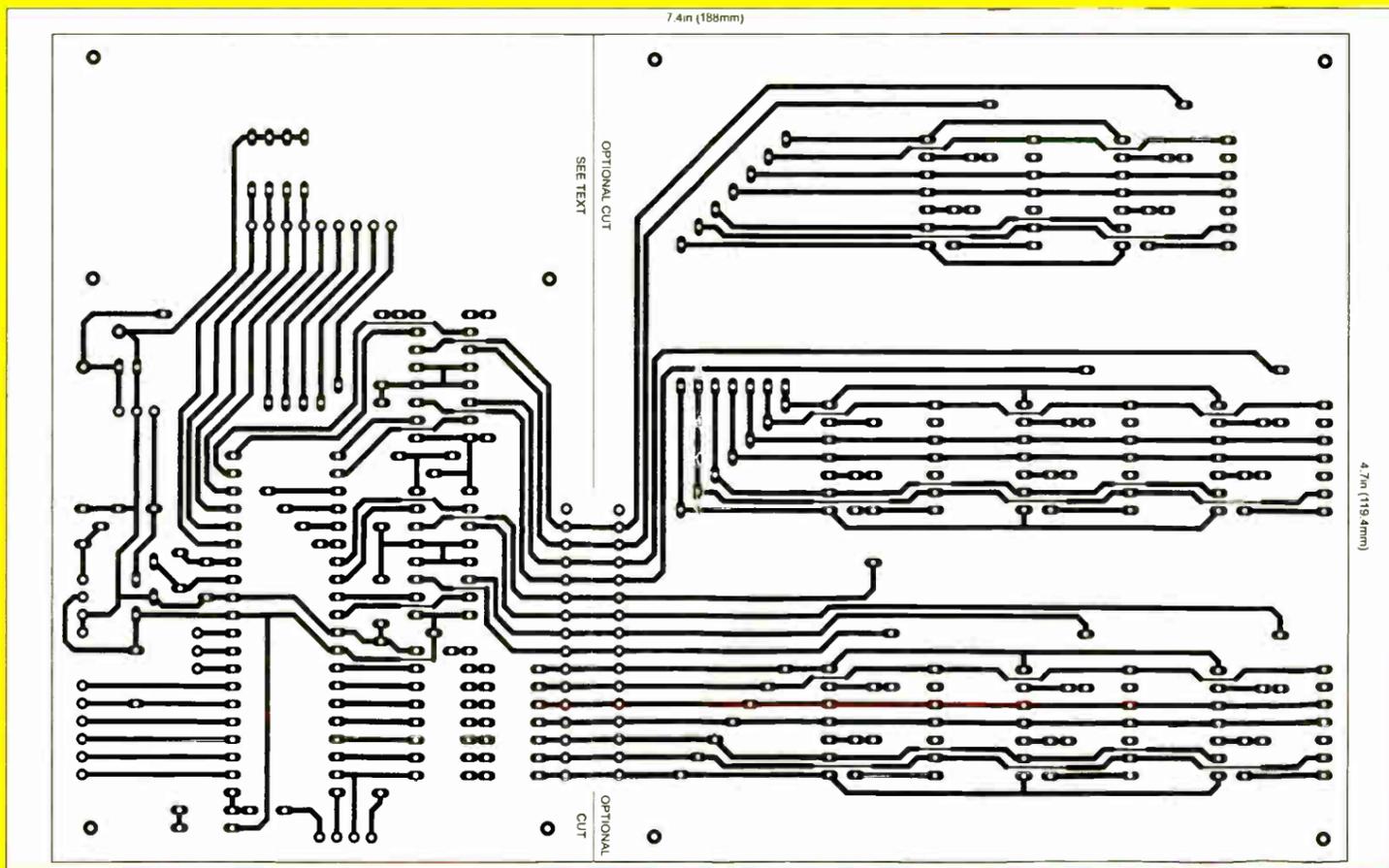


Fig.2. Component and track layout details for the Snooker and Darts Scoreboard



COMPONENTS

Resistors

- R1 1k
- R2, R10 to R13 10k (5 off)
- R3 to R9 330Ω (see text) (7 off)

Potentiometer

- VR1 10k preset, min. round

Capacitors

- C1 22μ radial elect. 25V
- C2 100n ceramic disc, 5mm pitch
- C3, C4 10p ceramic disc, 5mm pitch (2 off)

Semiconductors

- D1 1N4148 signal diode
- IC1 7805 1A +5V voltage regulator
- IC2 PIC16F877A microcontroller, pre-programmed (see text)
- IC3 ULN2004A 7-way Darlington line driver
- IC4, IC5 L293DN 16-pin Half-H driver (see text) (2 off)

Miscellaneous

- S1 4 x 4 data entry keypad
- S2 min s.p.s.t. toggle switch
- X1 to X8 7-segment common anode l.e.d. display, 33mm high, 22mm wide, pins at side, high brightness suggested (8 off)
- X9 4MHz crystal
- X10 alphanumeric 2-line x 16-characters (per line) l.c.d. display module

Printed circuit board, available from the *EPE PCB Service* code 530; case as required; 12V d.c. power source, min 500mA output (see text); 40-pin d.i.l. socket; 16-pin d.i.l. socket (3 off); 7-way s.i.l. socket (see text) (16 off); 1mm terminal pins or pin-header strips; p.c.b. supports as preferred; mounting nuts and bolts to suit application; connecting wire; solder etc.

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See
SHOP
TALK
page

Fit the remaining components in ascending order of size. Do not insert the d.i.l. i.c.s, i.e.d. displays, or connect the l.c.d. module until a thorough check of the assembly has been made, and the 5V output from regulator IC1 has been proved.

The type of case(s) chosen to house the units(s) is entirely up to personal preference.

Snooker Program

With all components present, connect power and recheck that powerline voltages are correct, that the l.c.d. module shows two lines of data (adjust preset VR1 to set the best contrast), and that the l.e.d. digits have some values present.

By default, the software runs the Snooker program (darts selection is covered presently). For snooker, the opening l.c.d. display is:



in which all values are in their reset (pre-game) state. Screen line 1 shows, in order, the ">" symbol, indicating that Player 1 is the current active player. Then follow the values of Player 1's score, the current Break count (followed by "B"), and Player 2's score, all zero at present. To the right of Player 2's score a blank cell should be shown.

The bottom line shows the number of frames won by player 1 (0), a "#" symbol and the current frame count number (1), the current value of the balls remaining on the table (147) and followed by "R" (Remaining), and then the frames won by Player 2 (0).

Pressing any of the keys numbered 1 to 7 (ball values) causes that value to be added to the current player's score. Simultaneously, the Remaining value is reduced by the same amount. The exception is when a foul has been called, which does not affect the Remaining count.

Change between players is caused by pressing key "C" (Change Player). If the change is from Player 1 to Player 2, the lefthand ">" on line 1 becomes blank and to the right of Player 2's score is shown "<". Pressing key "C" repeatedly cycles back and forth between players. Each press of "C" also resets the Break count.

Errors in pressing keys 1 to 7 can be corrected by pressing key "A" (Amend), which causes the last value keyed to be deducted from the active player's score, and added back to the Remaining count.

Fouls can be actioned by first pressing the dot key ("."), then pressing the key value appropriate to that to be awarded to the other player, whose score is then updated by that amount. Once that has happened, further presses of 1 to 7 are awarded to the current player as usual. The Remaining count is unaffected for Foul calls.

When the Remaining count has reached zero, the player active at that moment is awarded the frame and their frame score is incremented, and so too is the Frames

Played score. The next frame can then be started by pressing the "Blank" key, which resets the player frame scores to zero, and the Remaining count back to 147.

The l.e.d. digits show the current scores, Player 1 on line 1, Player 2 on line 2. The digits on line 3 show the Frames Played count.

Pressing key "B" (Block), the next l.e.d. digits block displays the current Break count on line 1. Line 2 shows the frames won by Player 1, a hyphen symbol ("-"), and then the frames won by Player 2. Line 3 again shows the current Frames Played count. It is assumed that neither player's frames won score will exceed nine before the game is won (a 19 frame game).

Pressing key "B" again reveals the third l.e.d. digits display block, in which the current Remaining value is shown on line 1. The other digits have no function for this display block and just show hyphen symbols.

The next press of key "B" reveals the first display block again. It is a 3-step repeating cycle.

Keys 0, 8, 9 and D have no function for snooker.

Darts Program

The Darts program can only be selected when the unit's power is being switched on. With the power off, press key "D" (Darts) and hold it pressed. Switch on the power while keeping "D" pressed. Once the l.c.d. screen has data on it, release "D". The program is now in Darts mode and can only be exited by switching off the power.

On entry to the Darts program, the l.c.d. will show the score for each player from which their throws are to be deducted (the "leg" count starting value). The values are each 501 by default until changed. The lower line shows the message SET HUNDREDS, as below:



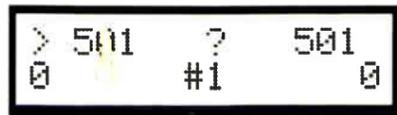
The l.e.d. digits show the 501 value on line 1, with lines 2 and 3 showing hyphen symbols (no function).

At this point, the leg count starting value can be changed. In a professional darts game the value is typically 501. In many amateur games, though, 301 might be selected. Other values ending in 01 might also be chosen, depending on the expertise of the players.

For simplicity, the program allows any hundreds value from 101 to 1001 to be selected by pressing the appropriate number key, e.g. "3" for 301. Note that "0" must be pressed for 1001. The selected value is displayed in the Player counts on l.c.d. line 1, and on the l.e.d. digits line 1 (1001 will only show as 001, though).

Once the required value is shown, press "D" (now used as the <ENTER> key). The value is then stored to the PIC's non-volatile EEPROM (electrically erasable programmable read-only memory) where it remains for future recall, even after the power has been switched off. It is the value that will be the default next time the program is run. But it may be changed at that time in the same way as above.

Having pressed "D" the l.c.d. screen shows:



in which both players score values are shown as the selected starting value (501, or other) on line 1. At the centre of line 1 is shown a question mark ("?"). This is where each throw count is temporarily displayed. At either side of Line 2 are shown the current legs won count for each player (0) and the number of the current leg (#1) in the centre.

The l.e.d. digits show 501 (or other) on lines 1 and 2, and the legs count on line 3.

The throw score is entered in standard calculator fashion. Enter the required value using any of the numbered keys (0 to 9) and then press "D" (again being used as the <ENTER> key). The entered value is deducted from the current player's running total.

While the throw score is being entered, the value is progressively shown at the centre of l.c.d. line 1, clearing back to "?" when "D" is pressed.

When a player's total reaches zero, their legs won count is automatically increased by one, as is the total legs count.

If an error is made in keying the correct number, continue by keying in "0" until the screen value reads 000, then key in the correct number. If after "D" is pressed it is realised that the wrong value has been entered, press key "A" (Add) to add the value back to the current player's score.

Although experienced darts players can calculate double and triple scores in their head, for the sake of those who are less able, another option is provided. Key in the basic number scored and press "D", then press the "." key to add the same value to the score again (double score). A second press of "." adds the same value again (triple score).

As with snooker, player change is done by pressing "C" (Change). Similarly l.e.d. display block change is done by pressing "B". There are only two display blocks for darts. The second shows the throw score on line 1 as it is being keyed in. Line 2 shows the legs won scores, and line 3 shows the total legs count (both as with snooker).

Pressing the blank key terminates a leg, incrementing the legs count and resetting player starting scores back to their chosen value (501, or other).

Software Aspects

There are some aspects of the software code that may be of interest to PIC programming readers. The first is the keypad reading routine. This is set out in full in Listing 1. The comments alongside various command lines should be self-explanatory.

It must be noted that the code is specific to the Port pins hardwired on the p.c.b. In other applications, in which other pin allocations have been made, the code will need to be modified. Examples of other codings can be found in the author's *Using PICs with Keypads* referred to earlier, and his *PIC Controlled Intruder Alarm* (Apr '02).

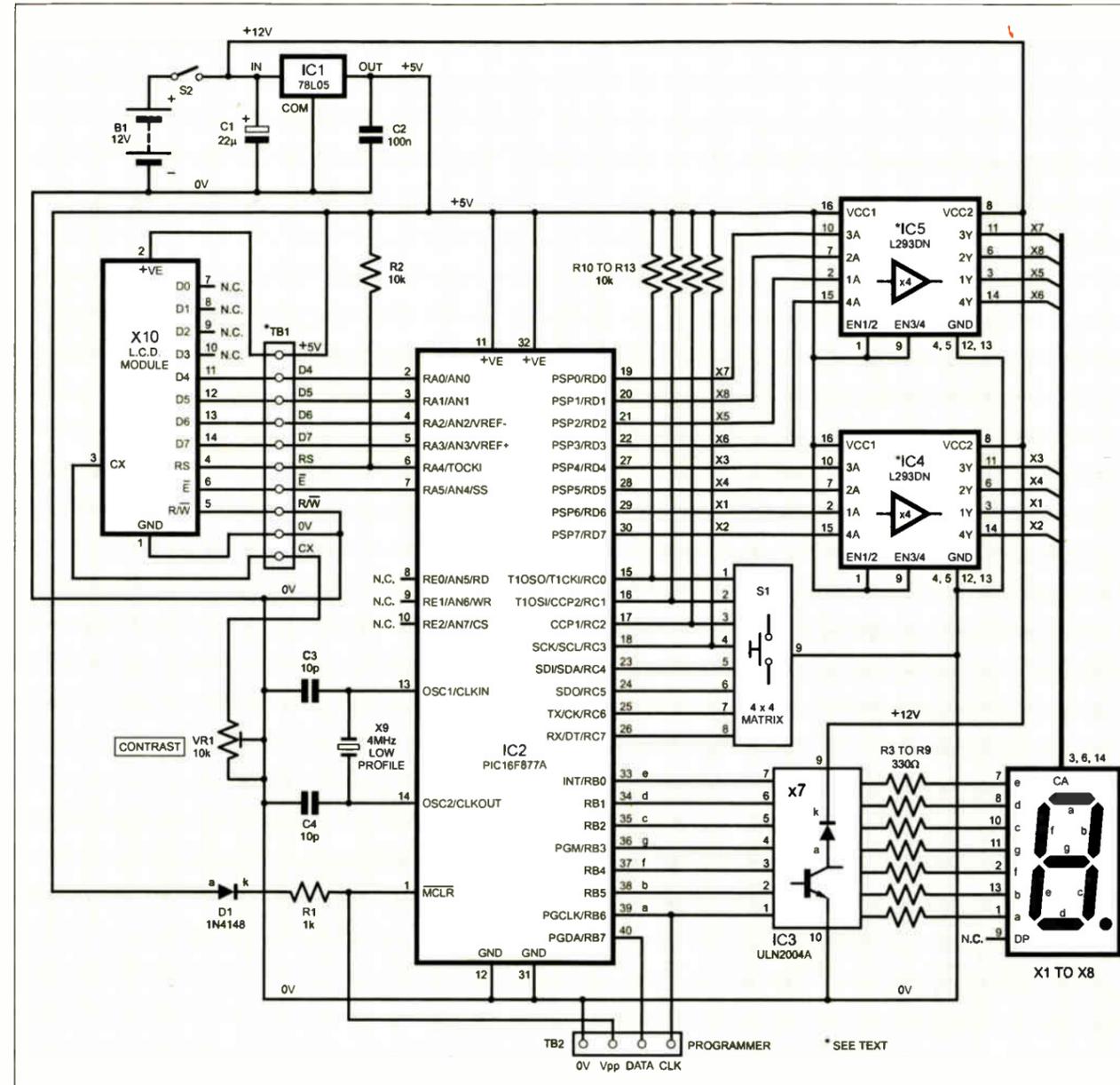


Fig. 1. Complete circuit diagram for the Snooker and Darts Scoreboard

Power Supply

The unit has been designed for powering at 12V d.c. Regulator IC1 reduces this to 5V as required by the PIC, l.c.d. and pins 16 of IC4 and IC5. Pins 8 of IC4 and IC5, and pin 9 of IC3, are powered at the basic 12V input voltage.

The unit may be run at 9V if preferred, although the l.e.d. ballast resistor (R3 to R9) values may need changing in order to increase the segment brilliance - a value of 220Ω each is suggested. A 15V supply could also be used, but the resistor values should then be increased, to say 470Ω.

The current consumption is high, mainly due to that taken by IC4 and IC5 through their 5V connections. Over all, with all l.e.d. digits showing "8", the total current drawn is about 185mA at 9V, 245mA at 12V, 300mA at 15V. Because the 5V line current is high, it might be preferable that a small heatsink should be used with regulator IC1 (although this was not done with the prototype).

Because of the high current drawn, operation of this unit from a small standard battery is not practical. However, a small 12V rechargeable battery would be ideal. Otherwise, a mains powered adaptor capable of supplying around 500mA at 12V could be used. It is not necessary for the 12V supply to be regulated.

Construction

Component and track layout details for the unit's printed circuit board are shown in Fig.2. This board is available from the *EPE PCB Service*, code 530.

The board has been designed so that it may be readily cut into two sections if preferred. In this case the Control section could go in one case on the adjudicator's table, and the Display in another, positioned some distance away for ease of audience viewing.

It will be seen that provision has been made for pin-header connectors to be used at the edges of the two board sections, for

the data signals. A power line connection for this section is not required.

Pinouts for common l.c.d. modules are shown in Fig.3, and those for keypad S1 in Fig.4.

There should be no difficulty over connection cable length, although tests on this have not been made. Whilst the data rate along the cable is moderately fast (100kHz or so), a cable length of two or three metres, or perhaps more, should be satisfactory. The use of colour-coded ribbon cable is recommended.

Provision for linking the keypad to the board via a connector is also made, although with the prototype it was connected directly to the board via a 9-pin single-in-line (s.i.l.) socket.

Assemble the board in order of link wires, quite a few of which are placed under i.c. and l.e.d. socket positions, followed by the sockets. Those for the l.e.d. digits are 7-pin s.i.l. sections, cut from 14-pin d.i.l. sockets and filed smooth.

The routine in Listing 2 shows the coding that controls the l.e.d. 7-segment display digits. It too is believed to be self-explanatory, but it is worth noting how the common anode control has to turn off the digits (**clrf PORTD**) before writing the 7-segment data to them via Port B. Failure to do so results in "ghosting" of the previous digit's value as well as the required value.

In relation to perhaps using the 7-segment control routine in another application, note that the segment codes are specific to common *anode* displays and the PIC pins to which their segment pins are connected. In this application they are in the order which best suited ease of p.c.b. layout.

A further point of interest regarding the l.e.d. display is that two sets of registers have been used for the respective Player Scores and other data storage variables. One set is usually in binary, using one or two registers (MSB and LSB), depending on the size of the value to be stored. The other set is basically in BCD (binary coded decimal) order and typically needing three bytes (MSB, NSB, LSB).

These registers hold the 7-segment code for decimal values, obtained when the binary values are converted to decimal for the l.c.d. display. This arrangement considerably speeds the rate at which the LEDSONA routine is actioned. Without this pre-conversion, the routine would need to include its own calls to the conversion routines prior to updating each digit display – a very time consuming process as LEDSONA is called so frequently.

Main Loop

Listing 3 shows the main loop which repeatedly updates the l.e.d. digits, reads the keypad and calls the routines which update score and display data as required. Measurements show that the typical cycling rate is about 100kHz.

Calls to the processing routines when keys are pressed momentarily slow down the multiplexed display cycling, but do not have a significant visual impact on the multiplexing. As a precaution, though, a few extra calls to the LEDSONA display routine are set into some longer sub-routines called by keypresses.

In particular, such a call is repeatedly made while the WAITSWITCHA routine is waiting for a key to be released. Similarly, the PAUSIT delay routine, called following WAITSWITCHA's completion, also makes repeated calls to LEDSONA. PAUSIT at this point is used to eliminate keypress release bounce.

RESOURCES

Software, including source code files, for this design 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 Snooker Scoreboard.

This month's *Shop Talk* provides information about obtaining pre-programmed PICs and component buying advice.

The PIC program source code (ASM) was written using *EPE Toolkit TK3* software (also available via the Downloads

LISTING 1

```

;***** GET KEYPAD VAL ROUTINE *****
GETKEY:  clrf SWITCHVAL      ; clear monitoring register
          movlw %11110000    ; set outputs RC7 to RC4 high
          movwf PORTC
          nop                 ; pause to allow PORTC to stabilise
          movf PORTC,W        ; get PORTC inputs
          andlw 15            ; isolate bits 0 to 3 (RC0 to RC3)
          btfsc STATUS,Z     ; is result NOT zero (are any keys pressed)?
          return             ; no, so return to main prog
          movlw %00010000    ; yes, find key pressed, trying bit 4 high first
          movwf PORTC        ; output initial val for RC7-RC4
          movwf KEYSTORE     ; and store into KEYSTORE
          clrf ROW           ; clear the Row count

GK2:     movf PORTC,W        ; get PORTC inputs
          andlw 15            ; isolate bits 0 to 3
          btfss STATUS,Z     ; is result zero (keys not pressed)?
          goto GK3           ; no
          movlw MATRIX       ; yes, add keypad matrix size (4 for 4x4)
          addwf ROW,F         ; to Row count
          rlf KEYSTORE,F     ; rotate RC7-RC4 value left
          movf KEYSTORE,W    ; get it
          andlw %11110000    ; isolate bits 7-4
          movwf PORTC        ; output to PORTC
          btfss STATUS,C     ; has KEYSTORE high bit entered Carry?
          goto GK2           ; no, so repeat search
          return             ; yes, so return to main prog

GK3:     movwf STORE         ; put current KEYSTORE value into STORE
          clrf COL           ; clear column number count

GK4:     bcf STATUS,C        ; clear Carry flag
          rrf STORE,F        ; rotate right STORE val
          btfsc STATUS,C     ; is Carry flag set?
          goto SUMIT        ; yes, so this key pressed, go finish answer
          incf COL,F         ; no, so try again
          goto GK4          ; repeat search

SUMIT:   movf ROW,W         ; sum up results to single answer
          addwf COL,W        ; add ROW to COL (total value between 0 and 15)
          call CONVERTKEY    ; convert this val to actual number of key
          movwf SWITCHVAL    ; (as given in called table), and store it
          return            ; return to main program

```

LISTING 2

```

;***** SHOW 7-SEGMENT DIGITS *****
LEDSONA: movf DIGITNUMBER,W ; get digit count value
          call ITEMNUMBER    ; get address of register to be displayed
          movwf FSR          ; put into indirect access register
          movf INDF,W        ; get segs val from reg pointed to
          clrf PORTD         ; turn off 7-seg anode enable (IC4/5)
          movwf PORTB        ; put segs data out to PORTB
          call DIGSHW        ; get which digit to show it on
          movwf PORTD        ; set PORTD digit select code accordingly
          incf DIGITNUMBER,F ; increment digit select multiplex count
          bcf DIGITNUMBER,3  ; restrict to 0 to 7
          return             ; return to main program

```

LISTING 3

```

;***** MAIN SNOOKER LOOP *****
MAIN:    call LEDSONA        ; display current l.e.d. digit
          call GETKEY        ; get key pressed if any
          movf SWITCHVAL,W   ; get result value
          btfsc STATUS,Z     ; is it greater than zero (key pressed)?
          goto MAIN         ; no, not pressed, repeat for next digit
          andlw %00001111    ; yes, key pressed
          movwf SWITCHVAL    ; isolate val in bits 0 to 3
          call ROUTESWITCH   ; process routine pointed to by this val
          call WAITSWITCHA   ; wait until key is released
          goto MAIN         ; repeat the loop

```

Table 1: L.E.D. Array Block Data Display Cycle

Block	Line	Snooker	Darts
1	1	Player 1 score	Player 1 score
1	2	Player 2 score	Player 2 score
1	3	Frames count	Legs count
2	1	Break count	Current throw
2	2	Frames won scores	Legs won scores
2	3	Frames count	Legs count
3	1	Balls remaining	-
3	2	-	-
3	3	-	-

Table 2: Keypad Switch Use

Snooker	Darts
1 to 7 ball numbers	0 to 9 score value entry (calculator style)
0, 8, 9 No action	A (Add) add back last score value entry
A (Amend) subtract last entry	B (Block) change LED display block
B (Block) Change LED Display Block	C (Change) change player
C (Change) change player	D (Deduct) (Enter) subtract score from countdown
D No action	● Deduct value again (for doubles/triples)
● Foul	□ (blank key) increment Leg count
□ (blank key) increment Frame count	

Table 3: Prototype Measurements

	9V	12V	15v	PIC and regulator only 8mA
All Digits Off	95mA	95mA	95mA	Each L293DN draws approx 40mA
All 8s On	188mA	245mA	300mA	Heatsink recommended for IC1 (see text)

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 XT, 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.

Be aware that the code, which has been written for a PIC16F877A, is not compatible with the ordinary PIC16F877 device. However, readers familiar with PIC programming can make it compatible by just two changes. At the head of the ASM listing are the statements

List P = PIC16F877A
include P16F877A.inc

in which the "A" should be deleted:

List P = PIC16F877
include P16F877.inc

Assembling the ASM code will now generate a HEX file suitable for the standard PIC16F877 device. □



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PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

AT school we learned about metres and kilograms, or for those of my generation and older it was feet, inches, pounds and ounces that we learned to use. The units of measurement used in electronics are less widely taught. Consequently, many people making a start in the hobby of electronics construction would not have learned about Ohms, Farads, and Henries at school.

Matters are complicated by the fact that some of the basic units of measurement used in electronics are either very small or huge. One minute you might be soldering a 5,600,000 ohm resistor to a circuit board, and the next you could be fitting a 0.000000001 farad capacitor!

The range of values covered is immense for some components. With resistors, for instance, the highest value that is generally available is a hundred million times larger than the lowest available value. The equivalent figure for capacitors is over one thousand million!

High Capacity

This can all be a bit confusing at first, but it all becomes very straightforward if things are rationalised.

Taking capacitors first, the basic unit of measurement is the farad, but for normal electronic circuits this is a huge amount of capacitance. The highest value I have ever used is a mere 0.0047 farads.

High value capacitors normally have their values expressed as so many microfarads, and one microfarad is equal to a millionth of a farad. The 0.0047 farad capacitor mentioned previously would normally have its value given as 4700 microfarads.

Even a microfarad is a substantial amount of capacitance by normal electronic standards. Many capacitors have values given in nanofarads

or picofarads. A nanofarad is one thousandth of a microfarad, and a picofarad is one thousandth of a nanofarad or one millionth of a microfarad in other words.

Abbreviation

The micro, nano, and pico prefixes are not specific to capacitance. They are used generally in metric measurement to indicate one millionth, a thousand-millionth, and a million-millionth of something.

The abbreviation for micro is the Greek letter mu (μ), but a lower case letter "u" is often used instead. On a circuit diagram or in a components list a 47 microfarad capacitor would therefore have its value given in the form "47 μ F" or "47uF". Presumably working on the basis that the farad is always the basic unit of measurement for a capacitor, this value would often be given as just "47 μ " or "47u".

The respective abbreviations for nanofarads and picofarads are "n" and "p", and these letters should always be in lower case. A value of 680 picofarads would therefore appear as "680pF" or just "680p" on a circuit diagram. A value of 22 nanofarads would be marked as "22nF" or "22n".

Space on circuit diagrams tends to be strictly limited, so things are often taken a stage further with the unit of measurement indicating the position of the decimal point. For example, values of 2.7 picofarads and 4.7 nanofarads are often given as "2p7" and "4n7" respectively.

On Your Marks

The value markings on capacitors can be something less than obvious at first glance. A 330 picofarad capacitor could and in many cases would have its value shown as "330p". Particularly

with ceramic capacitors, it is quite likely to be marked as "n33". In other words, the value is 0.33 nanofarads, which is actually the same as 330 picofarads.

Capacitors having values from 100 nanofarads to 820 nanofarads have a similar problem. A "470n" component might be specified in a components list, but this value could be given as 0.47 microfarads in some component catalogues.

This is most likely to occur with electrolytic components, which often have all the values given in microfarads in component catalogues.

"A nanofarad (nF) is one thousandth of a microfarad"

Letter Imperfect

Capacitors often have other markings, such as the maximum voltage rating and their tolerance. The latter is simply the maximum amount that the actual value of the component can differ from its marked value.

With capacitors the tolerance is often indicated by a single letter and a simple method of coding, so be careful not to interpret a tolerance code letter as part of the value. These are the tolerance ratings for the common code letters:

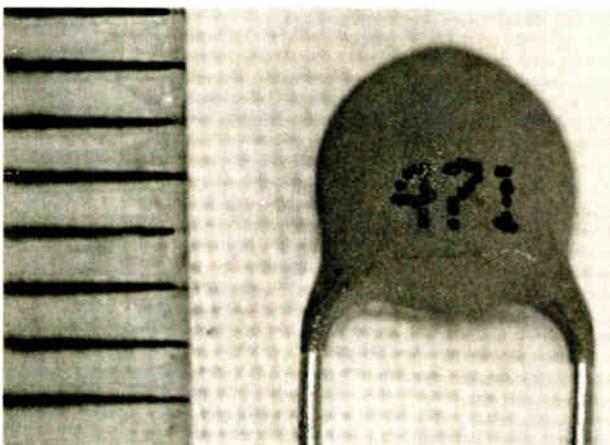
Code Letter	Tolerance
F	+/- 1%
G	+/- 2%
H	+/- 3%
J	+/- 5%
K	+/- 10%
M	+/- 20%

Capacitor value markings are sometimes in the form of a three-digit number. The first two digits of the label are simply the first two digits of the value. The third digit is the number of zeros that have to be added to the basic two-digit value.

For example, a capacitor marked "223" has "22" as the first two digits of the value, and three zeros must be added to these in order to provide the full value. This gives an answer of 22000, and as the value is in picofarads this is what would normally be regarded as a 22 nanofarad capacitor.

The example shown in Fig.1 is marked "471", indicating that it has a value of 470 picofarads. It is pictured beside the one-millimetre markings of a ruler, and the lettering is only a little over one-millimetre high. There are plenty of modern capacitors that are far smaller than this example, so even those with good eyesight might find it necessary to use a magnifier of some kind.

At one time it was common for some types of capacitor to have their value, voltage, and tolerance ratings marked using a system of colour coding. This method was based on the system of coding used for resistors, and had its advantages. However, it fell from favour some years ago and does not seem to be in use any more.



The three digit marking of 471 on this miniature capacitor (pictured beside the one-millimetre markings of a ruler) indicate it has a value of 470pF – 47 plus one zero

Resistance

The basic measurement of resistance is the Ohm. Normal resistors are generally available with values from about 1 ohm to 10 million ohms. High-power resistors are only available with relatively low values, going down to about 0.1 ohms.

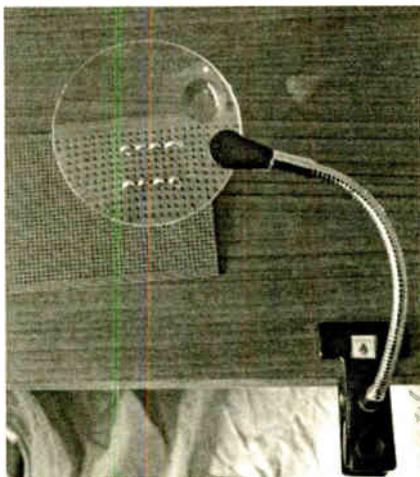
The Greek letter omega (Ω) is used to indicate that a value is in ohms, so a 330 Ω resistor has a value of 330 ohms. There can be practical difficulties in using anything other than normal alphanumeric characters, so the letter "R" is often used in place of omega. A value of 330 ohms would therefore appear on a circuit diagram or in a components list as either "330 Ω " or "330R", or perhaps even as just "330". (EPE always uses the omega symbol.)

"A picofarad (pF) is one thousandth of a nanofarad or one millionth of a microfarad (μ F)"

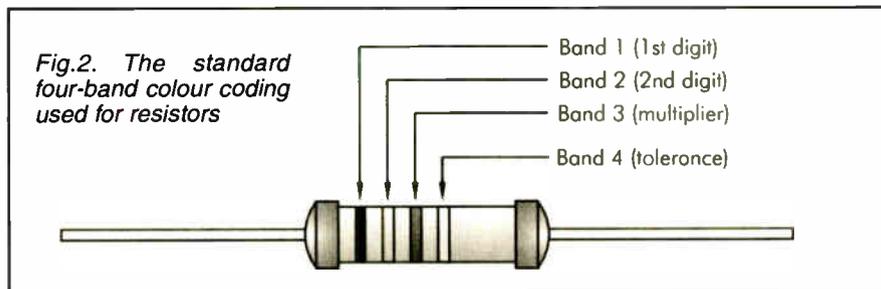
As with capacitance, it is now standard practice for the character denoting the unit of measurement to also indicate the position of the decimal point. A 5.6 ohm resistor would therefore have its value given in the form "5 Ω 6" or "5R6".

The basic ohm is used when dealing with resistors of several hundred ohms or less, but kilohms and megohms are used for higher value components. The prefixes "kilo" and "mega" are used in the metric system to respectively denote one thousand and one million of something. A kilometre is a thousand metres, and a kilohm is a thousand ohms.

The abbreviation for kilohm is "k Ω " or just "k", and the abbreviation for megohm is "M Ω " or just "M". Again, the letter indicating the unit of measurement is often used to show the position of the decimal point. A value of 4.7 kilohms would normally be marked on a circuit diagram as "4k7", and a value of 3.9 megohms would be marked as "3M9".



Using a magnifier can also be useful in identifying really small capacitor markings



Colour Code

While there are some resistors that have the value written on the body, together with a tolerance rating or code letter, this method is mainly restricted to high power resistors. Resistors having a power rating of about one watt or less almost invariably use colour coding to indicate the value and tolerance rating. The standard four-band coding uses the system shown in Fig.2. Table 1 shows the meaning of each colour, but some colours are only used in certain bands.

At one time it was normal for band 4 to be well separated from the others, but these days there is more or less equal spacing of the bands. There should still be no risk of getting bands 1 and 4 confused and reading the colours backwards. Band 1 is much nearer to its end of the body, and in some cases is right at one end of the body.

As an example of a colour code, suppose a resistor has bands that are green, blue, orange, and gold. Bands 1 and 2 provide the first two digits of the value, which in this case are green (5) and blue (6). The first two digits of the value are therefore "56". The third band provides the multiplier, and in this example it is orange (x1000). This gives a final value of 56 x 1000, which is 56000 ohms or 56k Ω . The fourth band is gold, indicating that the resistor's value has a tolerance of plus and minus 5%. It is worth bearing in mind that it is perfectly acceptable to use a component that has a tighter tolerance than the one specified in the components list. For instance, a 1% component can be used instead of a 5% type, but a 5% component should not be used in place of a 1% type.

Some resistors have a fifth band, but this only indicates the temperature coefficient of the component, which is normally of no great consequence. Therefore, you can just ignore the fifth band and use the first four in the normal way.

There is another five band version of the resistor colour code that seems to pop up every now and then. It uses three bands to provide the first three digits of the value. The other two bands then provide the multiplier and tolerance rating in the usual way.

The point of having three rather than two initial digits is that it enables non-standard values to be accommodated, which is probably of no practical importance to project builders. With normal (preferred) values the third band is always black (0). The value can therefore be calculated by ignoring the third band, and using the other four bands in the normal way. This figure is then multiplied by ten in order to give the actual value. For

Table 1: Resistor Colour Code

Colour	Band 1/2	Band 3	Band 4
Black	0	x1	-
Brown	1	x10	1%
Red	2	x100	2%
Orange	3	x1000	-
Yellow	4	x10000	-
Green	5	x100000	0.5%
Blue	6	x1000000	0.25%
Violet	7	-	0.1%
Grey	8	-	-
White	9	-	-
Gold	-	0.1	5%
Silver	-	0.01	10%
None	-	-	20%

instance, if the four bands give an answer of 22k, the resistor is actually a 220k component. Ending up with a mixture of normal four-band resistors and components that use this five-band method of coding would be likely to produce confusion and errors. If possible, avoid resistors that use this form of five-band coding.

"The abbreviation for ohm is Ω , for kilohm is k Ω and for megohm is M Ω "

Choked Up

Inductors, which are also called chokes, are not used a great deal in electronic projects. The basic unit of inductance is the Henry, which is a very large amount of inductance. Most inductors have their value given in microhenries, which are millionths of a henry. Large inductors have the value specified in millihenries (thousandths of a henry).

Large inductors mostly have the value written on the component, possibly with other parameters included such as a maximum operating current. Physically small inductors for use in low power applications often have the value marked using colour coding. The system used is essentially the same as the standard four-band resistor colour code, but it gives a value in nanohenries. Divide by one thousand to obtain a value in microhenries, or by one million for an answer in millihenries.

For example, suppose an inductor has the colour code yellow, violet, red, and gold. The first three colours provide a figure of 4700 (47 x 100), and dividing this by one thousand gives a value of 4.7 microhenries. The gold band indicates that the tolerance rating of the component is plus and minus five percent.

Controlling Model Railway Signals

John Waller

Using stepper motors to control the semaphore signals used with model railways

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* (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 herein may be a useful guide.

Signal Positions

The signal being controlled here is of the upper quadrant type, and is set to one of three positions to assert train control:

- The semaphore is set horizontally, and shows a red light, to signify danger; trains *must* stop in front of the signal
- The semaphore is set to 45° up, and shows a yellow light, to signify caution or "approach"; trains may proceed past the signal, but not exceeding a designated speed
- The semaphore points upright, and shows a green light, for safe or "clear"; train speed is unlimited by the signal alone. There are, of course, always other limitations on train speed

The semaphore signal is thus a good candidate for stepper motor control.

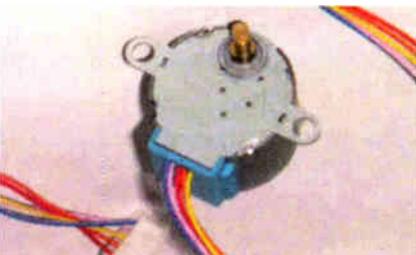


Photo 1. The stepper motor used in this controller

Stepper Motor

The 4-phase unipolar stepper motor used here is shown in Photo 1. The overall case is about 30mm in diameter. It is supplied by 12 volts and each of the four coils has a resistance of 200Ω. The output shaft is offset from the centre of the housing, indicating there is a gearbox inside. The shaft itself is rectangular, 5mm by 3mm, with rounded corners. This makes it simple to attach something to the shaft.

The motor comes with wires already connected to a 5-pin female header, with red as the common lead.

Semaphore Signal

Photo 2 shows the signal before connection to the motor. It is made by Tomar Industries, type H-853 (HO scale). The quadrant contains coloured lenses to show red, yellow, and green for the stop, caution, and safe positions, respectively, by being aligned to a white lamp. Thus it is important to position the quadrant to bring the appropriate lens in front of the lamp assembly.

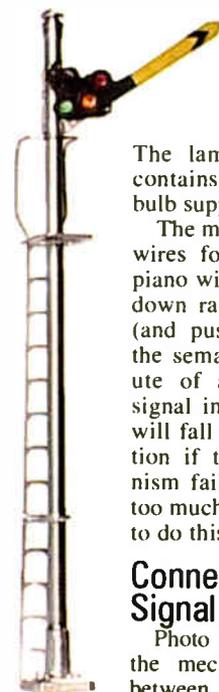
The lamp assembly itself contains an incandescent bulb supplied by 1.4 volts. The mast contains the two wires for the lamp, and a piano wire. Pulling the wire down raises the semaphore (and pushing it up lowers the semaphore). The attribute of an upper-quadrant signal in real life is that it will fall to the danger position if the driving mechanism fails. There is mostly too much friction in a model to do this.

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Connecting the Signal

Photo 3 shows details of the mechanical connection between the signal and the



motor. A plastic piece 30mm by 8mm, and 2mm thick is cut to fit over the shaft and glued into place. The semaphore wire is bent at 90° and inserted through a hole in the plastic and bent again to keep it in place.

The hole is 6mm from the shaft centre. The motor is mounted by means of slots and is positioned, with the semaphore at caution, to make the plastic piece approximately horizontal. Also shown are two mechanical stops, about which more will be said presently. Looking at the shaft end, the motor turns anticlockwise to raise the semaphore arm.

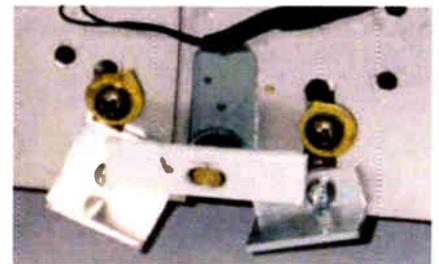


Photo 3. Connecting the signal to the motor

Motor Controller

The controller closely follows the concepts described by Andy Flind. A PIC16F628 is used with internal 4MHz clock, and all available pins, 16 in number, configured for digital I/O (input/output), noting that RA5 can only be an input. The circuit diagram for the Model Railway Signal Controller is shown in Fig.1.

The employment of 16 pins allows two complete motors to be driven, via transistors TR1 to TR8 which are buffered by resistors R3 to R10. There are also two outputs (RA6, RA7) for the lamps fitted to each signal, which allow the lamps to be flashed to warn trains that automatic block and signal control has failed, and trains must proceed slowly as if in an uncontrolled yard.

The values for resistors R13 and R14 should be chosen to suit the current drawn by the signal lamps. A value of 390Ω was needed with the prototype.

The transistors may be any small npn type capable of driving motors and lamps, such as

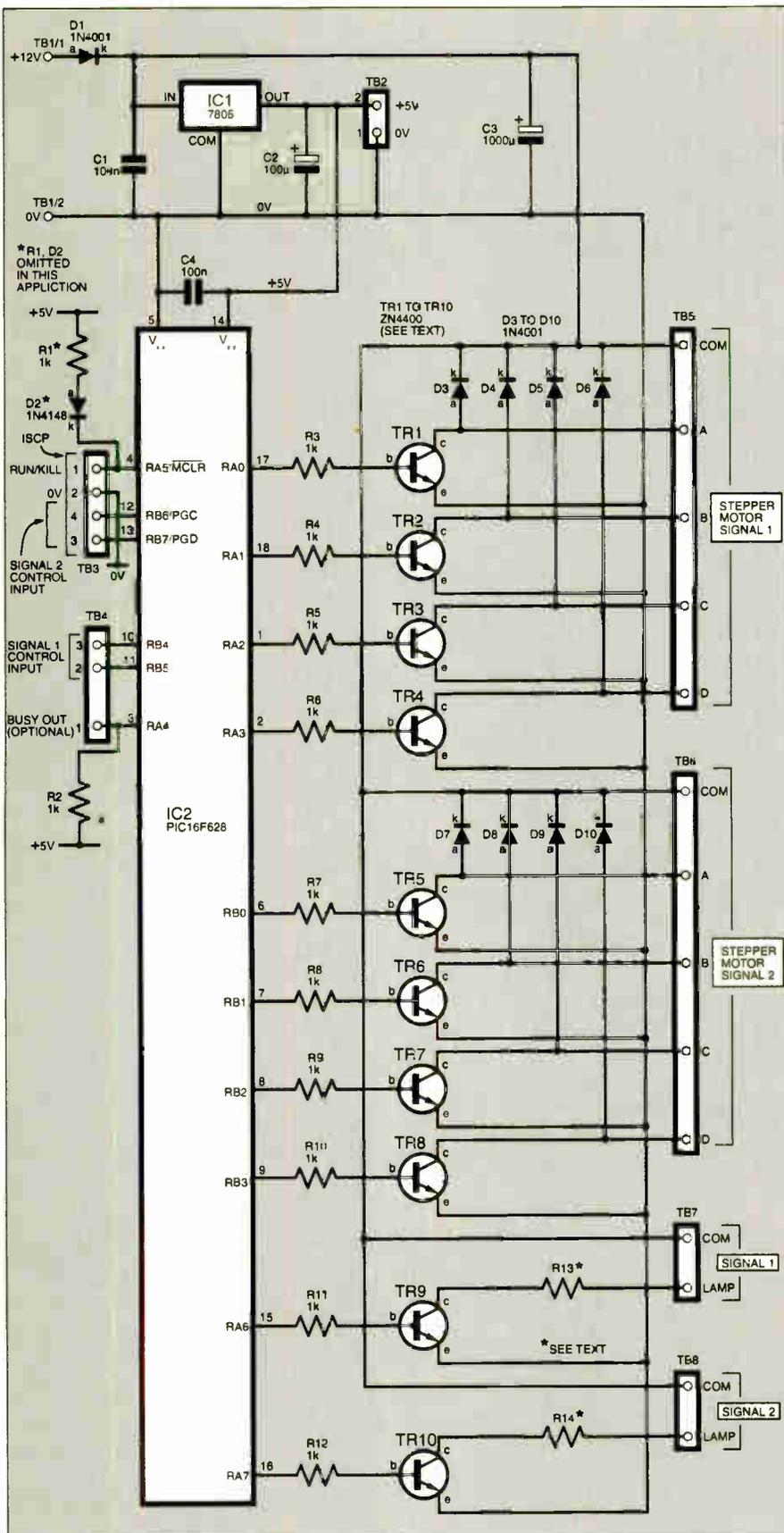


Fig.2. Circuit diagram for the Model Railway Signal Controller

ZN4400 or ZTX653 and having the same pin order as required by the printed circuit board. Diodes D3 to D10 suppress back e.m.f. pulses generated by the motor coils.

Controller I/O Allocation

The PIC's input/output allocation is itemised in Table 1, and the position orders from the host system are shown in Table 2.

The RUN/KILL input from the host system is used as follows:

- RUN, with RA5 set, indicates the host system is operating normally, and semaphore position orders should be obeyed
- KILL, with RA5 cleared, indicates an abnormal condition. Semaphore position orders are ignored and both signals are set to

COMPONENTS

Resistors

- R1 to R12 1k (12 off)
 R13, R14 to suit signal lamps 0.5W (see text) (2 off)
 R15 to R23 1k (9 off) (test only, see text)

All 0.25W 5% carbon film

Capacitors

- C1, C4 100n ceramic disc, 5mm pitch (2 off)
 C2 100µ radial elect. 25V
 C3 1000µ radial elect. 25V
 C5 1µ radial elect. 25V (test only, see text)

Semiconductors

- D1, D3 to D10 1N4001 rectifier diode (9 off)
 D2 1N4148 signal diode
 D11 to D14 red l.e.d. (4 off) (test only, see text)
 TR1 to TR10 ZN4400 or ZTX653 npn transistor (10 off)
 IC1 78L05 +5V 100mA voltage regulator
 IC2 PIC16F628 microcontroller, pre-programmed (see text)

Miscellaneous

- TB1 to TB8 1mm terminal pins or pin header blocks
 S1 to S5 s.p.s.t. min. toggle switch (5 off) (test only, see text)

Printed circuit board available from the *EPE PCB Service*, code 529; semaphore signal, Tomar Industries, type H-853 (HO scale) or to suit; stepper motor; 18-pin d.i.l. socket; connecting wire; solder, etc.

Approx. Cost
 Guidance Only

£16

excl signal & case

Table 1: PIC Input/Output Allocation

Pin	Direction	Function
RA0	O	motor 1 pole A
RA1	O	motor 1 pole B
RA2	O	motor 1 pole C
RA3	O	motor 1 pole D
RA4	O	Busy to host
RA5	I	RUN/KILL from host
RA6	O	Semaphore 1 lamp
RA7	O	Semaphore 2 lamp
RB0	O	motor 2 pole A
RB1	O	motor 2 pole B
RB2	O	motor 2 pole C
RB3	O	motor 2 pole D
RB4	I	position 1 order from host
RB5	I	position 1 order from host
RB6	I	position 2 order from host
RB7	I	position 2 order from host

Table 2: Position Orders from Host System

Order	RB4 and RB6	RB5 and RB7
No action	0	0
Danger	1	0
Caution	1	1
Safe	0	1

piano wire, with some in the motor gearbox. The user will have some control here according to the size of the hole in the arm attached to the motor shaft (Photo 3). Making the hole larger increases the backlash, decreasing it increases the friction.

The stiff piano wire should also be bent very carefully. The mechanical stop at the clear position is set so the signal semaphore arm is upright. The calibration procedure (see later) allows the number of steps, from any position to any other position, to be adjusted. These measures help to overcome the effects of backlash.

Software

The author used John Becker's simulation facility that has been part of his *TK3 PIC programmer* since V3.00. It was discussed in the March '05 issue, *PIC Toolkit TK3 Simulator and PIC18F Upgrade*.

Such a simulation is particularly useful for a PIC16F628 where all I/O (input/output) pins are allocated, with none to spare, for example to drive an alphanumeric liquid crystal display module, which can be very useful for debugging.

The high-level flowchart of the signal control program is shown in Fig.3. A timing loop circulates continuously, initiating action every eight milliseconds. At each such interval, the stepper motors are turned off, whether either are on or not from the previous interval. If required, a different pole piece in a motor is then energized. The operations which take place may be summarised as follows:

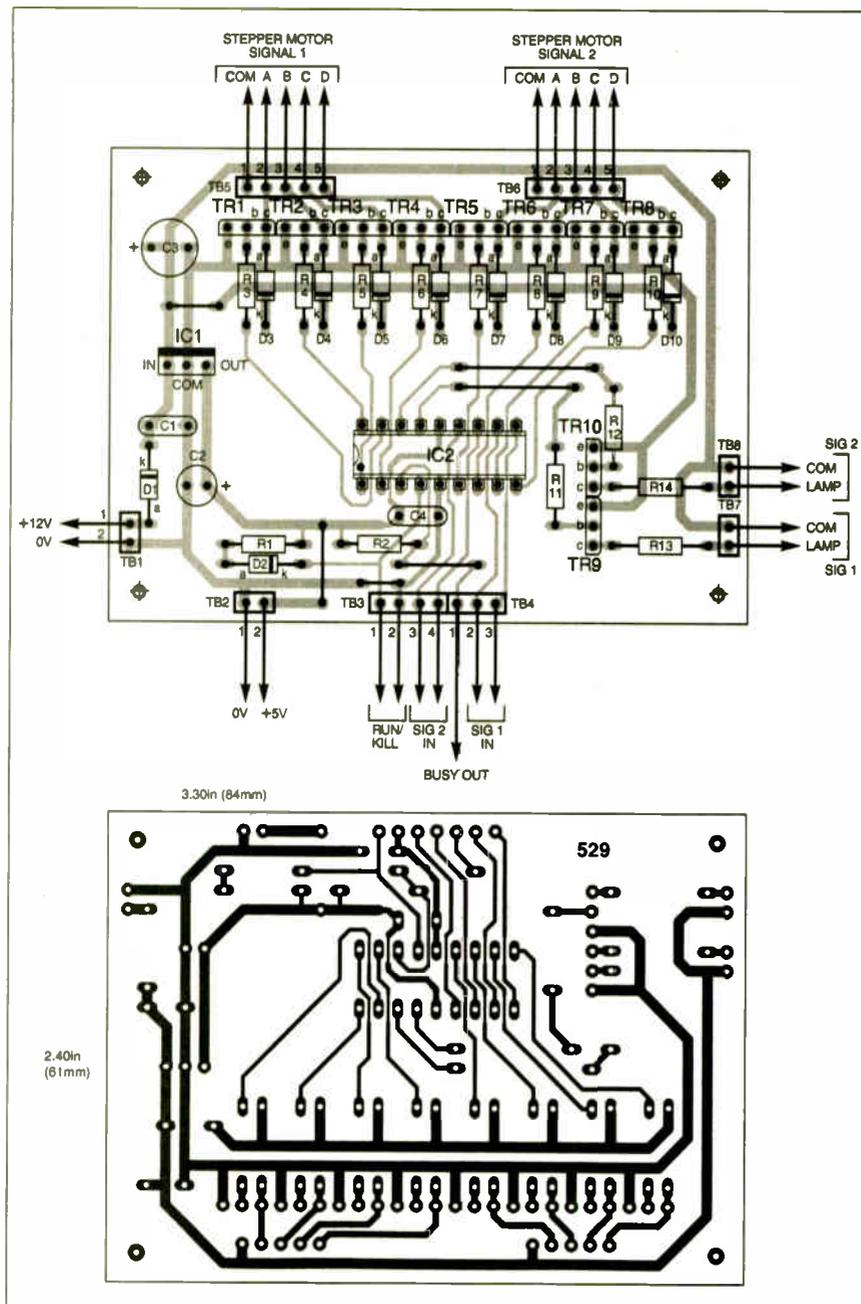


Fig.2. Component and track layout details for the Model Railway Signal Controller printed circuit board

clear with the lamps flashing. This message also goes to the train digital command control (DCC), which removes the control and power signal from the train tracks; see the author's article *Digital Command Control for Model Trains* (Aug '03). All trains stop (no doubt real railways would relish having this capability!).

Construction

Component and track layout details for the Model Railway Signal Controller printed circuit board are shown in Fig.2. This board is available from the *EPE PCB Service*, code 529.

Assemble the board in the usual order of ascending component size, taking care to position the diodes, transistors and electrolytic capacitors correctly as shown. Use a socket for the PIC, but do not insert the PIC until the board has been double-checked for correct component positioning, and that the output from regulator IC1 is at 5V, within a few millivolts.

Minimum and maximum motor rotation end stops can be fitted alongside the motor,

using small angled plates bolted to the backing plate. Software is set to cut out the motor at the correct points, but the end stops prevent undue force being applied to the signal lever.

Initialising the Signal

The host system starts up with RUN cleared. The signal moves to the clear position, and the lamp flashes. The number of motor steps assigned to this operation is sufficient that the signal will reach the clear position no matter where it starts from. All or part of this operation will be with the stepper motor driving against the stop (see Photo 3).

No damage occurs here, and the condition only lasts for about a second. But it guarantees putting the signal into a known position regardless of where it has been left with the power off. It is easy to turn the motor by hand, for example.

Backlash

Any mechanical system has some degree of backlash, or "lost motion". Most of the backlash with the signal is at the ends of the

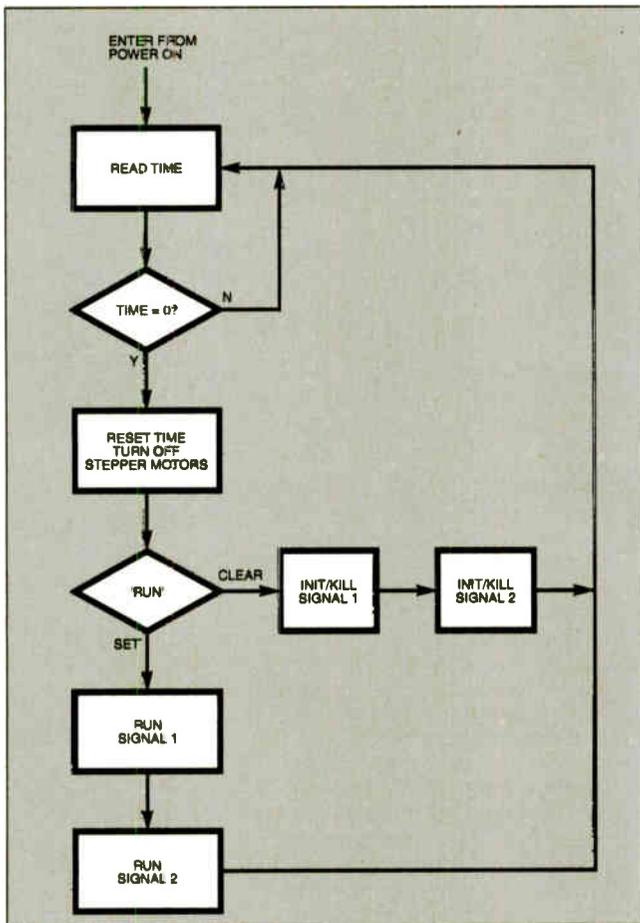


Fig.3. High-level flowchart of the signal control program

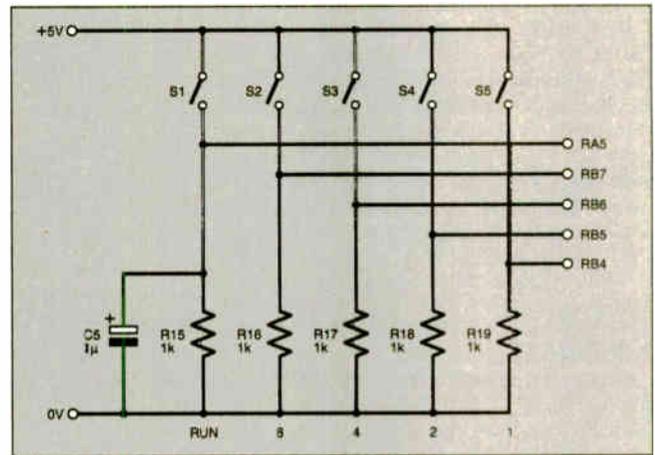
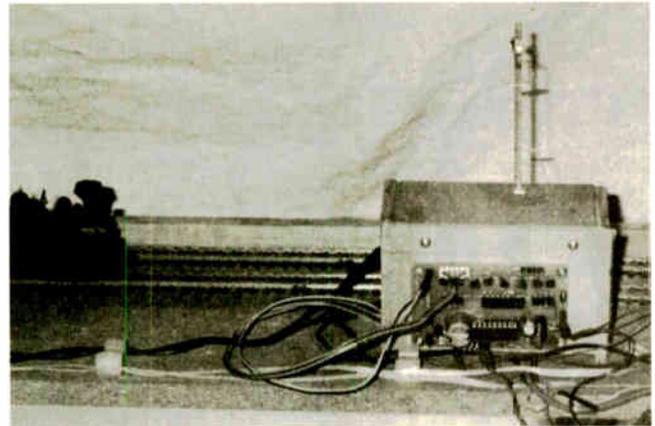


Fig.4. Calibration circuit diagram

- With RUN cleared, the semaphores are driven to the clear position (upright) and the signal lamp is toggled, as already explained, to indicate the host system is waiting to run, or has lost control over automatic operations. Once the motors have moved the number of steps designated for red to green motion, no further motor action occurs. If RUN is set before this occurs, the operation will always be completed first.

- With RUN set, the signal lamps are always on and the controller awaits a new order from the host system, always completing an existing order before starting a new one.

In practice, even in a model railway environment, the motors spend most of their time idle. The time interval of eight milliseconds is adjustable by factors of two, by changing the value of a mask in the software. The software is contained in the file `stepmtr.asm` (available as stated later).

The issue of completing an existing operation before commencing a new one could be contentious, especially if the new operation is to set a signal to danger. There is no queue of pending operations; the one that is present when the current operation is completed is the one executed next. The author will review this aspect after gaining experience with the controller. Interruption of an existing operation would be possible.

Testing

The stepper motor controller is tested and calibrated with a test box whose circuit diagram is shown in Fig.4. Constructional details for this are not offered, and it may be readily assembled on stripboard.

The test box simulates the commands from the host system, as shown in Table 1. The power for the box comes from the 5V/0V pins allocated on the p.c.b.

In Fig.4, switch S1 controls the RUN/KILL command, and the other four simulate the commands given in Table 2. The test box provides all of the functionality pertaining to normal operations; the switches and other components are mounted in a utility box.

Again following Andy Flind, a useful test device is shown at Fig.5 for monitoring outputs to a motor. It is inserted in the five-way cable between the controller and the motor, using compatible male and female headers. The l.e.d.s flash as the motor steps.

Calibration

Because of the mechanical tolerances in the system, especially backlash, the test box also provides means of calibrating each movement of the signal, as a number of steps stored in the PIC's EEPROM. The user would start with nominal values as given in the file `stpntmr.msg`, which is loaded separately into the PIC, using TK3's facility for this, or that of other programmers.

At each step of the calibration, the user selects the movement to be tested by setting the switches as given in Table 3. The switch settings column is the result of treating the switch positions as a binary sequence, as shown in the first four columns. Switch settings of 12 or greater are ignored.

To run the calibration the motor controller is powered on with the RUN switch (S1) closed, and then opened after the signal lamp lights. Normal operations with the host system are powered on with RUN cleared. The

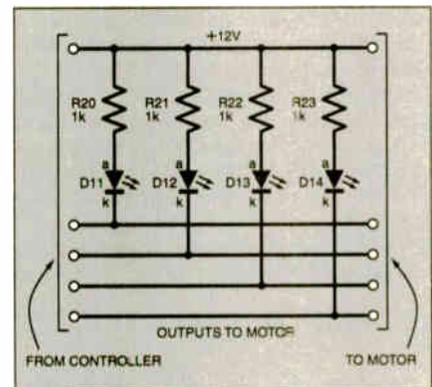


Fig.5. Motor test display circuit

calibration software has a timing loop similar to the main timing loop, but which runs much more slowly. The procedure is as follows:

- Make sure the semaphore has already been set to the required start position. For example, if the steps green to red or yellow are being calibrated, it is best to power on with RUN cleared, whereby the semaphore is set hard against the stop in the upright position, as already explained, then reset the controller with power off, set RUN, then power on again, to get back to calibrate. In other instances, the semaphore might already be in the yellow or red position from a previous calibration operation.

- Set the test box switches for the desired movement and signal from Table 3.

- Close the RUN switch and observe the movement of the semaphore.

- When the semaphore is in the required position, open the RUN switch; this stops

the movement and the number of steps for that movement is loaded automatically into the PIC's EEPROM, where it stays even after the power has been removed.

The procedure may be repeated as often as needed. The additional mechanical stop shown in Photo 3 should be used to prevent the motor moving the semaphore too far below the horizontal; the stress of a stalled motor is better taken by the stop and not the signal mechanism.

As a matter of perception, it looks bad if the arm is not truly upright or truly horizontal, for clear and danger positions, respectively. Conversely, the average observer will not notice if the arm is not exactly at 45° in the caution position, provided the yellow lens is aligned to the lamp, and there is some tolerance in this.

The calibration procedure provides means for setting the number of steps to reach the clear position. The author prefers to set default values here which ensure the semaphore will initialise to green from anywhere, as already explained. But the user can choose otherwise, and may also adjust step numbers in the `stpmtr.msg` file and load it into EEPROM (see Table 4). If *TK3* is used for this, it is possible to read the PIC's EEPROM contents after a calibration session.

Resources

Software, including source code files, for the Signals Controller 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 Train Signals. Download all the files within that folder.

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

If programming the PIC in situ, normal operating connections are removed from TB3/4 in order to connect the programming leads.

The PIC program source code was written using *EPE Toolkit TK3* software (also

Table 3: Selecting Calibration Movement

RB7	RB6	RB5	RB4	Switch settings	Semaphore	Movement
S2	S3	S4	S5			
0	0	0	0	0	1	green to red
0	0	0	1	1	2	green to red
0	0	1	0	2	1	green to yellow
0	0	1	1	3	2	green to yellow
0	1	0	0	4	1	red to green
0	1	0	1	5	2	red to green
0	1	1	0	6	1	red to yellow
0	1	1	1	7	2	red to yellow
1	0	0	0	8	1	yellow to green
1	0	0	1	9	2	yellow to green
1	0	1	0	10	1	yellow to red
1	0	1	1	11	2	yellow to red

Table 4: Number of steps values for upper quadrant signals H-853

1	; High count (A) green to red
20	; Low count (A) green to red
1	; High count (B) green to red
20	; Low count (B) green to red
0	; High count (A) green to yellow
138	; Low count (A) green to yellow
0	; High count (B) green to yellow
138	; Low count (B) green to yellow
1	; High count (A) red to green
20	; Low count (A) red to green
1	; High count (B) red to green
20	; Low count (B) red to green
0	; High count (A) red to yellow
138	; Low count (A) red to yellow
0	; High count (B) red to yellow
138	; Low count (B) red to yellow
0	; High count (A) yellow to green
138	; Low count (A) yellow to green
0	; High count (B) yellow to green
138	; Low count (B) yellow to green
0	; High count (A) yellow to red
138	; Low count (A) yellow to red
0	; High count (B) yellow to red
138	; Low count (B) yellow to red

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

PIC16F configurations embedded in it. If you wish to program the PIC yourself, simply load this HEX file into the PIC using your own PIC programming software and hardware.

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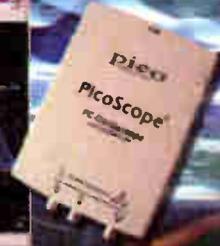
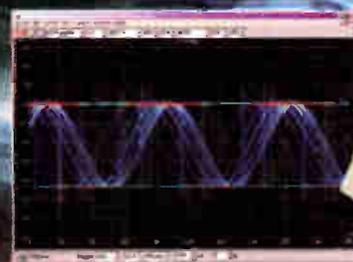
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★ LETTER OF THE MONTH ★

Digital Terrestrial TV

Dear EPE,

Thank you for Barry Fox's article *Digital TV Switchover* in the June issue. This subject has been a bee in my bonnet for a considerable time.

Barry says: "...A survey...of 4,000 viewers found that more than 70% are angry about [analogue] switch-off and suspicious of the Government's motives." I can't speak for the 2,800 in the survey, but I'll nail my banner to the same flag pole and tell things as they appear to me.

"Why did colour TV come in so quickly and so well?" I'll tell you why. It was because nobody was forced to give up B&W if they didn't want to. A B&W TV still works today, because the colour signal remains compatible with the original B&W standard. That is how it was designed. It would be far more relevant to compare digital switch-over with the change from 405 to 625 lines, which meant a period of simultaneous transmission on VHF and UHF until the population of active VHF receivers diminished below what was reasonable.

Out of Line?

The change from 405 to 625 lines, and then the introduction of colour, both conveyed significant improvements to the service that rewarded the audience with a much better viewing experience. Can the same honestly be said for digital terrestrial TV? As far as I can see, the consequences of having more channels to fill are that the existing resources are diluted across them. Witness the BBC having to trim its production teams, basically to find the funds to buy in more rubbish to populate the schedules. Witness also the migration of the traditional quality viewing away from the old traditional (analogue!) channels.

It seems to me that nobody has made a rational case for why we want digital terrestrial at all. Anyone who really wants lots of channels to surf can do so already, because they will have been drawn to satellite or cable before now. What other case (for the consumer) can there be? Improved picture quality? Maybe, but does anybody seriously have anything to complain about with 625-line PAL colour? Does anyone really need DVD picture quality on a broadcast channel?

Gainers and Losers

Having established in my thesis that the consumer has no need of it, and that the content will be worse as a result of it, who is driving it forward?

The broadcasting industry and Government, that's who. Why are they so keen? Money. The Government sees the possibility of licensing a whole new raft of services, and releasing the old frequencies for even more.

The broadcasters see new advertising or subscription revenue streams from new channels. Also (and get this one), once the analogue broadcasts are gone there is no guarantee that Freeview will remain free! Encrypted subscription-only TV becomes a distinct possibility. It doesn't matter whether the money comes from direct subscription, frequency licensing, or adverts – the result is the same in the end: we (the consumers) pay.

I don't think the average man in the street has woken up to the full consequences of analogue turn-off yet. He is still being seduced by the idea of lots more TV, but is gradually finding that most of it is utter pap. And, let's face it, you can only watch one channel at a time. He has yet to realise that *every* TV and video recorder throughout the house will have to be replaced, or at least converted with a set-top box. Just one box for the whole house will not do, because that would mean the kids upstairs have to watch the same thing as everyone else.

VCRs are not amenable to set-top boxes either, because there is no way to persuade the box to change channel and record something else unattended. These functions will have to be part of a VCR specifically designed for digital terrestrial. What is the cost of replacing all the receivers in a household? £1500? Hands up caravan owners with a TV, or people who use pocket TVs out and about at sports venues or whatever. You'll have no joy there when analogue is pulled.

No-Go Nooks

There are nooks and crannies in Britain that manage on a mediocre signal now, but will be no-go for digital. An analogue signal degrades gracefully, and has to go down a long way before it becomes totally indecipherable. Not so with digital: lose enough bits that the error correction gives up, and that's it. Nothing. Ask people with digital how often a bird on the aerial interrupts the programme. You could feed more power into each digital channel, but actually the broadcasters just want to spread it over more channels.

I'll go out on a limb here and suggest that analogue switch-off is also a nail in the coffin for electronic engineering in general. Tell me how many professionals and

enthusiasts first cut their teeth making a basic radio receiver? Maybe I'm stretching a point, but it is just possible for an interested amateur to put together a TV if he really tried, from scratch and first principles.

That is absolutely not possible for digital TV, and who says that radio broadcasts would not eventually go the same way? What happens in a national state of emergency, when some disaster has crippled the communications infrastructure and there is nobody to get a digital TV/radio to work? We could cope if analogue was still available.

Poorly Explained

Where is the imperative for analogue switch-off coming from? Am I missing something? The Government should at least be called to account by our political opposition, and yet there seems to be no opposition at all. As far as I know, neither the case for nor the case against has formed part of any of the party manifestos leading up to the recent general election.

There has been a general lack of consultation, and the Government should explain to us why they are doing this – in terms other than "wouldn't it be nice if...". They should at the same time explain why on the one hand they wish to get the nation fitter by taking more exercise and becoming involved in community activities, and yet on the other hand be seeking to provide more reasons (?) to be couch potatoes. Perhaps it is some kind of weird reverse logic aversion therapy.

I, for one, am 100% against analogue switch-off. There is no need of additional services beyond what's already available on cable and satellite, and what might be possible with broadband (just another form of cable really).

The publicly funded BBC should focus on putting quality programmes on its core services and forget about expanding into umpteen other channels. If there is a real consumer demand, let private enterprises serve it by whatever means available (Sky, NTL) and charge for it, but leave the existing service alone. I for one will join the ranks of giving up telly altogether if analogue goes – I can't find the time to watch the bits I would like to as it is.

Ken Wood, via email

Editor Mike replied to Ken:

Thank you for a very interesting letter – I am fully in agreement with you, even though I would like better quality pictures if possible.

Crossword Update

Dear EPE,

As a result of chatting with several readers I have made some updates to the Crossword Solver (May '05) code. These changes address the following issues:

1. The l.c.d. access routines would not always start properly on powerup. This was due to some critical timing issues associated with using the l.c.d. in 4-bit mode.

2. Words greater than 16 characters had a character missing when displayed.

3. The unit did not reject a request for a word longer than its biggest entry, resulting in rubbish being displayed.

All these are fixed in this release.

Mike Hibbett, via email

Thanks Mike, your new code has been put on our Downloads site and has also been sent to Magenta.

TK3 Link to Proton+

Dear EPE,

You may be interested to know that I have produced a *Toolkit TK3* link for PDS. The design of this link was not to modify the *TK3* source code but instead to change the file *TK3settings.txt*. *TK3Link* acts as the programmer by transferring the HEX and ASM files compiled by PDS along with the PIC type used in the code. Once this information has been transferred, *TK3* will be automatically launched. You can download from: www.foxnet.co.uk.

Your articles have been a great source of inspiration to me over the years, great work, thank you.

Paul Fox, via email

Thanks Paul, that's a great idea implemented. I've also put your code on our Downloads site, in the TK3 folder.

CADs Galore

Robert B. Fairbairn in Readout July '05 was asking about good low-cost CAD software for drawing p.c.b.s, etc. Lots of readers kindly responded, as follows. Thanks everyone.

Serif DrawPlus is a program which is easy to use and said to be as good as CorelDraw (usual disclaimer). I believe they are up to DrawPlus 9 or 10 now, but a free version of DrawPlus 4 can be downloaded from Serif's website at www.freerisefsoftware.com/default.asp.

Alan Jones, London

I have used Microsoft's Visio to produce schematic drawings for support documents whilst working in the UK electricity supply industry. It is fairly intuitive to use and I managed to obtain an OEM (no paper manual) CD ROM of Visio 2000 at a computer fair for around £35 for home use. Coming from the MS stable it has the advantage that it is compatible with Word, Excel, PowerPoint etc. AutoCAD is the de facto CAD standard in most industries, but is quite expensive and (in my experience) is not as intuitive.

Dave Reeves, Sutton Coldfield

Freeware software called Eagle should meet Robert's needs. The full version is for

professional applications, but I find the freeware version adequate for most hobbyists, supporting schematic layout and automatic generation of a "rat's nest" to facilitate artwork layout for a double-sided p.c.b. up to 4in x 4in (10cm x 10cm) in size. It also has an extensive library that can be easily expanded. Full details and the freeware download link can be found at www.cadsoft.de.

John Harris

I suggest that Robert takes a look at www.openoffice.org. Their drawing program is extremely good. I have used it on numerous occasions, although I have not drawn a circuit diagram.

Victor Moisey, University of Cape Town

I can recommend ePanorama website (www.epanorama.net/links/software.html) as an excellent resource. This site lists a range of packages in each category, for both Linux and Windows, with prices ranging from the free to the expensive professional packages. Many of the paid-for packages do include free demonstrations, so you can try before you buy.

Gavin Wheeler, Pembrokeshire

I recommend Matt Pyne's excellent open source program TinyCad for Windows. This is a full featured schematic design program which is described on Matt's site as follows:

"TinyCAD is a program to help you draw circuit diagrams. It comes complete with symbol libraries to get you started straight away. As well as being able to simply print your designs, you can use TinyCAD to publish your drawings by copying and pasting into a Word document, or saving as a PNG bitmap.

"You can use TinyCAD as a front end to a p.c.b. layout program (see the links), by getting TinyCAD to create a netlist of your circuit. It is fully open-source so you can use it for free and you can download the source code for use in your own projects."

Matt was extremely helpful with my installation problem in Win98 first edition (the latest issue solves the problems I experienced) and the program can export netlists to various freeware programs including SPICE, p.c.b. and stripboard layout software. These can be reached by links from Matt's site: <http://tinycad.sourceforge.net>.

David Howse

Provided Robert can access a Linux machine I would suggest he takes a good look at the gEDA suite at www.geda.seul.org. This is licenced under the GPL and therefore free to download and use. It has a circuit capture program "gshem", a p.c.b. layout program "PCB" and various other related tools. The learning curve is a bit steep but there is an active support group.

A 79MB CD ROM ISO image is available via this site. To show what is possible with this, take a look at <http://dlhamon.com/dspcard/index.html>. This site also has links to some interesting information on reflow soldering of multipin surface mount components using cheap sandwich ovens.

Colin Ager, Garboldisham, Norfolk

Rotary Encoders

Dear EPE,

I'd like to make a suggestion to anyone developing PIC projects. Many PIC projects feature a pair of Up/Down pushbutton switches which are used to set various parameters, the number being displayed on an l.c.d. However, this is not always very user-friendly, particularly if a parameter has to be changed frequently.

Rotary encoders look much like potentiometers, but contain a pair of switches which operate as the control is turned. By counting pulses, a PIC can tell how far the control has been turned, and by watching the order in which the switches operate, the PIC can tell whether the control has rotated clockwise or anti-clockwise. Now instead of pressing a button 30 times, one simply dials up the required number.

Rotary encoders also have the advantages of reducing the number of holes in the front panel, and constructors can choose from a wide range of knobs to give the project the desired appearance.

Rob Strange, Kenilworth, via email

Yes, Rob, the problem of communicating with a PIC can be significant in some cases and a multitude of options are available. A rotary encoder can be one answer, providing its starting position is always known (not actually the case with all such devices).

Frequency Calc Prog

Dear EPE,

Looking at July '05 page 483 (*LF and VLF Converter*) there's the usual resonant-frequency formula. Some time ago I wrote an HTML/Javascript program for this calculation. Feel free to invite readers to obtain a copy from me by sending a floppy and stamped/addressed envelope.

Godfrey Manning, 63 The Drive, Edgware, Middlesex, HA8 8PS.

Another useful offering Godfrey, thank you!

PC PWM PSU

Dear EPE,

I am building Robert Penfold's *Computer Controlled PWM Power Supply* from June '05. I would be grateful if you could explain to me the reason for using the 4k7 resistor between the emitter of the TIP121 transistor and ground. The article explains that this resistor is required to maintain a significant load on the TIP121. Why is a "significant load" required?

Noel Dillon, via email

Robert explains:

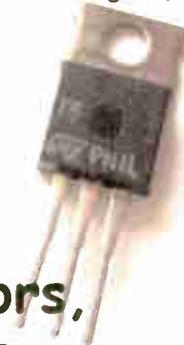
A power transistor does not usually operate properly unless it passes a current of a milliamp or two. The load resistor simply ensures that this condition is always met. In practice it is likely that there would be sufficient loading on the output anyway. It is only if (say) the output was checked using an oscilloscope or other high resistance load that the load resistor would be required. If you leave it out, the supply will still work properly in most situations.

Robert Penfold, via email



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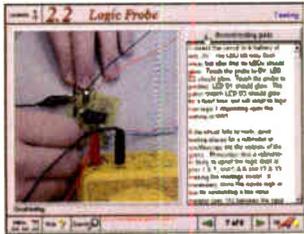


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ELECTRONICS PROJECTS

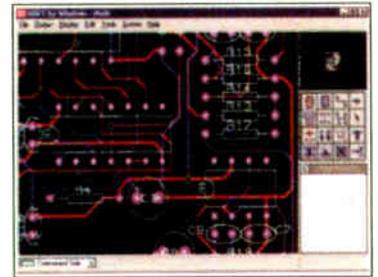


Logic Probe testing

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.

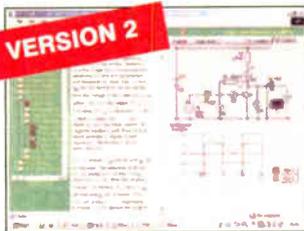
ELECTRONICS CAD PACK



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.

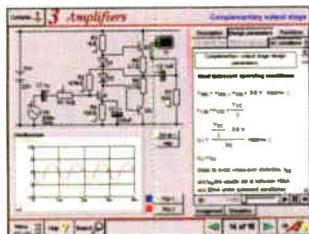
ELECTRONIC CIRCUITS & COMPONENTS V2.0



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.

ROBOTICS & MECHATRONICS

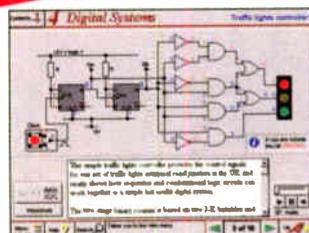


Case study of the Milford Instruments Spider

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
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

DIGITAL ELECTRONICS V2.0

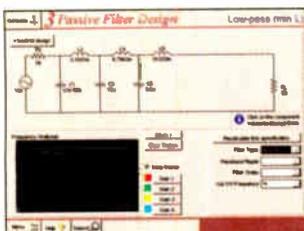


Virtual laboratory – Traffic Lights

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

PRICES

Prices for each of the CD-ROMs above are:

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Hobbyist/Student	£45 inc VAT
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Site Licence.....	£499 plus VAT

PICmicro TUTORIALS AND PROGRAMMING

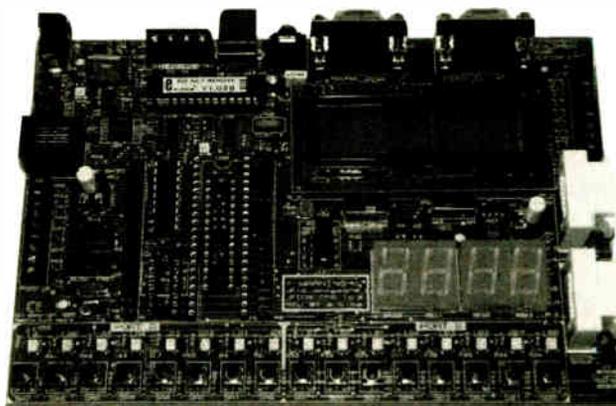
HARDWARE

VERSION 3 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual i.e.d.s, quad 7-segment display and alphanumeric i.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)



£158 including VAT and postage

supplied with USB cable and programming software

SOFTWARE

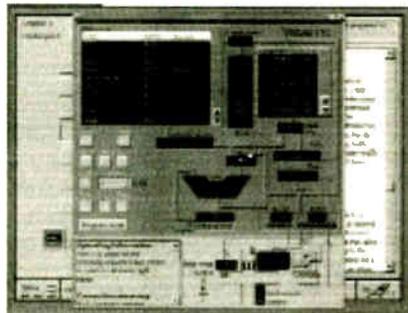
Suitable for use with the Development Board shown above.

NEW V3

ASSEMBLY FOR PICmicro V3 (Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

- 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.



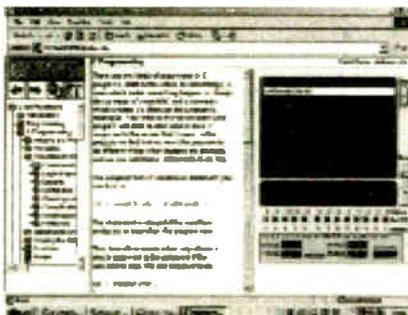
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

- 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.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

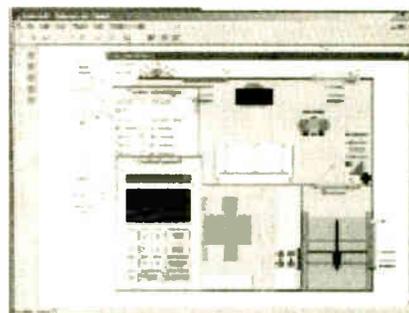
FLOWCODE FOR PICmicro V2

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and i.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
- Allows complex PICmicro applications to be designed quickly
- Uses international standard flow chart symbols (ISO5807)
- Full on-screen simulation allows debugging and speeds up the development process
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- Professional versions include virtual systems (burglar alarm, buggy and maze, plus RS232, IrDa etc.).



Burglar Alarm Simulation

PRICES

Prices for each of the CD-ROMs above are:

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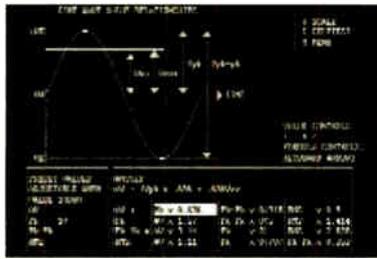
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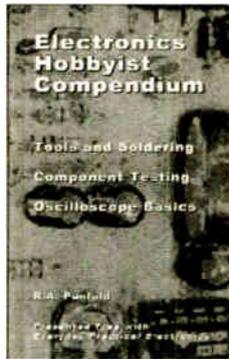
TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

EPE's own Teach-In CD-ROM, contains the full 12-part Teach-In series by John Becker in PDF form plus the Teach-In interactive software (Win 95, 98, ME and above) covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed Basic Soldering Guide which is fully illustrated and which also includes Desoldering. The Teach-In series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue. Each part has an associated practical section and the series includes a simple PC interface (Win 95, 98, ME ONLY) so you can use your PC as a basic oscilloscope with the various circuits.



Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM

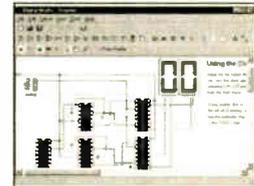


A hands-on approach to electronics with numerous breadboard circuits to try out.

£12.45 including VAT and postage. Requires Adobe Acrobat (available free from the Internet – www.adobe.com/acrobat).

FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning. **Hobbyist/Student £45 inc. VAT. Institutional £99 plus VAT. Institutional 10 user £249 plus VAT. Site Licence £599 plus VAT.**

ELECTRONICS IN CONTROL

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Contains a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects. Version 3 includes data and circuit modules for a range of popular PICs; includes PICAXE circuits, the system which enables a PIC to be programmed without a programmer, and without removing it from the circuit. Shows where to obtain free software downloads to enable BASIC programming. Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

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A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details). Also contains a **FREE 30-day evaluation of Paint Shop Pro 6** – Paint Shop Pro image editing tips and on-line help included!



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Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

Please send me: **CD-ROM ORDER FORM**

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- Assembly for PICmicro V2
- 'C' for PICmicro V2
- Flowcode V2 for PICmicro
- Digital Works 3.0

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 - Institutional
 - Institutional/Professional 10 user
 - Site licence



- PICmicro Development Board V2 (hardware)
- Development Board UK plugtop power supply
- Development Board 25-way connecting lead

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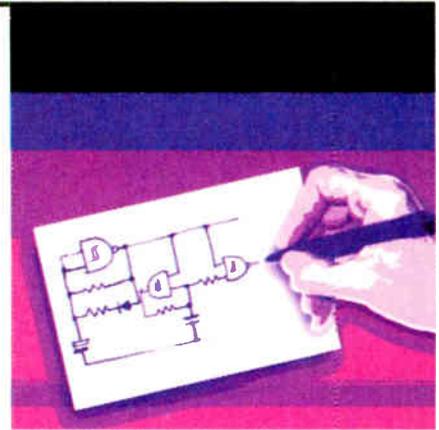
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Back to Basics – CMOS Logic Devices

Bart Trepak



Part 6 – Daily Reminder and Whistle Switch

Illustrates how useful circuits can be designed simply using CMOS logic devices as the active components

THIS little Daily Reminder gadget has been designed to be a reminder for doing regular events, such as taking medication. It not only indicates the day of the week but also sounds an alarm once each day. When the reset button is pressed, the alarm is cancelled and will not sound again until the following day.

The unit may also be useful as a week-days-only reminder, in which the alarm can be disabled at weekends. Although it is possible to set the day of the week, it is not possible with this simple circuit to set or show the time of day. The day of the week therefore changes and the alarm sounds every 24 hours from the time the unit is first started. It is an easy matter to start the unit at, say, 7.30 a.m. on the first day and it will then continue to sound the alarm at this time every day.

To save battery power, the display is only enabled when a switch is pressed. The alarm, however, will sound each day (unless disabled at weekends) and will sound for one minute unless silenced by pressing the reset switch.

Basic Operation

The basic operation of the unit is shown in the block diagram of Fig.6.1. The first part is a binary counter which provides the timebase for the circuit, dividing the input frequency to provide one pulse per day.

The clock signal to the counter is indirectly derived from the 50Hz (or 60Hz) a.c. mains frequency. The high input impedance of CMOS devices is used to advantage to pick up the frequency signal without the need for a direct connection to the mains supply. Of course, a mains electricity supply must be within the vicinity!

Since we are not concerned here with seconds or hours, the outputs of the counter are decoded for a count of 4,320,000 (or 5,184,000 for a 60Hz input) which is the number of mains cycles that occur in one day. The output of the decoder is used to reset the counter at the end of this count, following which it begins counting from zero again.

The daily reset pulse is also used to advance a divide-by-seven counter and

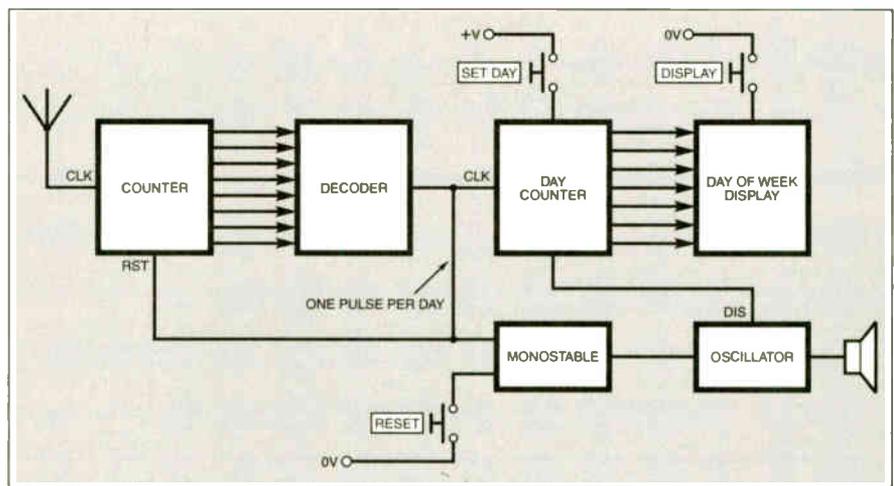
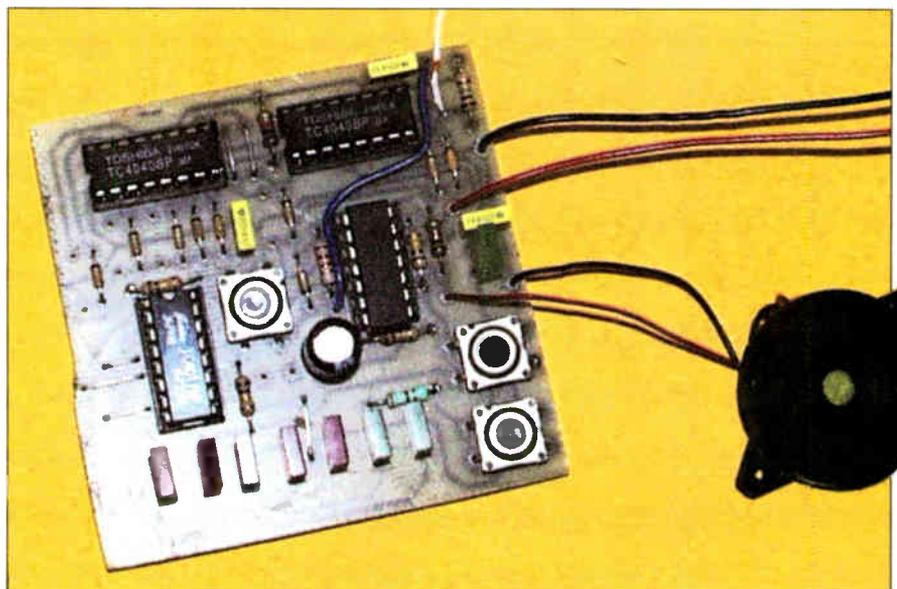


Fig.6.1. Block diagram for the Daily Reminder

the decoded outputs of this drive seven l.e.d.s to provide the day of the week display. It also triggers a monostable which enables an oscillator to sound the alarm for a preset time. The alarm continues until it is acknowledged by pressing the reset switch or the monostable times out.

Alternatively, it is possible to rewire the monostable to function as a bistable, in which case the alarm will sound continuously until disabled by pressing the reset switch. This may be useful in situations where an alarm sounding for only a short period may be missed.



COMPONENTS

DAILY REMINDER

Resistors

R1, R5	1M (2 off)
R2, R3, R6,	
R9	100k (4 off)
R4, R7	10k
R8	390Ω

All 0.25W 5% carbon film

Capacitors

C1, C3, C4	100n ceramic disc, 5mm pitch (3 off)
C2, C5	100μ axial elect. 16V (2 off)

Semiconductors

D1 to D9	1N4148 signal diode (9 off)
D10 to D17	red or green l.e.d. (8 off)
IC1, IC2	4040 binary ripple counter (2 off)
IC3	4017 decade counter
IC4	4093 quad Schmitt NAND gate

Miscellaneous

S1, S3, S4	min. push-to-make switch, p.c.b. mounting (3 off)
S2	see text
WD1	piezo sounder (passive)

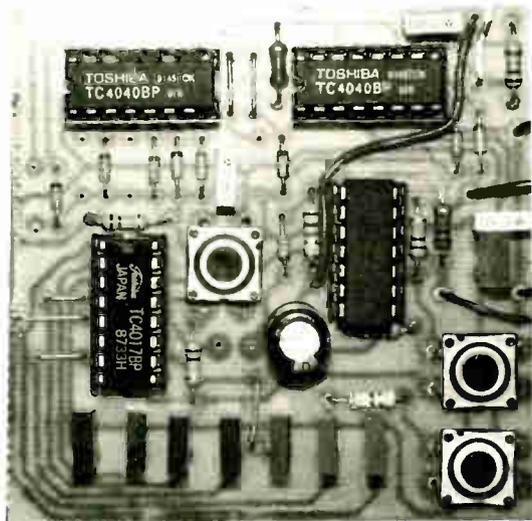
Printed circuit board, available from the *EPE PCB Service*, code 527; 14-pin d.i.l. socket, 16-pin d.i.l. socket (3 off); 9V battery and connector, connecting wire; solder etc

Approx. Cost
Guidance Only

£15

excl case and
batts

See
SHOP
TALK
page



gate, formed by diodes D1 to D8 plus resistor R3. Since these will all be switching high and low at various times, the output of this AND gate will normally hold IC4a input pins 1 and 2 low since at least one output of the counter will be low at any one time.

After 4,320,000 clock pulses, however, all of the selected outputs will be high together for the first time, so that the output of the AND gate will go high.

In theory, this output could be used to reset the counters, but in practice if one counter (or even one stage in the chain)

In this circuit, therefore, the output of the AND gate is connected to IC4a, which functions as an inverter so that its output goes low when the above count is reached. This sets the monostable formed by IC4b and IC4c, causing the output of IC4c to go high, resetting the counter chain via capacitor C1. The C1/R4 combination ensures that a pulse long enough to reset both counters is produced, after which they start counting from zero all over again.

With the counters reset, the output of the AND gate goes low again and the output of

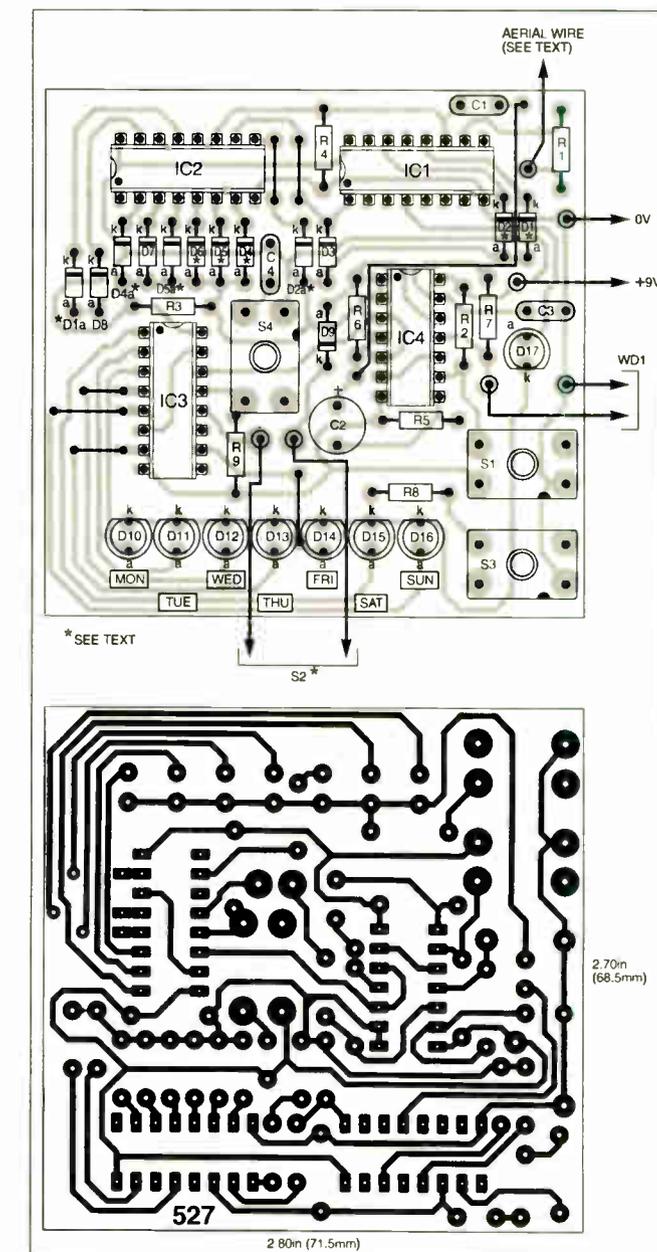


Fig. 6.3. Printed circuit board component layout, wiring details and full-size copper foil master for the Daily Reminder

responds to the reset pulse faster than the others and its output goes to zero, the output of the AND gate would go low again, which could result in a partial reset of the counter.

IC4a goes high, triggering the 4017 decade counter. IC3, causing its next output (e.g. Q1, Tuesday) to go high, and its previous output (e.g. Q0, Monday) to go low. This is indicated on the respective l.e.d. (D10 to D16) when the display switch S3 is pressed.

Output Q7 of the 4017 counter is connected to its reset input so that after Q6 (Sunday) the counter will be reset and output Q0 (Monday) will go high.

Since the clock input of IC3 is mostly held high, the counter can also be advanced on the negative transition of the CI input and this is used as a convenient way of setting the day display as required, using switch S4. Note that the counter will advance each time S4 is released rather than when it is pressed.

Weekend Break

The COUT (carry) output is also used in this circuit. This output is high when outputs Q0 to Q4 are high, but goes low when Q5 or above is high. This is the case when

the Q5 or Q6 (Saturday and Sunday) outputs are reached and so this output thus forms a convenient "weekend" output.

When the output of IC4c goes high, the oscillator formed by IC4d is enabled, sounding the alarm and alerting the user that a "new day" has begun (dependent on the time that the unit is first switched on).

If switch S2 is closed, however, diode D8 will ensure that the oscillator remains disabled at weekends because the low logic level at COUT will prevent the control input from going high. In this way the alarm can be disabled during weekends in applications that require this.

Once the alarm is sounding, it can be silenced by pressing switch S1, which resets the monostable IC4b/IC4c and disables the oscillator. If this is not done, the alarm will switch off automatically after a time determined by capacitor C2 and resistor R5, which with the component values shown will be around 70 seconds.

This period may be extended by increasing the value of C2 or R5, or made indefinite by replacing C2 with a wire link. This will effectively change the monostable built around IC4b/IC4c into a bistable and cause the alarm to sound continuously until silenced by pressing S1.

Construction

Printed circuit board component layout and track details for the Daily Reminder are shown in Fig.6.3. This board is available from the *EPE PCB Service*, code 527.

All of the components (with the exception of the sounder and battery) are mounted on the board. This includes the

push-to-make switches S1, S3 and S4, while S2 is implemented as a wire link which should be fitted if the alarm is not required at weekends. In applications where this requirement could change often, a miniature slide or toggle switch could be fitted on flying leads instead.

Care should be taken to ensure that all of the diodes are connected the correct way around. The layout diagram shows the position of the diodes D1 to D8 required for correct operation with a 50Hz mains frequency.

Connections are provided on the p.c.b. to position the diodes for 60Hz operation if required and this will involve *not* fitting diodes D1, D4, D5 and D6 as shown but in the alternative positions instead, numbered with an "a" suffix. Diodes D2, D3, D7 and D8 should remain in the positions shown for 50Hz operation.

Normal precautions regarding static electricity should be observed with the i.c.s and these should be fitted into sockets rather than soldered directly to the board. The piezo sounder WD1 should be soldered to the pads provided and here, although it may have black and red leads, the orientation is not important.

A short piece of sleeved copper wire should be soldered to the pad provided to act as an "aerial". A single core wire is better for this because it is stiffer and may be wrapped around a mains cable more easily should this be required.

Seven links are required in the layout and these can be made from discarded component leads, except the long one (between C1 and R6). This should be

made from a suitable length of insulated wire to prevent unintended connections to components along its length.

Testing

When assembly is complete and fully checked, a battery should be connected and the Display switch (S3) pressed. The Monday I.e.d. should be lit and I.e.d. D17 should flash at around 1Hz. If D17 does not light, the aerial should be placed close to a mains field such as exists around the power cable to an appliance.

In some cases, the aerial may need to be wrapped around the cable a few times to give reliable results. It does not matter if the appliance is switched on or not as long as it is plugged in and the supply is *not* switched off at the socket. In this respect it is therefore best to utilise an appliance which is never switched off, such as a fridge/freezer.

Once D17 is flashing, Set Day switch S4 should be pressed repeatedly until the correct day is displayed (S3 should be kept pressed to enable the display). The setting up is now complete and the circuit will sound the alarm every 24 hours from this time. Switch S1 should be pressed to cancel the alarm after it has sounded.

Since the circuit will only sound the alarm after 24 hours, which is a rather inconveniently long time to spend testing the rest of the unit, things may be speeded up somewhat by temporarily removing IC2. This will cause the display to change and the alarm to sound after only 2816 input pulses, or about 56 seconds with a 50Hz input enabling the operation of the unit to be checked rather more quickly.

Whistle Switch

MOST modern remote controls use either infra-red or radio as the transmission medium because there are fewer natural interference sources of such radiation to upset the working of the system. They do, however, all have the major disadvantage in that a special transmitter is required to operate the link.

The system to be described here differs in that it uses sound as the medium so that no special transmitter is required. Unlike most sound-operated switches, which can be triggered by any sound of sufficient amplitude, this circuit is sensitive only to sound in a relatively narrow frequency band. It is specifically designed to respond to a whistle and will therefore ignore many naturally occurring sounds of other frequencies.

The frequency range to which the unit responds can be made quite small, allowing a number of units to be used in the same area. The sensitivity is such that operation from another room is possible. In practice, however, the difficulty in producing a whistle of exactly the right frequency means that the frequency range to which the receiver responds has to be broadened somewhat, thus limiting the possible number of independent receivers.

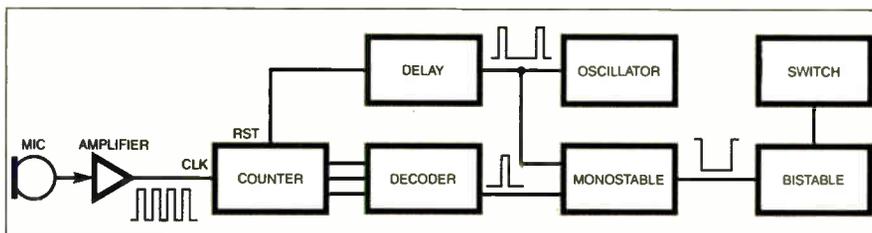


Fig.6.4 Whistle Switch block schematic diagram

For those who have difficulty in whistling, a simple tin whistle can provide a handy transmitter.

A relay, RLA, allows external devices to be controlled by this unit. **Note though that a.c. mains powered devices should only be connected by those who are suitably qualified or supervised.**

Basic Operation

A block diagram of the Whistle Switch is shown in Fig.6.4.

The input signal is picked up by a microphone and amplified before being applied to the clock input of a counter. The counter circuit assesses whether the frequency is within a certain range. Although

the circuit could be designed to determine the frequency quite accurately, in this application it would not be desirable as few people are able to whistle consistently at a given pitch.

The counter's measurement cycle is controlled by an oscillator which periodically resets the counter to initiate the next measurement. The counter is coupled to a decoder which determines if the expected count is received within a given time.

The output of the decoder is sampled at the end of each measurement period by a re-triggerable monostable. This ensures that only one output transition is obtained during each whistle command, which may extend over a number of measurement

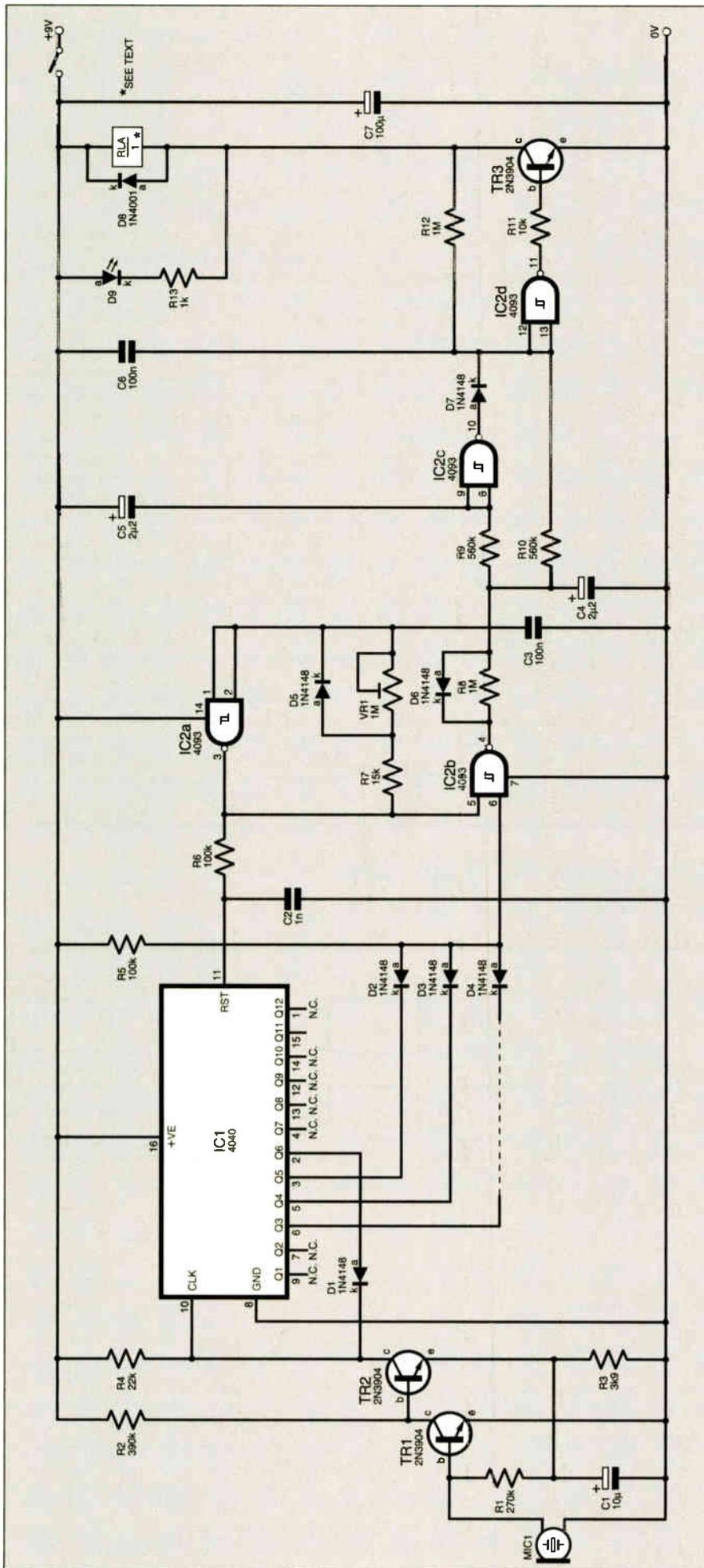


Fig.6.5. Circuit diagram for the Whistle Switch

cycles. The monostable's output is applied to a bistable which drives a relay switching it on or off each time a whistle in the correct frequency range is detected.

Circuit Diagram

The Whistle Switch circuit diagram shown in Fig.6.5 effectively uses the first six stages of a type 4040 binary counter, IC1, to determine the frequency of the signal. The whistle sound is detected by a piezo element, MIC1, amplified by the high gain amplifier formed around transistors TR1 and TR2, and then used to trigger the counter.

The amplifier uses relatively high value collector load resistors to achieve high gain and low current consumption (about 150µA) making it ideal for battery operation. The prototype easily worked over ranges in excess of seven metres, not necessarily within line of sight.

An oscillator built around Schmitt trigger NAND gate IC2a produces short pulses which regularly reset the counter via its pin 11. The pulse's mark-space width is determined by the imbalance between the charging and discharging rates of capacitor C3. The charging is principally via diode D5 and resistor R7. Discharging is via R7 and preset VR1, the latter slowing the rate. The pulse width is further modified by the action of resistor R6 and capacitor C2.

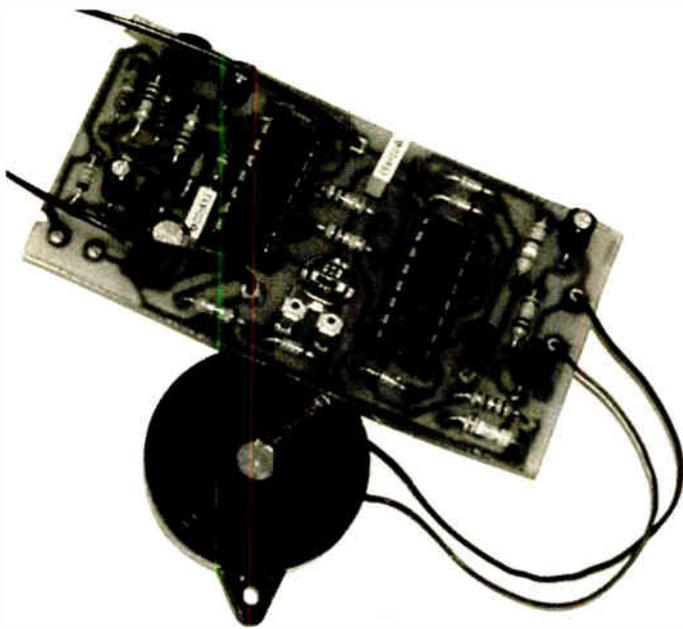
The waveforms in Fig.6.6 illustrate those that appear at various points in the circuit when an input in the required frequency range is detected. Starting at the end of each reset pulse, the counter counts the incoming clock signal (c) causing the counter's Q1 to Q6 outputs to change as shown (d to i).

The number of input cycles since the reset is shown above waveform (a). Diodes D2 and D3 on the outputs Q4 and Q5, together with resistor R5, form an AND gate whose output is shown in waveform (j). It will be seen that the output of the decoder will only go high after 24, but less than 32, input pulses have been received. The dashed waveforms in (d) to (j) indicate what would happen if the next reset pulse did not occur at the time shown.

If the output of IC2a goes high during this time window, the output of NAND gate IC2b will go low as shown (k). Following a short delay (set by R6 and C2), the counter is reset via pin 11, causing all of its outputs and the output of the decoder to go low. The output of IC2b will therefore go high again so that only a short pulse is produced. The pulse duration is determined by the difference in time between IC2a going high and the counter being reset.

If too few input pulses (frequency too low) occur before IC2a output goes high, the output of the decoder will remain low and no output pulse will appear on IC2b output before the counter is reset.

The width of the decoder window may be made narrower by adding diode D4 to the decoder so that its output will go high only after 28 (but less than 32) input pulses have been detected, or wider by leaving out D3, producing an output after 16 clock pulses. Decoding counter outputs Q2 and Q1 could make the window narrower still, but in this application this would require a very



precise whistle frequency to operate the unit.

If more than 31 input pulses occur before the reset pulse (i.e. the input frequency is too high), outputs Q1 to Q5 will go low and output Q6 will go high. This will "short out" R4 via diode D1 preventing further input pulses from being counted so that the output of the decoder will remain low and prevent IC2b generating an output pulse when the reset pulse occurs. Higher whistle frequencies will therefore also be ignored.

The time between reset pulses, and thus the range of input frequencies which will be detected, can be varied by means of preset VR1 which sets the frequency of the oscillator.

When the output of IC2b is high, capacitor C4 is charged at the rate set by resistor

R8, but when a correct frequency whistle is detected and the output of IC2b goes low, C4 is quickly discharged via diode D6. Provided the whistle continues to be received, C4 is unable to recharge via R8 and the voltage across it remains low. This low logic level is applied to the input of the bistable formed by the remaining gates IC2c, IC2d and transistor TR3, which also serves as a relay driver.

Bistable

If IC2d inputs 12 and 13 are high, its output will be low and

TR3 switched off causing its collector (c) to be high. This will keep IC2d's inputs high via feedback resistor R12 and the circuit will remain in this state indefinitely. If on the other hand IC2d's inputs go low, its output will go high, TR3 will switch on and its low collector voltage will keep IC2d input low so that the circuit will also be stable in this state.

Assuming that the inputs of IC2d are high (relay off), when the voltage across C4 goes low, capacitors C5 and C6 charge via R9 and R10, causing the voltage at IC2c and IC2d inputs to fall. The charging resistors are equal in value, but since C6 has a much smaller value than C5, the voltage at IC2d's inputs will fall much faster and will reach the lower logic threshold first. Consequently, IC2d's out-

put will switch high, turning on TR3 and energising the relay.

If the whistle now ceases, the voltage across C4 will rise, C5 and C6 will discharge and the circuit will remain in this new state. If another short whistle is now detected the process would be repeated and the output state would not change. However, if the whistle now lasts long enough for the voltage across C5 to reach the lower logic threshold of IC2c, its output will go high and discharge C6 via D7,

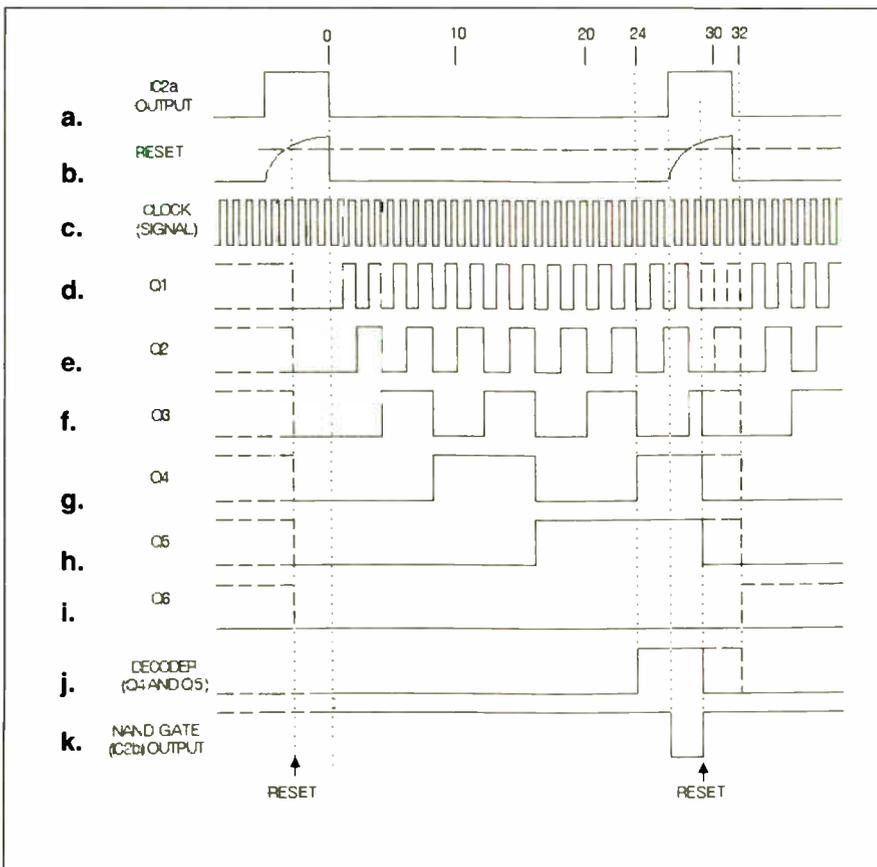


Fig.6.6. Whistle Switch circuit waveforms

COMPONENTS

WHISTLE SWITCH

Resistors

R1	270k
R2	390k
R3	3k9
R4	22k
R5, R6	100k (2 off)
R7	15k
R8, R12	1M (2 off)
R9, R10	560k (2 off)
R11	10k
R13	1k

All 0.25W 5% carbon film

Potentiometer

VR1	1M skeleton preset
-----	--------------------

Capacitors

C1	10 μ radial elect. 16V
C2	1n ceramic disc, 5mm pitch
C3, C6	100n ceramic disc, 5mm pitch (2 off)
C4, C5	2 μ 2 radial elect. 16V (2 off)
C7	100 μ radial elect. 16V

Semiconductors

D1 to D7	1N4148 signal diode (7 off)
D8	1N4001 rect. diode
D9	red l.e.d.
TR1 to TR3	2N3904 npn transistor (3 off)
IC1	4040 12-stage ripple counter
IC2	4093 quad Schmitt NAND gate

Miscellaneous

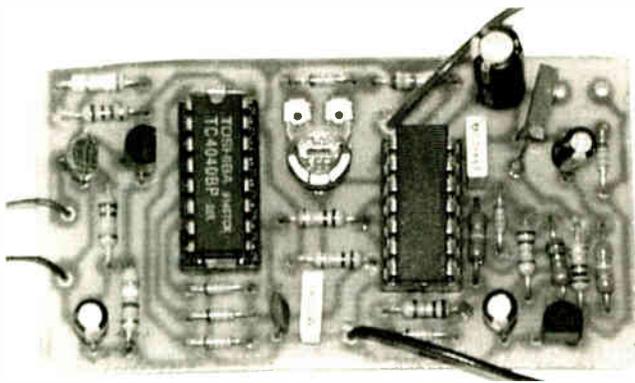
MIC1	piezo element disc, passive
RLA	relay (see text)
S1	s.p.d.t. toggle switch

Printed circuit board, available from the EPE PCB Service, code 528; 14-pin d.i.l. socket, 16-pin d.i.l. socket (3 off); 9V battery and connector (see text), connecting wire; solder, etc.

Approx. Cost
Guidance Only

£12

excl case, relay
and batts



Completed prototype Whistle Switch circuit board. The two unconnected pads at the top right go to the relay coil

The relay can therefore be switched on by means of a short whistle, while a longer one will switch the relay off. Indication of the relay's state is provided by l.e.d. D9, which is buffered by R13.

Diode D8 inhibits back-e.m.f. generation when the relay switches off.

Construction

Printed circuit board component layout and track details for the Whistle Switch are shown in Fig.6.7. This board is available from the *EPE PCB Service*, code 528.

Construction should proceed with normal precautions being taken to observe the correct polarity of semiconductors and electrolytic capacitors. The polarity of the piezo sounder is unimportant. Observe the normal antistatic precautions when handling the i.c.s. Do not insert the i.c.s. until the board has been fully checked for errors.

The type of relay fitted will depend on the type of load to be controlled and the output contacts should be rated to handle the current and voltage to be switched. The relay coil should be connected to the circuit board with flying leads and diode D8 fitted on the board.

The circuit will operate from a range of voltages from 5V to 12V and the relay should be chosen for the voltage used, although in practice most relays will operate from a range of voltages. Higher resistance coils are to be preferred as these will draw less current.

The circuit draws less than 1mA from a 9V supply, but this rises substantially when a relay is switched on so that in most applications a small d.c. mains adapter will be a more practical proposition.

Testing

The circuit may be tested using a battery supply. A relay need not be fitted at

this stage as i.e.d. D9 will indicate its correct operation. If an oscilloscope is not available should fault finding be needed, a digital voltmeter connected across capacitor C4 can indicate when a whistle in the correct frequency range has been detected.

The upper voltage across C4 varies with the supply voltage, but it will be seen to fall to below 2V when a correct frequency whistle is received. Adjust preset VR1 until the circuit responds, with l.e.d. D9 turning on and off accordingly.

Because of the relatively high values of resistance in the circuit, the capacitors in the bistable can take a few moments to charge or discharge between operations. This means that the circuit cannot be switched on and off in quick succession. This is not a problem in normal use but should be borne in mind when testing the unit.

The completed unit should be mounted in a suitable box and the choice of this will be dictated as much by personal preference as by the application to which the unit is to be put. Remember to leave a hole near the microphone to allow the sound to enter.

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Parking Radar and a Telephone Switch.

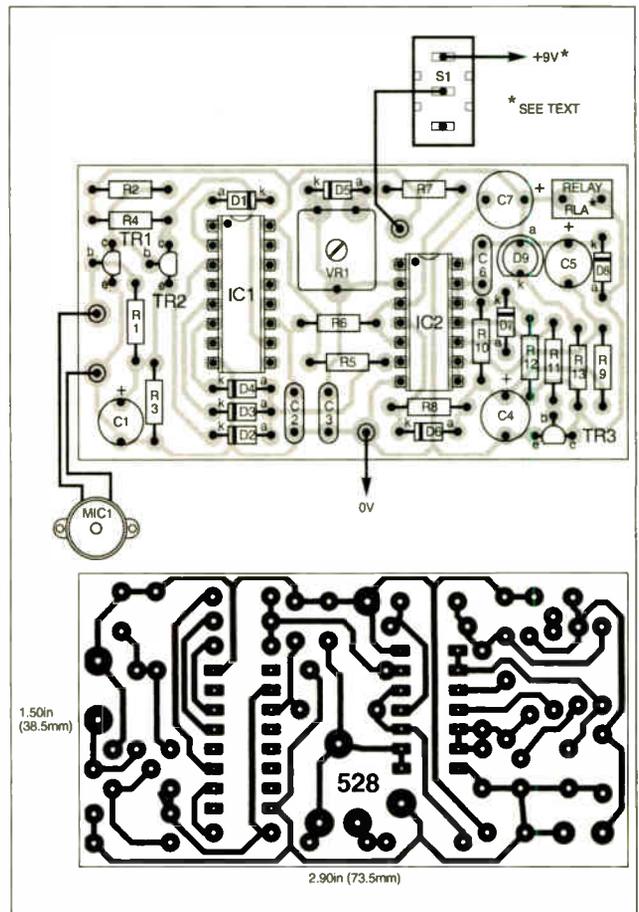


Fig.6.7. Whistle Switch printed circuit board component layout, wiring and full-size copper foil master

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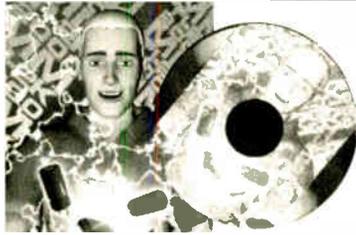
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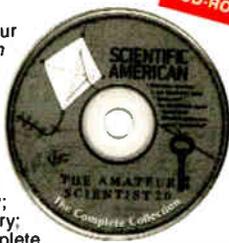
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PIC N' MIX

JOHN BECKER

Our periodic column for your PIC programming enlightenment

Using a DS1267 dual digital potentiometer with a PIC

THIS month and next we examine how a digital potentiometer chip can be interfaced to a PIC. The device chosen is the Maxim DS1267 dual digital potentiometer. This is available in three standard dual-in-line (d.i.l.) pinned versions, in which the two pots each have basic values of 100k (DS1267-100), or 50k (DS1267-50) or 10k (DS1267-10).

The one chosen by the author for use in a forthcoming design for *EPE* is the DS1267-100. For the sake of this demo, any of the three devices may be used.

The DS1267 consists of two digitally controlled solid-state pots. Each pot consists of 256 resistive sections. Between each section on both ends of the pot are tap points which are accessible to the wiper. The position of the wiper on the resistive array is set by an 8-bit value.

Control of the device is via a 3-wire serial interface. This interface allows the device wiper position to be written or read.

Both potentiometers can be connected in series or stacked for an increased total resistance with the same resolution. The DS1267 can be cascaded or daisy-chained. Its pinout diagram is shown in Fig.1 and the pin descriptions are given in Table 1.

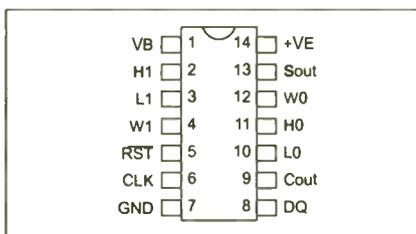


Fig.1. Pinouts for the DS1267

Operation

The two 8-bit wiper values and the stack select bit are written to a 17-bit I/O (input/output) shift register. The register arrangement is shown in Fig.2.

The controlling serial interface consists of three input signals, RST, CLK and DQ.

The RST control line must be high to begin any communication with the

Table 1: DS1267 Pin Descriptions

L0, L1	low end of resistor
H0, H1	high end of resistor
W0, W1	wiper terminal of resistor
SOUT	stacked configuration output
RST	serial port reset input
DQ	serial port data input
CLK	serial port clock input
COUT	cascade port output
+5V	+5V supply input (range 4.5V to 5.5V)
GND	ground (0V)
VB	substrate bias voltage (range -5.5V to 0V)

DS1267. The CLK line provides timing synchronisation for data input and output. The DQ line is used to transmit data to the 17-bit shift register.

The 3-wire protocol is illustrated in Fig.3a. As shown, the 3-wire port is inactive when the RST signal input is low. Communication via the port requires the RST input to be in a high state. Data is then entered into the device on the low to high transition of the CLK line. Basic timing is shown in Fig.3b.

It is worth noting that although timing notations are quoted in Fig.3b, and quantified in the full datasheet, the controlling PIC code shown in Listing 1 does not need these values to be actively considered. The demo software has been used successfully with a DS1267 and a PIC running at 10MHz.

Shift Register

Data written to the DS1267 is stored in the 17-bit I/O shift register (Fig.2). Bit 0 of the register contains the stack select bit, discussed presently. Bits 1 to 8 contain the wiper position for pot 1. Bit 1 is the MSB and bit 8 is the LSB. Bits 9 to 16 contain the wiper position for pot 0, with bit 9 as the MSB and bit 16 as the LSB.

Data transmission always begins with the stack select bit, followed by the pot 1 and then pot 0 wiper positions. When wiper data is to be written to (or read from) the DS1267, 17 bits (or some

integer multiple) of data must always be transmitted. Transmissions which do not send a complete 17-bits (or multiple) will leave the register incomplete and possibly an error in the desired wiper positions.

After a transmission has been completed, the RST signal should be taken low again for the new wiper position to become valid. On device power-up, the wiper positions are set at 50% of the total resistance, or binary value 10000000 (decimal 128).

Demo Program

The demo program, whose main code is shown in Listing 1, illustrates how data can be written to the pots. It was written for a PIC16F628, but can equally well be used with other PICs, such as the PIC16F8x and PIC16F87x families. All that is necessary is to change the PIC type references at the head of ASM code.

As written, the demo uses PIC pins RB0 to RB2, but other pins may be allocated instead. The connections between the DS1267 and the PIC are shown in Fig.4. The PIC may be run with any clock rate, crystal or RC controlled, with the configuration settings value amended to suit. The prototype was run at 4MHz, although the code has also been run on a 16F877 at 10MHz.

Note that if a -5V supply is not available, the -5V supply pin(s) may be connection to the 0V line.

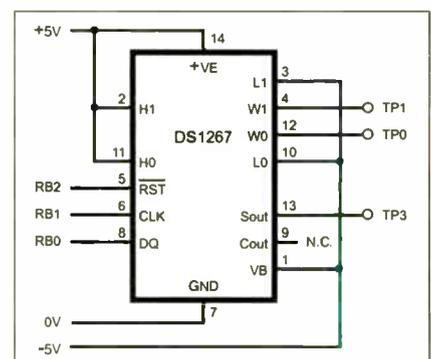


Fig.4. Demo connections

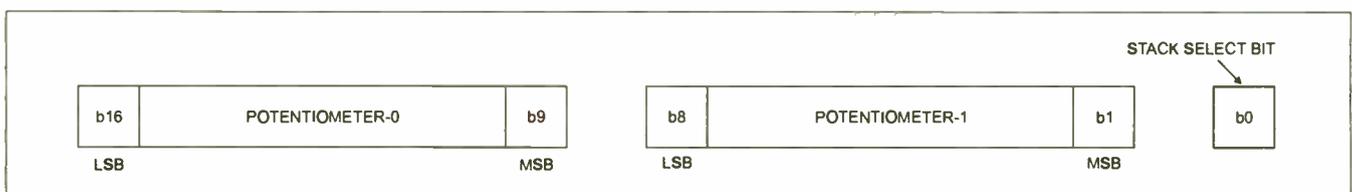


Fig.2. Internal register arrangement for the DS1267

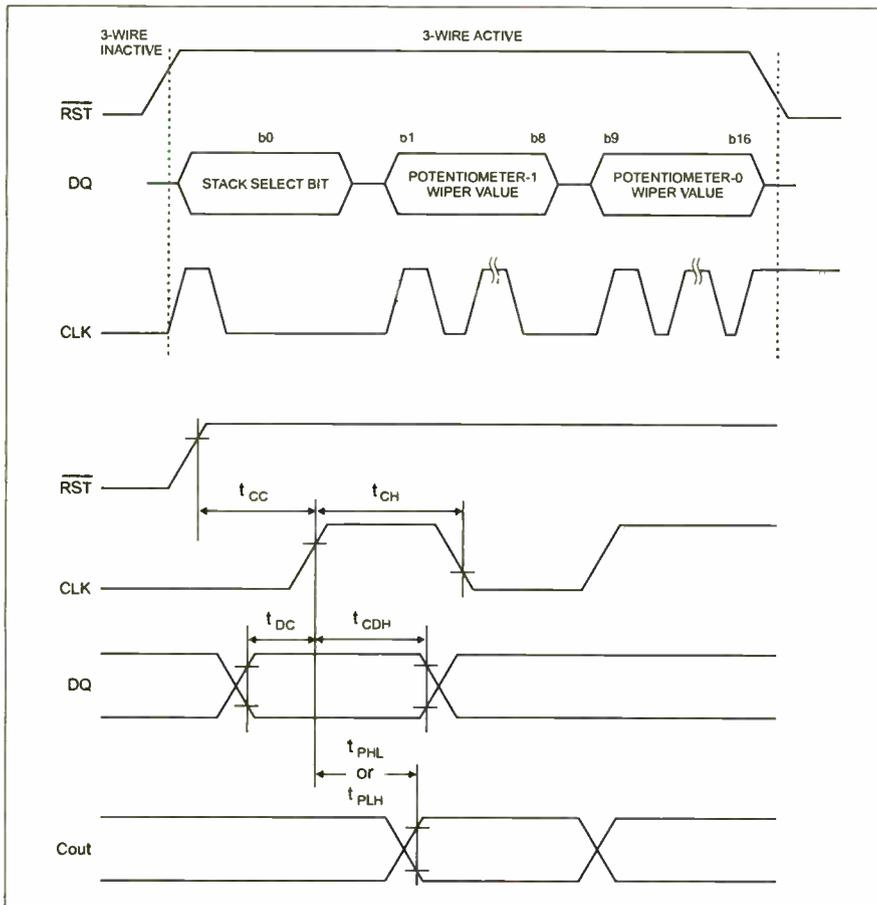


Fig.3. Control waveforms for the DS1267

LISTING 1. Demo Code

```

SETPOTS:  bsf PORTB,POTRST ; set to dig pot to receive data
           bcf PORTB,POTDATA ; clear stack bit
           call CLKPOT ; send stack bit

           movf POTVAL1,W ; send pot 1 val (chip 1)
           call POTOUT
           movf POTVAL0,W ; send pot 0 val (chip 1)
           call POTOUT
           incf POTVAL0,F ; inc pot 0 val
           decf POTVAL1,F ; dec pot 1 val
           goto ENDPOT ; delete this if sending to 2 digipot chips

           bcf PORTB,POTDATA ; clear stack bit
           call CLKPOT ; send stack bit
           movf POTVAL3,W ; send pot 3 val (chip 2)
           call POTOUT
           movf POTVAL2,W ; send pot 2 val (chip 2)
           call POTOUT
           movlw 3
           addwf POTVAL2,F
           movlw 5
           addwf POTVAL3,F

ENDPOT:   bcf PORTB,POTRST ; disable dig pot from receiving data
           goto SETPOTS ; repeat

POTOUT:   movwf STORE ; copy W into STORE
           movlw 8 ; set loop for 8 actions
           movwf LOOP

DIGLOOP0: bcf PORTB,POTDATA ; clear data bit
           rlf STORE,F ; rotate store left (MSB out first)
           btfsc STATUS,C ; is CARRY set?
           bsf PORTB,POTDATA ; yes, set data bit
           call CLKPOT ; send data bit
           decfsz LOOP,F ; dec loop, is it 0?
           goto DIGLOOP0 ; no, repeat for next bit
           return

CLKPOT:   bsf PORTB,POTCLK ; take dig pot clk high
           bcf PORTB,POTCLK ; take dig pot clk low
           return

```

The code is essentially a loop in which different values are written cyclically to the DS1267 pots. When the outputs of the pot wipers are viewed on an oscilloscope, a falling sawtooth will be seen on wiper W0, and rising sawtooth on W1.

In Listing 1, the registers which hold the code to be written to the pots are named POTVAL0 and POTVAL1. In the PIC initialisation routine (not shown) they are first set to zero.

On entry to the routine starting at SETPOTS, the RST line is taken high, and the stack bit is cleared (bcf PORTB,POTDATA). The CLK line is then toggled up and down in sub-routine CLKPOT. This sets the stack bit into the DS1267 as bit b0.

Next POTVAL0's value is copied into W, the POTOUT routine is called, and the contents of W copied into STORE. A loop counter is now set for eight cycles. Within the loop the POTDATA bit is first cleared and the STORE register rotated left and into CARRY. If CARRY is set, so the POTDATA bit is also set. The CLK line is again toggled to send the data bit to the DS1267.

The loop counter is then decremented and, if not zero, the process is repeated for the next bit in STORE. When all eight bits have been sent (bits b1 to b8), a return from loop occurs. The process is then repeated for the POTVAL1 value (bits b9 to b16).

Following the return from this loop the POTVAL0 value is then incremented and POTVAL1 decremented. A jump is then made to ENDPOT, at which point the RST line is taken low, completing the sending of all 17 bits.

The data sending routine is then repeated by a jump back to label SETPOTS.

This continues indefinitely until the power is switched off. The result is the rising and falling ramp waveforms from the wipers as stated above.

The ten commands following goto ENDPOT will be discussed next month.

Stack Waveform

The output at stack register pin SOUT depends on the value of the stack register bit (b0). If b0 = 0 then the waveform at SOUT is the same as that at wiper W0. With b1 = 1 then the output is the same as at W1. This can be proved by monitoring W0 and SOUT while the PIC holds the demo code as illustrated. Now, in the ASM code, amend the line:

```

bcf PORTB,POTDATA ; clear stack bit
to:
bsf PORTB,POTDATA ; set stack bit

```

Re-compile the code to HEX and send that to the PIC. Now monitor SOUT and W1 to prove that the waveform of W1 is now being output at SOUT.

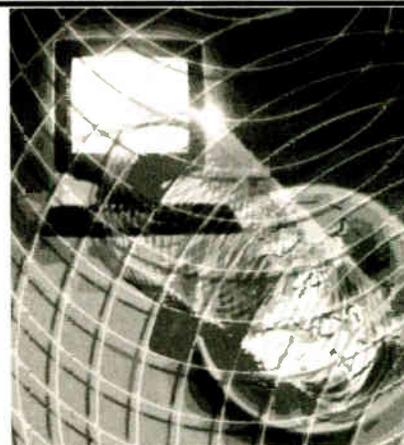
Resources

Software for this demo can be downloaded free from the EPE Downloads site, accessible via the home page at www.epemag.co.uk. It is held in the PICnMix folder, under PNMSEP05.

The complete datasheet for the DS1267 can be downloaded from www.maxim-ic.com.

Net Work

Alan Winstanley



A Growing Band

In the UK, the number of broadband users has outstripped dial-up (narrowband) customers for the first time. Last month I described how – at last! – ADSL broadband suddenly arrived in my worklab after many years of frustration and eager anticipation. The service (Tiscali's 512k) is bearing up well, although there have been a few worries about the reliability of outbound email.

One practical problem relates to the conversion of the fax line for broadband. A microfilter is used to enable the fax machine – an unreliable HP 6110 all-in-one – to function on the broadband line. Annoyingly, some fax machines now have problems negotiating properly when trying to send a fax to the author, whilst other machines are perfectly fine. Talk about one step forward...

Outward Bound

The other problem experienced after the broadband conversion has been the sending of email. This has proved somewhat unreliable at times, possibly due to maintenance or overloaded servers, but it has occasionally been a trial to send mails through Tiscali's outbound mail servers. Problems come and go in phases.

As regular *Net Work* readers will know, outgoing emails are usually handled by the ISP's own SMTP (Simple Mail Transfer Protocol) server. If this were not the case, then users could connect to the Internet through any ISP and then potentially burden another ISP's outgoing mail server with spam.

Other strange outbound mail problems can arise due to a number of reasons. BT's own Internet Service Provider has been known to cause erratic problems when trying to send mail under a user's own domain name. Outbound mails with a FROM: address of <me>@mydomain.co.uk may fail to be sent, and only by sending it as FROM:<username123>@btconnect.com (or similar) will mails be successfully transmitted.

In one case that the writer had to deal with, after a long spell without any problems at all, BT's broadband service suddenly blocked the transmission of a business customer's domain mail, and in a rather unusual move, BT validated the registration details of the said domain name by searching Nominet's database. BT is checking up on its customers. Not convinced by what they found, mail relaying is still denied by BT and the customer is still unable to send his own domain mail, effectively being treated as a serial spammer.

If your ISP does not allow outbound mail relaying then it will not be possible to use your domain name as a sender's address. Amongst other ISPs, Tiscali, Demon and Wanadoo (formerly Freeserve, and due to change its name to Orange) will all allow own domain mails to be sent successfully without problems.

AOL users who also have their own domain name have the same mail relaying problem:

only <screenname>@aol.co.uk/.com succeeds as a FROM: address. Incidentally, AOL users are not compelled to use AOL's proprietary email and browser programs. They can use Microsoft Outlook, Outlook Express, Eudora or other IMAP compatible software to handle emails, and can also fire up MSIE to surf the web after connecting to the net through AOL.

Other outbound mail problems suffered by the author include mail bouncing due to the temporary blacklisting of a Tiscali SMTP server, perhaps the after-effects of a spam campaign. The problem for the author, then, was to find an alternative and more reliable way of sending multiple domain emails that short-circuited Tiscali.

ISP-Independent Mailing

This month I suggest a way in which outgoing emails can be sent regardless of which service provider is used to connect to the Internet. AuthSMTP (www.authsmtp.net) is a service designed specially for those who suffer SMTP problems with their ISP. Instead of using your ISPs' server, send all outgoing mail through AuthSMTP instead. The cost of the service is trivial at entry level, just £14 or \$25 per year, allowing up to ten FROM: addresses and 1,000 mails/100MB of outbound mail per month. At the other end of the scale, for £4,505 or \$8,009 per year, you can send up to half a million emails per month, or 50GB worth.

After completing the online sign-up procedure, which includes a rigorous verification of email addresses, AuthSMTP was enabled, although there were initially some frustrating problems when trying to get the author's Eudora mail software to use AuthSMTP properly. These were eventually overcome and no such problems are anticipated with e.g. Microsoft Outlook.

The author has nothing but praise for the pre-sales and technical support supplied by AuthSMTP, who delivered very rapid responses even in the early hours of the morning.

Their SMTP service provides a very simple control panel that enables usage to be monitored or new addresses to be set up. All outbound problems have been eliminated, and two months of testing have shown how AuthSMTP complements the broadband connection well, handling attachments and domain mail flawlessly. And remember that using AuthSMTP means that you can connect to the net using any ISP and simply configure your email program to send out via AuthSMTP. This

could be an ideal solution for many users that suffer problems sending mail, or even if you use a laptop around the country (world), you can fire all your email through the same SMTP server regardless of how you connect to the Internet. Users can sign up for a 14-day trial.

My thanks to reader *David Sims* who suggests a freeware program called Netmeter which helps you to gauge monthly usage. Similar to the DU Meter program I mentioned last month, you can download it from <http://readerror.gmxhome.de/>.

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

AuthSMTP is an independent SMTP server that may solve many problems with outgoing emails

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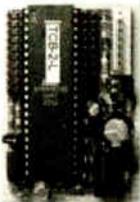
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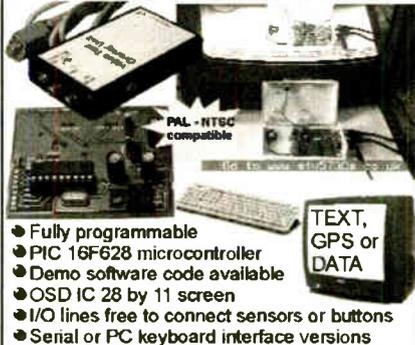
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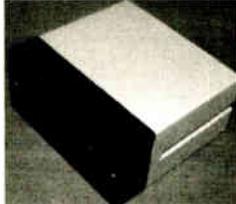
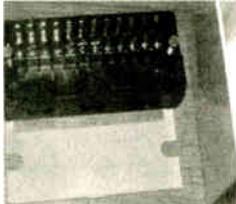
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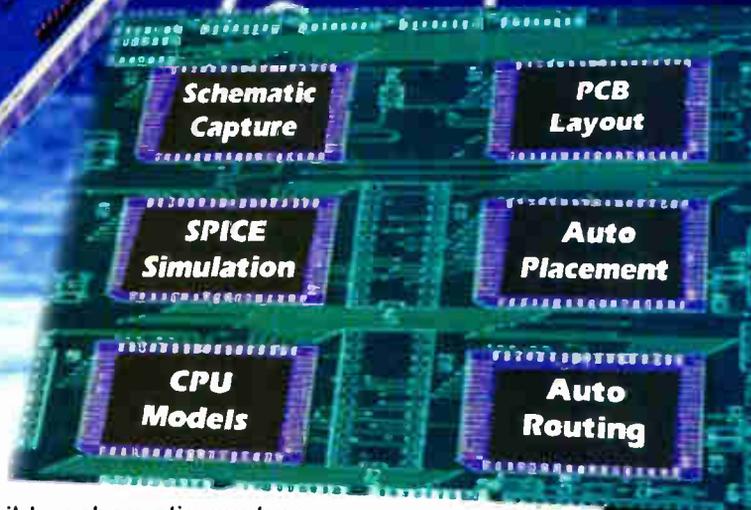
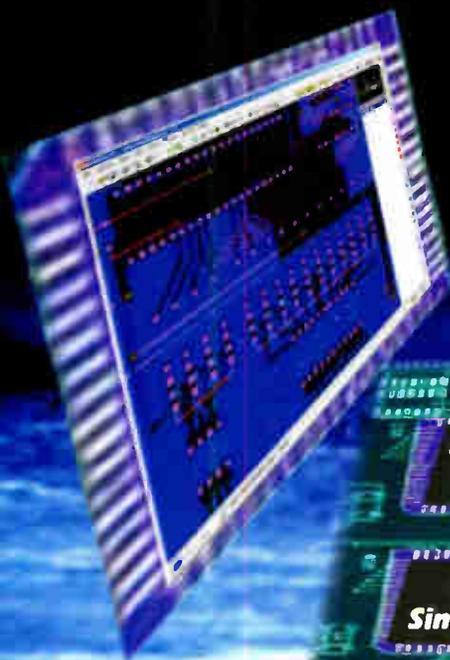
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