THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY

PRACTICAL ELECTRONICS

MARCH 2005

£3.10

PIC TOOLKIT TK3 SIMULATOR & PIC18F UPGRADE

Mini simulator providing initial software testing

CAT FLAP

Give your cat the key to the door

HEADPHONE AMPLIFIER

A stand-alone or add-on project

BINGO BOX

Versatile number generator & checker

www.epemag.co.uk

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

Built in Audio .15lux CCD camera 12vdc 200ma 480 lines s/n ratio >48 db 1v P-P output 110x60x50mm ref EE1 £108 90

Metal CCTV camera housings for internal or external use Made from aluminium and plastic they are suitable for mounting body cameras in Available in two sizes 1- 100x70x170mm and 2- 100x70x280mm Ref EE6 £22 EE7 £26 Multi position brackets Ref EE8 £8 80

Excellent quality multi purpose TV, TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV ideal for use in boats and caravans 49.75mhz-91.75mhz VHF channels 1-5, 168.25mhz-222.75mhz VHF channels 6-12, 471 25mhz-869.75mhz, Cable channels 112 325mhz-166 75mhz Z1-Z7, Cable channels 224 25mhz-446 75mhz Z8-Z35 5" colour screen, Audio output 150mW, Connections, external aerial, earphone jack, audio/video input, 12vdc or mains, Accessories supplied Power supply Remote control Cigar lead power supply Headphone Stand/bracket 5" model £139 Ref EE9.

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

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

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

A high quality external colour CCTV camera with built in Infra red LEDs measuring 60x60x60mm Easy connect leads colour Waterproof PAL 1/4" CCD542x588 pixels 420 lines .05 lux 3.6mm F2 78 deg lens 12vdc 400ma Built in light level sensor £108 90 Ref EE13

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

A small colour CCTV camera just 35x28x30mm Supplied with bracket, easy connect leads. Built in audio. Colour 380 line res, PAL 0.2 lux +18db sensitivity Effective pixels 628x582 6-12vdc Power 200mw £39 60 Ref EE16

Complete wireless CCTV sytem with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output 380 lines colour 2 4ghz 3 lux 6-12vdc manual tuning Available in two versions, pinhole and standard £79 (pinhole) Ref EE17, £86.90 (standard) Ref EE18

Peltier module. Each module is supplied with a comprehensive 18 page Peltier design manual featuring circuit designs, design information etc etc The Peltier manual is also available separately Maximum watts 56.2 40x40mm Imax 5.5A Vmax 16 7 Tmax (c-dry N2) 72 £32 95 (inc manual) REF PELT1, just manual £4.40 ref PELT2

GASTON SEALED LEAD ACID BATTERIES
1.3AH 12V @ £5.50 GT1213
3.4AH 12V @ £8.80 GT1234
7AH 12V @ £8.80 GT127
17AH 12V @ £19.80 GT1217

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

COMPAQ 1000mA 12vdc power supplies, new and boxed 2 metre lead DC power plug 2 4mmx10mm £5.25 each, 25+ £3 50 100+ £2 50

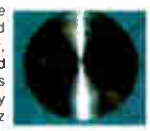
1.2ghz wireless receiver Fully cased audio and video 1.2ghz wirelessreceiver 190x140x30mm metal case, 4 channel, 12vdc Adjustable time delay, 4s, 8s, 12s, 16s. £49.50 Ref EE20

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

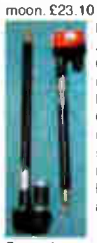
The TENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart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

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

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



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



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

Samarium magnets are 57mm x 20mm and have a hole (5/16th UNF) in the centre and a magnetic strength of 2.2 gauss We have tested these on a steel beam running through the offices and found that they will take more than 170lbs (77kgs) in weight before being pulled off. With keeper £21 95 REF MAG77

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

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

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

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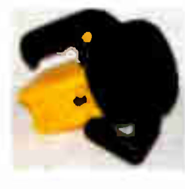
Ultra-compact, lightweight, easy to use and comfortable to hold, the new NVMT is unique for a night scope in offering a tactile, suregrip plastic bodyshell and, for extra protection/grip, partial rubber armouring. Currently the top of the range model, the NVMT G2+ features a 'commercial' grade" Gen 2+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

55 - 200 WATT INFRA RED TORCHS



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

AIR RIFLES FROM £24.70

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

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

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

LOCK PICK SETS 16, 32 AND 60 PIECE SETS

This set is deluxe in every way! It includes a nice assortment of balls, rakes, hooks, diamonds, two double ended picks, a broken key extractor, and three tension wrenches. And just how do you top off a set like this? Package it in a top grain leather zippered case.
Part: LP005 - Price £45.00
This 32 piece set includes a variety of hooks, rakes, diamonds, balls, extractors, tension tools ... and comes housed in a zippered top grain leather case. If you like choices, go for this one!
Part: LP006 - Price £65.00
If your wants run toward the biggest pick set you can find, here it is. This sixty piece set includes an array of hooks, rakes, diamonds, balls, broken key extractors, tension wrenches, and even includes a warded pick set! And the zippered case is made, of course, of the finest top grain leather. First Class!
Part: LP007 - Price £99.00

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

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

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

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EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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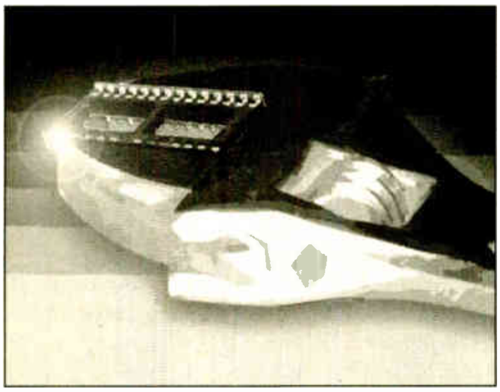
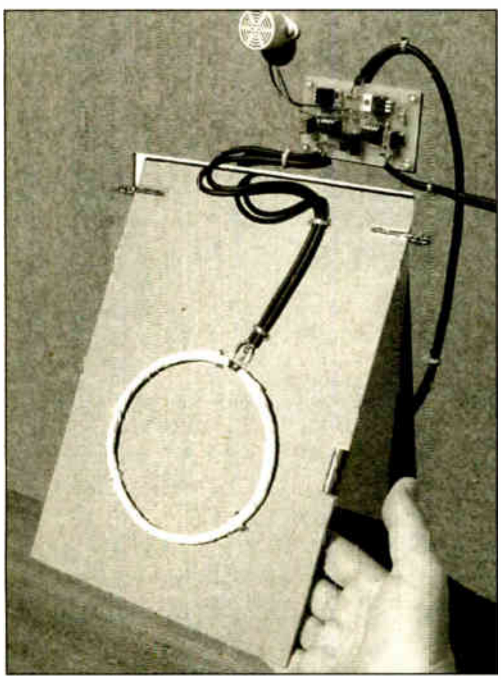




Projects and Circuits

Series and Features

Regulars and Services

Our April 2005 issue will be published on Thursday, 10 March 2005. See page 147 for details

Full Details on the web – http://www.fored.co.uk

NEW FROM FED – FEDPIC Key - USB In Circuit Programmer / Debugger

FEDPIC Key – Ultra-Miniature USB In Circuit Serial Programmer and Debugger

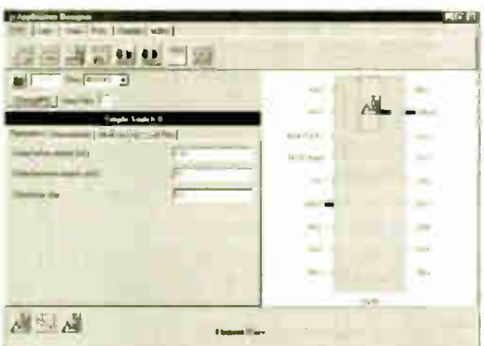
Pricing £60.00

Description : Our new in-circuit programmer/debugger for PIC's operates on the PC USB port, requires no additional power supply and the programmer application runs under Windows '98, ME, 2000 or XP.
Programs : 12Cxxx, 12Fxxx, 16Fxxx, 18Cxxx and 18Fxxx devices and flash upgradeable for future devices.
Operates on a simple 6 pin SIL connector and includes the FED In Circuit Debugger. FEDPIC Key Debugger has the same functionality as our standard ICD described below, but runs 3 times faster !

FED – PIC and AVR – ANSI C Compiler products

Visual Development for the FED C Compilers
WIZ-C for PIC, AVIDICY for AVR

- An application designer for the FED PIC or AVR C Compilers FULLY including the PIC or AVR C Compiler
- Drag a software component on to your design & set up the parameters using check boxes, drop down boxes and edit boxes (see shot below
- Connect the component to the device pins using the mouse
- Select your own C functions to be triggered when events occur (e.g. Byte received, timer overflow etc.)
- Simulate, Trace at up to 10x the speed of other simulators
- Generate the base application automatically and then add your own functional code in C or assembler
- WIZ-C supports over 80 PICS - **16F87x,16F627/8, 16C55x,16C6x, 16F8x, 16C7xx 18Cxx, 18Fxxx, 12F629/675 etc.**
- AVIDICY supports normal and Mega range devices
- Demonstration download available :
  www.fored.co.uk/CDemo.htm



Screen shot (left) shows push button element connected to a PIC. Parameters may be set to control debounce and repeat. C function may be specified to call when the button is pressed

FED ANSI C Compiler for PIC and AVR

- C Compiler designed to ANSI standards
- Supplied with library routines for C standard functions and many interface applications including I2C, LCD, LED's, timers, EEPROM, IRDA,Dallas 1 Wire, Hex Keypad, Maths, asynchronous serial interfacing, clocked data etc.
- With complete development/simulation environment including LCD/Keypad/LED/RS232 terminal
- View your simulation on a logic analyser application showing waveforms, timing or analogue results
- Profiler shows execution count, execution time and average time for functions and code blocks
- Smart linker – efficiently tiles routines throughout memory to minimise long jumps and page setting bits
- Supports the FEDPIC Key and FED In Circuit Debugger for PIC devices 16F87x and 18Fxx devices – See web site for more details.

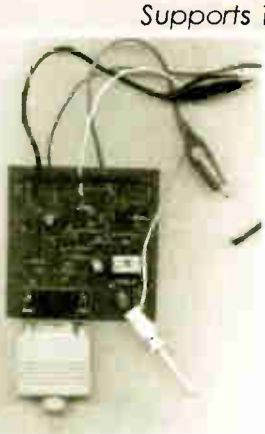
WIZ-C and C Compiler Pricing :

AVR or PIC C Compiler	**£60.00**
AVR or PIC C Compiler Professional	**£90.00**
AVIDCY or WIZ-C	**£70.00**
AVIDICY or WIZ-C Professional	**£100.00**

WIZ-C products are provided with introductory tutorial, full extensive manuals provided on CD.
All prices may be **reduced by £20.00** if the product is purchased at the same times as WIZ-ASM, serial or USB programmerd, or our Development board.

In Circuit Debugger board (or use the new FEDPIC Key)

Supports 16F87x and 18Fxxx



- CD and FEDPIC Key, alow real hardware to be examined & programs to be debugged and to be run in real time on your application
- The FED ICD requires only one data I/O pin on the PIC which can be chosen from any of ports B, C or D.
- Can program and re-program applications in circuit
- Up to 13 breakpoints (18F version)
- Run, Animate, single step and step over, run to cursor line, set PC to any value in the program
- Trace execution in the original C or Assembler source files
- View and change values of PIC special function registers, W and the ports.
- Standard serial interface to PC

Programmers and Development Board

(See web pages)

USB Programmer - 40 pin multi-width ZIF socket. Same range of devices as our serial programmer (below).
Price : £90/kit

PIC Programmer - Handles serially programmed PIC devices in a 40 pin multi-width ZIF socket. 16C55X, 16C6X, 16C7X, 16C8x, 16F62x, 16F8X, 12C508, 12C509, 16C72XPIC 14000, 16F87X, 18Cxxx, 18Fxxx, 12F6xx etc.
Also In-Circuit programming.
Operates on PC serial port
Price : £46/kit, £60/built & tested

Development Board – For ALL 40 pin PICS from 16cxxx, 16Fxxx and 18C/Fxxx. Includes In-Circuit Programmer – NO separate programmer required. LCD interface, hex keypad, LED's and Driver, 32 I/O pins on header, I2C EEPROM, 2 Serial Interfaces, Will run FED PIC BASIC (supplied free on CD ROM), 1A 5V regulator etc.
The CD-ROM is supplied with FED PIC BASIC and Compiler
Price : £36/kit, £46/built & tested, CD - £6.00.
Manual on CD-ROM or download free from our web site

Forest Electronic Developments
12 Buldowne Walk, Sway,
LYMINGTON, Hampshire. SO41 6DU
Email – info@fored.co.uk
Web Site – http://www.fored.co.uk
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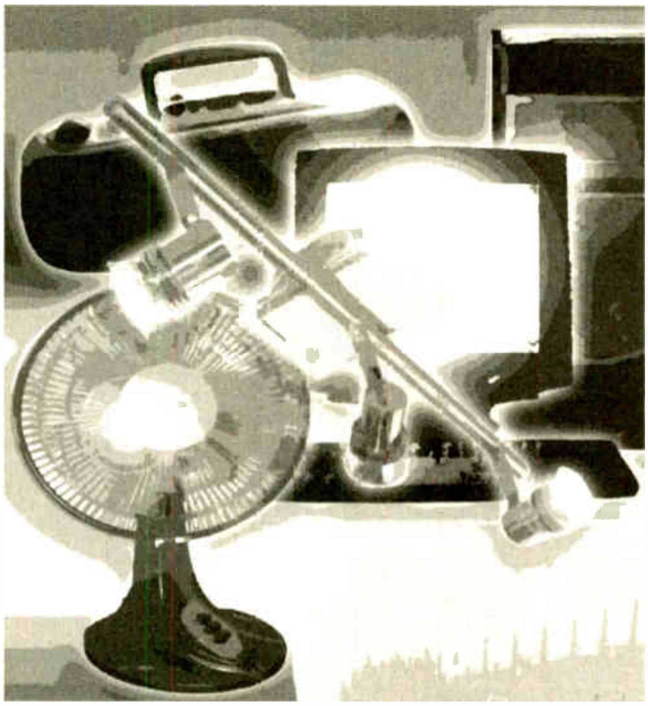
NEXT MONTH

SAFETY INTERFACE

A flexible safety interface for a PIC/logic/PC to mains controller

The advent of the PIC micro-controller has revolutionised electronics in recent years. The number of components needed for a control circuit has dropped dramatically, and controlling devices that operate at low voltages is relatively straightforward. Controlling mains powered devices, however, is generally not so straightforward, primarily for safety reasons.

This project will enable the constructor to experiment in regulating power to, or simply switching on and off, mains powered equipment, via a PIC or logic circuit, or if used with EPE's Serial Interface, *a PC in safety.*



BACK TO LOGIC BASICS

In this short series of articles we illustrate how useful circuits can be simply designed just around a CMOS logic gate or two. We start off with a brief refresher on a few CMOS devices, and follow with a Freezer Door Alarm project to build. During the series we also present:

Water Level Detector; Burglar Alarm; Animal Scarecrow; Digital Lock; Door Chime; Electronic Dice; Kitchen Timer; Electronic Room Thermometer; Daily Reminder; Whistle Switch; Parking Radar; Telephone Switch; Noughts and Crosses Engima; Weather Vane.

The designs are based on low cost components, have printed circuit boards and are well suited to construction by "early starters" to electronics. All are battery powered.

SIMPLE 550Hz TO 30MHz RADIO RECEIVER

Updating the Spontaflex circuit of Sir Douglas Hall KCMG,MA

Sir Douglas, who died last year, was an "inveterate experimenter with radio" whose ingenuity inspired and delighted a generation of electronics enthusiasts in the '60s. This receiver is an updated version of perhaps his most famous circuit and is presented with an add-on i.c. amplifier to give a more powerful output. The highly sensitive tuner section uses just two transistors in a reflex design which wrings the last ounce of performance from the devices. The set will receive a.m. and s.s.b. signals.

PIC 18F MICROCONTROLLER FAMILY INTRODUCTION

This article is an introduction to Microchip's new PIC18F series of high-end microcontrollers, with special reference to the PIC18Fxx2 family. At present this comprises the four devices PIC18F242, PIC18F252, PIC18F442 and PIC18F452.

In many ways these 18F devices are similar to, and backwards compatible with, their 16F counterparts. They have been enhanced in quite a number of ways, and the good news is that, for readers familiar with the 16F series, there isn't a steep learning curve before you can start using them.

Programs written for a 16F can usually be ported to run on a similar 18F with only a modest amount of work – it's not a rewrite job, although there are a few nasty pitfalls to avoid that we'll discuss. You can learn about a number of the new features gradually, and only when you need them.

See page 191

APRIL 2005 ISSUE ON SALE THURSDAY, MARCH 10

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Prices Exclude Vat @17½%.
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ESR Electronic Components.
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VISA

See Next / Last Months Ad. for ELECTRONIC COMPONENTS

PCB Production - Processing Equipment

We carry a large range of the photographic & chemical processing equipment for PCB production, a full list with full technical specifications is available in our catalogue or visit our web site.

UV Exposure units
2 x 8W Tubes, 6 min timer
229 x 159mm working area
Model 332-002 £88.78
4 x 15W Tubes, 7½ min timer
330 x 260mm working area
Model 332-004 £194.51

Chemical Processing
Low cost plastic tray £1.80
Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable for boards upto 320 x 260mm.
Universal Tank with heater
Model 333-007 £161.60
Bubble etch Tank with heater & bubble pump.
Model 333-004 £198.50

Any of these items carriage £5.50

PCB Production - Laminates

Copper clad - paper
Single sided low cost paper composite board

100 x 160mm Board	£0.44
100 x 220mm Board	£0.62
160 x 233mm Board	£1.02
220 x 233mm Board	£1.40
8" x 12" Board	£1.70

Copper clad - glass fibre
Single & Double 1.6mm 305g/m²

100 x 160mm Single	£0.85
100 x 220mm Single	£1.25
160 x 233mm Single	£2.29
220 x 233mm Single	£2.88
8" x 12" Single	£3.44
100 x 160mm Double	£0.88
100 x 220mm Double	£1.25
160 x 233mm Double	£2.30
220 x 233mm Double	£2.90
8" x 12" Double	£3.50

Photoresist Coated
1.6mm 35 micron Pre-coated with a high quality photo-resist layer. Available in low cost paper composite or Glass fibre, Single & Double sided. Other sizes also available.

Size	Paper Single	Paper Double	Glass Fibre Single	Glass Fibre Double
4 x 6"	£1.47	£1.82	£1.89	£2.17
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 - Development

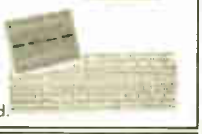
0.1" Copper Stripboard

Size	Tracks/Holes	
25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
95 x 127mm	36T / 50H	£1.41
95 x 432mm	36T / 170H	£4.39
100 x 100mm	39T / 38H	£1.40
100 x 500mm	39T / 199H	£6.20
119 x 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99

Solderless Breadboard

Tie Points & Size	Power Rails	
390 81 x 60mm	2	£2.75
840 175 x 67mm	2	£4.86
740 175 x 55mm	1	£4.03
640 175 x 42mm	0	£3.08

Many other sizes available, also jump wires & matrix board.



PCB Production - Tools

Drill Bits
HSS parallel shank bits available in sizes from 0.3mm to 2.0mm
0.3-0.95mm in 0.05mm steps £0.60ea £4.00/10
1.0-2.0mm in 0.1mm steps £0.40ea £3.60/10
HSS Reduced shank (2.35mm) bit available in sizes from 0.6mm to 1.7mm in 0.1mm steps £0.84ea £7.60/10
Reground Tngsten carbide reduced shank (3.2mm) available in sizes from 0.6 to 1.6mm in 0.1mm steps £1.90

Drilling Machines
Expo reliant 12V drill, 3.8mm capacity, 8400rpm £12.78

Minicraft MX1 230V, 8000 - 21000rpm with chuck & collet.
Model EPE270-390
Normal price £48.51

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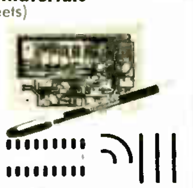

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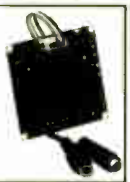

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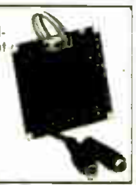

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Availability – Export

Once again I feel compelled to write about the availability of *EPE*. Unfortunately all the export copies of last month's issue were lost in a warehouse fire at Thurrock in Essex.The fire actually forced the closure of the M25 motorway and caused major traffic problems for two days. Over 120 fire appliances attended over a period of five days. Fortunately no one was injured.

So, if you normally buy your magazine from a bookstall outside of the UK you would have missed out on the February issue – all *subscription* copies were, however, supplied as normal. If you need a February '05 copy we have a few in stock – see the *Back Issues* page (page 215). When these are all gone the alternative is to download a copy from our *EPE Online* web site at **www.epemag.com**, the price there is $5 (US) for one issue or $10.99 (US) for a one year subscription (12 downloadable issues), which represents an incredible bargain. You could also subscribe to the printed issue to make sure of future copies – see page 191.

Availability – UK

Sometimes it is also not that easy to get copies of *EPE* in the UK, though we have not had any delays in publishing or missed issues in the last 20 years; so don't believe anyone who tells you anything different. With so many magazines now being published most newsagents can only carry a limited range and even the larger stores have a limit to the number of magazines they stock. This means that to ensure a copy of *EPE* each month you might need to order a copy from your newsagent, either to be "shop saved" for you or delivered to your home.

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You will find a subscription order form on page 191.

Mike Kenward

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Cat Flap

Thomas Scarborough

Using your cat's magnetic attraction to keep stray moggies, and other unwelcome intruders, from invading his/her kingdom

CATS are not very brave. The author's work-desk is situated next to a window where the household cat jumps in and out. Occasionally, working late at night, a foreign cat will poke its nose through the window. On noticing the author (before the author has noticed the cat) the cat will sometimes retreat in such panic that it strikes the window with a bang. It is this characteristic of the cat – its extreme nervousness on entering unfamiliar terrain – that is exploited in this design.

The project described here is a Cat Flap with a difference, both conceptually and electronically. The flap itself swings freely, and is not released with a catch, as is usually the case. This simplifies the design a great deal.

An "authorised" cat may walk freely in and out of the flap. However, if a foreign cat (or perhaps a rat or a mongoose – depending on where you live!) opens the flap, even to a crack, it is surprised by whatever might meet the constructor's fancy – perhaps an ultrasonic shriek, or a spotlight – but nothing that might harm the cat. Bearing in mind a cat's timidity, this is bound to keep a foreign cat at bay.

Having said this, the circuit has been so designed that it may also be used as a "stock standard" cat flap, whereby a flap releases when the "authorised" cat comes near, yet remains locked to foreign cats. The only drawback here is the additional work required to manufacture a mechanical catch for the flap.

In Concept

The core consideration of this design was how to distinguish a foreign cat from one's own. The obvious solution was to tag one's own cat, and to detect the tag. A common solution is a magnet – except that a magnet does not typically offer good range unless it is combined with a sophisticated (and often pricey) sensor.

Some traditional cat flaps use reed switches, in combination with a magnet on the cat's collar. However, the author could not see how such devices should work reliably with (typically) less than 3cm (1·18in.) range. Either a greater range was required, or another method of detection.

The solution was found in a novel detector using a coil with a Faraday shield, located on or in the flap. This detects a small neodymium magnet up to about 20cm (7·90in.). Even half this range would be adequate to detect a cat approaching the flap. The magnet is of course attached to the cat's collar.

As soon as the cat approaches the flap, the circuit detects the magnet attached to the cat's collar and a simple timer is triggered. The purpose of the timer is to disable a reed switch on the side of the cat flap.

Consider what happens if the reed switch is *not* disabled – that is, if a *foreign* cat pokes its nose through the flap. In this case, the reed switch activates whatever surprise the constructor might wish to have in store for the cat. However, if the reed switch is first disabled through the timer, a cat is able to walk freely through the flap – until the timer resets.

A reed switch of course is activated by a magnet, and to avoid any conflict with the magnet on the cat's collar, the switch's activating magnet is mounted on the flap, so that when the flap moves, so does the magnet. Therefore the magnet remains stationary in relation to the flap, and remains undetected by the coil which is also mounted on the flap.

Circuit Description

The full circuit diagram for the Cat Flap is shown in Fig.1. The circuit exploits a few simple scientific facts. If magnetic field lines approach a conductor at 90 degrees to the conductor, a current is

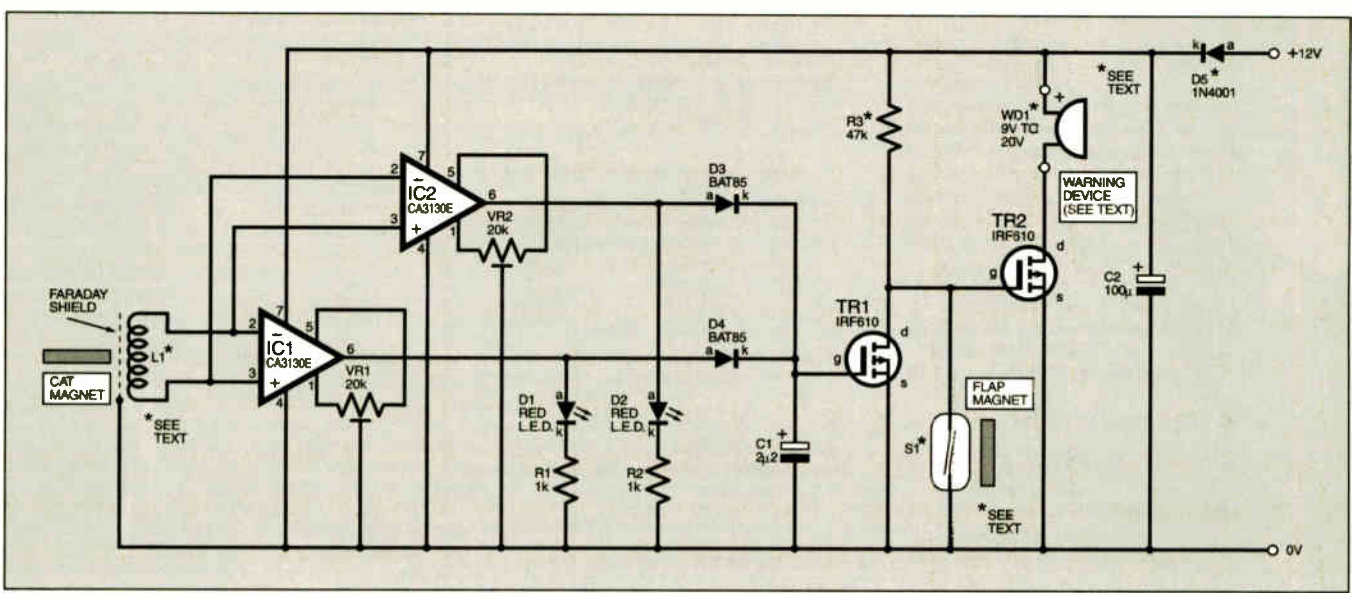


Fig.1. Complete circuit diagram for the magnet-activated Cat Flap

generated in the conductor. Further, the greater the length of the conductor, the larger the current that is generated. Therefore, as a magnet's North or South pole approaches sensing coil L1, so a potential difference is created across the inverting (pin 2) and non-inverting (pin 3) inputs of IC1 and IC2.

Coil L1 is wired to the inputs of IC1 and IC2 in a complementary fashion, and this is because the current flows in different directions in the coil, depending on which magnetic pole approaches the coil. If only one i.c. were used in the circuit, the cat would only be detected moving in one direction – unless, of course, it should walk backwards through the flap!

Preset potentiometers VR1 and VR2 are offset adjustments, and bias the internal circuitry of IC1 and IC2 so that their outputs are ordinarily *just* held "low". With extremely light 5pA internal biasing at its inputs, the CA3130E does not require further external biasing in this application.

A Faraday shield is added to coil L1 to preclude any capacitive coupling, and this is described in more detail below. In view of the extreme sensitivity of the circuit, coil L1 must be wired to the printed circuit board (p.c.b.) through screened wires.

Surprise, Surprise

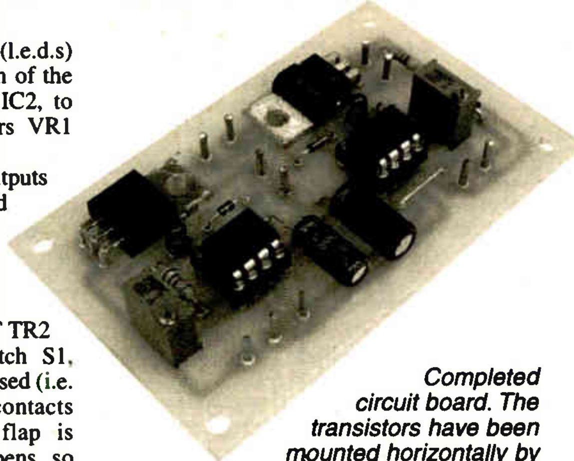
When a magnet approaches coil L1, the output (pin 6) of either IC1 or IC2 will go "high", thus charging capacitor C1, and causing transistor TR1 to conduct for several seconds. Light emitting diodes (l.e.d.s) D1 and D2 give a visual indication of the status of the outputs of IC1 and IC2, to confirm that preset potentiometers VR1 and VR2 are suitably adjusted.

Diodes D3 and D4 isolate the outputs of IC1 and IC2 from each other, and serve to maintain the charge on capacitor C1. The value of C1 may be altered to change the timing period.

Ordinarily, the gate of MOSFET TR2 is held "low" through reed switch S1, which is closed when the flap is closed (i.e. flap magnet holding switch contacts together). However, when the flap is opened (removing magnet), S1 opens, so that only resistor R3 and MOSFET TR1 are left in circuit.

Everything now depends on the potential at the junction of R3 and TR1. If an "authorised" cat has just triggered IC1 or IC2 (by the influence of the "cat magnet" on the field coil L1), thereby charging capacitor C1, TR1 will conduct, and TR2's gate (g) will be held "low".

However, in the absence of an "authorised" cat, TR1 will fail to conduct, and TR2's gate will be taken "high" through resistor R3. Transistor TR2 thereby conducts, triggering whatever surprise one might have in store for the cat. This "surprise" is wired between the drain (d) of TR2 and the positive supply line. Note that S1 need not necessarily be a reed switch. This may also be a pressure switch or a broken beam, or anything that should best suit one's requirements.



Completed circuit board. The transistors have been mounted horizontally by carefully bending their leads prior to soldering

If a "stock standard" cat flat is preferred, components R3, S1, and TR2 are removed from the circuit, and a solenoid is wired in place of R3, to release a catch on the flap. In this case, one needs to bear in mind that a solenoid generates a fairly strong electromagnetic field, so that this will need to be mounted some distance from coil L1 – about 30cm (11·8in.) should be adequate.

A diode should be wired across the solenoid – cathode to the +12V line – to reduce the back e.m.f. generated when TR1 switches off.

COMPONENTS

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See SHOP TALK page

Resistors

R1, R2	1k (2 off)
R3	47k

All 0·25W 5% carbon film

Potentiometers

VR1, VR2	20k 25-turn cermet preset, top-adjust (2 off)

Capacitors

C1	2µ2 radial elect. 16V
C2	100µ radial elect. 16V

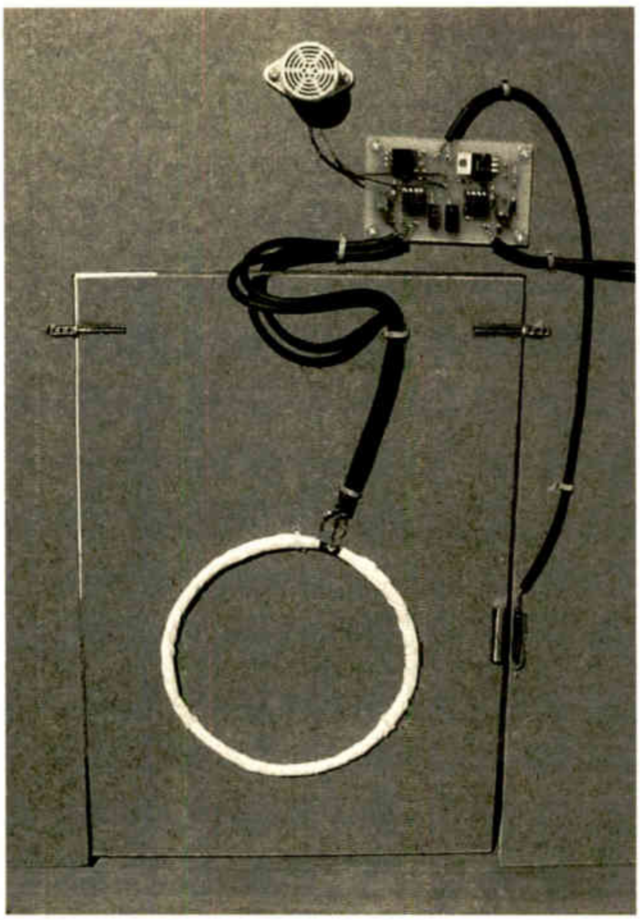
Semiconductors

D1, D2	3mm red l.e.d. (2 off)
D3, D4	BAT85 signal diode (2 off)
D5	1N4001 50V 1A rect. diode (or suitably rated for load – see text)
TR1, TR2	IRF610 power MOSFET, or equivalent (2 off)
IC1, IC2	CA3130E CMOS op.amp (2 off)

Miscellaneous

S1	reed switch, normally open contacts, with magnet
L1	70 turns 30s.w.g. (0.315mm) enamelled copper wire wound on 120mm diameter former = 30 metres

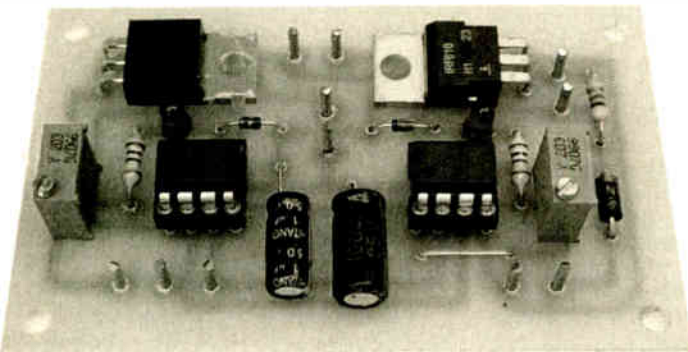
Printed circuit board available from the *EPE PCB Service*, ABS plastic case (if required); battery clip or power socket (if required); 8-pin dual-in-line (d.i.l.) socket (2 off); screened microphone cable (about 1 metre); small neodymium magnet (preferred) for cat's collar, see text; suitable external alarm circuit, i.e. miniature buzzer – see text; materials for cat flap; cable ties; solder pins; solder, etc.



Note that the circuit should not be mounted too close to any heavy electrical equipment, e.g. a dish-washer, since this may also trigger the circuit. If in doubt, test the circuit in situ before fixing it permanently. Alternatively, reduce the circuit's sensitivity through adjustment of presets VR1 and VR2 (see later).

No special supply decoupling is required, particularly in view of the fact that its most sensitive component, coil L1, is isolated from the rest of the circuit. A regulated 12V power supply is suggested for the sake of stability. A 9V supply would also suit.

Diode D5 is included for supply reverse polarity protection. This should be suitably rated for the load (warning device) wired in to the circuit. No on-off switch is used, since the circuit is likely to be used on a continuous basis.



Construction

The Cat Flap circuit is built on a small single-sided printed circuit board (p.c.b.) measuring just 77mm (3in.) × 47mm 1·85in.). The topside component layout and full-size underside copper foil master pattern are shown in Fig.2. This board is available from the *EPE PCB Service*, code 491.

Note that no relay is included on the p.c.b. This is for two reasons. First, the external circuit (e.g. an ultrasonic alarm) might not require this. But secondly, if a relay were to be mounted too close to coil L1, its electromagnetic field could upset the circuit, and additional circuitry would be required to "blank it out". If a relay is used, mount it some distance from coil L1, and use a diode across its coil to suppress back-e.m.f. (the cathode of the diode is wired to its positive terminal).

Begin construction by soldering in position the eleven solder pins, the two 8-pin dual-in-line (d.i.l.) sockets and resistors R1 to R3. Position and solder presetsVR1 and VR2, electrolytic capacitors C1 and C2, then diodes D3 to D5 on the board. Light emitting diodes D1 and D2 may be soldered directly to the p.c.b., or mounted elsewhere by means of sheathed wires.

Next, solder MOSFETS TR1 and TR2 on the board, double-checking the pin connections are correct. Note that their pins should be carefully bent over so that the bodies of the transistors lie parallel with the p.c.b., see Fig.2.

Before inserting IC1 and IC2 in their d.i.l. sockets and testing the circuit, we need to wind coil L1 and complete the construction of the mechanical flap.

Sensing Coil Details

In the prototype, coil L1 was 70 turns of 30s.w.g. enamelled copper wire, wound on a 120mm (4·7in.) former. However, this is not critical, and the number of turns, the wire gauge, and the diameter of the coil may all be changed a fair deal without significantly influencing the circuit. However, more turns will increase the sensitvity of the circuit. The completed coil should be wrapped tightly in insulating tape.

Now a Faraday shield is required, which, in this instance, takes the form of a tin-foil wrapping for the coil which goes all the way around it, *excepting* a small section about 5mm (0·2in.) or 10mm (0·4in.) wide. That is, a small section of the coil insulating tape is left exposed underneath the Faraday shield.

The Faraday shield now needs to be connected to the p.c.b., and for this purpose, a bare wire may be wrapped around the shield. This is later soldered to the screen of a screened cable, and taken to the p.c.b. The Faraday shield (baking-foil) is similarly wrapped with insulating tape.

In A Flap

A suggested cat flap construction assembly is shown in the photographs. Alternatively, you can purchase a ready-made unit from a local Pet shop or DIY superstore and adapt it to yours needs.

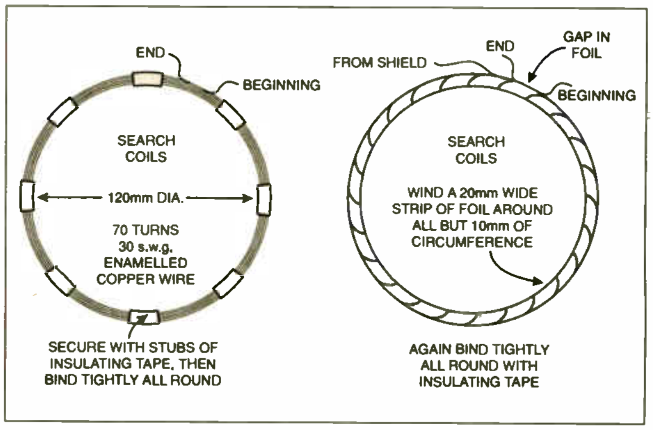


Fig.3. Suggested winding procedure for the cat sensing coil. The winding sequence is shown on the opposite page

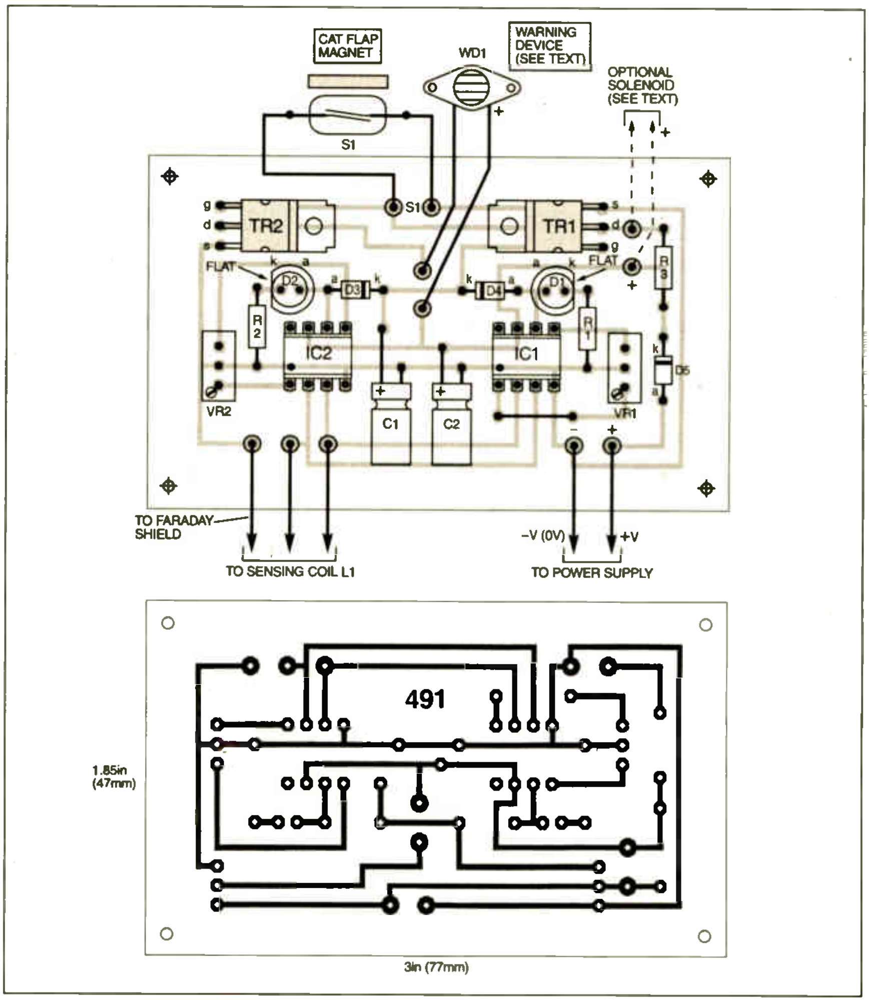
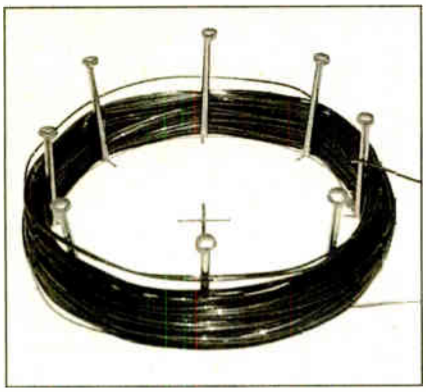
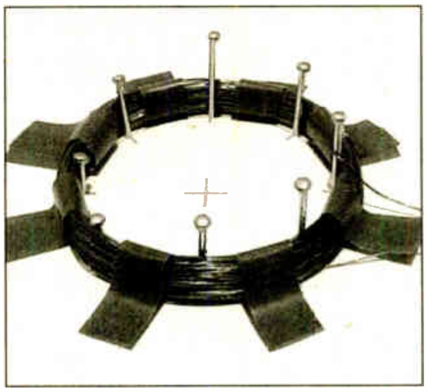


Fig.2. Cat Flap printed circuit board component layout, wiring detail and full-size underside copper foil master pattern. Note that screened cable must be used to wire the coil and Faraday shield to the p.c.b.

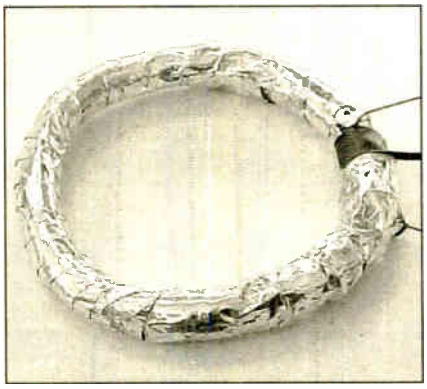


Enamelled copper wire (30s.w.g.) wound around guide pins (former)

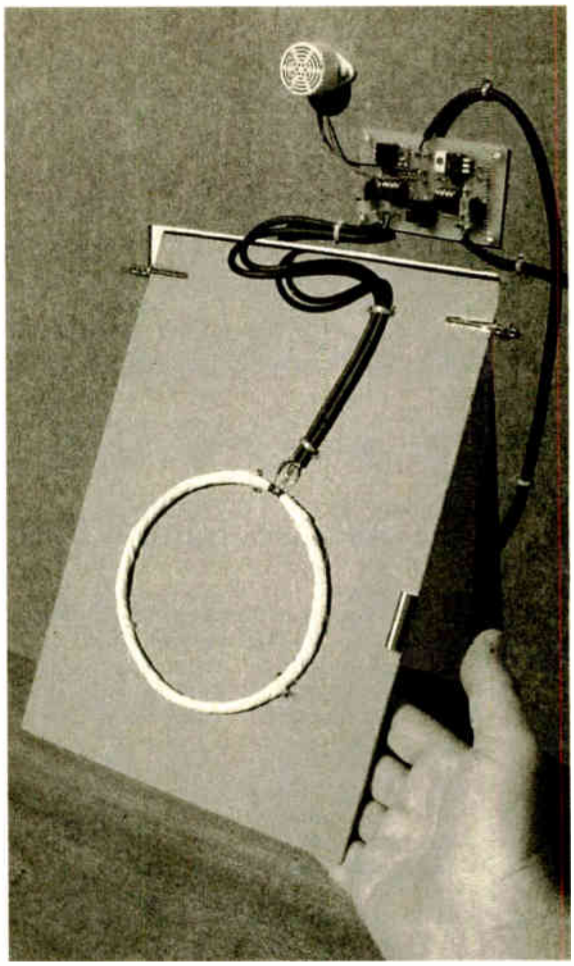


Strips of insulating tape used to hold the coil windings together

Taped-up coil and the Faraday shield connecting wire



Tin-foil Faraday shield, awating final covering of insulating tape



Cat Flap arrangement showing components mounted on and around the flap. The flap needs to swing freely in both directions.

The flap needs to be able to swing freely in both directions. At one or the other edge of this flap, on the fixed frame which surrounds it, mount reed switch S1 (on the right edge of the flap in the photo). Wire this to the p.c.b. by means of screened audio cable, with the screen being soldered to the p.c.b. 0V copper track as shown in Fig.2. An attendant magnet is mounted on the flap as shown, so that when the flap is closed, reed switch S1 contacts are held closed, and when the flap is opened, they are released and revert to being open.

Coil Mounting

Next, mount coil L1 on the flap as shown in the photograph, so that this swings with the flap. Coil L1 needs to be wired to the p.c.b. by means of twin-core screened "figure-8" cable (two separate screens), or with two separate screened cables as in the photograph. Leave a loop of cable where the top of the flap meets the frame, so that the wire flexes easily as the flap opens and closes.

Wire up the external circuit (a simple buzzer is shown in the photograph). Wire up the 12V power supply, again using screened cable, observing the correct polarity. Finally, insert IC1 and IC2 in the d.i.l. sockets, checking their orientation. Take anti-static precautions – that is, before handling, ensure that your body has been discharged to earth. If desired, an ABS plastic case may be used to house the circuit board.

Lock-Out

If a "standard" cat flap is preferred, omit components R3, S1, and TR2 from the p.c.b., and wire a solenoid across the solder pads to the left of resistor R3's position in Fig.2. Bear in mind again that this will need to be mounted some distance from the sensing coil L1. For this purpose, a long actuating shaft will be required to move the flap's catch.

As a suggestion, a section may be cut out of the flap so that the flap swings freely past the catch when the catch is lifted. When the catch drops, it will hold the flap.

Current consumption is about 2·2mA on standby, rising to about 10mA when an "authorised" cat is detected. To this is added the current required by the external warning circuit should a foreign cat (or any other animal) poke its nose through the flap.

Setting-Up and Use

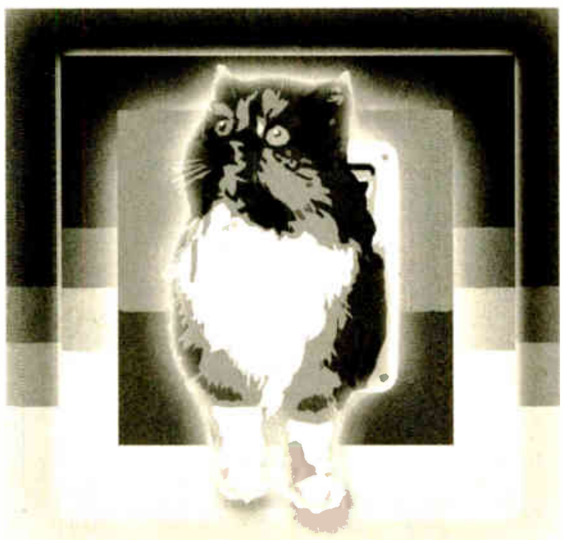
It need hardly be said that the circuit may be used in many applications beyond a Cat Flap. Examples would be a magnetic lock, a device to detect a model train passing over a track, or a circuit which detects magnetisation in metal objects.

Setting-up is "a snap". Attach the power supply. Turn preset potentiometers VR1 and VR2 anticlockwise until l.e.d.s D1 and D2 *just* extinguish. Then turn them further back (anticlockwise) a further quarter turn, so that the circuit will not spuriously trigger.

A neodymium magnet is to be preferred for attaching to the cat's collar. This needs to be mounted with either of its magnetic poles at approximately 90 degrees to the sensing coil L1.

When a magnet approaches coil L1 from either side, l.e.d. D1 or D2 will illuminate. If the flap is opened immediately after this, the external circuit will remain inactive. Failing this, it will be activated.

All that now remains is to find the household cat and attach the magnet to his or her collar. Not only should *you* be happy, but your cat also, whose home is now a safe haven, free from marauders. □



News . . .

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

DISASTROUS

Power Line Communication could prevent essential amateur radio assistance at times of disaster. Barry Fox reports the concerns

THE Tsunami disaster, and before that the hurricanes in the Caribbean and the 9/11 terrorist attacks on New York and Washington, have all highlighted the value of shortwave amateur radio in an emergency situation. In each case hams were able to communicate, over long distances with low powered SW transmitters, long after power supplies, phone lines and cellphones had gone down, preventing Internet access.

The Amateur Radio Service is now warning that unless there is tighter control on interference from the new "powerline" technologies being planned to satisfy the world's appetite for ever-faster Internet connections, there may be no such emergency links in the future.

"A few dB of extra interference noise and I would not have been be able to hear the Sri Lankan signal", said Hilary Claytonsmith, a consultant on electromagnetic compatibility for the International Amateur Radio Union, and herself a keen radio operator who was monitoring emergency traffic after the Tsunami struck.

"I doubt reception would have been possible in a PLC-enabled age" (Power Line Communications). "It is nonsense to say in the case of an emergency there would not be any mains power and so no PLC interference. The signals need to be received in an area outside the disaster area, where there may well be PLC".

Power Line Communications

The US government gave the green light to Broadband over Power Line in October 2004; in Europe the European Commission is close to allowing Power Line Communications. The names are different but the technology is the same. Broadband data is sent into the home, and around the home, as a high frequency signal piggybacked on the existing low frequency mains supply.

The powerline systems can deliver up to 5Mbps over the "last mile" from the streets and into the home – with 10Mbps promised later. So PLC provides welcome commercial competition for the phone and cable companies. It is cheaper and more convenient than laying fibre, or using satellites, or transmitters on balloons and airships.

But the mains is a hostile environment with ever-changing patterns of interference being fed back into the supply from mechanical switches, electronic control circuits, electric motors in power tools and appliances, and central heating thermostats. So the powerline data must be spread wide over many high frequency carriers to ensure that something always gets through the interference. The frequencies used range up to 30MHz – which by unhappy coincidence is the radio band that travels best round the world. And unfortunately the mains wiring works like a broadcast antenna and radiates the data signal to cause interference in the radio band below 30MHz.

Protected Status

The amateur band is protected against interference by the International Telecommunications Union. So the US government's Federal Communications Commission changed Part 15 of its rules on wireless transmission to allow data up to 80MHz on power lines, provided that the operators use electronic filters on their equipment to "notch" out frequencies which are proven to cause interference.

The Consumer Electronics Association, whose members sell the equipment consumers use with broadband connections "applauds" the FCC's decision because "it will advance consumer use of new technologies and products". Only one of the Commissioners, Michael Copps, was unhappy with the decision. Copps warned that the FCC must "work hard to monitor, investigate and take quick action" over interference, not let cases "take years to resolve".

Signal Notching

The European Commission, CENELEC (the European Committee for Electrotechnical Specification) and COCOM (the EC's Communications Committee), have spent the last two years trying to agree on draft rules for "notching" to balance "technical, social and economic" factors against the "importance" of services which suffer interference.

But who will decide what's "important", and how will they judge importance, ask hams. Jonathan Stott of the BBC's R&D centre at Kingswood Warren in Surrey agrees with the FCC and EC decisions to abandon any attempt at setting emission limits. "A level high enough to permit PLC operations offers no protection to reception of broadcasting. A level low enough to protect reception of broadcasting will prevent PLC operations."

But Stott warns that simple notching will cause unforeseen problems. "There is risk that the PLC operators will become censors – it would be an absolute gift to the regimes in countries where freedom of expression and uncensored access to the internet is non-existent. Countries may choose to jam broadcasts".

Two-Way Option

So Stott's team at Kingswood Warren has thought laterally. If a PLC system can radiate interference in the broadcast bands, it must also pick up broadcast signals.

According to the BBC's new plan, all PLC equipment would have to "listen" for any radio broadcasts in the vicinity, and automatically switch to different data frequencies for as long as the broadcast continued. But this will only happen if the system providers are forced to build intelligent listening and self-adjustment into their modems.

Technical details of the PLC systems on offer (Main.net of Reston, Virginia; Ascom in Berne Switzerland; DS2 in Valencia, Spain) are often sparse because the technology is proprietary and still on trial and developing (**www.ascom.com/**; **www.ds2.es/**; and **www.powerline-plc.com/**).

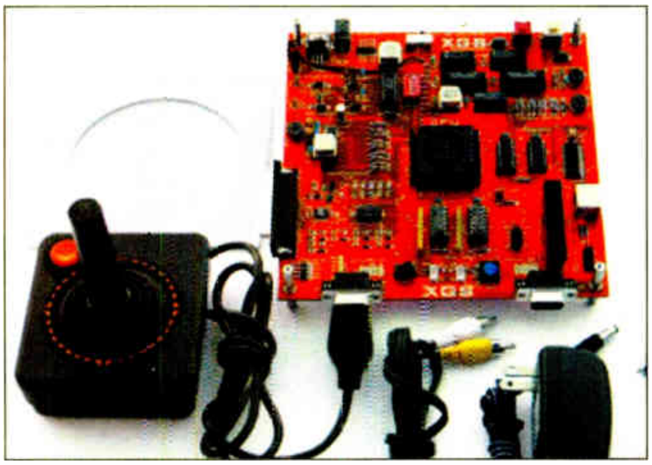
BBC researchers analysed the signals that leak from trial set-ups and found that Main.net data is spread over a wide frequency band, much like a 3G phone system; Ascom uses four 1MHz carrier bands at 2·4, 4·8, 8·4 and 10·8MHz; and DS2 and an industry standard system called HomePlug use OFDM (orthogonal frequency division multiplexing) like European digital radio and TV, to put the data on many narrow carrier waves.

Surface Wave Exploitation

There is now a dark horse in the race, from Corridor Systems of Santa Rosa, California. Corridor relies on the "surface wave" effect. When very high frequency signals are launched straight down a cable they tend to stay inside the cable, near the surface. Overhead power lines are used to carry data on frequencies ranging from 800MHz and 10GHz. This is far above the frequencies used for conventional PLC and safely above the amateur bands.

The signals get from the overhead cables into homes by local radio transmitters, like Wi-Fi hotspots, which are fixed to the cables near homes that want to buy data. Corridor is so confident that its system causes no interference that it recently published full technical details and an open letter to the FCC with test results (**http://www.corridor.biz/pdf/031201-fcc-letter.pdf**)

Corridor has so far satisfied critics in the radio community that its claims are justified. The FCC has approved the system by saying that because it works above 80MHz it need not comply with the special requirements for systems below 80MHz (notching and listing service areas on a database).



XGameStation

The XGameStation is the world's first video game system development kit designed for education. The kit comes with an assembled XGameStation console, joystick, controller, cables, CD containing all system software and tools necessary to develop the system. An extensive eBook explains how the system was designed and how it works from the ground up.

Everything from basic digital logic to computer engineering to circuit board design to firmware and low-level software is covered. The kit is aimed at everyone from seasoned engineers to absolute electronics newbies. It is designed to teach students and hobbyists how to develop hardware that can be used for video game applications.

Andre LaMothe, CEO and Chief Scientist of Nurve Networks LLC, says that "like all revolutionary ideas, the XGameStation is equal parts fantasy and reality. On the one hand it addresses a real problem that has existed for years – that no hobbyist game programmer or hardware hacker has a unified, inexpensive platform they can actually build, take apart, and own exclusively. On the other hand, it will power a next-generation synergy of hardware, software, imagination and creativity of unparalled proportions".

For more information contact Nurve Networks LLC, Dept *EPE*, 402 Camino Arroyo West, Danville, California 94506, or browse **www.xgamestation.com**.

Radio Anorak

Astonishing – we have come across a "radio powered-jacket for kids on the go". Wild Planet, a toy maker known for its spy gear and adventure gadgets has teamed up with clothing retailer GAP to produce "Hoodio", a fleece jacket with a waterproof FM radio control panel sewn into one sleeve, a detachable power pack hidden in a pocket, and removable speakers built into the hood.

Hoodio is to be sold at GapKids stores in the UK, USA, Canada and France, as we go to press the web site states a US price of $29.99. Be aware that the web site cautions that the Hoodio may obstruct your side vision and what you can hear around you.

For more information browse ***www.wildplanet.com.***

Ground Transient Terminator

The Ground Transient Terminator (GTT) technology developed by ECM Electronics and 9 Corporation, could well find beneficial use by those professionals who are plagued by electrical transient and surge problems.

Ground transients are one of the most frequent problems and can cause significant disruption to the operation of microprocessor-based equipment. Current microprocessors expect to see less than 0·5V between neutral and ground lines. If the micro sees more than 0·5V, system lock-ups, communication errors, reduced operating productivity, unreliable data, fragmented hard drives and damage to equipment may be seen, causing operational problems that cannot be duplicated or explained.

The GTT is the first device that can be safely placed between case ground and equipment in order to eliminate ground transients, helping prevent the problems from occurring. It is a passive filter that works by opposing changes in electron flow on the ground wire. This slows the damaging rise and fall time of a transient voltage waveform, rather than clipping it off, controlling frequency instead of amplitude.

For more information contact ECM Electronics Ltd, Dept *EPE*, Penmaen House, Ashington, London Road, Pulborough, W.Sussex. Tel: 01903 892810: Fax: 01903 892738. Email: ecm@ecmelectronics.co.uk. Web: **www.ecmelectronics.co.uk. Also browse: www.9corp.com.**

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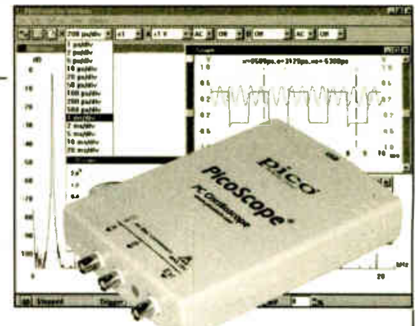

WIN A PICO PC BASED OSCILLOSCOPE WORTH £599

- 5GS/s Dual Channel Storage Oscilloscope
- 50MHz Spectrum Analyser
- Multimeter
- Frequency Meter
- USB Interface

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every 12 months, Pico Technology will be awarding a PicoScope 3205 digital storage oscilloscope for the best IU submission. In addition, a DrDAQ Data Logger/Scope worth £59 will be presented to the runner up.

NiCad Battery Discharger – Useful Flattery

WHEN faced with a set of partially discharged NiCad batteries it is not certain how long you need to recharge them for, so it is best to completely discharge them before giving them a full charge.

The circuit diagram shown in Fig.1 was built to discharge either a single battery to 1V, or a set of four batteries to 4V final voltage at a rate of about 25mA to 30mA, then switch itself off. It is based on a two-transistor latch circuit which turns itself off when the current flowing through it falls to a predetermined value. Its operation is as follows:

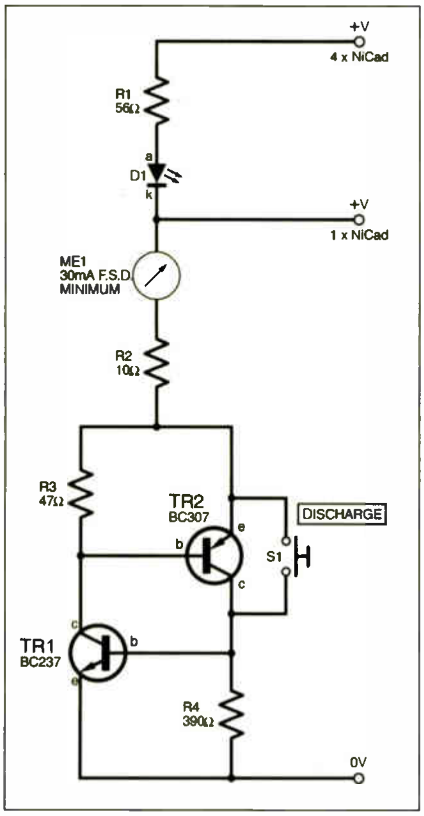

Fig.1. NiCad Battery Discharger circuit diagram

Circuit Details

With a single battery connected and switch S1 pressed, the current flows through resistor R2, meter ME1, and transistors TR1 and TR2. When S1 is released, the circuit latches, each transistor providing the required base current for the other.

Current continues to flow through the circuit with slowly reducing battery voltage, until the minimum latching current is reached. At this point the current through TR1 is no longer sufficient to provide the required voltage across resistor R3 to keep transistor TR2 turned on. Consequently, the latch turns itself off and the battery is discharged no further.

The value of the minimum latching current is determined by resistor R3, and a value of 47Ω gives about 15mA. As the latch is current-controlled, the "unlatch" voltage is determined by the series resistance values. Bearing in mind that about 0·8V is developed across the latch itself, so a resistance of 13Ω (R2 and ME1 in series) gives an unlatch voltage of 0·8V + 0·195V = 0·995V.

Four Cells

For use with four NiCads in series, l.e.d. D1 and resistor R1 are used in series with the basic circuit to provide an additional 3V drop at 15mA, giving an unlatch voltage of 4V.

The unlatch voltages can be trimmed by adjusting the values of resistors R1 and R2, so if you choose to use a multimeter in place of meter ME1, trim resistor R2's value to retain the correct unlatch voltages. Meter ME1 should have a minimum f.s.d. of 30mA, and an internal resistance of about 3Ω.

The transistors I used were BC237 (*npn*) and BC307 (*pnp*), though other similar devices should work fine.

P.A. Tomlinson, Hull

PICO PRIZE WINNERS

Once more it's time to decide the lucky winners of superb PC-based Oscilloscopes, generously donated to *Everyday Practical Electronics* by Pico Technology, to whom we extend our appreciation for sponsoring the column again. For more information about Pico's range of PC-based test equipment visit their web site at **http://www.picotech.com**, or see their advertisement elsewhere in this issue.

EPE Editor Mike Kenward and Technical Editor John Becker considered all *Ingenuity Unlimited* entries published over the last twelve months, and the lucky prizewinners were finalised as follows:

Winner – receives a superb PicoScope3205 Digital Storage Oscilloscope worth £599:
Manual Bit-Stream Selector by Godfrey Manning, Edgware, Middlesex (*EPE* August 2004)

Runner-Up – a Pico DrDAQ Data Logger/Scope worth £59:
Mouse Trapped Indicator by C. Embleton, Darlington, Co. Durhamm (*EPE* May 2004)

Slumber Alarm – Wake-Up Call

THE circuit diagram shown in Fig.2 was produced to prevent an elderly women falling asleep on public transport and missing her destination. The problem was caused by the combined soporific effects of the warm environment she was in, the road or rail vibrations she was subjected to, and the side-effects from prescribed medication .

During a journey the Slumber Alarm delivers a tone in the person's ear via an earpiece (the prototype used one half of a personal stereo headset) and ideally the person presses the Reset button (S4) muting the tone. Approximately ten seconds later the tone sounds again; the person having to cancel the tone again.

This continues throughout the journey keeping the wearer alert; although they could still fall asleep for the reasons mentioned earlier. If the Reset switch is not pressed (because the person is sleeping) eventually the tone will sound at a greatly increased volume awakening the person in time to alight at their destination; or perhaps one stop further on.

The output signal (pin 3) from the low power 7555 timer/oscillator IC1 feeds 1Hz pulses to l.e.d. D1 and the Clock input (pin 14) of IC2, a 4017B decade counter, which counts up from zero. When output Q9 (pin 11) of IC2 goes high, as ten seconds elapse, IC3a inverter sets latch IC3b/IC3c. With switch S2 set at Normal, this enables oscillator IC4a/IC4b generating the "wake-up" tone which is fed to Volume control VR2, transistor TR2 and earpiece LS1.

Pressing and releasing Reset switch S4 resets IC2 via inverter IC3d and resets the latch (IC3b/IC3c) muting the tone. Counter IC2 now resumes counting and ten seconds later the tone is heard again.

If Reset S4 is not pressed the tone sounds continuously (which may or may not awaken the sleeper) and because IC2 is still enabled it continues counting. Eventually, IC2's output Q8 (pin 9) goes high again and along with IC3b's output (remaining high from before) it is decoded by IC4a/IC4b switching on transistor TR1, thus bypassing VR2, and increasing the tone's volume – awakening the person wearing the alarm.

Setting Up

To commission the circuit, ensure switch S3 is set to Soft, adjust Volume control VR2 to midway and connect a 9V battery (B1). Operate On/Off switch S1 and check that l.e.d. D1 is flashing at approximately 1Hz. Now set switch S2 to Demo/Test enabling the oscillator, resetting/disabling IC2 and the latch and connecting transistor TR1 base (b) to switch S3. As TR1 is biased off so VR2 is not short circuited, therefore, the tone heard in the earpiece is at soft volume.

Insert the earphone (LS1) in the person's ear and adjust VR2 until the volume is acceptable; the volume level may be adjusted later to compensate for road or rail noise. Reposition the earphone near but not in the ear and set preset VR1 to its mid-track position. Set switch S3 Loud and adjust preset VR1 until the tone from the earphone is very loud yet tolerable for the person to wear it in their ear momentarily.

Finally, set switches S2 to Normal, S3 to Soft and S1 to Off. Using a dab of adhesive or hot melt glue on preset VR1's adjuster control, secure its wiper in position .

The Slumber Alarm in now ready for use. – Happy Snoozing!

Chris Embleton,
Darlington, Co. Durham.

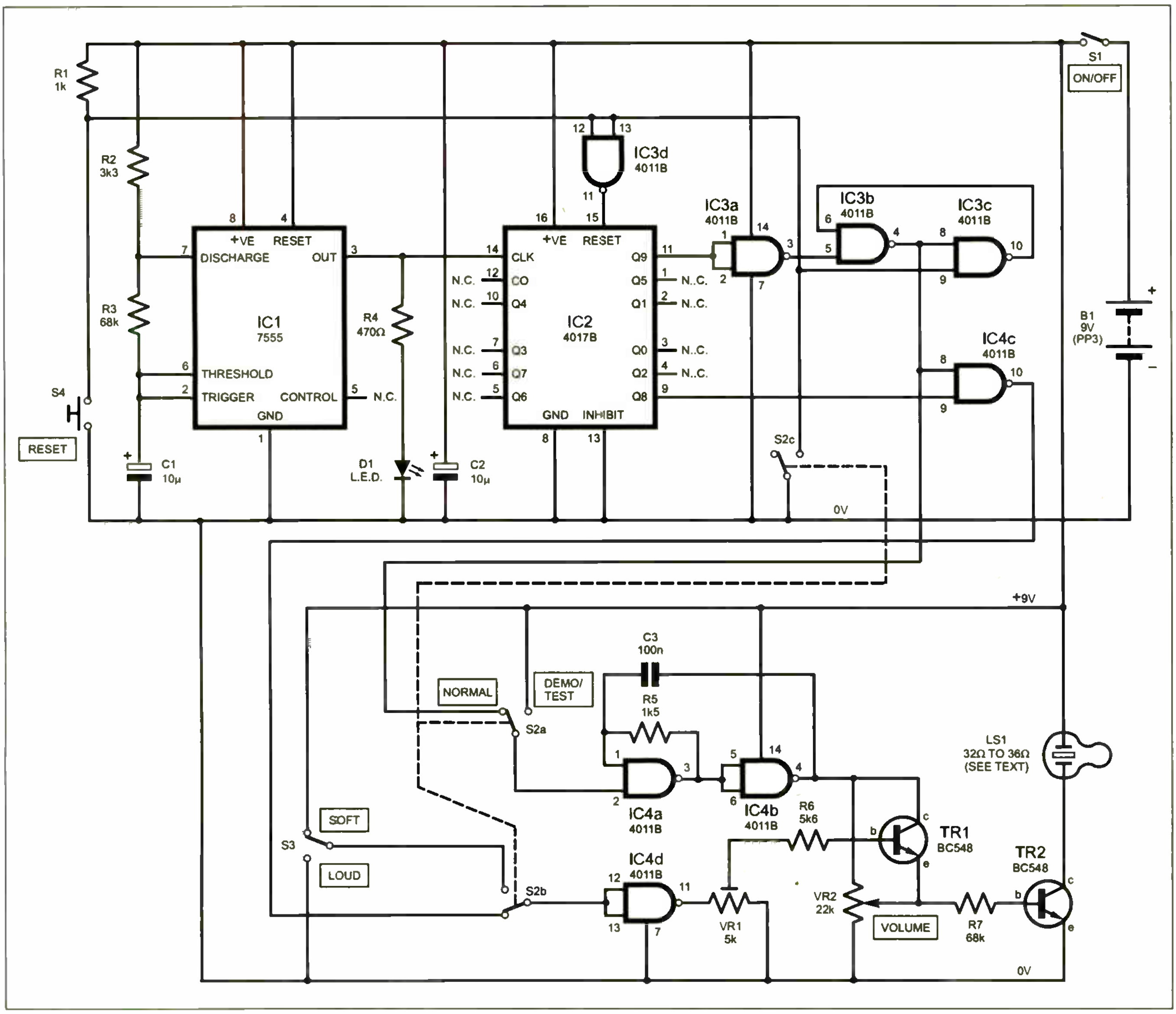

Fig.2. Circuit diagram for the wake-up call Slumber Alarm

Audio Illusion – Ears a Ping-Pong

THE circuit pictured in Fig.3 is a revamped version of one which appeared in *IU* some years ago. It is a classic auditory illusion that has had psychologists and neuroscientists puzzled for decades. Unlike the original circuit, which required three oscillators, this circuit uses just one. Also, it perfectly fulfils the theoretical requirements of the illusion by automatically generating the three frequencies required.

In the classic illusion, a two-tone "siren" plays into stereo headphones. The two tones are separated by one octave, and alternate at roughly 4Hz. However, the siren is played out-of-phase into each earpiece. If all were well, each ear would hear a two-tone siren, as they ought to do. However, in reality the mind perceives a two-tone "ping-pong" effect, which jumps from ear to ear. What has the mind done with the missing tones? Further, if one reverses the headphones, the tones fail to reverse with the headphones, but "stay where they were".

A single oscillator-divider IC1 provides the two audio tones through its outputs Q4 and Q5. One of these tones (from Q5) is exactly half the frequency of the other (Q4), so that these are separated by exactly one octave as required. Output Q13 switches an electronic version of a d.p.d.t. relay, comprising IC2 and the inverter formed around transistor TR1 and resistor R3. Thus the two tones are played out-of-phase. The effect is the same whether headphones or loudspeakers are used.

Thomas Scarborough,
Cape Town, Rep. S. Africa

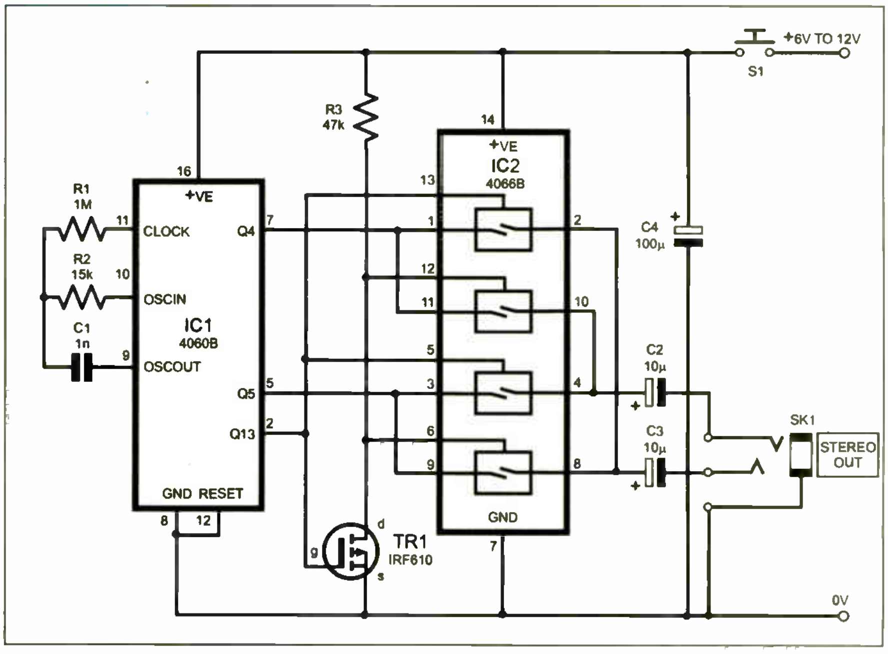

Fig.3. Circuit diagram for creating an audio illusion

INGENUITY UNLIMITED
BE INTERACTIVE

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

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Continuous Power	150W
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AC Frequency	50Hz
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Dimensions	165x91x58mm
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Part No. 12V	651.626
Part No. 24V	651.629
Continuous Power	300W
Peak Power	1000W
Output Voltage	230V AC
AC Frequency	50Hz
Efficiency	90%
Stability	+/-10%
Dimensions	190x91x58mm
Weight	1.1kg

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Part No. 12V	651.632
Continuous Power	600W
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Output Voltage	230V AC
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Continuous Power	600W
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Stability	+/-10%
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THD	<4%
Dimensions	80x242x255mm
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Part No. 12V	651.605
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Stability	+/-10%
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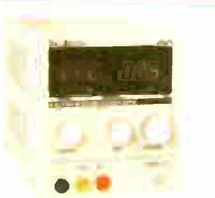

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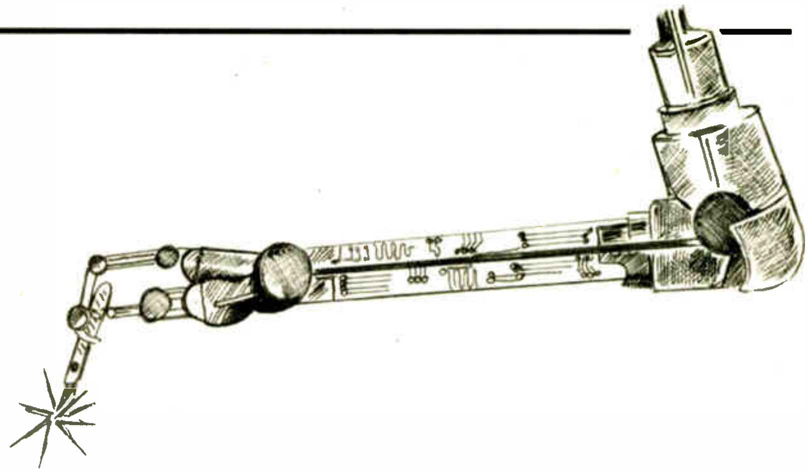


Alan Winstanley and Ian Bell

We return to basics this month, looking at square waves and offering advice for dealing with crimped connectors

Being Square

"I'm currently reading a book called Getting Started In Electronics *in which there are some terms and definitions relating to electronics. The bit that's puzzled me is the meaning of "Square Wave – a signal which oscillates between two fixed voltages."*

"That's it! I'm confused because I understand a sinewave but never quite understood the meaning or application of a so-called square wave and the reference to a fixed voltage. What does a square wave do? Please can you help. Thanks from ***Geoff,****" in the* EPE Chat Zone **(www.epemag.co.uk).**

After our three-part primer on the PC USB (Universal Serial Bus), it's back to basics in *Circuit Surgery* with an introduction to some of the most common waveforms and signals that are present in many electronic circuits.

Waveforms are the product of both analogue and digital electronic circuits. Analogue waveforms can be thought of as being comprised of "wavy lines" and may be, for example, an audio output from a microphone or loudspeaker, or a.m. or f.m. radio signals. A digital signal is recognisable by clearly defined step changes of level: personal computers and PIC microcontroller logic circuits are full of these digital signals.

Sometimes, we need to convert one sort of signal to the other, for which an analogue-to-digital converter (ADC) or digital-to-analogue converter (DAC) circuit will be used. Examples of signal conversion are found in audio CD systems, which process digitised forms of analogue signals (the original music) and outputs them as "wavy lines" to an audio amplifier, to be played over some headphones or loudspeakers.

In Fig. 1 some square wave signals have been drawn. The first thing to point out is that a square wave does not have to be "square shaped"! They can be rectangular, or they can be brief "blips". They merely represent a step change from one level to another and back again: they can be a stream of pulses, or "ons" and "offs".

Another point is that they don't necessarily have to represent voltage (symbol *V*): they can relate to current (symbol *I*) or some other physical phenomenon. In microelectronics though, square waves are most often seen when discussing voltage signals, logic levels and pulse trains.

In Fig. 1a a square wave is shown that plots voltage against time. The shaded area represents the square wave, and it is either "low" at 0V, or "high" at a voltage labelled V_1. We can put more interesting labels on this square wave. If the "on" time is t_1 as shown, and the "off" time is t_2 then the **period** of this square wave is $T = (t_1 + t_2)$. If t_1 is say 0·05 seconds (50 milliseconds) and t_2 is 0·02 seconds (20 milliseconds), the period is 0·07 seconds.

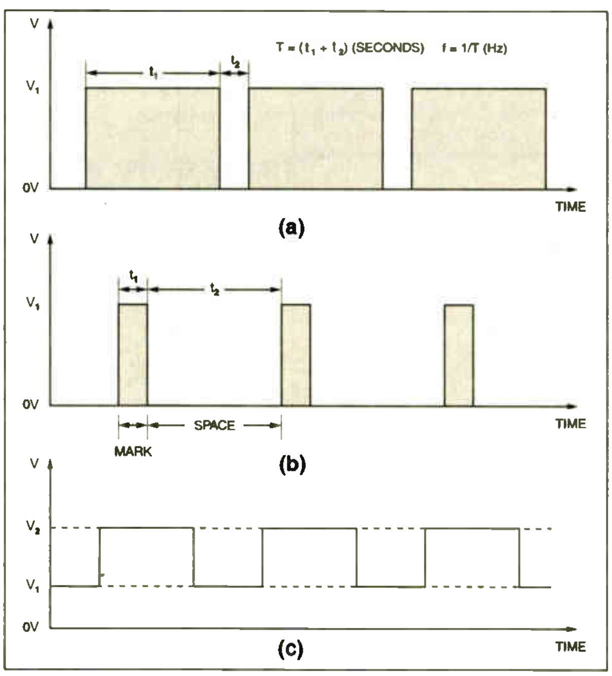


Fig.1. Some examples of square wave: a) showing the total period $T = (t_1 + t_2)$; b) illustrating the mark/space ratio and c) showing square waves do not have to cycle between zero and another level

The frequency *f* of a wavefrom is the reciprocal of the period in seconds, i.e. $f = 1 / T$(Hz).

Frequency is the same as the number of cycles per second and is measured in Hertz (Hz.) Our square wave has a frequency of 1/ 0·07 = 14Hz.

In Fig.1b another square wave is shown, but this time the "high" period t_1 is much shorter than the "low" period t_2. If t_1 is now 20 milliseconds and t_2 is 50 milliseconds then the frequency of the square wave is still the same!

The "on" time t_1 may be referred to as the **mark** and the "off" time t_2 as the **space**. The mark-to-space ratio indicates the waveform's **duty cycle.** A 100% duty cycle would mean that the voltage would be permanently high at V_1. A 50% duty cycle means that the voltage is on for 50% of the time.

On Duty

The term *duty cycle* often appears in other areas. When buying a computer printer, for example, the printer's "duty cycle" rating indicates the intended rate of usage, usually in sheets of paper printed per month. This helps you to choose a printer that will cope with the likely demand. A heavy-duty printer might have a duty cycle of 150,000 pages per month; my Deskjet 1220C inkjet has a duty cycle of 5,000 pages per month.

Cheap domestic waste paper shredders have appalling duty cycle ratings as befits their price, often requiring a "rest" (that's the "space" in the square wave of shredding operation) after a few minutes of use (the "mark"). If you exceed the rated duty cycle, or feed through too many sheets at a time, the motor will overheat and trip out. In this context a duty cycle of 10% means that it must rest for 90% of the session. By uprating the motor, cutters and power supply, the duty cycle could be improved towards a theoretically unstoppable 100% "continuously rated".

As mentioned earlier, a square wave will step between one level and another, but this doesn't have to be from *zero* to some other level. In Fig 1c a square wave is shown that has been level-shifted from 0V and is superimposed on a higher voltage. It now cycles (oscillates) between two levels, V_1 and V_2 but can still be classed as a square wave. The principles of calculating frequency and duty cycle are the same.

In our examples the square wave oscillates between two fixed levels, which means that we can class them as **binary** signals. These are at the root of operation of logic circuits and PIC projects.

In binary circuits the voltage levels are strictly specified. A classic TTL logic circuit would use square wave signals of 0V (logic low) and +5V (high), though a tolerance is permissible on these values that allows for consistent operation between different chips. Data sheets tell us what these *threshold* values are, and designers have to ensure that digital circuits operate correctly at them. Modern low power circuits use lower threshold values, e.g. +3·3V.

In practical electronic circuits, square waves are not perfectly shaped. It takes a finite amount of time to switch between low and high states, and if we enlarge a square wave sufficiently (say, by measuring them and changing the time base of an oscilloscope) then eventually we can see that it starts to take on a "trapezoidal" shape rather than the perfect square. Therefore, of interest to advanced circuit designers are the *rise time* and *fall time* of a pulse or a square wave, which relates to how fast the leading edge and trailing edge of the square wave can change from one state to the other. In most hobby circuits this doesn't matter, but when clock frequencies in modern personal computers are reaching the gigahertz (1,000,000,000 cycles per second) level then it becomes critical.

Sine of the Times

A familiar sinewave is shown in Fig.2. Unlike a square wave, which *switches* between two thresholds, a sinewave *swings* between two **peak voltages**. The example swings around the 0V axis between $+V_{pk}$ and $-V_{pk}$. This is like the domestic mains voltage supply. The frequency is calculated the same way, using $f = 1/T$. A standard 50Hz mains sinewave has a period T of 20 milliseconds.

Why is the mains voltage a sinewave and not a square wave? Electricity is produced at power stations by means of huge "electromagnets" spinning around inside generators. The output voltage therefore rises as the rotating electromagnet approaches the surrounding coils, before the magnet moves away again and then actually reverses in polarity. The sinewave reflects this rising, falling and reversing of the generator coils by having a *positive* and *negative* cycle.

The British mains supply is officially labelled as 230V a.c., though in reality it is more like 240V a.c.; this value is termed the **r.m.s.** (root mean square) voltage and if we multiply this by 1·414 – the square root of 2 – we can calculate the approximate peak voltage of 339V a.c., giving us a **peak-to-peak voltage** of 678V a.c.

To round off this simple introduction, Fig 2 also shows a sawtooth (b) and triangle (c) waveforms. These might be seen in timing or synchronising circuits. The classic 555 timer chip produces a square wave output and its *RC* timing network can be a useful source of a sawtooth waveform. *A.R.W.*

A Source of Mystery

"I am in the USA and have recently downloaded the Dec 2004 issue of your online magazine (**www.epemag.com**) *and would like to try out the* Super Vibration Switch *project. However, I am finding it very difficult to locate the required components. I would like to know if there is a store that you could recommend?*

*"Any information you can offer would be helpful. Also, in the same project, can metal film resistors be substituted for the carbon film resistors? Thank you, from **Fred Adams, USA**" (by email).*

One source in the USA I can suggest is Digi-Key Corporation (**www.digikey.com**) based in Minnesota. They have a downloadable catalogue, and UK readers may be interested to know that there is a UK freephone number available. Prices are available in Pounds Sterling and are said to include duty and brokerage fees.

Unfortunately it is hard these days to design a project assuming that all components can be sourced from one store. We do specify sources for any unusual parts in our *Shoptalk* column. Part of the deal of modern hobby electronics is that it may be necessary to deal with a number of suppliers (vendors), though we know this can impact on the construction cost due to multiple postage charges incurred. Try gathering together some catalogues, or check over *EPE* advertisers' web sites to see what's on offer, and group orders for projects together to save postage. Order extra regular parts for "stock" as well.

It is perfectly alright to use metal film types in place of the carbon film ones we mentioned in the Parts List. We specify ordinary carbon film types as these are "vanilla flavour" resistors that are used universally in normal applications. Metal film types are of a higher quality, and have uses in low noise projects or ones where closer tolerances are needed on component values. *A.R.W.*

Crimping or Soldering

One of my favourite TV programs is *American Chopper*, a piece of theatre about a US custom motorcycle factory (**www.orangecountychoppers.com**) run by its cantankerous owner, helped by his long suffering sons. My eyes lit up (as did the bike's headlight, in fact) in a recent programme when they were wielding a soldering iron and doing some wiring up on their latest bike. Which leads to my next reader's question:

*"I have just been told that you should never solder crimped spade connectors after they have been crimped. At UWE I was told this should not be done, yet I have now been told that I should! What is your view? Many thanks, **Philip**." (by email).*

In my view, crimped wires do not need to be soldered "for luck". The good folks of *OCC* were seen to be twisting and soldering some motorcycle wires together rather than using crimp connectors. In another programme on satellite TV, I groaned when I saw a huge battery terminal wire being crimped and soldered – it was for a home built 4 × 4. On a custom bike intended mainly for show, then it doesn't matter much, but there are good reasons why soldering can be inferior to crimping an electrical joint – and why the two shouldn't be mixed.

The factor affecting reliability here is vibration, and it doesn't take an Orange County chopper to cause work-hardening metal fatigue on soldered joints that have to flex in use. Many devices vibrate – computer power supplies have a fan, and disk drives vibrate as well. When a multistranded wire is soldered (whether crimped or not), then the solder turns it into a brittle solid-core wire.

Vibration causes the wire to flex, which as we all know will eventually fracture the joint. Strain reliefs are used in many connectors that need to be soldered, to improve reliability. Even the crimps of a spade terminal often include some form of strain relief to grab the insulation and grip it firmly, to avoid fracture.

If you look under the bonnet (hood) of a car, almost all wiring is terminated in crimped connections. Apart from helping the cost and speed of assembly, this is done when terminals are too large for ordinary soldering (the 12V battery, starter motor etc.) or if the wire is going to be subject to vibration or stress. Using the proper tools and connectors, crimping allows good, consistent and reliable joints to be made every time. *A.R.W.*

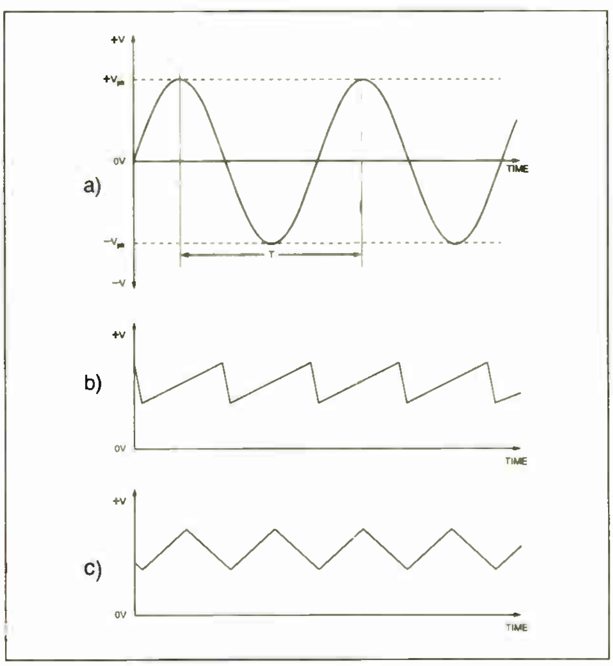


Fig.2. A sinewave (a) has a period T and swings from $+V_{pk}$ to $-V_{pk}$. Example waveform (b) is referred to as a sawtooth and (c) is a triangle wave.

Special Feature

Stereo Headphone Monitor

by Terry de Vaux-Balbirnie

Usable as an add-on for last month's Sound Card Mixer or as a stand-alone unit

THIS circuit was designed to be built into the *Sound Card Mixer* (Feb '05). With it, the user may monitor the output using a pair of headphones and make accurate adjustments while recording is in progress. Some readers will not need this facility because their configuration already allows headphone monitoring. This is why the circuit was not included as part of the original design.

Equally useful to some readers is the ability to use the circuit as a self-contained unit. This will allow listening to the sound output from any Line level source, such as an electronic musical instrument, using headphones.

If the *Sound Card Mixer* has been constructed in the specified sloping-front case, there will be ample space inside to accommodate this new circuit and it may share its power supply. The additional current depends on various factors but it is likely to be in the region of 10mA to 15mA. The total current requirement of the Mixer will then rise to some 55mA. This will reduce the life of the battery pack so, for long periods of use, a larger set of batteries may be used. If these will not fit inside the case, they could be sited externally.

Stereo Amplifier

The Stereo Headphone Monitor is just a small stereo power amplifier. It provides sufficient output to operate a pair of standard headphones having an impedance of 32 ohms approximately. The unit is fitted with a volume control which allows the sound to be adjusted to a comfortable listening level. Using this does not affect the signal passing to a sound card or other device.

When built into the *Sound Card Mixer*, you could use headphones having a boom microphone attached. This would be ideal for commentaries and "voice overs". The advantages of adopting this method are that the hands are kept free and a constant speaking distance is maintained with the microphone.

Circuit Description

The full circuit diagram for the Stereo Headphone Monitor is shown in Fig.1. Integrated circuits IC1 and IC2 are the actual amplifiers. Two are required – one for each channel. These can provide 325mW into an 8Ω load. However, since headphones have a much greater impedance than this, the available output will be reduced. This does not matter because only a very small output is sufficient to fully load the headphones.

The circuit comprises two sections and a small number of components common to both. The part centred around IC1 is associated with the Left channel while that based on IC2 is responsible for the Right. Since these parts are identical, only a description of the left channel is needed. Note that components in the left channel (and those common to both) are labelled with single figures – for example, C1, C2, and C3 while in the right one, the corresponding components are prefixed with a "1" – C11, C12, C13, etc.

Power Supply

The power supply may consist of a 6V or 9V battery. If used as a stand-alone unit, four AA size alkaline cells would be satisfactory. Current flows via diode D1 to charge capacitor C5. Sudden surges of current occur on the sound peaks and batteries alone might not be able to provide these, especially when they are nearing the end of their life. This would result in distortion. The capacitor holds a reserve of charge which will provide any instantaneous current demands.

Diode D1 gives supply reverse-polarity protection and also isolates the power supply from that of the *Sound Card Mixer* if this is shared with it. The positive supply feed is made to IC1 pin 6. Pin 2 (the inverting input) is connected to 0V together with the actual 0V connection, pin 4.

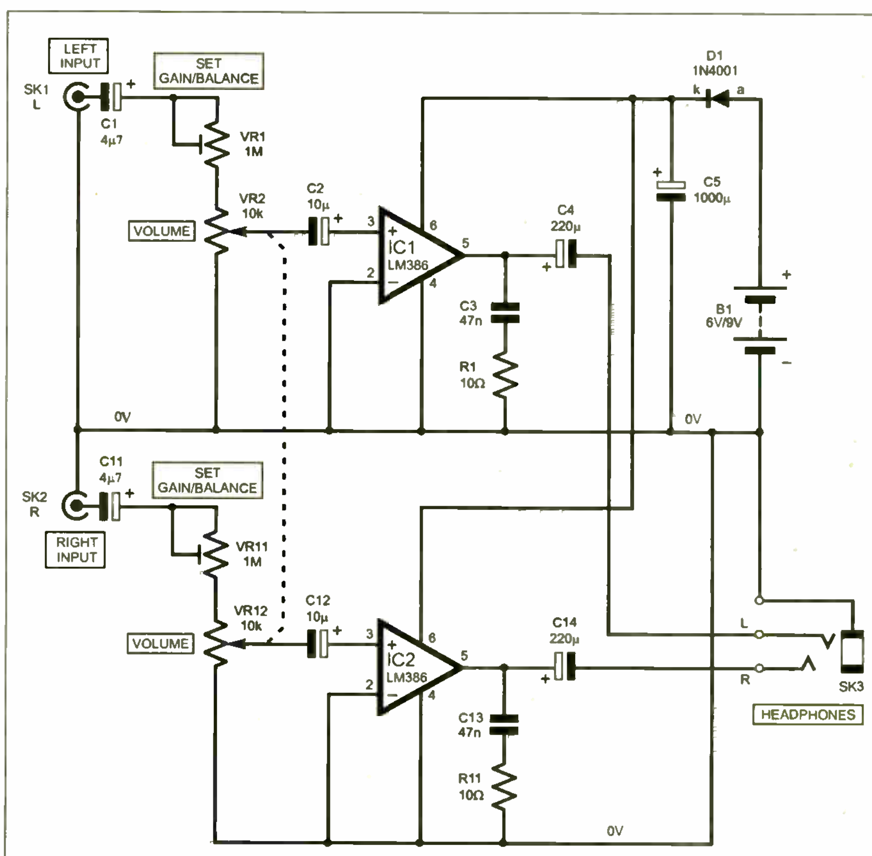


Fig.1. Complete circuit diagram for the Stereo Headphone Monitor.

The signal input is made to IC1 pin 3 (the non-inverting input). However, a line level signal would be too high and must first be reduced. This is carried out using a potential divider arrangement. The incoming a.c. (audio) signal flows through capacitor C1, preset potentiometer VR1 and rotary Volume control VR2 to the 0V line.

To the Maximum

Suppose VR1 is adjusted to maximum resistance (1MΩ). With VR2 at its minimum setting, the voltage at its sliding contact (wiper) will be zero. When VR2 is set to maximum, the signal voltage will be divided by 100 approximately. With preset VR1 adjusted to less than maximum resistance, a smaller amount of attenuation (reduction) is provided.

COMPONENTS

Resistors

R1, R11	10Ω (2 off) 0·25W 5% carbon film

Capacitors

C1, C11	4μ7 radial elect. 35V (2 off)
C2, C12	10μ radial elect. 16V (2 off)
C3, C13	47n ceramic disc, 5mm pitch (2 off)
C4, C14	220μ radial elect. 16V (2 off)
C5	1000μ radial elect. 16V

See SHOP TALK page

Potentiometers

VR1, VR11	1M carbon preset vertical (2 off)
VR2/VR12	10k min. dual-ganged rotary carbon, p.c.b mounting, with 5mm matrix pin spacing, log. (see text)

Semiconductors

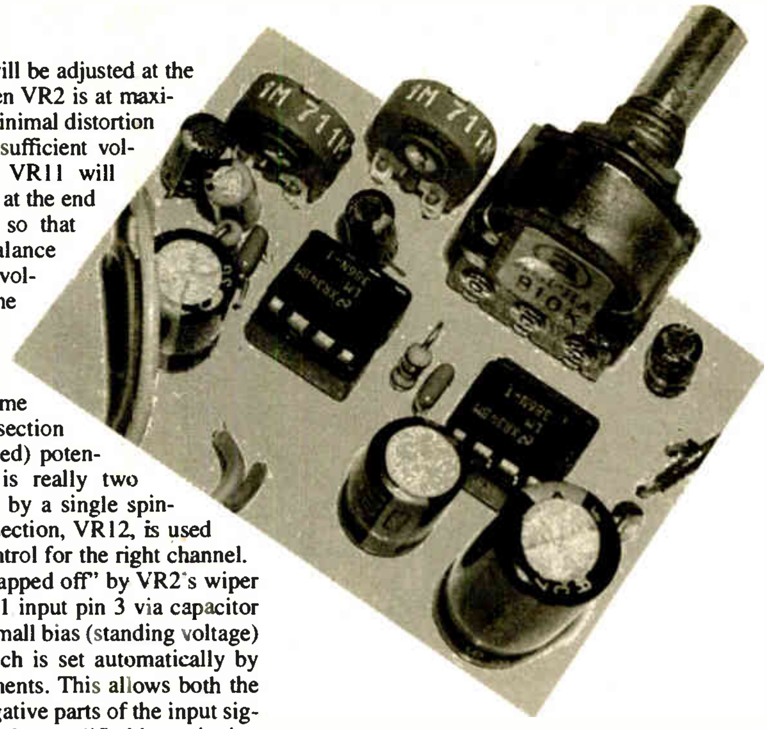
D1	1N4001 50V 1A rectifier diode
IC1, IC2	LM386N-1 power amplifier (2 off)

Miscellaneous

SK1, SK2	phono socket (2 off) (see text)
SK3	3·5mm stereo jack socket (see text)
B1	AA-size alkaline cells (see text) (4 off)

Printed circuit board, available from the *EPE PCB Service*, code 490; metal case (see text); control knob; 8-pin d.i.l. sockets (2 off); PP3-type battery connector; connecting wire; solder, etc.

Approx. Cost Guidance Only **£11**



Preset VR1 will be adjusted at the end so that, when VR2 is at maximum, there is minimal distortion combined with sufficient volume. VR1 and VR11 will also be adjusted at the end of construction so that there is a balance (equality) in the volume between the left and right channels.

Note that VR2 (left Volume control) is one section of a dual (ganged) potentiometer. This is really two units controlled by a single spindle. The other section, VR12, is used as a Volume control for the right channel.

The signal "tapped off" by VR2's wiper is applied to IC1 input pin 3 via capacitor C2. There is a small bias (standing voltage) on this pin which is set automatically by internal components. This allows both the positive and negative parts of the input signal waveform to be amplified by swinging above and below this voltage.

The output appears at pin 5 and the signal flows via capacitor C4 to the left-hand headphone output. Capacitor C3 connected in series with resistor R1 stabilise the amplifier and prevent any oscillation that might otherwise occur.

Construction

Construction of the Stereo Headphone Monitor is based on a single-sided printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 490. The component layout and actual size copper master track pattern are shown in Fig.2.

Begin construction by soldering the two 8-pin i.c. sockets in position then add the fixed resistors and preset potentiometers (VR1/VR11). Follow with the capacitors – most of these are electrolytic and care must be taken to place them with the correct polarity as indicated. Add diode D1, taking care over its polarity.

Solder Volume control potentiometer VR2/VR12 in place. It would be better if this is a logarithmic (log) type because it provides an improved physiological response (angle of rotation against perceived change in volume). However, an ordinary linear (lin) unit would be satisfactory.

Assembly

Adjust presets VR1/VR11 to approximately mid-track position. Solder pieces of stranded connecting wire to the power supply and the input and output pads. Using coloured wires will help to avoid errors. Insert the i.c.s into their sockets. The completed p.c.b. is shown in the photograph.

The circuit panel is very small and light so may be mounted using the potentiometer bush fixing alone. If the circuit is to be used as an add-on unit for the *Sound Card Mixer*, decide on a suitable position for it inside the case. Remove the existing p.c.b. to prevent damage and move any wiring out of the way.

Drill holes for the potentiometer bush and headphone jack socket. In the prototype, the socket was mounted at the front of the unit because this avoids trailing wires.

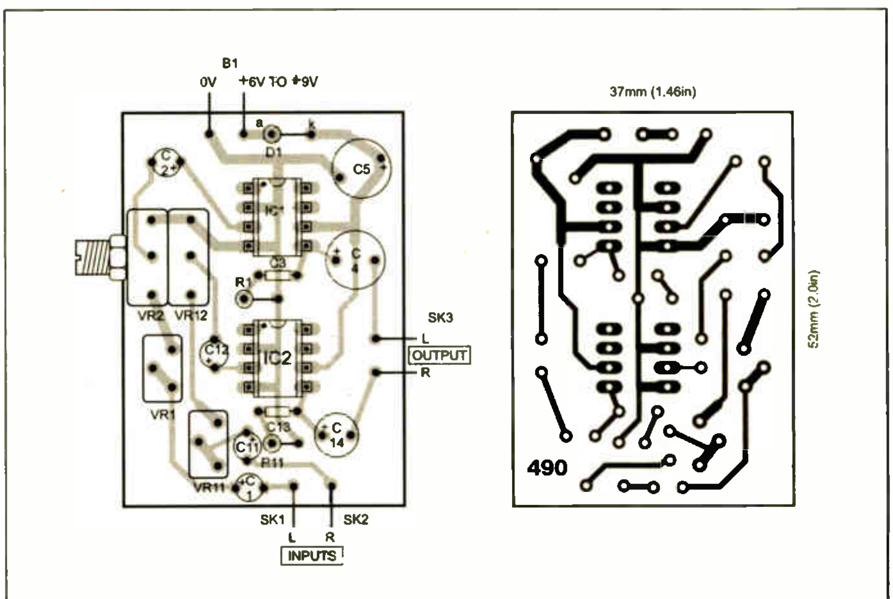
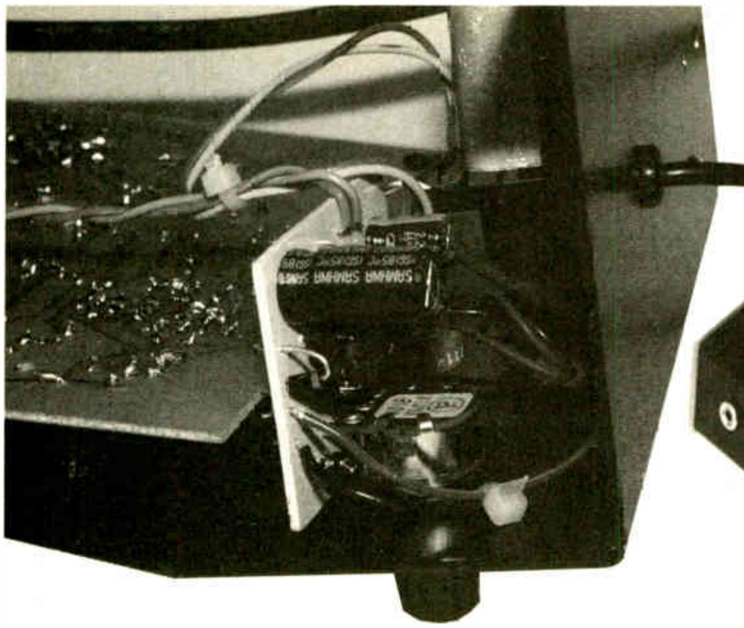


Fig.2. Printed circuit board top side component layout, wiring details and full-size underside copper master for the Stereo Headphone Monitor



The Stereo Headphone Monitor circuit board mounted at the rear of last month's Sound Card Mixer project

The knob on the top/back of last month's Sound Card Mixer is the volume control for the Headphone Monitor. The Headphone socket can be seen on the front edge of the case

Interwiring

If the unit is to be built into the *Sound Card Mixer* case, refer to Fig.3. This shows the connections needed to the existing wiring. The supply positive feed is made to the on-off switch (so that the switch controls both sections). The 0V connection is made to the rear solder tag. There are already connections made here so it will be best to desolder them, twist all the wires together and solder the joint again. Make sure this work is sound.

The left and right Monitor's input connections are made to the *Sound Card Mixer's* output wires (see Fig.3). In the prototype, the wires were cut at a convenient place and the new ones soldered to them. Heat shrinkable sleeving should be used to insulate the joints.

For the output (Headphone) socket SK3, use a 3·5mm stereo jack type (or as appropriate for the headphones used). The socket used in the prototype made an automatic sleeve connection with the metal case (0V). If this type is used, scrape away the paint around the hole on the inside of the case so that good electrical contact is made. If the socket is fully insulated and does not make a 0V connection in this way, the sleeve connection will need to be hard-wired to a 0V point (to the solder tag at one of the phono sockets for instance).

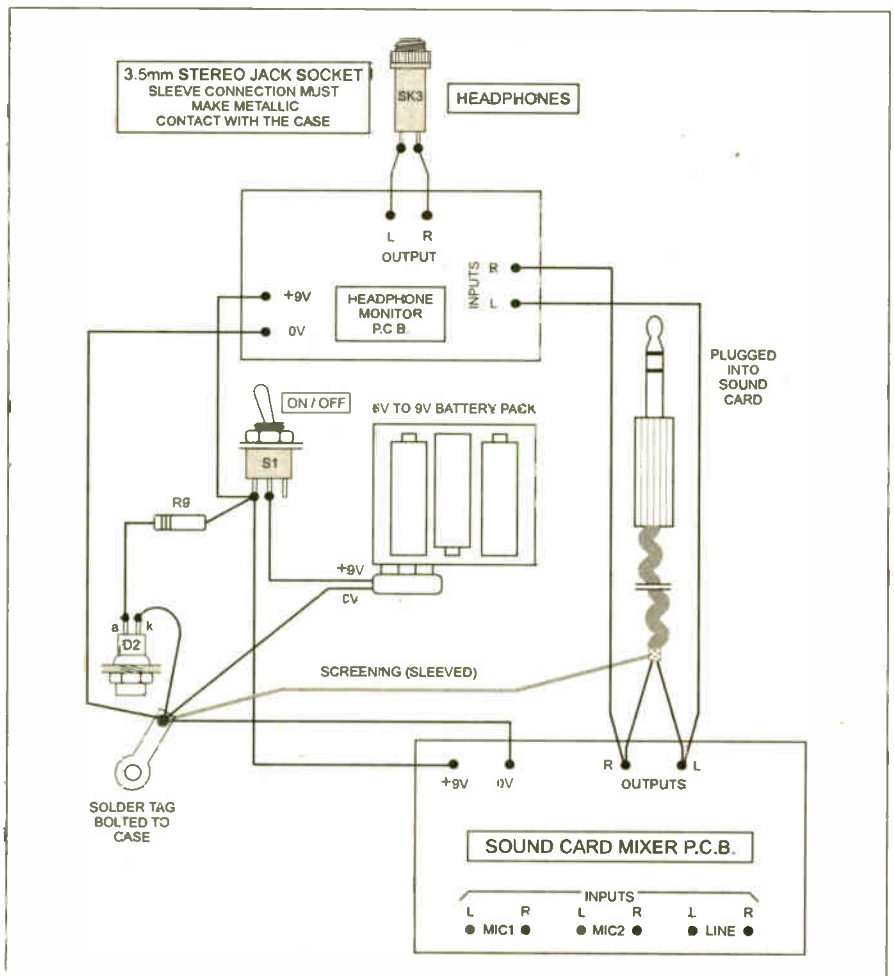


Fig.3. Interwiring between the Headphone Monitor and last month's Sound Card Mixer's components and circuit board

Free Standing

If the Monitor circuit is constructed as a free-standing unit, choose a suitable metal box large enough to accommodate the circuit panel, battery pack, on-off switch, phono input sockets and headphone jack socket. Drill the fixing holes for these parts and attach them. Make sure the soldered joints on the underside of the p.c.b. are kept several millimetres clear of the base of the box. This will prevent any short circuits with the metalwork.

Refer to Fig.4 which shows the internal wiring. The sleeve connections of the phono sockets, that of the headphones socket, the "0V" wire on the p.c.b. and the battery "0V" ("negative") wire, are inter-connected and must make metallic contact with the case ("earth") via a solder tag.

The sleeve connections of uninsulated "single hole fixing" phono sockets make an automatic connection with the metalwork. These are usually supplied with a solder tag and, fitted to one socket, may be used for all the 0V connections. Scrape away any paint around the fixing hole to make sure a good contact is made. If any of the sockets do not make the "earth" connection automatically, you will need to hard-wire them to a separate solder tag. Make sure this makes good electrical contact with the metal case.

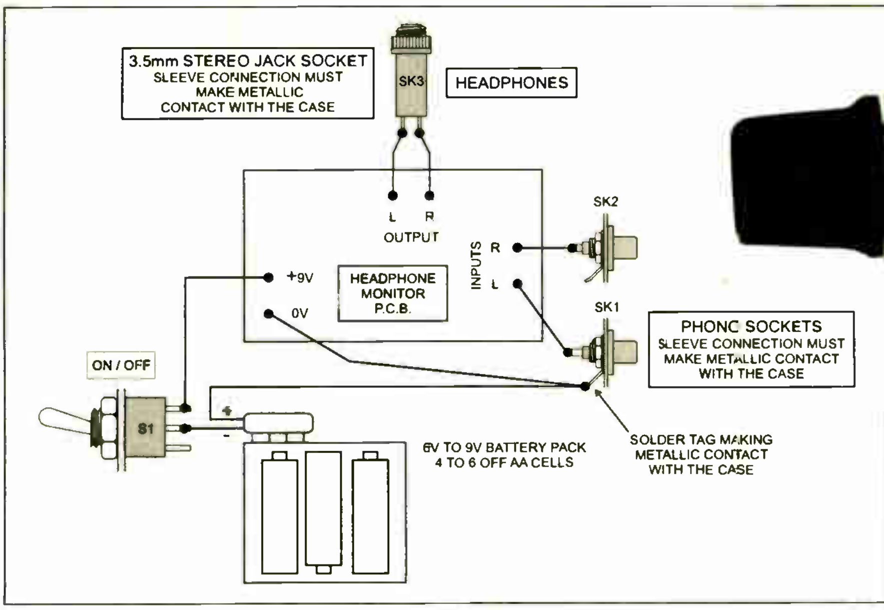
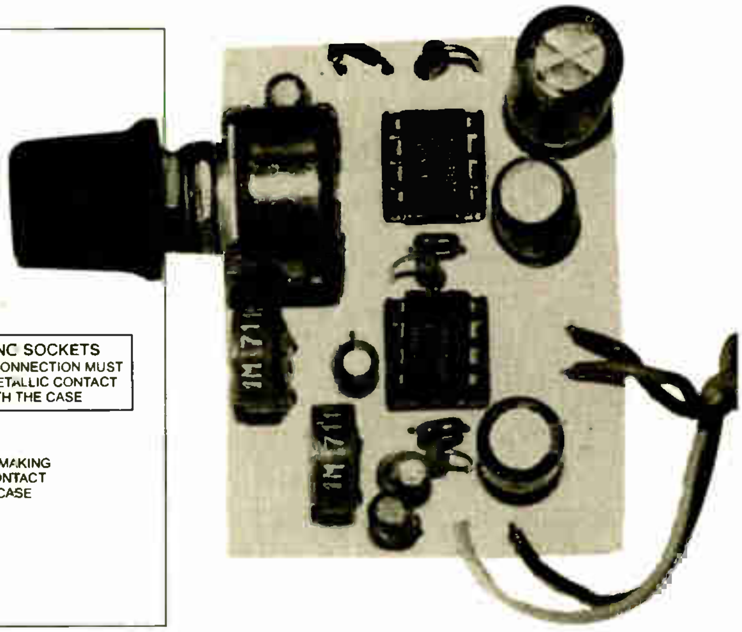


*Fig.4. Interwiring for the "stand-alone" version of the Headphone Monitor. The sleeve connections for the jack socket and phono sockets must make a good "earth" (0V) with the **metal** case*



The completed Headphone Monitor circuit board ready for mounting in a suitable metal case

Testing and Listening

Turn the Volume control to minimum (full anticlockwise rotation). Plug the headphones into the jack socket. Apply a Line level signal to the input and switch on the supply. A suitable signal may be obtained from a tape deck, CD player or possibly a camcorder's audio output.

Listen cautiously to the headphones in case there are any surprise loud noises. Advance the volume control and check the sound quality. If it is very weak despite the Volume control being set to the maximum, reduce the settings of presets VR1/VR11 equally by clockwise rotation of the sliding contacts (as viewed from the left-hand edge of the p.c.b.). You may need to remove the circuit panel to do this, or you might be able to do it with it in place using a thin screwdriver.

If the sound becomes very distorted as the volume is turned up, decrease the settings. Aim for maximum undistorted sound when the volume control is turned fully clockwise. Presets VR1/VR11 should also be individually adjusted for an equal volume between left and right channels. □

PIC Electric MK2

John Becker - Part 2

Monitor the cost of running your mains electrical appliances

LAST month we described the circuit diagram and construction of this mains power monitoring design. We conclude now by describing its testing and setting-up and then discuss it's optional use with a PC.

Control Board Tests

Connect the Control board to the Sensor board. Check that the +5V supply line is still correct. If so, the d.i.l. i.c.s, including the pre-programmed PIC, can be inserted and the l.c.d. connected. Again check that the +5V line is correct. Adjust preset VR1 until the l.c.d. screen display is clearly visible.

At the moment of power connection to the unit, the PIC software enters an initialisation routine setting various "housekeeping" factors, including the setting of the l.c.d. into 4-bit 2-line mode. On completion, the screen briefly displays an opening message and states the number of serial memory chips installed, either none or one with PIC-Electric, e.g.:

```
PIC ELECTRIC MK2
1 EEPROM CHIP
```

The program then goes into its main monitoring routine with the screen displaying voltage, plus current and wattage for the *two* channels (even if only *one* sensor is installed). The following is an example display when Channel 1 has a load connected to its sensor:

```
2.60A  657W  253
00.0A    0W    V
```

At this time, the voltage value will be present but the current and watts values should be zero. It is worth noting that in the UK the mains a.c. supply voltage is permitted to vary within a 6% range of the nominal value of 230V a.c.

The reading on your screen, though, will likely be different from the true a.c. voltage present. So too will the amps and watts value(s) differ from those that actually exist when an appliance is connected to a sensor. PIC-Electric needs "tuning" via the switches before the correct values are displayed, as described in a moment.

Press and release Step switch S3, to display the second l.c.d. screen, as described above. An example is:

```
5.07          432
0.00      0:17.36
```

in which the running cost for Channel 1 at this moment is 5·07 (pence, or whatever your local currency is – it does not matter to the software what your currency is called, as long as it is a decimal currency). Channel 2 has so far not clocked up any reportable cost. The elapsed time since PIC Electric had power applied is 17 minutes and 36 seconds. The last memory address at which sample data has been stored is 432 (out of 32768).

Pressing S3 again re-displays screen 1.

Fine Tuning

Each time PIC-Electric is powered-up, part of the initialisation routine fetches certain correction and value factors from its internal EEPROM. Until changed, the values are those used by the author with the prototype.

There are two paths through which the values can be changed. In path one, mains frequency synchronisation can be adjusted, plus the voltage and amperage correction factors. In path two the cost per unit of electricity used can be set, and selection of whether PIC-Electric is to be used on a 50Hz or 60Hz mains supply (this affects internal timing factors). It is not necessary to specify the local mains a.c. supply voltage (230V/110V) standard.

The essential factor to change first is the local mains frequency, 50Hz or 60Hz. This can only be done, though, following the setting of the local electricity unit cost (although you may use the author's default setting for the time-being if you prefer).

To enter this correction path, press Reset switch S4 and *hold* it pressed. Now press switch S1 (Up) and hold it pressed, then release S4 and then briefly after release S1. The following default message is displayed (showing the local cost of the author's electricity units as 8·37 pence per kilowatt hour):

```
.    8.37  CHANGE
PRICE UNITS
```

With this screen showing, the integer cost per unit (8 in this case) can be changed. Pressing S1 increases the value (maximum range 999). Pressing S2 (Down) decreases it (minimum value 0). Having set the desired value (see your latest electricity bill), press Step switch S3, to display the message PRICE DECIMALS on line 2.

Now the decimal values can be changed (from 37 in this instance) using S1 and S2. The range is 00 to 99, cyclically rolling-over at the extremes.

Having set this value, press S3 again to enter the mains frequency selection mode, in which line 1 shows the existing frequency selection, with line 2 blank:

```
50Hz CHANGE
```

Only S2 changes the setting, slowly alternating between 50Hz and 60Hz for as long as S2 is pressed. Release S2 when the desired frequency is shown. Switch S2 may be re-pressed if necessary.

This frequency value selection is used by the PIC software in its clock counting routine, determining the number of mains cycles that should be counted before updating the seconds counter. It is also used to set the delays between synchronously reading the upper and lower peaks of the sensors' output voltage levels.

Pressing S3 again causes the cost and frequency values to be stored in the PIC's EEPROM, where they remain until changed another time, even when power is disconnected. The message STORED is shown until the switch is released, following which the PIC ELECTRIC MK2 title is shown.

Taking Samples

The 50Hz (or 60Hz) signal at PIC pin RA4 is monitored for change by the software. RA4 is a Schmitt Trigger input triggered when an input signal crosses intermediate upper or lower thresholds. Each time the signal crosses the upper threshold, the software starts a timer. At the time-out, there is a timed delay after which the voltage at ADC pin RA1 is read, synchronously with one waveform peak relating to the current monitored via Channel 1.

A second synchronous delay then occurs on the opposite peak of this waveform and the voltage value is read. A similar pair of delays follow for reading Channel 2's current via ADC pin RA3. Then the voltage at ADC input pin RA0 is read, from whose value the a.c. mains voltage is assessed.

It will be seen from the graph in Fig.7 why the delays are required. The initial trigger threshold at RA4 occurs before the peak of the 50Hz/60Hz mains cycle. The first delay sets the timing between that trigger threshold and the waveform's upper peak, at which the first PIC sample is taken. The second delay is set to synchronise the next PIC sample reading with the lower peak of the waveform. Between them, these two readings give the peak-to-peak value of the waveform, from which the current drawn via sensor X1 is assessed.

The following two delays are timed for the next waveform cycle to be monitored at its peaks, for assessing Channel 2's current.

Adjusting Synchronisation

Synchronisation of the sample taking in relation to the trigger point is determined by a value held in the PIC's EEPROM. Until changed, that value is the one used by the author, but individual versions of PIC-Electric Mk2 may benefit from adjustment to it due to normal differences in the tolerance of the associated components. Adjustment is simple.

To enter this correction path, press Reset switch S4 and hold it pressed. Press Down switch S2 and hold it pressed, then release S4 and briefly after release S2. On screen line 2 will be shown the message CHANGE SYNC. The PIC now monitors the amperage value for Channel 1. In this mode, the sampling rate is increased to about five times faster than normal to speed up the software's response to the switch presses about to be made.

With no appliance load plugged into Channel 1, Line 1 should show a value of 0·00A, but maybe flickering to 0·01A as well.

Plug in an appliance drawing a known amount of power, say a 60W table lamp. The value displayed on Line 1 will change to reflect the current being drawn by it, approximately 0·24A with the prototype and a nominally 60W lamp. The displayed value may be slightly unstable due to noise on the mains supply line.

Switches S1 (Up) and S2 (Down) are now used to change the synchronisation timing value upwards or downwards. All that is necessary is to observe the screen value by pressing one or other switch and holding it pressed. It does not matter which switch is used at this moment, but S1 is suggested.

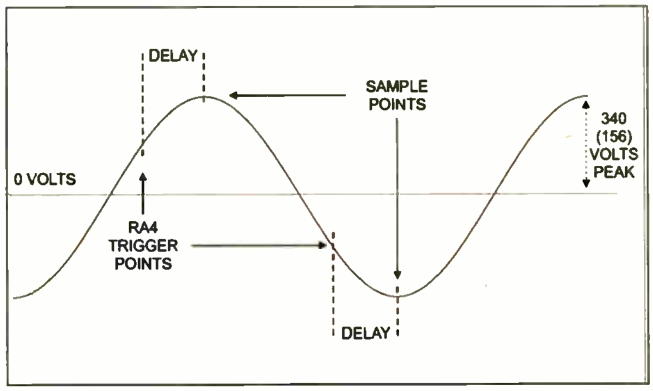


Fig.7. Waveform sampling logic

With switch S1 pressed, the screen value should change upwards or downwards, but be aware that the apparent response rate is quite slow, so be patient. If the value falls below the starting number, release S1 and press S2 to reverse the direction of change.

The idea is to use the switches until the displayed value is at the highest number that can be achieved. Let the value rise to just beyond its peak and start falling again. Now use the other switch until the peak value is again achieved, then finally release that switch. The value shown is the optimum when the synchronisation point is central to the upper peak of the waveform, as shown in Fig.7.

More Scope

A facility to use a dual-channel oscilloscope to monitor the waveform and synchronisation point has been provided, although its use will not significantly affect the accuracy of the adjustment as provided by the above technique.

Clip one scope channel probe to test point TP3 and adjust the scope's display amplitude and sampling rate so that three or four complete a.c. waveforms are displayed on its screen. Clip the other scope channel's probe to test point TP10, and set the scope's sync setting to that channel, for positive edge triggering. Adjust the amplitude setting for scope channel 2 so that the two waveforms are superimposed.

It may be seen that the a.c. waveform is not truly sinusoidal, due to the presence of the bridge rectifier, but may be more like a flat-peaked triangle wave. Scope channel 2's waveform will consist of two cycles of a squarewave, followed by a single cycle gap, followed by two more cycles of a squarewave, etc.

The rising edge of the pulses occurs on the rising edge of the a.c. waveform, or near to its upper flat peak. The falling edges of the pulses will be in a similar position in relation to the falling edge of the a.c. waveform.

Using switches S1 and S2, the pulse edges will be seen to slowly shift their position relative to the a.c. waveform. The optimum position is when they are central to the a.c. waveform peaks.

Adjusting Volts Reading

When satisfied with the synchronisation setting, press switch S3. The screen now changes to show a nominal voltage value on the upper line and the message CHANGE VOLTS on the lower.

The displayed value now needs to be adjusted until it corresponds with the actual mains a.c. voltage value present at the input to the unit. Set your multimeter to a range suited to monitoring a.c. mains voltages. Observing normal mains safety practice, clip its leads to the mains input test points TP8 and TP9. Note the reading.

Now use switches S1 and S2 to adjust the unit's screen value until it shows the same voltage. The rate of change is faster than for the synchronisation change. Release the switch being used when the values match.

Adjusting AMPS Reading

When the volts reading has been set, press switch S3 (Step) to enter the amps setting screen. Its lower line will show CHANGE AMPS, with the upper line showing three values, in order of amps, volts and watts.

The amps and volts values will be those set in the previous two modes. The watts value is the result of those values being multiplied. Using switches S1 and S2 again will be seen to adjust the amps and watts values, but not the volts value (although it is possible that this may change independently if the a.c. mains supply voltage changes).

There are two techniques for tuning the unit to the correct amperage value.

If you have the facilities for monitoring a.c. mains current, note the real-time value of the current actually been used by the appliance connected to the unit. Then adjust the unit's amps display to match.

Otherwise, assume that the stated wattage of the appliance is correct, i.e. that a 60W lamp is actually drawing 60 watts (unlikely, but probably close enough). Then adjust the display until that wattage value is shown.

Again, once satisfied, press switch S3. The settings established in these three modes are now recorded to the PIC's EEPROM, for immediate use and future recall. The message SYNC STORED is displayed briefly once S3 is released, and the unit then enters the normal monitoring mode.

The correction values may be changed again at any time if you wish, by the same techniques.

From here on, further presses of S3 then alternate the display between its two screens as described earlier.

Switches S1 and S2 have no effect during normal monitoring.

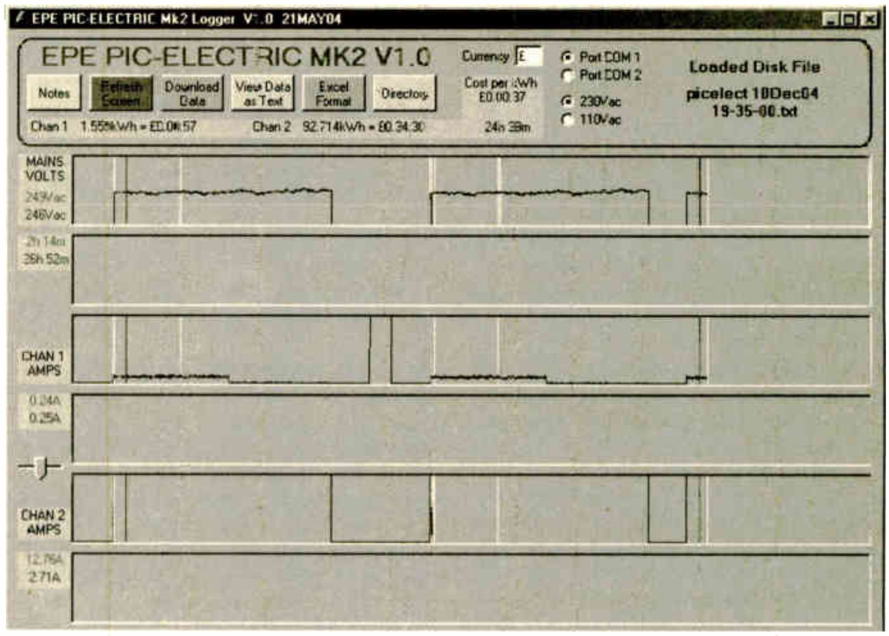
Pressing Reset switch S4 in monitoring mode has three effects: it resets the clock and cumulative cost counters to zero, and causes a Start flag to be set into the serial memory at its present count address (as discussed previously).

Clearing Serial Memory

As said, sample data is recorded continuously to the serial memory while the unit is powered, the address counter eventually rolling over to zero and restarting upwards, overwriting previous data.

The serial memory may be cleared whenever you want. Again, two switches are used, to prevent inadvertent clearing before you are ready! To start the clearance process, first press Reset switch S4, hold it pressed, now press S3, hold it pressed, then release S4, and then release S3.

This action cause the screen display to change to CLEARING EEPROM on Line



1, with the clearance progress shown on Line 2, as in the following example:

The count value changes in steps of 256 during the clearance progress, until the full 32768 bytes have been cleared to zero. The chip number does not change in this design as only one memory chip is used.

Clearance is quite slow as various timing factors are involved in the process. It takes about two and a half minutes to fully clear the chip.

Once clearance has been completed, the address count is set to zero and normal monitoring mode is again entered.

PC Software

Recorded data can only be downloaded and viewed via a PC screen using the specially written software referred to earlier.

To run the program, open the PIC-Electric Mk2 folder and double-click on **PICelect.exe**. The first time that the program is run it creates several additional files to which it refers each time the program is subsequently loaded. These include various settings which may be changed by the user from within the program, plus details of file data paths accessed via the Directory function.

Following this brief procedure, a nearly full-screen display on which graph data will later be drawn is shown. It also has various control buttons.

First note the two "radio" buttons towards the top right, labelled COM1 and COM2. Connect a standard serial port cable (the same type as you use with a modem) into the COM port socket that you wish to use, and into the PIC Electric Mk2 connector at the other end. Set the screen COM port choice accordingly.

Download Data

The next button of immediate interest is the Download Data button. It is via this option that monitored data recorded by the PIC is downloaded.

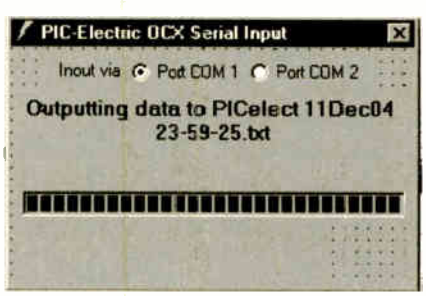
Note that the data in the PIC's serial memory is unaffected by the download and remains

intact. Further recordings may be made to the memory following a download, and the whole batch input as a block at a later time.

Assuming that you have first reset the serial memory, and have already been recording data for a while, click on the Download button to reveal the Download screen.

To start the download, click on the subscreen's Start button. The PC sends a handshake command (the letter "G", for Go), the PIC acknowledges by sending back the letter "R" for Received, and starts to output the stored serial memory data to the PC, in blocks of 1024 bytes. Data is transferred at 9600 Baud, 8 bits, no parity.

On receipt of each data block the PC and PIC again exchange "G" and "R" and another block is sent. This continues until the PIC has output all 32K bytes of its memory. A bargraph on the PC screen shows the download progress, and the PIC unit's screen displays the message OCX DATA TO PC. At the end of the data transfer, the PIC resumes sampling, recording and output to the l.c.d. as usual.



Once the PC recognises that a time-out has passed during which it has received no data, it exits Receipt mode and outputs the received data to two text (TXT) files in the same folder as the other PIC-Electric files are held.

These are named with prefixes of "PICelectOrigData" and "PICelect", followed by a unique date and time identity, as applies at the time of the download.

The first file contains the original data as received from the PIC, but now in ASCII text format compiled from the binary format in which the PIC sends it.

The second file comprises "processed" data in which each pair of twin-byte values of the recorded data are combined into one decimal value with a fixed length of five characters, followed by a comma. It is this file that the PC uses when it displays the waveforms generated from the data.

This file can be viewed as text data by clicking the Main screen's View Data as Text button. The data is input to either Windows Notepad or Wordpad, depending on its length.

Text file viewing is only available once the complete cycle has been completed. Once the text files have been stored to disk, the program automatically hides the Download screen and plots the processed data onto it as waveforms relating to the data values. The speed of this depends on the speed at which your PC operates.

The graphing area consists of six "picture" windows. The top pair are for the volts display, the next pair for Channel 1 amps data, and the bottom pair for Channel 2 amps data.

Data plotting commences at the left of each of the top pairs, continues to the far right and follows on into the second of the pairs, and again through to the far right. The entire set of data is displayed.

There are several informative labels above and to the left of the display area. Three labels state the function of each display window pair. Each pair has two additional labels which are updated when the mouse is clicked on any selected point in the windows.

Selective Analysis

Clicking the mouse left button in a window causes a vertical red line to be drawn at that point, and in the other two equivalent windows for the other display pairs. Clicking the mouse right button causes a blue line to be similarly drawn. Re-clicking either mouse button shifts the appropriate line to the new position.

The labels at the left of the window pairs show the recorded values for the positions indicated by the vertical coloured lines, each label text having the same colour as the line. The values are suffixed by "V" or "A" as appropriate to the window pair.

On a label below the volts values, the elapsed recording time at the vertical lines is displayed, in the same colours as the lines, in hours and minutes. The left of the upper window of each pair is taken as zero time. The far right of the lower window is the maximum elapsed time since zero hours. It is at this point that the most recent sample value is plotted.

Immediately below the control buttons at the top left of the screen two other labels display the elapsed time between the coloured vertical markers, and the cost of the electricity used during that time.

The timings do not take into account any periods during which the unit is unpowered. Vertical white lines on the screen indicate where these breaks occurred.

Costings

The cost per unit of power (1kWh) is that set into the PIC as described earlier and downloaded at the same time as the sample data. It cannot be changed on the PC screen. This value is also stored in the text file of the downloaded data. (In reality, you could actually change that value in the file if you wished, and for the new value to be used when that file is re-imported for display.)

The costs are displayed as (for instance) pounds, pence and hundredths of a pence, e.g. £9·27:03 – nine pounds, 27·03 pence.

Above the cost per unit label is a "cosmetic option" facility. It shows the "£" symbol as appropriate to UK readers (and some other countries). The symbol may be changed to suit other currencies, e.g. to a dollar symbol, "$". The selection available, though, depends on the capabilities of your keyboard and the PC's character generator.

Click on the box, change the symbol, then click on the word SAVE that is now shown beside it. On doing so, the symbol is saved to disk on your PC, for recall next time the program is run.

Following the symbol change, all cost displays will now be prefixed with that symbol.

Scaling

PIC-Electric Mk2 has been designed for use on both 110V a.c. and 230V a.c. mains voltages. Whilst no change is required to the PIC unit in this respect, the PC screen display can be tailored to give better resolution of the recorded voltage variations that occur naturally with any mains supply. Two radio buttons (below the COM buttons) select the options, and the chosen one is stored to disk for future recall.

The first difference between the options is that the horizontal yellow lines in the voltage windows are positioned differently. They indicate the vertical windows position at which the nominal standard of 230V a.c. or 110V a.c. occurs.

Secondly (and most importantly), with the 230V a.c. selection, only voltages between 200V a.c. and 300V a.c. are plotted. Any values above or below those extremes are not displayed. With the 110V a.c. setting, the display limit is 0V a.c. to 150V a.c.

Between the amps labels is a slider button. This has three positions and sets an amp amplification factor which is applied to the scaling of the amps displays, allowing better viewing of low current values. The settings are ×1, ×10 and ×100.

Directory Use

The Directory button allows previously recorded data files to be selected for display. The Directory screen is similar to those used with the author's other VB6 programs. Full details of its use can be read via the Notes button seen near the top when that sub-screen is displayed.

In brief, folder paths are selected via the left-hand path menu, and files within a selected path selected by double-clicking on a named file in the right-hand list. This causes the Directory sub-screen to close and the file data to be loaded. If a file name is only clicked once, it is not actually selected, but is just highlighted and a return to the Main screen can be made by using the Exit button.

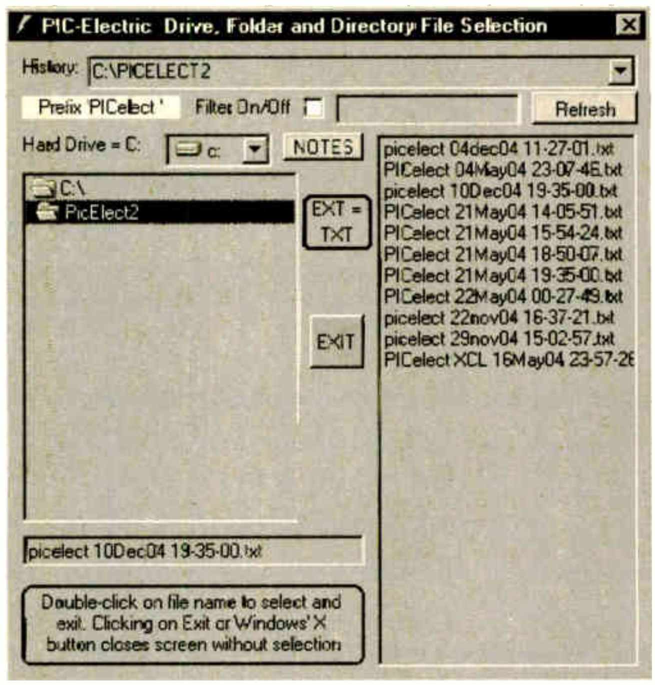
All path files are pre-selected for a prefix of "PICelect". You may also add your own filter to this prefix via the text box provided, allowing file names that only conform to the prefix and filter characters to be listed, allowing selection by date, for example. The filter function can be turned on and off via its click box.

A history of the folder paths accessed is recorded to disk when new ones are selected. This is recalled each time the program is loaded and a particular path can be selected via the dropdown History option.

The name of the loaded disk file is shown at the top right of the main screen.

Refresh Button

The PC screen waveform display is "volatile" in that if the screen is minimised, using the normal Windows button for this, when it is restored the waveforms will no longer be shown. Click the Refresh Screen button to cause them to be redrawn.



Example of the Directory screen through which files prefixed "PICelect" can be selected for input.

Main Screen Notes

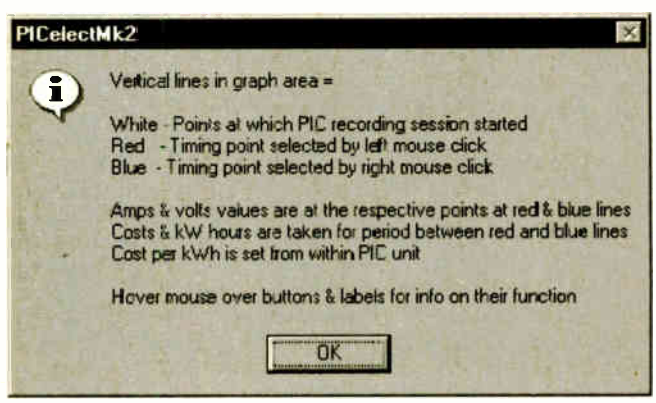
Clicking the Notes button on the main screen displays a sub-screen with a few useful comments about the main screen – such things as hovering the mouse over the buttons and labels, causing a "Tooltip Text Box" to appear and briefly describe the function of the button or label. Click OK to close the sub-screen.

Graphical Analysis

The Excel Format button converts loaded data files to a format suited for use with Windows Excel graphing software. This format is in four columns, oldest sample at the top, newest at the bottom. The columns are in order of Start Flag (as discussed earlier), volts, amps Channel 1, amps Channel 2.

Excel, or variants of it, is available as standard on many PCs and is believed to be part of the Windows Office suite. As well as offering graphing facilities, Excel provides for mathematical expressions to be computed. These options allow the data to be examined in more substantial detail than the PIC-Electric program can offer.

Brief information about using Excel was given in the author's *Earth Resistivity* article (May '03) Part 2, page 363. Excel's own Help file, though, taught the author all he knows about it. Read it and experiment to find what Excel can do! □



RESIDENT EVIL

Forget about the Ghost in the Machine – what if the spook is malware? What might happen when viruses contaminate the telephone network? Mark Nelson has heard some alarming reports.

EVEN people with minimal interest in the inner workings of the telephone system have a vague awareness that the network is controlled by computers. There's a natural follow-on from this: anything that affects computers could therefore affect the telephone system. And if telephones could be crippled by viruses, that's pretty bad news.

Bad news, because up to now telephones have been remarkably resilient to the kind of outages that beset computers. Telephone handsets themselves are generally line-powered, so they are unaffected by mains electricity failures, whilst the power supply at exchanges is derived from storage batteries with diesel generator back-up.

The processors that control the electronic switching fabric of digital exchanges are protected from outside influences, meaning that hackers and crackers simply cannot nobble them. Up to now there have been no reports of public exchanges being reprogrammed maliciously, mainly because the processors used are highly proprietary and outsiders have no access to the code used.

Well Documented

This is an accurate description of the public switched telephone network but is less appropriate to the internal systems used in business, manufacturing and public utilities. Many telephones, particularly those connected as Voice over Internet Protocol (VoIP) devices to data networks (LANs), rely for power on mains adapters and some of the smaller private switches (PABXs) are totally dependent on the mains (which as we know, can and does fail).

The software used on commercial PABXs is well documented (you can buy programming manuals on the Internet) and most switches have a programming port for the specific purpose of remote updates by modem to their code. The telephone numbers of these "back door" ports are generally easy to guess, the passwords are frequently unaltered from the default and there have been many instances of unauthorised alterations going undetected until a massive phone bill is received.

According to Cardiff-based telecomms consultant Richard Cox, the phone pirates' method is alarmingly simple. "It only works because people don't take the most basic security precautions", he says. "Infiltrators break in via these 'maintenance ports' and set up their own re-routing facilities on direct inward dialling lines. The hackers can do this because owners often do not change the password code from the default settings of 000 or 111; once logged on, they can make the changes they want and even change the passwords to lock out the legitimate system manager.

"The maintenance ports are normal ex-directory phone lines and discovering these is not as difficult as it might seem. The likely exchange prefixes can be determined by logical survey, then the actual number obtained with the aid of a scanning program and a phone-connected PC."

New Threat

This kind of interference is the direct action of humans and has been going on for more than ten years. The new threat concerns the possibility of telephones being crippled by viruses, or rather the telephone system as a whole rather than individual handsets. In point of fact we have already had telephones affected by viruses; "crippled" is too strong a word but there are several recorded incidents of mobile handsets infected by malware, mostly of the harmless proof-of-concept variety. But it's perfectly clear that any device that's processor-controlled can have its method of operation altered if someone manages to reprogram the processor.

Earlier I mentioned that public exchanges were relatively immune to unauthorised manipulation and this is likely to remain the case. The vulnerability applies particularly to business users who operate "converged" networks that combine voice and data over the same infrastructure.

A virus that can bring down a data network can also cripple voice calls because speech is encoded as the same kind of IP packet as data. And when firms deploy the VoIP systems, mentioned above, on their networks and also provide direct dialling-in facilities from the public network, they are particularly at risk.

Compromised by Complacency

Whilst IT managers are well aware of external threats to data security, far fewer realise that on converged systems voice is also vulnerable. Reports in the trade press bear witness to this concern. Ian Shepherd of Telindus states that IP voice networks have already been compromised because of complacency.

"Where you have taken an existing IP infrastructure and added voice, then organisations are getting viruses and denial of service attacks. We know that this happens. If you get something nasty, it will be the voice that goes down first. We are not seeing directed attacks focussed on SIP or H.323 (the two main VoIP protocols in use) but this will come."

How will it come, though? Where does the threat enter the system? Joseph Seanor, Security Managing Consultant with systems provider Avaya, explains it will be by viruses. The first point of vulnerability is the servers on which IP voice switches run. Many of these use the Windows operating system and are connected to the Internet in order to receive updates to Windows. The other place where viruses can enter the system is in the office: a user brings a virus-infected laptop computer to work, then hooks it up to the VoIP phone line in his office instead of using the network connection.

More Insidious

Losing your enterprise voice network, even temporarily, is bad news for any organisation but at least the failure will be self-evident. A second risk, where calls are intercepted by persons unknown, is more insidious simply because it might go undetected. As VoIP blogger Tom Keating says on his website **(http://blog.tmcnet.com/blog/tom-keating)**, "Imagine for a moment working for a stock exchange company; you could install a network sniffer program that captures VoIP streams. Knowing the IP address of a particular IP phone, you can filter the traffic and tap into someone's VoIP conversation."

To counter this threat major equipment managers such as Cisco and Alcatel are now developing add-on modules for encrypting voice traffic. Alcatel's product, developed by defence contractor Thales, uses a hardware encryption system rather than software in order to avoid affecting quality of service (any delay to speech packets results in undesirable break-up, as on a bad mobile call).

Also unlikely to be detected, at least initially, are Denial of Service (DoS) attacks, and even if they are generic bandwidth starvation attacks, targeting your network as a whole rather than voice in particular, the system will still feel the pain. This in turn means that network managers must monitor calls effectively to know when the system is performing above or below user expectations, not necessarily a simple inexpensive exercise.

No doubt all these issues are no more than teething troubles but they do illustrate that new technologies certainly bring new problems. But now let's change the subject and close with a report that has to be a sign of the times. The last manufacturer of audiotape in America has closed down.

That's right: surprising its workers and everybody else for that matter, Quantegy (whose tape was formerly known as Ampex and before that, Irish) shut down its factory in Opelika, Alabama without notice. Pundits reckon it may signal the end of tape recording, as well it may.


PEAK
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but smart
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PIC N' MIX

ANDREW JARVIS

Our periodic column for your PIC programming enlightenment

High Level Languages – A First Visit to the C Side!

MORE often than not recently, it seems that every project I attempt uses a different PIC, and program writing is taking longer than it used to. Largely, I think this is because the memory available to me is increasing, which does invite larger and more complex designs.

Reusing existing code helps but is not always straightforward, especially when porting it between PIC families with different instruction sets and some inevitable device dependencies that creep in. Essentially, what is needed is reduced development effort and portability, or put more simply – a high level programming language.

Crafty Code

A language like C should allow us to produce a program code that is independent of any one PIC type (or indeed microcontroller type) and that is expressed in a more intuitive, English-like style. Ultimately though, it will be translated into many assembler instructions in a way that we cannot control.

This translation creates a fear of so called "code bloat" – inefficient compiler generated code that wastes precious memory. It's easy to spot – as is sometimes the case when compiled code is reverse engineered and passed off as assembler. You see code positioned erratically or unused, flags tested unnecessarily and too much jumping around. Not the sort of things a human would do.

As assembler programmers, we are in total control of our chosen device. Each line of our carefully, if slowly, crafted code maps one-to-one with a PIC instruction so that we know exactly what it is doing at any time. (Well, OK, most of the time then!)

Once we start to use a high level language, we rely on the compiler vendors to do an efficient job with our code – guided by as many hints as we can give them along the way. In practice, true portability won't be achieved anyway because of variations between compiler vendors and their different adoption of standards. Some things that we could do in assembler just won't be possible, but most should be a lot easier.

Catch 22

There's usually a trade off between power and portability – consider the instruction based timing loops of *PIC n' Mix* July '04. (If you missed it, we looked at ways of generating precise delays using detailed knowledge of instruction cycles). This sort of thing is not easy with C, we have no idea of knowing which particular instructions a compiler will generate when code is compiled.

LISTING 1

```
delay1  equ 0x20
delay2  equ 0x21

        org 0               ; reset vector
        goto start

start
        banksel TRISIO      ; bank 1
        clrf TRISIO         ; set as outputs

        call 0x3FF          ; OSCCAL
        movwf OSCCAL

        banksel GPIO        ; bank 0
        clrf GPIO           ; reset GPIO
        movlw 0x07
        movwf CMCON         ; set digital IO

        clrf delay1         ; init delay
        clrf delay2         ; loop counters

        movlw 0x01
loop
        xorwf GPIO, F       ; toggle
wait
        decfsz delay1, F    ; inner loop
        goto wait
        decfsz delay2, F    ; outer loop
        goto wait
        goto loop           ; start over
```

But then if we are after portability – why would we want to produce code that has a dependency on the underlying instruction set? Much better we write our code firmly in the problem domain and let the compiler worry about how it translates into the specific requirements of a PIC.

Nonetheless, most C compilers will actually provide extensions that let us mix C code with assembler, so you can in fact still write instruction based, PIC dependant code. And one reason you might do so is to write an accurate delay routine.

There isn't space here to offer anything like a full "C for PICs" type tutorial. If you have experience of assembler but not C, then it shouldn't be too difficult to tag along, reading it is much easier than writing it! If your interest is sparked there are many good references you can follow up. Start with the definitive *The C Programming Language* by Kernighan and Ritchie, and **www.microchipc.com/** is an excellent PIC resource where you can find lots of sample code and links to other sites of interest.

Hi-Tech PICC Lite

Hi-Tech PICC Lite is a great introduction to the C programming language for PICs. "Lite" inevitably means "limited" in some way, but as you will see, nothing that prevents us creating hobby projects for the more popular PICs. The compiler can be downloaded from the Hi-Tech website: **www.htsoft.com/downloads/demos.php**. The manual is a separate download: **www.htsoft.com/downloads/manuals.php**.

The MicrochipC website given above also offers an interesting "Frequently Asked Questions for Hi-Tech C", which could save a lot of time. The 362-page PICC manual contains a great description of the general compilation process, in addition to documenting the language, extensions and error messages. It is an excellent resource for students and hobbyists.

The best news is that it's all free (Professional C compilers for PICs are normally in the "hundreds of pounds" bracket). Second best is that it will only compile for about 10 PICs, but they include 16F84(A), 16F627(A), 16F877(A) and 12F629/675. Sound familiar? The latter three have recently been added to *Toolkit TK3*, which makes PICC Lite a good choice for *EPE* readers.

Other compilers, like the ones from Microchip (C17 and C18), will only target the 17 or 18 series devices respectively (which it is generally acknowledged are much more suited to C programming for a number of reasons, including their greater memory and stack sizes).

Good News Wizard

If you are familiar with the Microchip MPLAB IDE, there's more good news – PICC Lite integrates seamlessly. Creating a new C project is as simple as starting the Project Wizard, selecting a PIC, then choosing the Hi-Tech PICC toolsuite. You can build, simulate and debug C code in just the same way as you did for the Microchip MPASM toolsuite.

It is strongly recommended to use this free IDE with PICC Lite (and MPASM too!), though its size can be a deterrent if you don't have access to a fast internet connection. The full install for version 7.00 weighs in at 25MB. If this is too much, there is a command line alternative for PICC, which is documented in the manual, and also an unsupported "DOS style" text based IDE called HTLPIC, which has a useful C library reference off the help menu.

TK3 users will have to break out of the MPLAB to program the PIC. The hex file

LISTING 2

```
unsigned char delay1;
unsigned char delay2;

void main(void)
{
   TRISIO = 0;
   OSCCAL = _READ_OSCCAL_DATA();
   GPIO = 0;
   CMCON = 7;

   for (;;)
   {
      GPIO ^= 0x01;
      while (--delay1 > 0)
      {
         while (--delay2 > 0);
      }
   }
}
```

generated by the linker can be found in the project folder you chose from the project wizard, or as otherwise set in the PICC Linker tab of the build options for your project. Select this file from *TK3* then Send Hex from the main screen as usual. Don't forget to make sure the correct PIC type is set.

Since there's no room for a C tutorial, we'll turn the whole thing on it's head for a bit of fun and see what the compiler produces. Listing 1 shows the first example of the flashing l.e.d. code from *PIC n' Mix* July '04, mentioned earlier – and chosen here because I wanted to compare the output from the compiler against the smallest complete assembler program that I could remember writing previously. It's slightly updated to target the 12F629, which wasn't supported by *TK3* at the time.

Compare it to Listing 2, which is a C equivalent. Variables **delay1** and **delay2** are declared as externals so that they will be initialised to zero by default (automatics are not). Special function registers can be accessed with no regard to correct bank settings, and the iterations are controlled by an infinite **for** loop. The real interesting part though, is **OSCCAL**.

There was first the question of how to express **call 0x3FF** in C without resorting to mixing in some assembler – which would be easy enough to do in this case with the ASM directive. Then looking through the 12F include file the following macro definition was found which sent me running for Kernighan and Ritchie muttering about how we were trying to make life easier!

```
define _READ_OSCCAL_DATA()
(*(unsigned char(*)())0x3FF)()
```

We know that 0x3FF is the address of a (very small) function that returns the OSCCAL calibration value with a simple **retlw** instruction. The "unsigned char" is the most efficient data type on the mid-range PIC because it maps directly onto 8-bit bytes, in this case the literal value returned in the W register. The macro is therefore casting the address into the desired type, i.e. a pointer to a function that has no arguments and returns an unsigned char, before then calling it.

Listing 3 is the assembler that the PICC compiler creates from the C code in Listing 2 (with maximum optimisation set). It was generated by the Hex to MPASM facility of *TK3*, but it would be just as easy to use the -S compile flag of the PICC compiler, or to import the HEX file into MPLAB.

The label **Jump1005** is the equivalent of our original **start** label in Listing 1. It is interesting to note that the optimiser has not stopped the unnecessary bank select bit (**STATUS<5>**) switching between **TRISIO** and **OSCCAL**, probably because of the subroutine call to 0x3FF, which of course could leave **STATUS** in an unknown state – when writing the assembler of Listing 1 we had the benefit of knowing that it would not.

It's also worth a reminder that this is the **Lite** version of the compiler. Although Level 9 was set for the global optimiser, the manual does state that for PICC Lite, there is little advantage in using levels above three. There's a couple of differences with the timing loops too, but they remain essentially the same. The first half of Listing 3 looks to be startup code, including the section from label **Jump10** which initialises the two-loop counter variables to zero, as we expected, using indirect addressing.

LISTING 3

```
List P = PIC12F629, R=DEC;
include P12F629.inc

REG20         EQU H'20'
REG21         EQU H'21'

              ORG 0

JUMP0         clrf STATUS
JUMP1          movlw 0
JUMP2          movwf PCLATH
JUMP3         goto JUMP4
JUMP4         movlw 32
JUMP5         movwf FSR
              movlw 34
              call JUMP13
              clrf STATUS
              goto JUMP1005
JUMP10        xorwf FSR,W
              clrf INDF
              incf  FSR,F
JUMP13        xorwf FSR,W
              btfss STATUS,Z
              goto JUMP10
              retlw 0

              ORG 1005

JUMP1005
              bsf STATUS,5
              clrf TRISIO
              bcf STATUS,5
              call 0x3FF
              bsf STATUS,5
              movwf OSCCAL
              bcf STATUS,5
              clrf GPIO
              movlw 7
              movwf CMCON
JUMP1015
              movlw 1
              xorwf GPIO,F
              goto JUMP1020
JUMP1018
              decfsz REG21,F
              goto JUMP1018
JUMP1020
              decfsz   REG20,F
              goto     JUMP1018
              goto     JUMP1015
```

Next time – some more PICC and a look at the library functions. We'll **printf()** to an LCD, **getch()** from a keyboard and mix in John Becker's PS/2 interfacing code of *EPE* August 2004.

Constructional Project

Bingo Box

David Coward

PIC power helps pick those numbers without a traditional bag!

MOST people will have played Bingo or similar Lottery style games since their early years. Methods abound for the selection of random numbers – usually between 1 and 89 – ranging from wooden balls in bags to the washing-machine-like Lotto creations as seen on television.

This project applies modern PIC-based electronics to the traditional game, resulting in a gadget that is completely fair, requires no set-up time and, most importantly in family circles, removes all arguments about who should be the "caller"!

Basic Bingo

The basic Bingo Box is simply constructed on a single printed circuit board (p.c.b.) containing two 7-segment displays, a few pushbutton switches (most importantly the "Bingo" button) and a keypad. Once "Bingo" has been called (or "pressed" in fact) the keypad is used to validate the potential winner's numbers.

The Bingo Box provides for manual and automatic number generation. In this latter mode, a number is generated automatically after a pre-programmable delay of up to 99 seconds. A "rewind and replay" function is also provided, as is the ability to change the range for which numbers are generated – useful for quick games!

The project also demonstrates and applies a number of techniques previously featured in *EPE* projects, including large 7-segment l.e.d. displays. Most fun of all (and very useful for school/club bingo evenings) the Bingo Box can control the enormous electrically operated 7-segment mechanical displays described in John Becker's *PIC Big Digit Display* article, May '02 (for which at the time of writing, the parts are still readily available). These devices can be driven from an expansion p.c.b. enabling constructors to customise the Bingo Box to their own specific requirements.

Bingo Circuit

The circuit diagram for the basic Bingo Box is shown in Fig.1. At its heart is a PIC16F877 microcontroller, IC1, clocked at 20MHz as set by crystal X1. The PIC drives display module X2, a 10mm common anode dual 7-segment l.e.d. display.

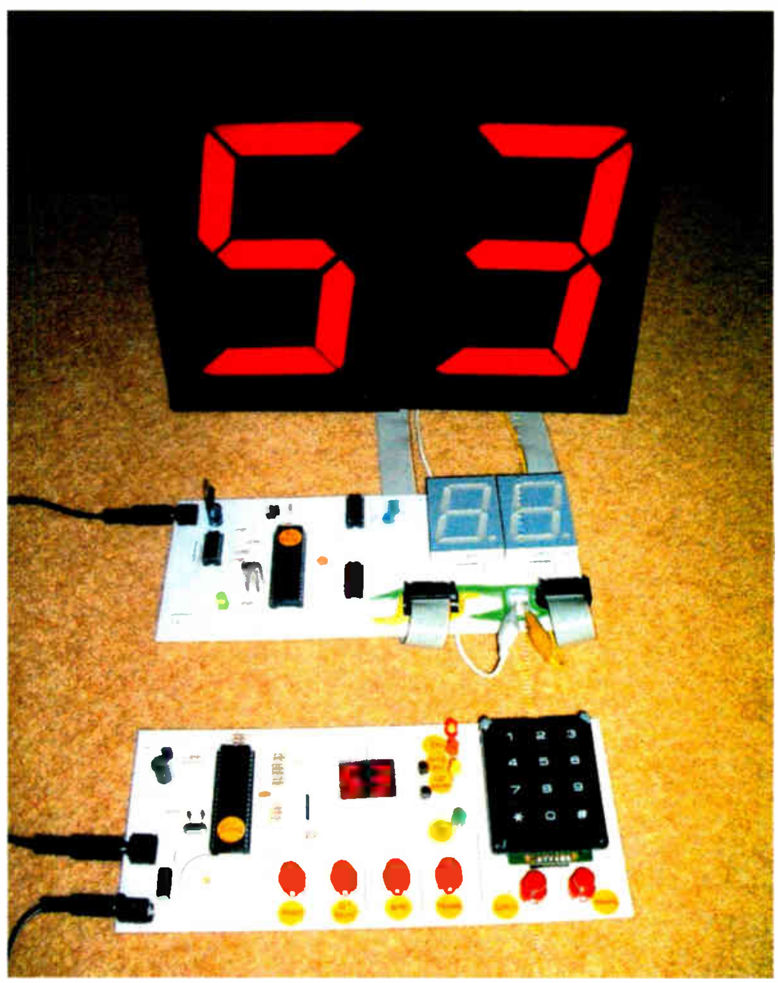
This multiplexed display's segments are controlled by PIC PORTB, RB1 to RB7, via buffer resistors R1 to R7. PORTC pins RC0 and RC1 control the display's multiplexed selection via transistor drivers TR1 and TR2, whose bases are buffered by resistors R8 and R9.

To illuminate a segment, the software turns on the appropriate transistor via PORTC and loads the segment pattern into PORTB. This technique has been used many times in previous *EPE* projects. Provided that the multiplex rate is fast enough, no flickering is apparent.

Light emitting diodes D1 to D4, which provide various game indications, are connected to PORTA, RA1 to RA4, via current limiting resistors R15 to R18.

Piezo sounder WD1 is used to provide audio feedback on key presses and produces tones to indicate right and wrong numbers at the checking stage. It is controlled by pin RA0. As it is a high impedance device, an additional driver and limiting resistors are not needed.

It is intended that power for the circuit is supplied by a 12V battery, via switch S7. This



Two large "big-digit" mechanical 7-segment displays connected to the volt-*display interface board, which is also linked to the main Bingo Box p.c.b.* a g e

PORTE pin RE0 provides a serial output of the generated number at 9,600 Baud to the Big Digit expansion unit, via jack socket SK1, to be described later.

Keypad

PORTD is used to monitor the keypad, X3, and the game selection switches, S1 to S6. Current buffering is variously provided by resistors R10 to R13, and four resistors within resistor module RM1. The latter bias pins RD4 to RD7, holding them high unless a key or switch is pressed.

The keypad contains an internal 4 × 3 matrix, whose connections are brought out on seven pins as illustrated in Fig.2. In the prototype, the columns on the keypad appear on pins 1, 3 and 5 and the rows on 2, 4, 6 and 7. This is significant because to identify which key has been pressed, the software interprets the combination of row and column – so keypads with different pinout patterns will give different results! This can give rise to very strange effects, so only use the recommended type!

Bigger L.E.D. Displays

A basic PIC pin is capable of providing enough current and voltage to drive a single l.e.d. via an appropriate current limiting resistor. Most 7-segment l.e.d. displays generally comprise chains of l.e.d.s forming each segment. Commonly available 25mm (1in.) displays use a chain of two l.e.d.s per segment and larger 55mm (2·2in.) displays use three, as illustrated in Fig.3. An unassisted PIC cannot source or sink enough current to drive these types of display properly and so other techniques must be deployed.

These methods have been well documented in previous *EPE* articles, but in a nutshell, ULN2004A type devices containing seven Darlington pair transistor drivers are used to provide current sinks in a common anode style arrangement. The drivers, illustrated schematically in Fig.4, have built in base

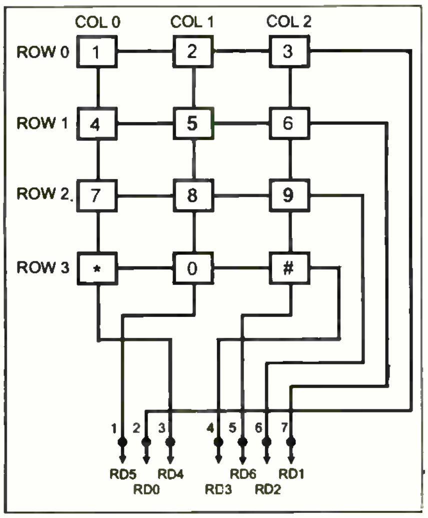
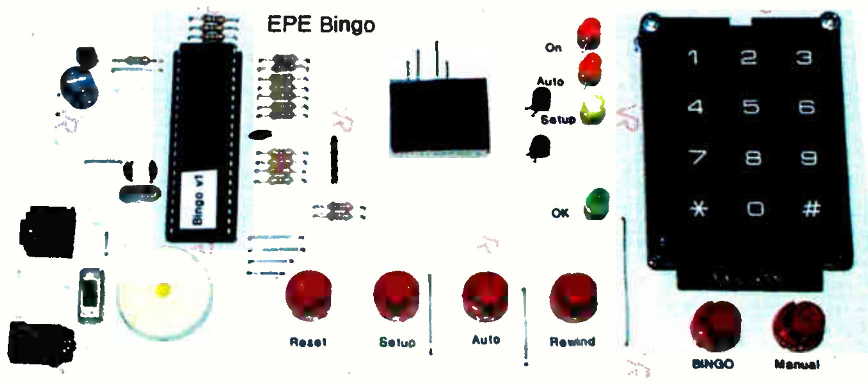


Fig.2. Keypad pinout details



Component layout on the main Bingo Box circuit board

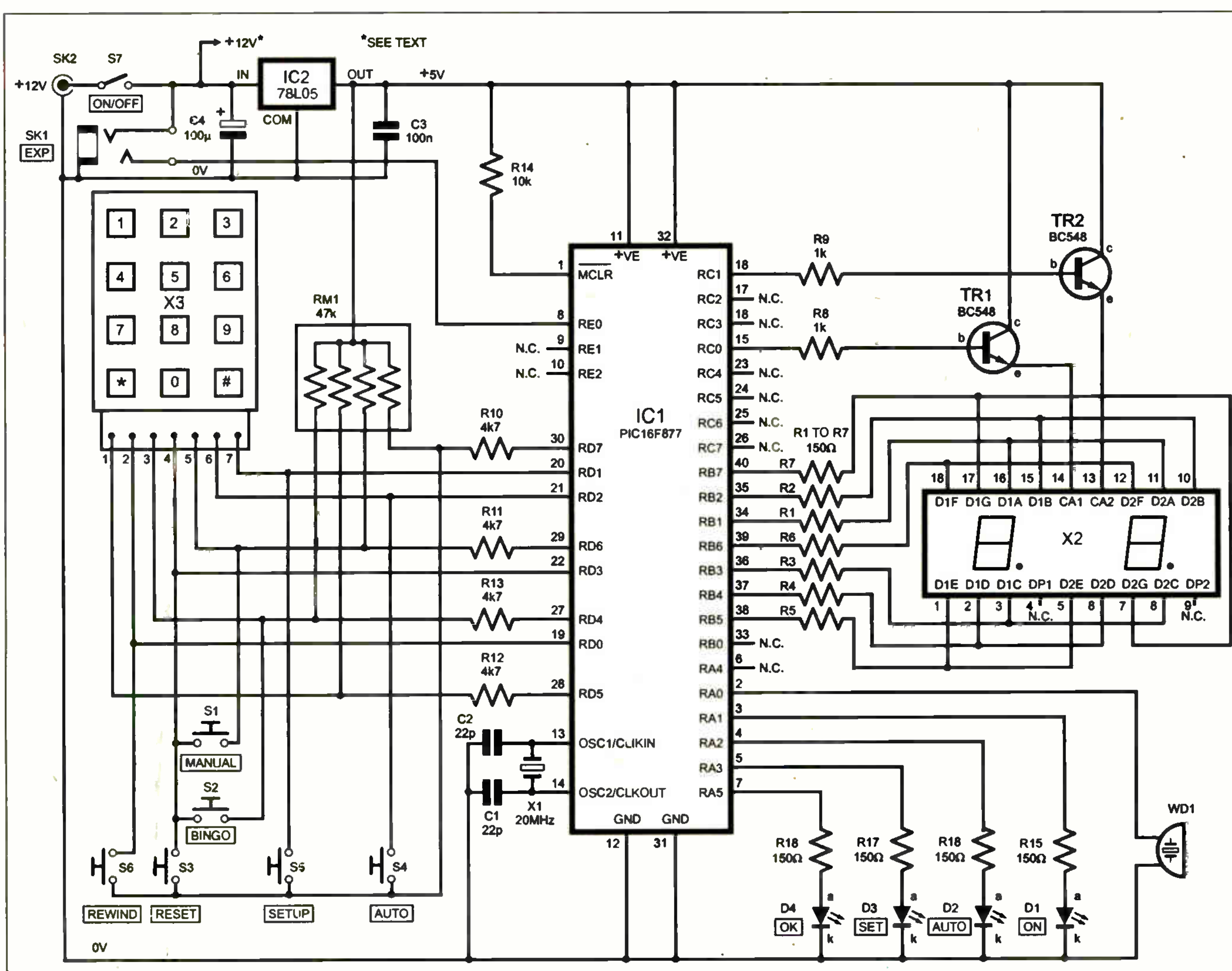


Fig.1. Full circuit diagram for the basic Bingo Box

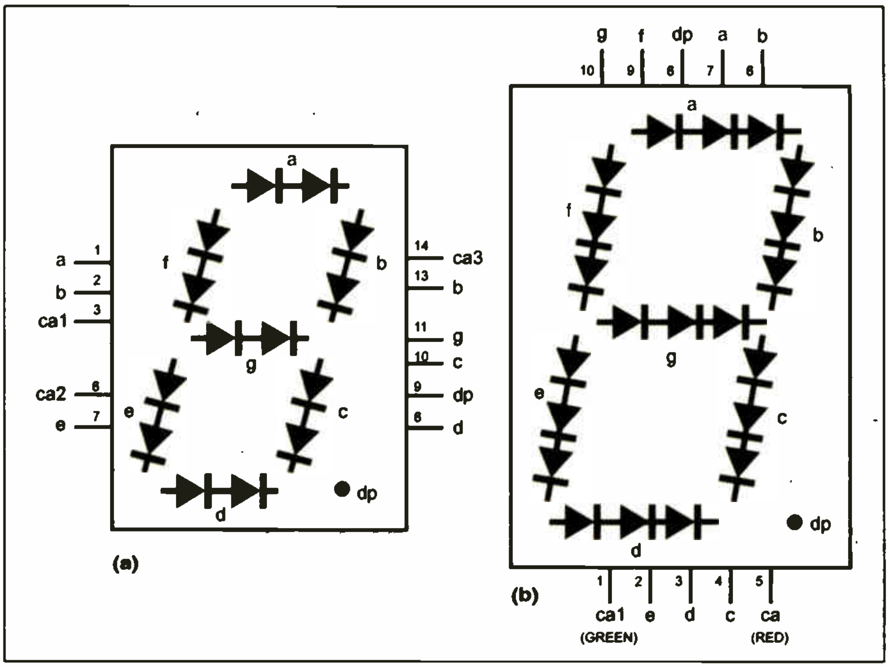


Fig.3. Showing the usual number of l.e.d.s that make up two popular sizes of 7-segment display: (a) 25mm (1in.), groups of two and (b) 55mm (2.2in.) groups of three

resistors and so can be directly connected to PIC ports without additional buffering. The driver outputs can be used to control common anode style displays of the type used in the Big Digit extension about to be described.

There are several ways to provide a current source for the multiplexed displays. Simple transistor drivers of the type used to drive the displays in the basic Bingo Box are one possibility. But as greater currents are needed for the larger displays, an L293DN motor driver is used as the current source – a configuration also seen in a number of previous *EPE* projects.

Absolutely Massive Displays

The use of ULN2004A and L293DN devices is identical to the driver configuration used in the *Big Digit Display* (May '02) and so it is only a matter of software design to produce a device capable of driving both large l.e.d. displays (where the segments are driven in a continuous loop using multiplexing techniques) and the mechanical Big Digits (where the segments are pulsed on or off).

The circuit diagram of the Big Display driver is shown in Fig.5. PIC16F877 microcontroller IC1 is used to control the displays. It is clocked at 4MHz, as set by crystal X1.

The large 7-segment l.e.d. displays have their segments controlled by PORTB, whose outputs are buffered by the 7-way ULN2004A current sink IC2, the output currents of which are buffered by resistors R2 to R8.

The value of these resistors sets the brilliance of the display. A value of 470Ω was found to be adequate for most types of l.e.d., but can be reduced or increased depending on the brightness required. Check the l.e.d. datasheet for the maximum current that it can take.

PORTA selects which digit is activated during the multiplexed cycle. Via buffer resistors R12 to R15, pins RA0 to RA3 control the drivers within IC4, which in turn control the common anodes of the display. IC4 is enabled by biasing its control pins 1 and 9 high via resistor R9.

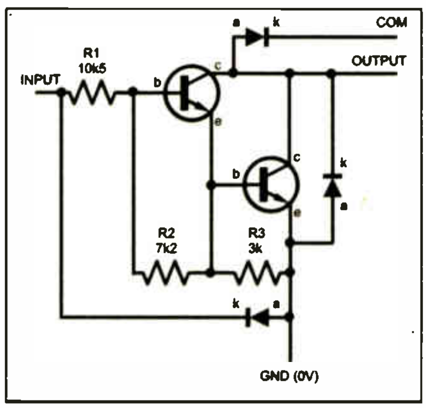


Fig.4. Single stage schematic diagram for the ULN2004A Darlington array

The mechanical Big Digits require push-pull control of their segments. They are turned on by IC2 and off by IC3. The latter is controlled by PORTD. Digit selection is again controlled by IC4, but by the other pair of its drivers. Connection to the digit segments is via connectors 1 and 2, and TB1.

The software has been written to drive *either* the large 7-segment l.e.d. display *or* the "mechanical" Big Digits, but not both at the same time. The logic level on pin RA4 determines which software routine is selected. For the Big Digit display, pin RA4 is held high via resistor R10. For the l.e.d. display, the pin is taken low by connecting jumper pins JP1.

The main p.c.b. is connected to the Big Digit driver via socket SK1. The connecting lead provides the power and the serial data from PIC pin RE0 in the main unit.

Power Supply

A 12V d.c. power supply is required for this design if the Big Digits are to be used. If only l.e.d. displays are used, a lower supply is acceptable, down to, but no less than, 7V. Voltage regulator IC5 provides a stabilised +5V supply for the PICs.

The raw power can be supplied from a mains-powered battery eliminator, but should not fall below 12V under load if the mechanical Big Digits are used.

Construction

Component and track layout details for the Bingo Box and the big Digit Display are shown in Fig.6 and Fig.7 respectively. These boards are available from the *EPE PCB Service*, codes 492 (Main) and 493 (Display).

Before beginning construction of the Big Digit board, decide which size of digit you would like to use. The p.c.b. makes provision for two sizes of 7-segment l.e.d. as well as the mechanical Big Digits via connectors 1 and 2, and TB1. Note that IC3 is only required if the board is to drive the mechanical displays.

The 55mm on-board displays used in the prototype contain both red and green l.e.d.s, the selection of which is determined by connecting the appropriate common anode. For green displays, links LK2 and LK4 should be inserted, whilst red displays require LK1 and LK3.

Assemble the boards in the preferred order of ascending component size, using sockets for all the dual-in-line i.c.s, and correctly observing the orientation of all polarity sensitive components. The use of pin-strip sockets for the 7-segment l.e.d.s is advisable.

Keypads normally come with pre-attached pins. It is advisable to use an appropriate socket for this too rather than solder the pins to the p.c.b. All switches and push-buttons (including the keypad) are shown as p.c.b. mounted types to ease construction. However, these can be mounted off-board if required and connected using suitable flying-leads. In particular, it might be a good idea to use a remotely mounted heavy-duty pushbutton for switch S2 on the Bingo Box ("Bingo!") ... but this is left to the constructor's discretion!

The segments of the mechanical displays can be connected to the p.c.b. using a wiring harness as described in the original article. However, for ease of disconnection, IDC cable can be used to make the connections, as shown in Fig.8. The common anode drives for the displays are via the 2-way screw terminal connector, TB1.

Testing

The p.c.b.s can both be tested in the same way. After construction, check that all power voltages are correct at the i.c. sockets (with the i.c.s omitted at this stage). Ensure that the output of regulator IC5 is +5V (within a few millivolts).

After this, two wander leads can be used to test the displays. With reference to the appropriate circuit diagram, one end of the first wander lead is plugged in to pin 11 or 32 of the PIC (IC1) with the other end inserted into the port pin associated with the anode of a display. This will be RC0 (pin 15) or RC1 (pin 16) for the Master p.c.b. and RA0 (pin 2) or RA3 (pin 5) for the Big Digit board.

For the master board, a lead plugged into IC1's pin 12 or 31 (0V) can then be touched briefly to each PORTB pin that connects to a display. One l.e.d. segment should light up for each touch. The big digit l.e.d. display can be tested using the same principle, except that the second

BINGO BOX – CIRCUIT BOARD CONSTRUCTION

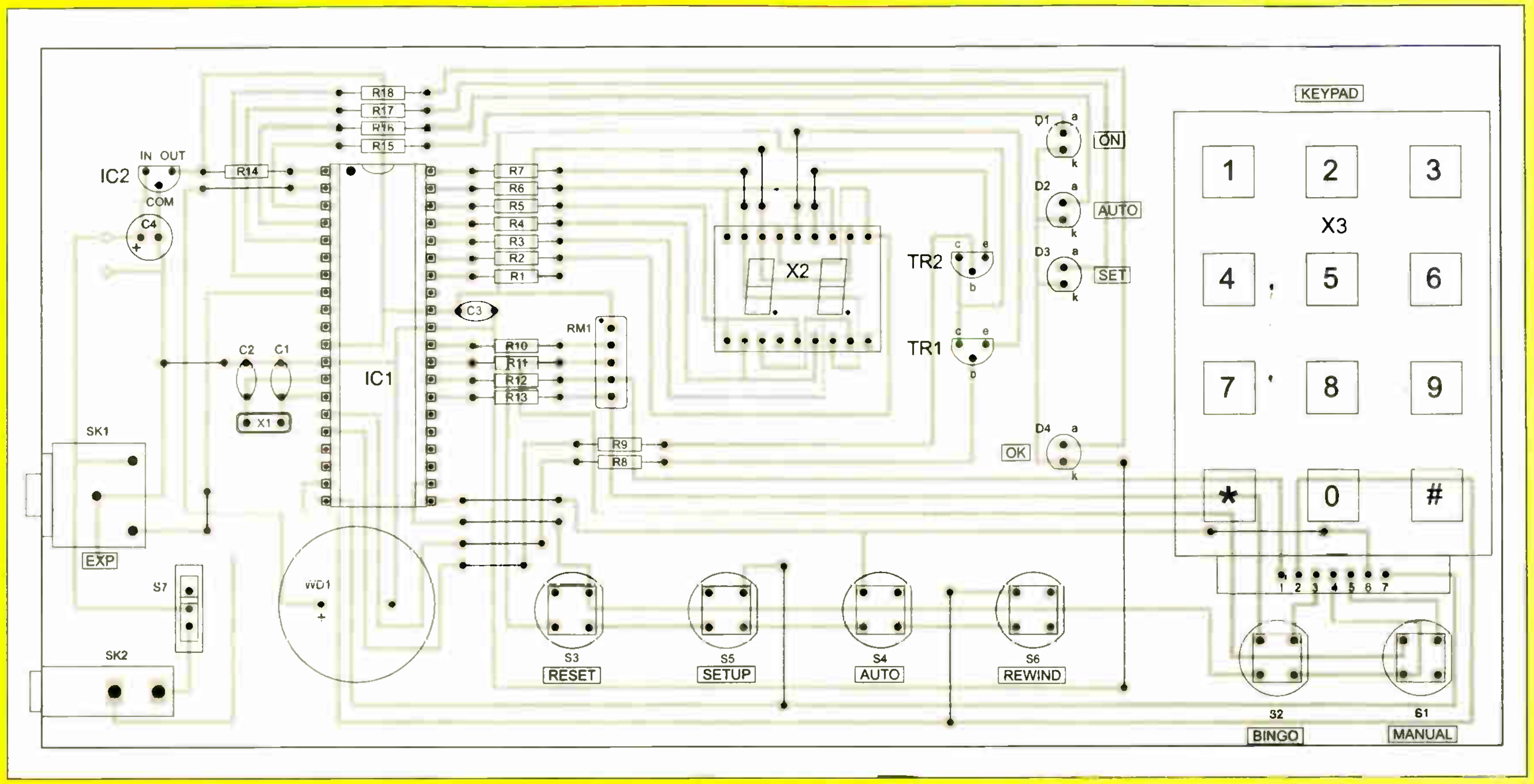
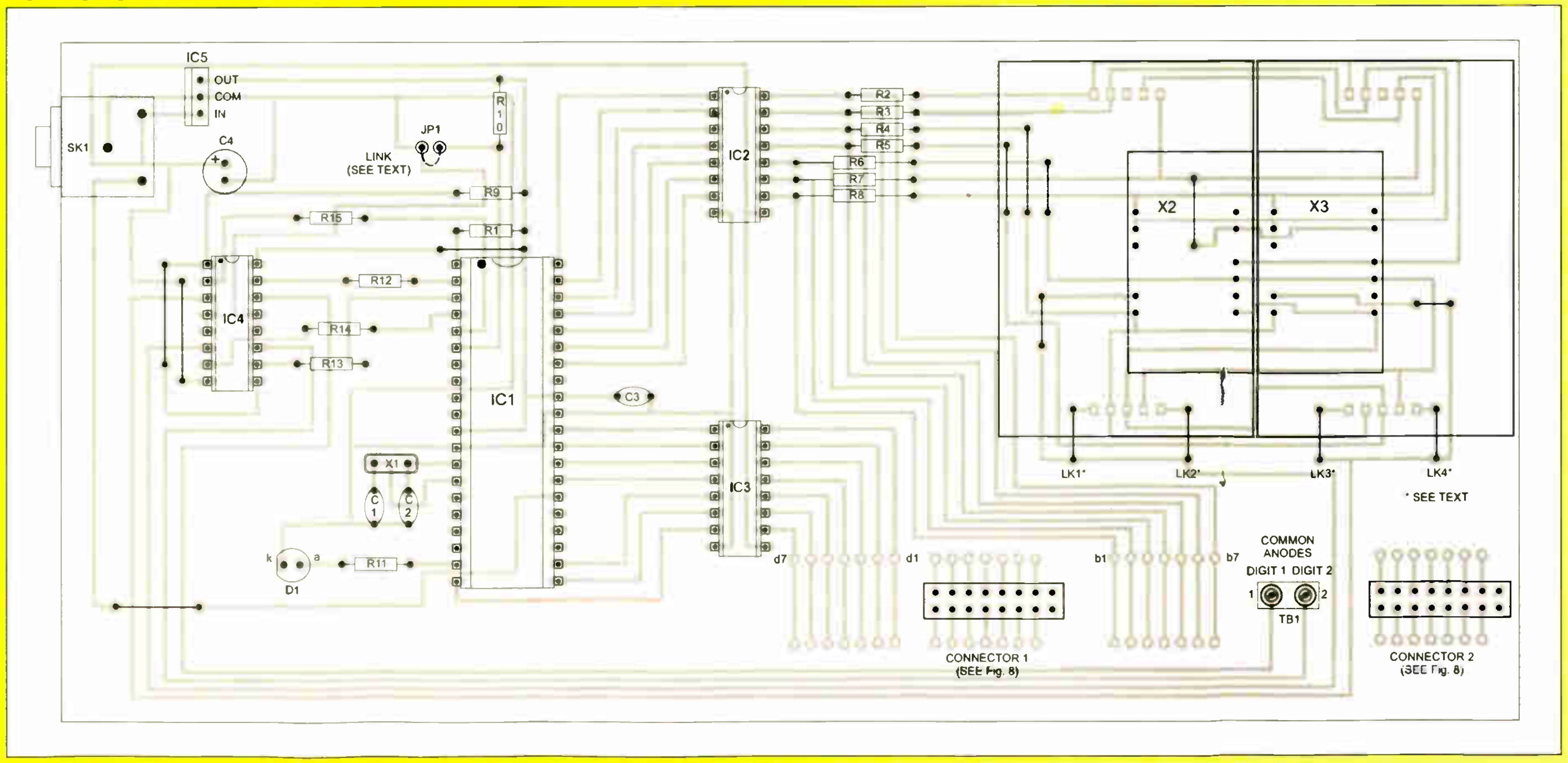


Fig.6. Printed circuit board component layout for the basic Bingo Box

Fig.7. Big Digit Display printed circuit board component layout



COMPONENTS

Approx Cost Guidance Only **£29** *excl. PCB & Display Case*

BINGO BOX

See SHOP TALK page

Resistors

R1 to R7, R15 to R18	150Ω (11 off)
R8, R9	1k (2 off)
R10 to R13	4k7 (4 off)
RM1	47k 4-way commoned s.i.l. module
R14	10k

All 0.25W 5% carbon film unless marked.

Capacitors

C1, C2	22p ceramic 5mm pitch (2 off)
C3	100n ceramic disc, 5mm pitch
C4	100µ radial elect. 16V

Semiconductors

D1 to D4	5mm l.e.d., colours to suit (4 off)
TR1, TR2	BC548 *npn* transistor (2 off)
IC1	PIC16F877-20 microcontroller preprogrammed (see text)
IC2	7805 +5V 1A voltage regulator

Miscellaneous

S1 to S6	push-to-make switch, p.c.b. mounting (6 off)
S7	s.p.s.t. toggle switch, s.i.l., p.c.b. mounting
SK1	2.5mm power jack socket, p.c.b. mounting
WD1	piezoelectric buzzer, p.c.b. mounting
X1	20MHz crystal
X2	dual 7-segment common anode l.e.d.
X3	4 x 3 pushbutton keypad

Printed circuit board, available from the *EPE PCB Service*, code 492 (Main); 40-pin d.i.l. socket; 2 x 9 way s.i.l. sockets; case to suit; connecting wire; solder, etc.

COMPONENTS

Approx Cost Guidance Only **£30** *excl. Big Digits (optional)*

BIG DIGIT DISPLAY

See SHOP TALK page

Resistors

R1	10k
R2 to R8	470Ω (7 off)
R9, R10	1k (2 off)
R11	150Ω
R12 to R15	4k7 (4 off)

All 0.25W 5% carbon film.

Capacitors

C1, C2	22p ceramic disc, 5mm pitch (2 off)
C3	100n ceramic disc, 5mm pitch
C4	100µ radial elect. 6V

Semiconductors

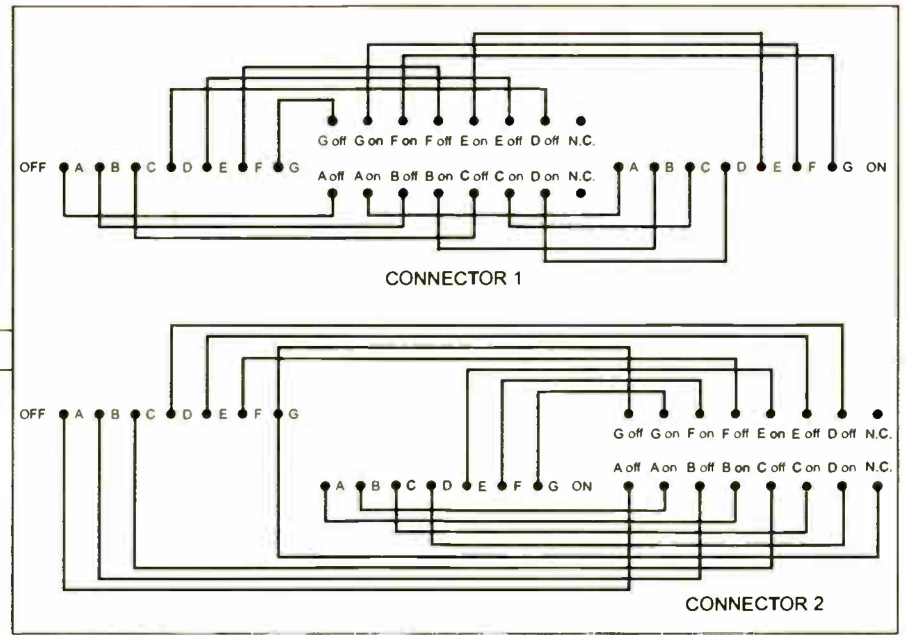
D1	red l.e.d., 5mm
IC1	PIC16F877-4 micro-controller, preprogrammed (see text)
IC2, IC3	ULN2004A Darlington array (2 off) (see text)
IC4	L293DN motor driver
IC5	7805 +5V 1A voltage regulator

Miscellaneous

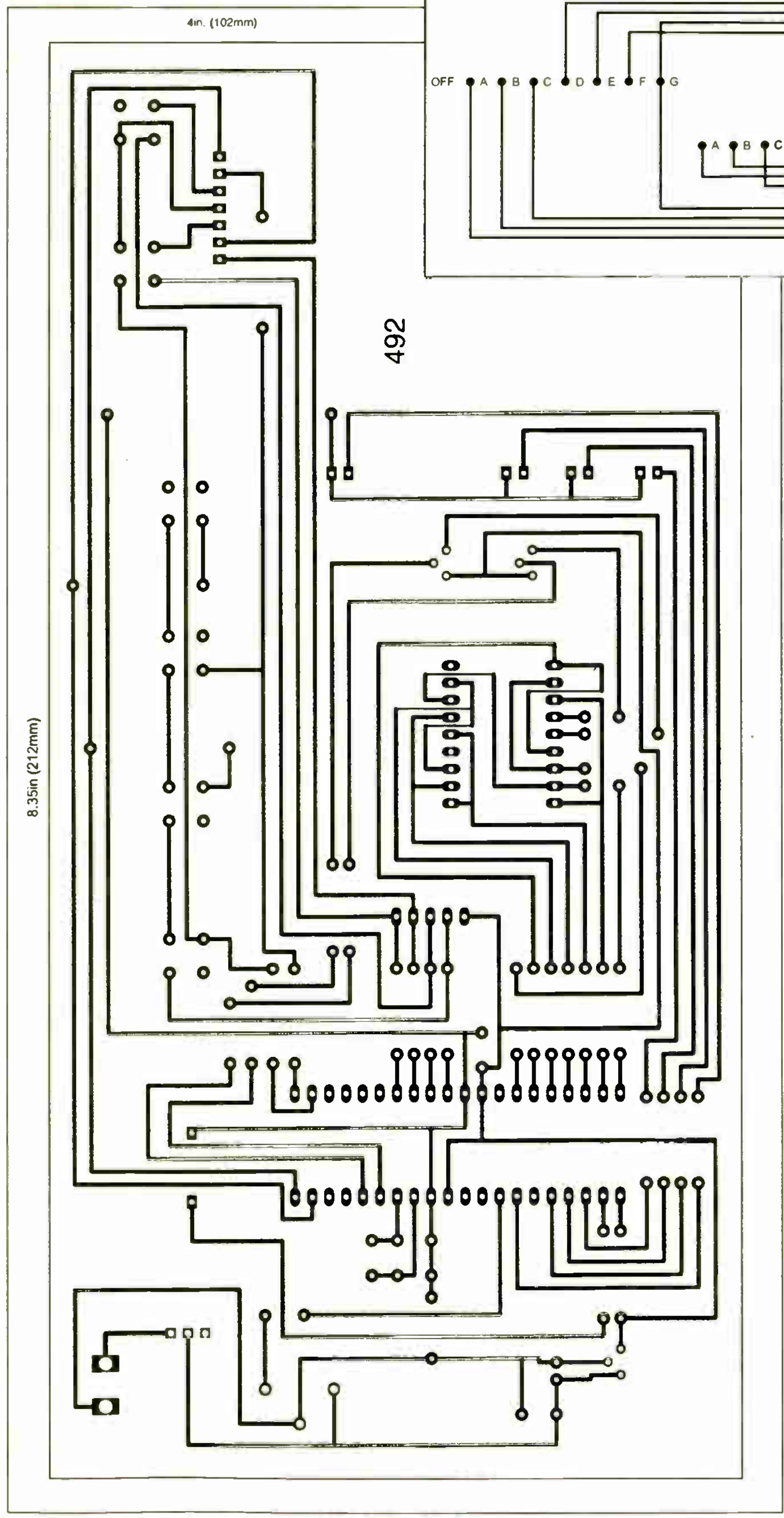
ST1	3.5mm stereo jack socket, p.c.b. mounting
CON1, CON2	16-way IDC p.c.b. header plug (see text) (2 off)
TB1	2-way terminal block
X1	4MHz crystal
X2, X3	common anode 7-segment l.e.d., (2 off) (see text)

Printed circuit board, available from the *EPE PCB Service*, code 493 (Big Digit); 16-pin d.i.l. socket (3 off); 40-pin socket; case to suit; 16-way IDC cable and 16-way IDC p.c.b. leader plug (2 off) if required – see text; connecting wire; solder, etc.

Fig.8. Interwiring links for connecting the mechanical displays to the Big Digit Display board



The full-size underside copper foil master pattern for the basic Bingo Box printed circuit board is shown below



wander lead must also connect to a +5V supply pin instead of to 0V.

If the mechanical displays are used, the test sequence is carried out on PORTA and PORTD. With the common anode connected as described above, a brief touch of a wander lead between the +5V supply and PORTA socket pin will result in a segment turning on. A similar brief touch to the corresponding PORTD pin will turn it off again. Note that care must be taken to ensure that the contact is *very brief*, otherwise over-heating and damage may occur within the display or driver chip.

Always ensure that the power is off before making any changes to the p.c.b.s. It must also be off when plugging in the inter-board connector – the mechanical design of the socket is such that the positive supply voltage could be applied directly to the PORTC serial input. As the voltage is well in excess of the +5V permissible for the PIC, the PIC could die.

In Use

On power-up, the master Bingo Box display will show "- -", the On l.e.d. (D1) illuminates and the default time delay for the automatic mode is set at five seconds. This is the standby mode. To change the delay, which is the time between numbers being generated in automatic mode, press switch S5 (Setup), then enter the time in seconds using the keypad and press Setup again to store the time.

To change the number range, enter setup mode as described above and then press the "#" key. Now use the keypad to enter the maximum number in the range followed by the "#" key again. After this, pressing Setup returns the unit to standby mode. Note that 00 is not a permitted number!

To start producing numbers automatically, press S4 (Auto). Numbers will now be generated after the preset time interval. L.E.D. D2 will illuminate to show that the mode is automatic and a short tone is generated via buzzer WD1 for approximately one second before each new number is displayed. In manual mode, each press of S1 (Manual) generates a new number. Number generation

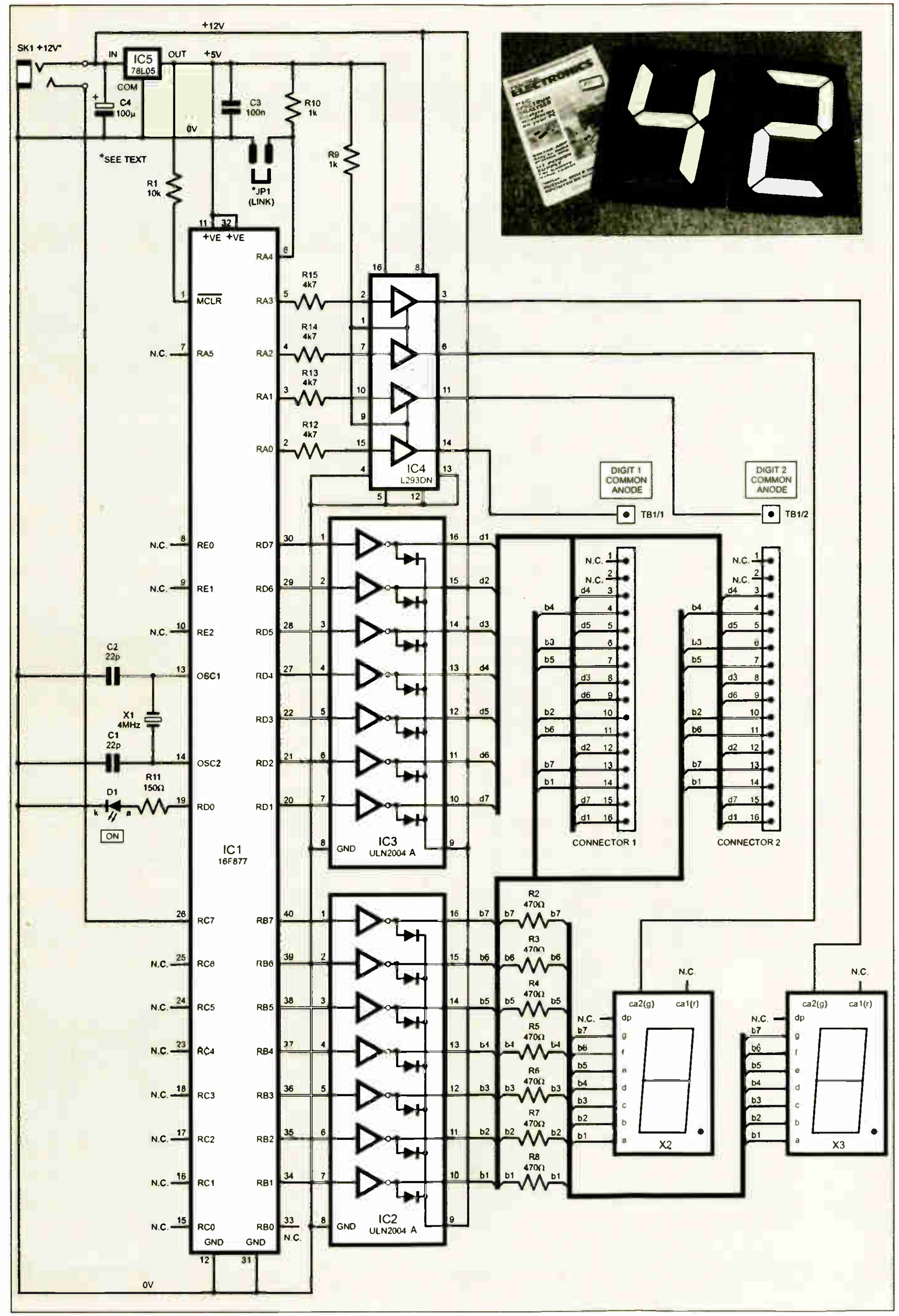


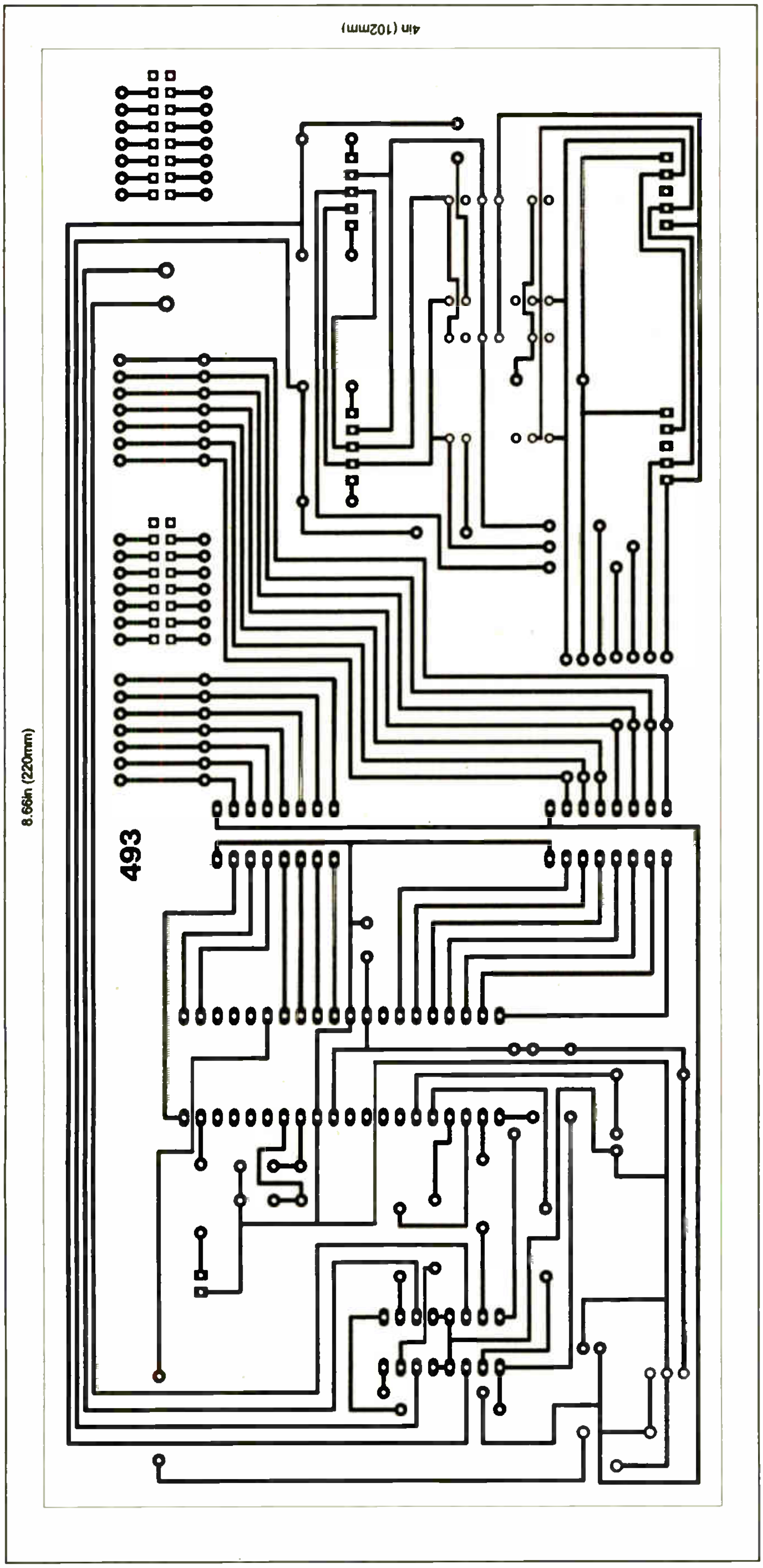
Fig.5. Complete circuit diagram for the Big Digit display driver stages

stops when all numbers in the defined range have been generated.

If someone believes they have a "Bingo!" situation, they should press the Bingo button S2. The on-board display will show "- -" and l.e.d. D1 (On) will flash. The player should then enter their numbers via the keypad signifying the end of each 2-digit number with the "#" key. If it is a valid number, l.e.d. D4 (OK) will light and a high frequency beep will be heard.

If the number has not been called, a low frequency sound will be produced and the machine will go into a standby mode, waiting for either the Auto or Manual keys to be pressed. During checking, it is usual for any externally mounted displays to show the last number generated.

The Rewind key (S6) replays the last 10 numbers at the rate of one every two seconds and the Reset key (S3) clears all memory ready for another game. This will also reset the Big Display board if it is connected.



Full-size copper foil for the Big Digit p.c.b.

Bingo Software

The software is written in WIZ-C. As usual, all source code together with compiled hex files is available for download from the *EPE* web site, via **www.epemag.co.uk**. Preprogrammed PICs can be obtained as given in this month's *Shoptalk*. The C source code is fully commented.

For your general interest – WIZ-C has an application designer style front-end in which basic devices are visually connected to PICs using "drag and drop" functionality. The basic devices used in the Bingo Box are a keypad, an asynchronous serial interface, an EEPROM and a variety of timers and output ports. The WIZ-C software creates the basic code required to drive these devices and, where required, provides "events" which user routines can process. An example of an event is a key press or a timer overflow.

The use of an application designer considerably speeds up the development cycle and removes much stress from the programmer – although the PIC world is divided between assembler purists, who like to control the behaviour of the silicon on each and every clock cycle, and those who simply want to build things in the shortest possible time!

It is not the purpose of this article to debate the relative merits of each, so C source, ASM and hex files are all provided! The assembler generated by the compiler is not directly TASM or MPLAB compatible, but those with the keypad difficulties mentioned earlier may find it useful in modifying the software to suit their pinout arrangement.

Random Generation

The most unusual aspect of the software is the random number generation. Given that all PICs begin in a similar state, and given the same set of conditions and stimuli will end up in the same state, how is it possible to generate randomness?

There is much debate about this matter, but the Bingo Box uses time as a variable and re-seeds the random number generator at arbitrary intervals during program execution. In practice, the number sequence does appear to be truly random!

Acknowledgement

John Becker's various PIC designs previously published in *EPE* for driving multiple l.e.d.s and Big Displays are gratefully acknowledged. □

SHOP TALK
with David Barrington

Cat Flap

Although it is to be preferred, it is not absolutely necessary to use neodymium magnets for the cat's collar called up in the *Cat Flap* project. Almost any fairly strong small bar magnet should produce results. In fact, the only "neodymium" magnets we have come across when scouring listings have been disc types.

For the flap magnet you could purchase one of the many encapsulated types advertised for alarm circuits. These are usually sold with an accompanying reed switch in a matching package. The reed switch needs to be one with "normal open" contacts.

A source for the specified IRF610 MOSFET seems to be rare and the only one we have come across so far is **Cricklewood *(☎ 0208 452 0161* or *www.cricklewoodelectronics.com)***, specify by type number. We understand that transistors TR1 and TR2 are not at all critical in this circuit and components advertisers should be able to offer suitable alternative/equivalent devices.

As suggested by the author, readers should keep to the specified CA3130E op.amp as, apart from the preset potentiometers, no further input biasing is needed. Small quantities of 30 s.w.g. enamelled copper wire can be obtained from **JAB *(☎ 0121 682 7045* or *www.jabdog.com)***, mail order only.

The small printed circuit board is available from the *EPE PCB Service*, code 491 (see page 221). One small observation we would make is that the completed circuit board should be housed in a small plastic case. Even though it is mounted on the inside of the door, a wet moggie's fur could cause havoc with the electronics! Maybe the coil should also be covered with some thin plastic sheet?

Headphone Monitor

We do not expect any buying problems to be encountered when shopping for parts for the *Headphone Monitor* project. Like most volume controls, you should specify that you require a *logarithmic (log.)* type when ordering the dual-ganged (stereo) rotary potentiometer.

Whether you chose to build this little stereo power amplifier as a stand-alone unit or incorporate it in last month's *Sound Card Mixer* project, it must be housed in a metal case/console for extra screening. If added to the Mixer and run for prolonged periods from the same supply, the power supply may need uprating. If used as a stand-alone monitor/amplifier, four AA size alkaline cells should be sufficient.

If you wish to use the same miniature, metal bodied, 3·5mm stereo jack socket as used in the model, this came from **Maplin *(☎ 0870 429 6000* or *www.maplin.co.uk)***, code FK03D. Note that the sleeve connection of any jack socket used must make a good "ground" (0V) connection to the metal case. The LM386N power amp i.c. is stocked by most of our components advertisers.

The printed circuit board is available from *EPE PCB Service*, code 490 (see page 221)

Bingo Box

With such a variety of 7-segment displays on the market now, and most stocked in one form or another by our components advertisers, readers should have no trouble in finding a suitable display device for the *Bingo Box* project. The ones mounted on the author's p.c.b.s are manufactured by **Kingbright** and are stamped: series DA56-11EWA (2001-43) dual display for Main board; and series SBA18-11EGWA (2003-43) for the Display p.c.b. Note that common anode devices are needed. The 3 × 4 matrix keypad should be readily available.

For the optional off-board "giant" displays, bulk purchasing has enabled **Display Electronics *(☎ 0208 653 3333* or *www.distel.co.uk)*** to offer the "British Rail" giant 10 inch 7-segment electromechanical display at a very reasonable price; claimed to be less than 30 per cent of the original. A single display module (code RW44) costs just £29.95 plus VAT and £99 plus VAT for four units (code PH26). A carriage charge may need to be added to these prices.

It is important that constructors specify the suffix **D** when ordering the L293DN stepper motor driver i.c. The **D** denotes it is a 16-pin device and has diode protection. Do **not** use other L293 device types as they may not have the same characteristics and could be 20-pin versions. The one used in the prototype was purchased from **Rapid Electronics *(☎ 01206 751166* or *www.rapidelectronics.co.uk)***, code 82-0192.

The six pushbutton switches used are the 4-terminal "click-effect" types with a polarising flat on one side. Each switch contact is connected internally to two pins (terminals), hence the polarising flat, for ease of track layout on p.c.b. You can, of course, use other switches but you will probably need extra link wires to complete the circuit connections.

For those readers unable to program their own PICs, fully programmed PIC16F877 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). You will need two PICs, one for each board, a 20MHz version for the Main p.c.b. and a 4MHz version for the Big Digit p.c.b.

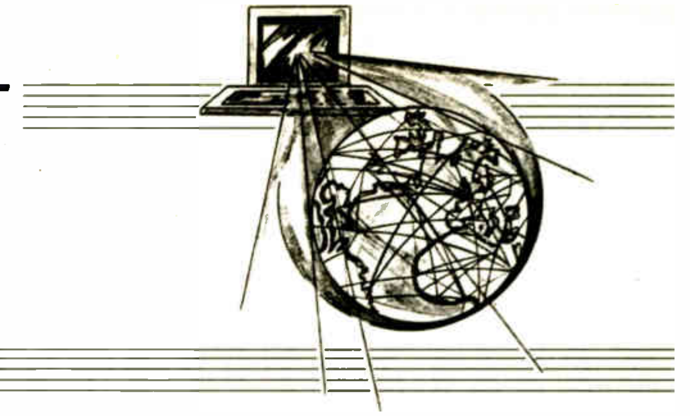
The software, including source code files, is available on a 3.5in. PC-compatible disk (Disk 8) from the *EPE Editorial Office* for a sum of £3 each (UK), to cover admin costs (for overseas charges see page 221). The software is also available for *Free* download via **www.epemag.co.uk**.

The printed circuit boards can be obtained from the *EPE PCB Service*, codes 492 (Main) and 493 (Display) see page 221.

PLEASE TAKE NOTE

Speed Camera Watch *(Jan '05)*
To clarify the connections between the GPS module and p.c.b., we have been advised that the colour coding is: red to JP5-1; green to JP5-2 (unused); yellow to JP5-3 (unused); blue to JP5-4; white to JP5-5; black to JP5-6.

SURFING THE INTERNET



NET WORK

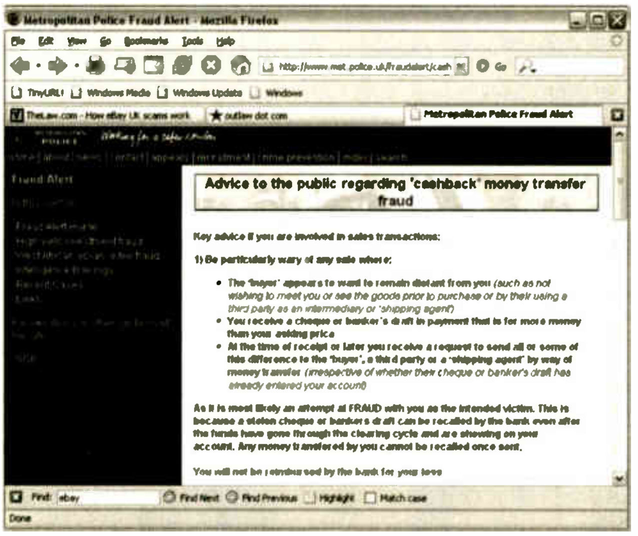
ALAN WINSTANLEY

In last month's *Net Work* I outlined some practical tips to help you avoid getting your fingers burnt on eBay. I am postponing the promised item on "phishing" fraud. Instead, here's more topical news and feedback on eBay and related frauds.

Cashback Fraud

Whilst the vast majority of eBay transactions are successful, it is wise to keep one's feet superglued to the ground when placing a bid or selling an item. Both cowboy sellers and cowboy customers exist on eBay just as they do in real life. The latest form of fraud doing the rounds involves sellers receiving strange offers to buy the item for sale, and actually the buyer offers to pay a whole lot more for the item than is being asked for!

Due to a little-known loophole in UK banking regulations, it is one of the worst scams around, because there is a nasty sting in the tail that may not be felt until weeks after the event when your money disappears for good. It affects anyone selling items, whether on the Internet, in eBay or in, say, car sales magazines, or any other form of media, especially when the item for sale is quite valuable.



My thanks to *EPE* reader Bryan Staines who emailed to say:

"I auctioned my Norton motorcycle on eBay making the bidders clearly aware that the payment conditions would be cash on collection only. I received a winning bid but was suspicious as the bidder was based in Singapore (showing a **yahoo.sg** mail address), however I mailed him (he had an English name) and asked for his requirements regarding collecting the motorcycle.

"He said he had a client in the U.K. that owed him money and he would arrange for his client to make a personal cheque out to me, for me to deduct the value of the Norton, and to transfer the remainder to him via Western Union Transfer. I immediately replied stating that this was not acceptable and that I assumed the transaction was now null and void, needless to say I have not had a reply.

"It reinforces your comment of *Caveat Emptor*. My congratulations to you on your excellent *Net Work* column."

A few points here: firstly, anyone can set up a Yahoo, Geocities or Hotmail email address in a trice, so dealing with someone having such an address should set alarm bells ringing. The mention of Western Union in the same breath is also a huge warning sign. The chances are that the money transfer is an attempt to convert a fraudulent money order or cheque into hard cash. The web site **http://the-law.com** contains many useful forum messages on eBay fraud. Also read **http://tinyurl.com/59w65** if you have time!

Generating a Loss

Shortly afterwards, regular reader Dave Preston emailed with a similar story:

"Recently I sold some unwanted test equipment on eBay, and one item in particular, a nearly new TGR1040 1GHz RF Generator, has been causing me some problems. Twice previously, it has attracted bids but not enough to warrant its reserve of £950. However, on a recent attempt to sell it, after Day One I had a reply from someone wanting to buy it. After an email to find out more, I got the following reply:

'Hello, thanks so much for your fast response... The bank draft/ money order that will be issued will include the money for the sales of your item + the shipping cost and my commission.

'I would like to restate clearly that this item will be shipped to Africa and I have a shipping agent who would take good care of this. You will be required to cash the bank draft/ Money Order and deduct the funds for the sales of your item and have the excess funds sent to the shipper via Western Union Money Transfer at one of their outlets around you in order to schedule the pick up of the item.

'All necessary transfer papers will be duly signed by the shipper on behalf of my client when the shipping agents comes for the pick up of the item. I will be willing to entertain more of your questions that might arise and you are free to mail me. If you really show willingness and would really want to sell this item fast, please provide your contact details so that I can have it forwarded to my client for immediate payment issuance.'

Accredited View

Dave asked for my views on this transaction. This type of "cashback fraud" is one of the nastiest forms of Internet scams around at the moment. The criminals supposedly send you "excess funds", from which you deduct the amount of your sale to keep. You forward the surplus (the cashback amount) to a "shipping agent" using Western Union. You send the goods. Then, the original payment bounces, due to a little-known loophole in the way UK banks operate. You lose everything.

The London Metropolitan Police web site has useful data on this "cashback fraud", see **http://www.met.police.uk/fraudalert/cashback_fraud.htm** (or, **http://tinyurl.com/44c23**).

Also explained on the excellent legal web site **Out-Law.com** (in an article at **http://tinyurl.com/5jmrg**): "Under the clearing system used by the banks, while cheques may appear to clear within a matter of days, the banks are entitled to reclaim the value of the cheque if it later turns out to be stolen or issued fraudulently, often weeks later. This means that the victim is then out of pocket to the tune of the refund and the item he thought he was selling."

A stolen identity may be used to pay you, perhaps with a stolen cheque or money order, but in the case of cashback fraud, you will lose the goods you sent out, you will lose all monies including the "surplus" funds that you helpfully mailed out via Western Union but worst of all, as the Police mentions, **you will not be reimbursed by the banks for any of your losses**.

Sometimes, greed and naivety take over when deals seem too good to be true. The Internet offers rich pickings for villains who will defraud you without mercy, and there is no doubt that Internet fraud in many forms will soar in coming years. With ID theft increasingly rife, some think that eBay singularly fails to protect its customers adequately enough against fraud and has a lot to answer for. You can email the writer at **alan@epemag.demon.co.uk**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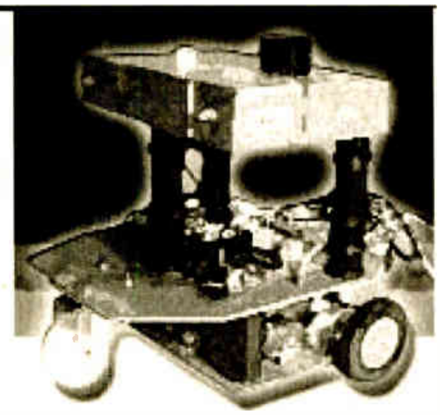
Smart Karts



Owen Bishop

Part 6 – SK-3 Push and Grab Software

LAST month we described the circuits and construction of the third incarnation of our mobile robot, calling it SK-3. This month we describe how to make SK-3 wield its pusher and grabber via its software. The software comprises four sub-programs that are selected by switches S1 and S2. The first two are for the SK-3 with its pusher attached, the other two are for use with the grabber.

Sub-routines

For previous Smart Kart versions, each of the four sub-programs has been self-contained, except that they all call the same delay sub-routine, **Pause2**. This month's programs have several quite long routines in common so we are setting these up as sub-routines that can be called from any of the four programs. This should make it easier and quicker for you to write your own programs, if you decide to do so. Here is a list of the sub-routines, stating what each does and what (if any) values it returns.

Pushdown: Lowers the pusher to the surface, then raises it just clear

Pushup: Calls **Pushdown:** then raises the pusher well clear of the surface

Ready: Initialises the robot; takes up any slack in the winch cord, raises the pusher or jaws clear of the surface

Jopen: Open the jaws to their widest extent. Not applicable to the pusher

Detect: Samples the Red-On and LDR signals. Returns with values in the register **object:** 01 = sensor swamped by bright light, 02 = no object detected, 03 = object detected. This sub-routine is described in more detail later

Grabbit: Assumes that **Ready:** and **Jopen:** have been called, so jaws are wide open. Closes jaws until they have gripped an object or the jaws are in contact with each other. Returns with values in the working register, **W:** 00 = no object grabbed, 01 = object grabbed. Not applicable to the pusher

Circulate: Action described later under "Deal the Pack"

Pickup: Detects and picks up an object, calling **Takeit:** to close the jaws

Raster: Scans an area about 30cm square, looking for an object. Returns when an object is found or when 20 scans have been completed

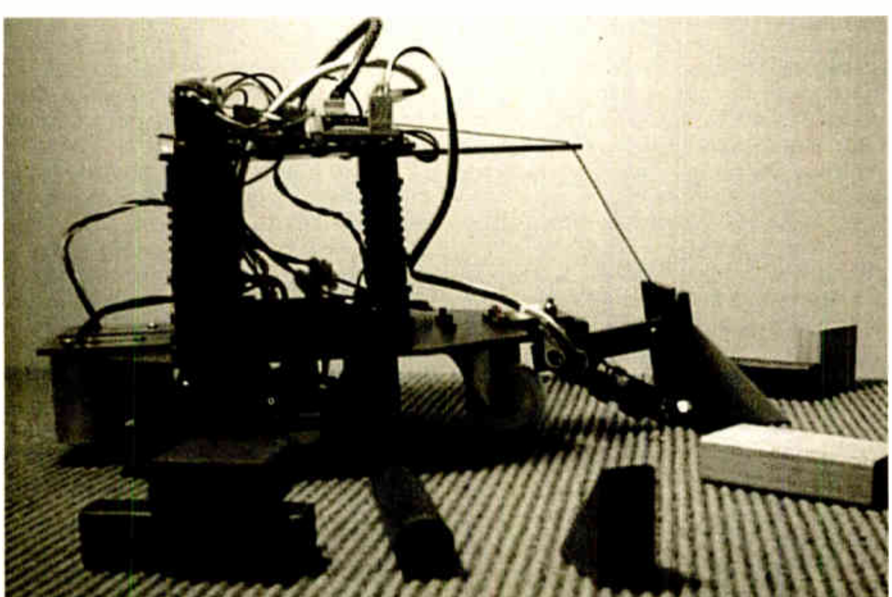
Takeit: Closes the jaws on an object presented to them

Pause2: Provides a delay up to about eight seconds, the length depending on the value in register W when the subroutine is called

Clean Sweep

When running the sub-program **Behave1:** the robot uses its pusher to sweep an area clear of small objects. The program is selected by switching off both Select switches, S1 and S2. Group A inputs of the Distribution board are used throughout the program.

Although the program has an extremely simple action – sweeping blindly to and fro to clear the area – you are able to modify the robot's behaviour while the program is running and so teach it how best to do its work. The light sensor is not required in this program.



Clearing an area using SK-3's rear mounted pusher attachment

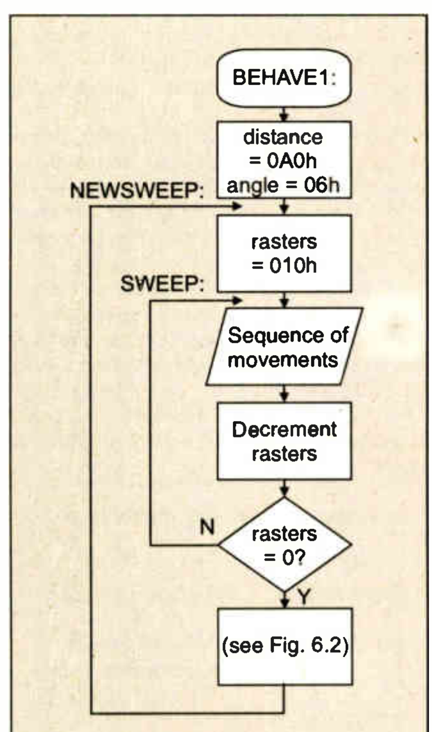


Fig.6.1. Outline flowchart of Behave1:

The robot performs a repeating series of sweeps across the area. It lowers its pusher and then reverses (pusher leading) a fixed distance, pushing objects before it, spins left through a small angle and stops. For the return journey it raises the pusher and moves forward (pusher behind) the same distance, and spins right through an equally small angle. This brings it back to a position slightly to the right of its original position, but it is still facing in the same direction. In this way, it sweeps the area from left to right.

Unfortunately, a problem with robots of this type is that wheel slippage may upset this neat scheme. It depends on the kind of wheels and their frictional grip on the surface. Wheels with spongy rubber tyres are the best but are not easily obtainable in a suitable size. But try it with the wheels you have, as the teaching aspect of this program is of interest and mirrors the kind of program used in some industrial robots.

Start-Up

The program begins by initialising three variables (Fig.6.1). **Distance** controls the length of each sweep, **angle** controls the angles turned through at the ends of each sweep, and **Rasters** is the number of sweeps attempted.

The first half of the program, which begins at label **Newsweep:**, follows the pattern of many of the programs that we have already studied. It consists of a sequence of routines for sending the code for a particular action to Port A (for the drive motors) or to Port B (for the winch motor). An example is the spin left routine in Listing 2.1 in *EPE* Nov '04.

In the case of the winch motor, code 010h raises the pusher and code 020h lowers it. At the end of the sequence, **rasters** is decremented. If **rasters** has not reached zero the program loops back to repeat the sequence.

Operator Link

If **rasters** has been reduced to zero, the program drops through to the sequence illustrated in Fig.6.2. This gives the operator the opportunity to change the value of angle, to vary the spacing between successive sweeps. The operator communicates instructions to the robot by means of the infrared sensors. These are used in other programs for line-following and similar tasks but now we put them to a novel use.

The long delay is to give the operator time to insert a piece of black card beneath one or both of the sensors. The input from the sensors is read at the end of the delay. First we read the left sensor input at RB7. The input is high (bit set) if the surface below it is white (or light in colour). It is low (bit clear) if the surface is black (black card beneath). Here is the extract from the assembler code for taking a decision based on the state of RB7:

```
btfss portb, 7     ; skip if left sensor
                     is on white

goto setangle      ; to change angle

goto newsweep      ; repeat sweeps,
                     angle unchanged

setangle:
   movlw 03h       ; load small change of
                     angle into W
```

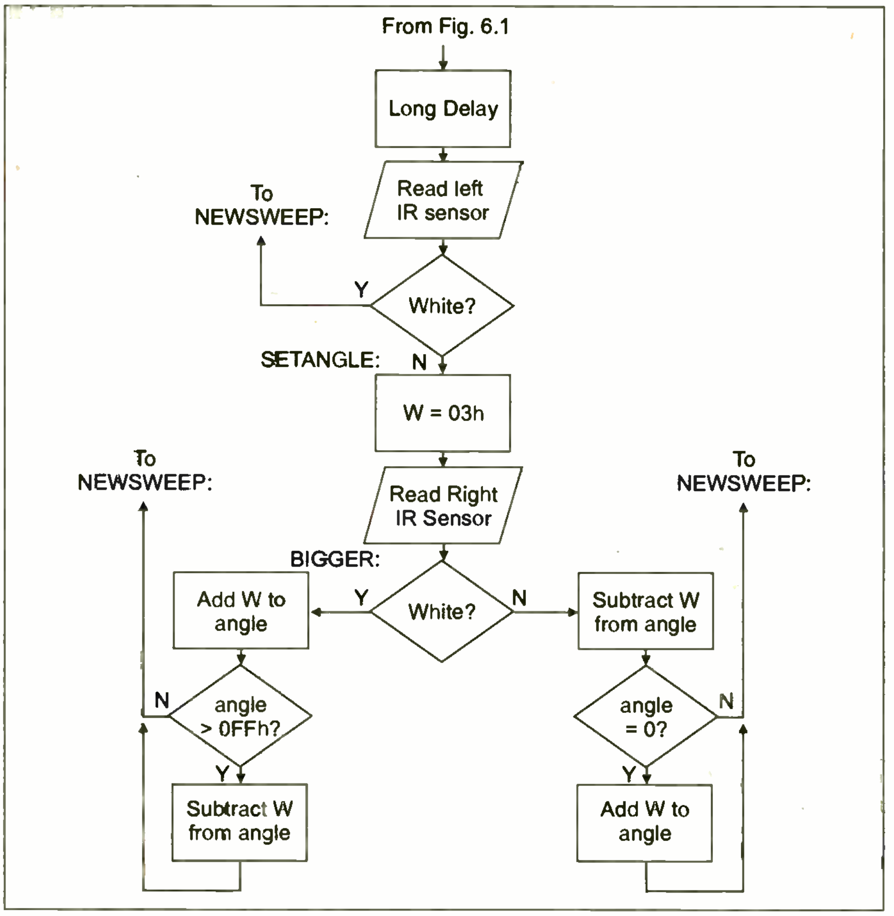


Fig.6.2. Detailed flowchart of the sensing routines of Behave1:

The effect of this is to loop back to **Newsweep:** to repeat the sweeps unchanged if the card under the left sensor is white, or to alter the angle if the card is black.

After **Setangle:** the program reads the input from the right sensor, at RB6. Depending on the input at RB6, the value previously stored in **W** (03h, see extract) is either added to or subtracted from **distance**. Given a low input (black), **distance** is reduced by 03h; given a high input (white) **distance** is increased by 03h.

Before the PIC loops back to **Newsweep:** there are sequences in both branches of the program to restore the value of **angle** should it ever be reduced to zero or increased beyond 0FFh. If it is reduced to zero, the Zero flag (bit 2 in the **Status** register) is set. The program tests this bit and acts accordingly. If **angle** is increased above the maximum (0FFh), the Carry flag (**Status** bit 0) is set. The program tests this bit and if necessary restores **angle** to its previous value.

Summing up, the area is prepared by scattering it with toy bricks or other objects. The robot is placed at the edge of the area, pusher facing toward the area. It sweeps back and forth across the area 20 times, pushing the objects out of the area. Then it pauses for about 10 seconds.

Assuming that the surface is white or light-coloured, you can alter the variable angle by placing (or not placing) a piece of black card beneath the IR sensors (Table 6.1). Increasing angle increases the spacing distance between adjacent sweeps.

The robot then repeats the sweeping action, with changed spacing if so instructed. This can be repeated with changed spacing any number of times.

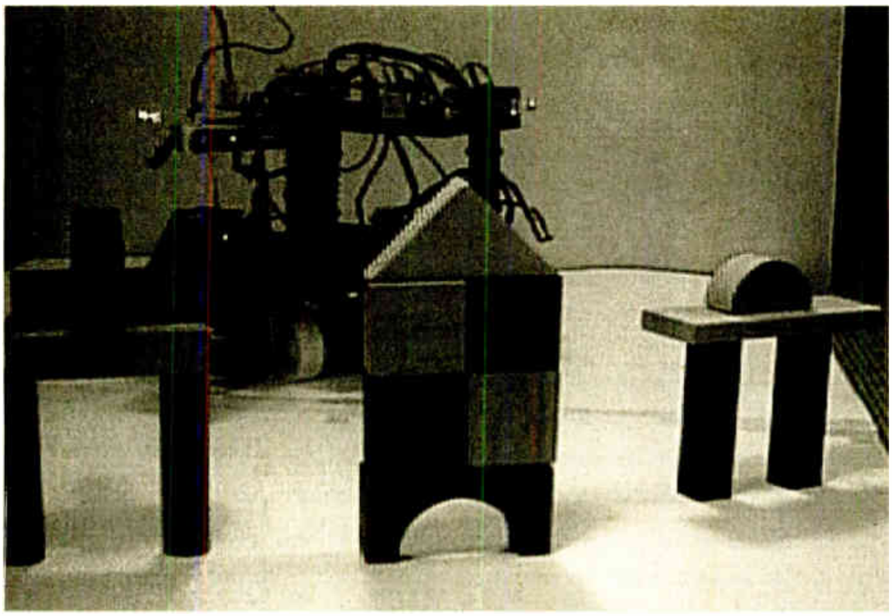
Random Demolition

The Random Demolition program (**Behave2:**) might well be called "Bull in a China Shop". Another name might be "Monte Carlo Walk", for the robot is made to wander around in a very erratic and random (actually pseudo-random) way. The program is selected by setting switch S1 on and S2 off.

Before running the program, prepare the area by scattering it with objects to be demolished. If you are using toy bricks, now is your chance to construct structures that look sturdy but are easily toppled. Place these in a row with about 10cm gap between them. Put SK-3 about

Table 6.1: Changing the angle

White/Black state	*RB7 (left)*	*RB6 (right)*	*Action*
On white surface	1	1	**angle** not changed (no black card) spacing unchanged
Black card beneath both sensors	0	0	Increased **angle** gives both sensors increased spacing
Black card beneath left sensor only	0	1	Decreased **angle** gives left sensor only decreased spacing



Smart Kart SK-3 ready for a devastating "demolition" charge in Behave2: mode

10cm from the line, with its pusher toward the buildings. As an alternative to bricks, you could scatter the area with skittles and make a game of it.

This program uses the light sensor to detect the objects. We mounted the sensor on the end of the cord support, aimed downward to a point about 20cm in front of the pusher. The program's flowchart is shown in Fig.6.3. It begins by lifting the pusher well above the surface, as it is not being used at this stage. Then a random number is generated, using a routine similar to, though simpler than, the random number routine described for SK-1, in its maze-running program (*EPE* Nov '04).

The random number is held in the variable **random**. While the program runs it may take any of the values between binary 00000001 (01h) and binary 11111111 (FFh). The value is sent to Port A to control the drive motors. Port A has only five bits, so the upper three bits are ignored. Bit 4 goes to RB4 which is used to select Group A or Group B inputs. The state of bit 4 is not relevant during this part of the program, so can be ignored.

This leaves the lower four bits (RB3 to RB0) with which to control the motors. Of the 16 possible binary combinations of 0 and 1, we have normally used only seven. For example, 1010 drives both motors forward. A motor stops if its two inputs are both low, or if they are both high, as can be verified by studying Part 1 Fig.3.

This means, for example, that codes 0001 and 1101 both stop the right motor and drive the left motor in reverse. Similarly, codes 0000, 0011, 1100 and 1111 all stop both motors. So any of the 16 possible groups that are sent to the motors can have some effect in driving or stopping the robot.

After the code has been sent to the motors, **Pause2:** is called and the motors run (or do not run) for about one second. Then a new random number is generated and the robot performs another movement. The effect of all this is to make the robot move about irregularly but, on average, not travel very far from its original position.

Detective

The Demolition program relies on the **Detect:** subroutine to tell the robot when there is an object within range of its pusher or grabber. This subroutine is called after each random movement. **Detect:** is used also by the two grabber programs. The sensor (or light probe), was described in Part 5 (Fig.5.2).

A flashing beam of red light from l.e.d. D2 is directed ahead of the pusher or grabber (ahead, that is, when the robot is running in reverse). If an object is present the beam is reflected back, and falls on the LDR. Blue l.e.d. D1 is there for visual effect and plays no part in detection.

To detect an object reliably, we make use of two signals:

- Red-On: low when the l.e.d. D2 is off, high when it is on
- LDR: low when light falls on it, high when there is little shown or no light

The waveforms in Fig.6.4 show the signals as the l.e.d. flashes. There are three possible outcomes:

- If an object is present, both signals alternate and are opposite in phase
- If the sensor happens to be directed toward a bright room light or a sunny window, the LDR signal is permanently low. We say that the sensor is "swamped". Under this condition, it is not possible to know whether there is an object present or not
- If there is no object present (and no swamping), LDR is permanently high.

To differentiate between these three results we sample the signals at two stages, as indicated by the dashed lines in Fig.6.4. If an object is present, the LDR signal is the inverse of Red-on at both stages. Table 5.1 in Part 5 shows that the Red-on and LDR signals are both sent to Port B pin RB3. Red-on is selected as one of the Group A inputs; LDR is selected as a Group B input. As shown in the flowchart of Fig.6.5, **Detect:** begins by selecting Group A (output RA4 high) and reading the Red-on signal at RB3.

The first requirement is that the program should be synchronised with the flashing of the l.e.d. The program waits for Red-on to go low (D2 off), then waits for it to go high (D2 on). Group B inputs are then enabled and, after a delay to allow the voltage to settle, the

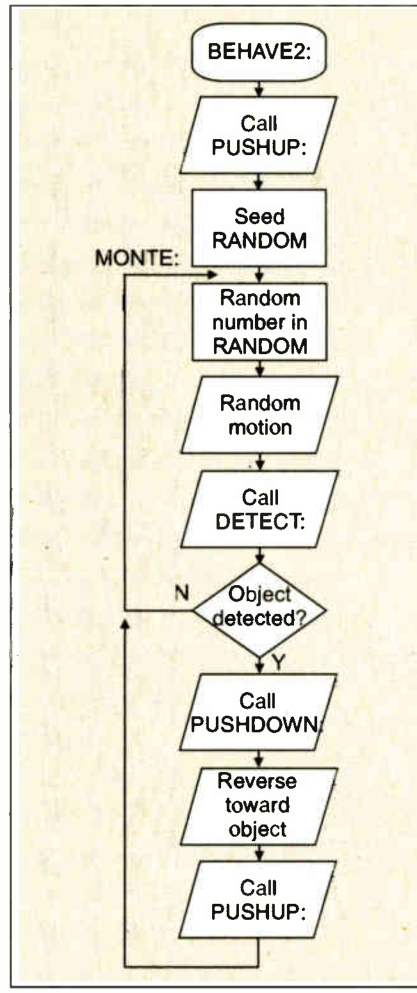


Fig.6.3. Flowchart of Behave2:

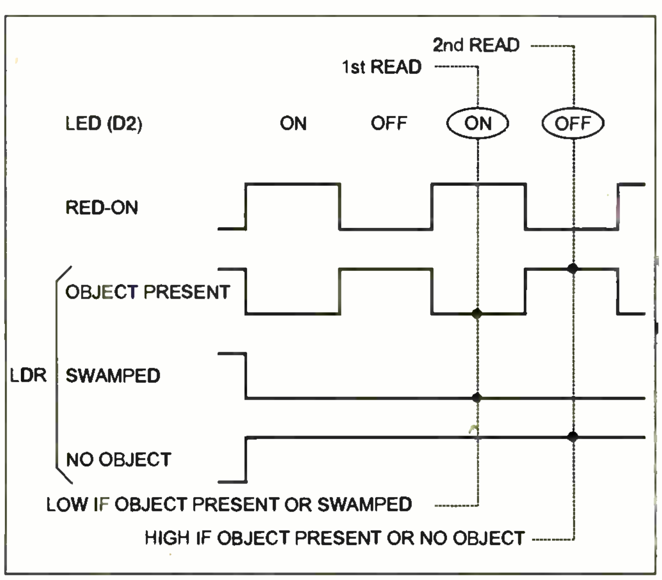


Fig.6.4. Timing diagram of the Detect: subroutine

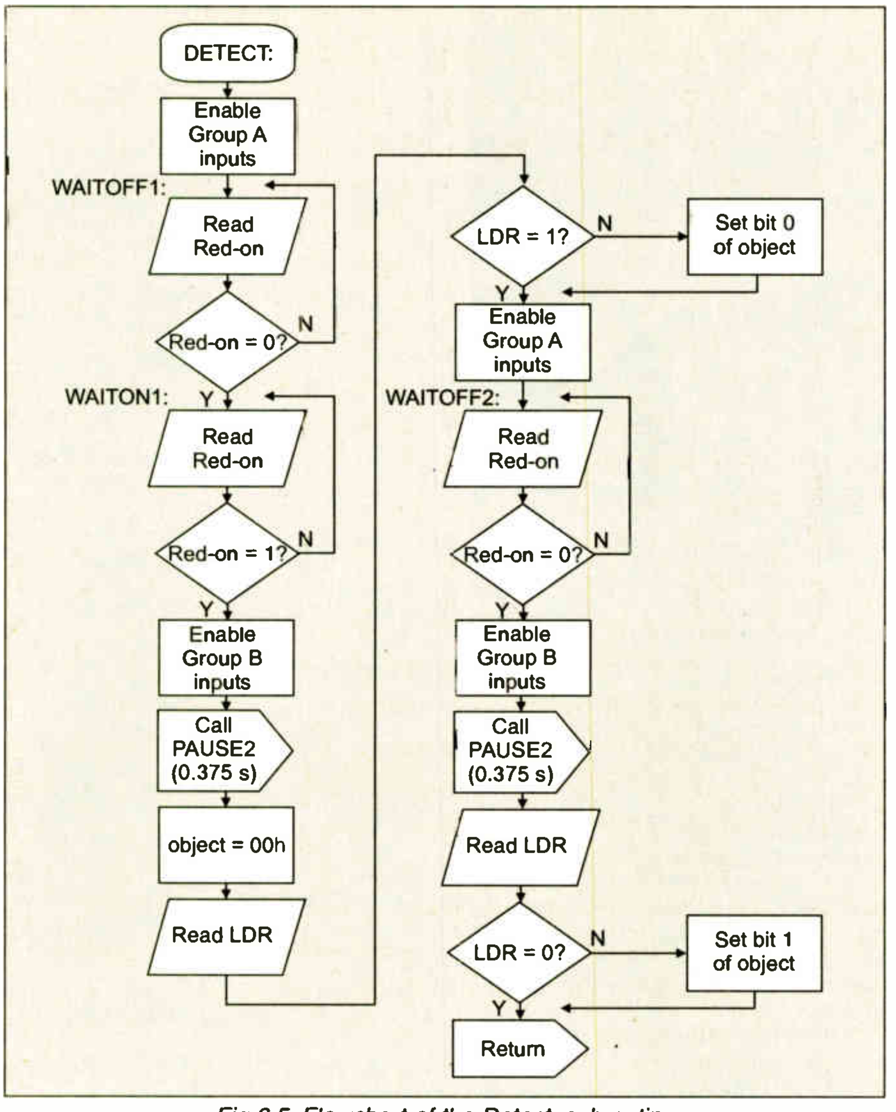


Fig.6.5. Flowchart of the Detect: subroutine

program resets the variable **object** and reads the output from the LDR. This is the first read shown in Fig.6.4. If no light is detected, LDR is high and the program enables Group A again. Otherwise, if there is reflection from an object or the LDR is swamped, bit 0 of **object** is set to 1.

Now the program waits for Red-on to go low, when it samples LDR again. This is the second read in Fig.6.4. Bit 1 of **object** is set if the LDR detects no light (either an object is present but not illuminated, or there may be no object and the LDR is not swamped). The final result is that if an object is definitely detected and the LDR is not swamped, **Detect:** returns with both bits of **object** set (**object** = 3).

On return from this subroutine, **object** is tested using a short routine:

Although we normally test for the value 03h, it is also possible test for two other values (01h and 02h) in **object**, as explained in the list of subroutines at the beginning of this article. It is not normally possible to return 00h.

Charge!

Returning to the flowchart of **Behave2:** (Fig.6.3), we can see what happens on return from **Detect:**. If no object is detected the program simply loops back to **Monte:** and the robot continues its Monte Carlo Walk.

If an object is detected, the robot lowers the pusher and charges toward the object and beyond, demolishing it on its way through, like skittles!

Search and Eliminate

The Search and Eliminate routine, **Behave3:**, is selected by switching S1 off and S2 on before pressing the Reset button. The routine's flowchart is shown in Fig.6.6.

It begins by calling **Ready:** and **Jopen:** to make the robot ready for action. Then it calls **Raster:** in which SK-3 runs forward and backward to search for an object. On its backward runs, it stops eight times to call **Detect:**, repeating for 20 runs. It returns from **Raster:** as soon as it detects an object within reach of its jaws, or after it has completed 20 runs.

On its return, the program examines the contents of **object**. This holds the value 03h if an object has been detected, as explained previously.

If an object is detected, the program continues by calling **Grabbit:** to operate the jaws. It assumes that the jaws are already wide open and raised a few millimetres above the surface. It does not test for an object because it is assumed that **Detect:** has already been called.

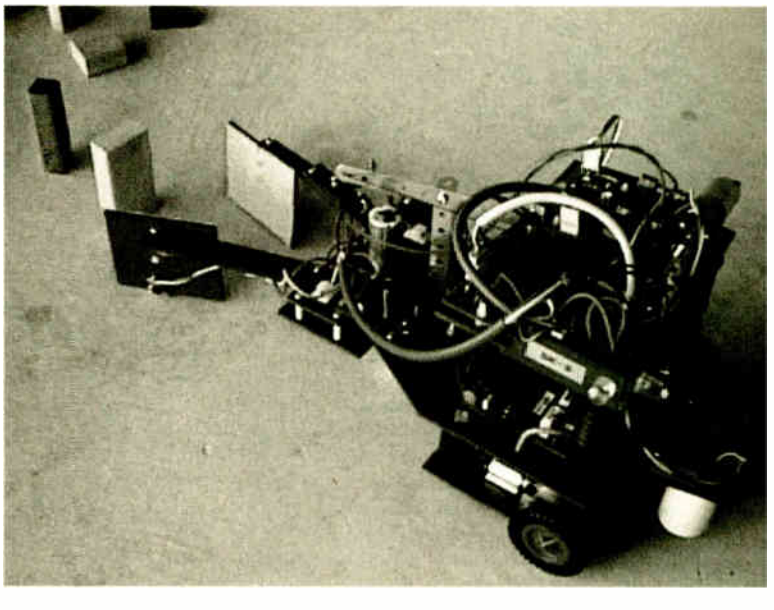
Its first action is to reverse the robot a few centimetres closer to the object, to obtain a better grip. The next stage is to select Group B and switch on the jaws motor to close the jaws. While the jaws are closing it reads the input from microswitch S4. This is one of the limit switches mounted on the gearbox.

When the jaws eventually come together, S4 closes and gives a high output. If the input from this switch is low, it means that the jaws have not reached their closed positions. The program also reads switch S5, which is the microswitch on the pressure jaw. Its output goes low when there is pressure on the jaw, indicating that the jaws are gripping an object.

The flowchart in Fig.6.7 shows the part of **Grabbit:** that uses the two microswitches. The PIC waits in a loop,

```
movlw 0FDh              ; Put FDh into W (effectively -3)

addwf object, W         ; Add object to W, which gives
                          zero if object = 3

btfsc status, Z         ; Test zero flag

goto found              ; If Z = 1, object detected

; continue with program ; If Z = 0, no object detected
```

Smart Kart SK-3 getting to grips with some "building bricks" that are wanted at another location.



reading the input from S4 and S5 until either the jaws are closed but empty, or an object is gripped. If there is nothing in the jaws, the motor is stopped and the program returns with 00 in **W**. If an object is gripped, the motor is allowed to run a little more to tighten the grip, and then stopped. The program raises the jaws and returns with 01 in **W**.

If an object is successfully grabbed, the robot runs a zigzag course away from the site, drops the object, lowers the jaws to rest on the surface (a safety precaution in real life), and the program ends. However, two things may happen to prevent the program reaching its end. The robot may fail to find an object or, having found one, may fail to grab it firmly.

In the first event, the program goes to **Waiting:**, where it enters a loop. This loop is based on the assumption that no, or very few, objects are available. SK-3 stays in one place with its jaws open, waiting for an object to be placed between them. It waits indefinitely but, as soon as we give it an object, it tries to grab it, and the program continues as before.

If it fails to grab the object, the program enters another loop at **Nextgo:**. This loop assumes that there are plenty of objects but they are difficult to pick up. The loop gives the robot five tries at the **Raster:** routine, looking for other objects. If it still fails to find one it goes to the **Waiting:** loop where it waits to be given one.

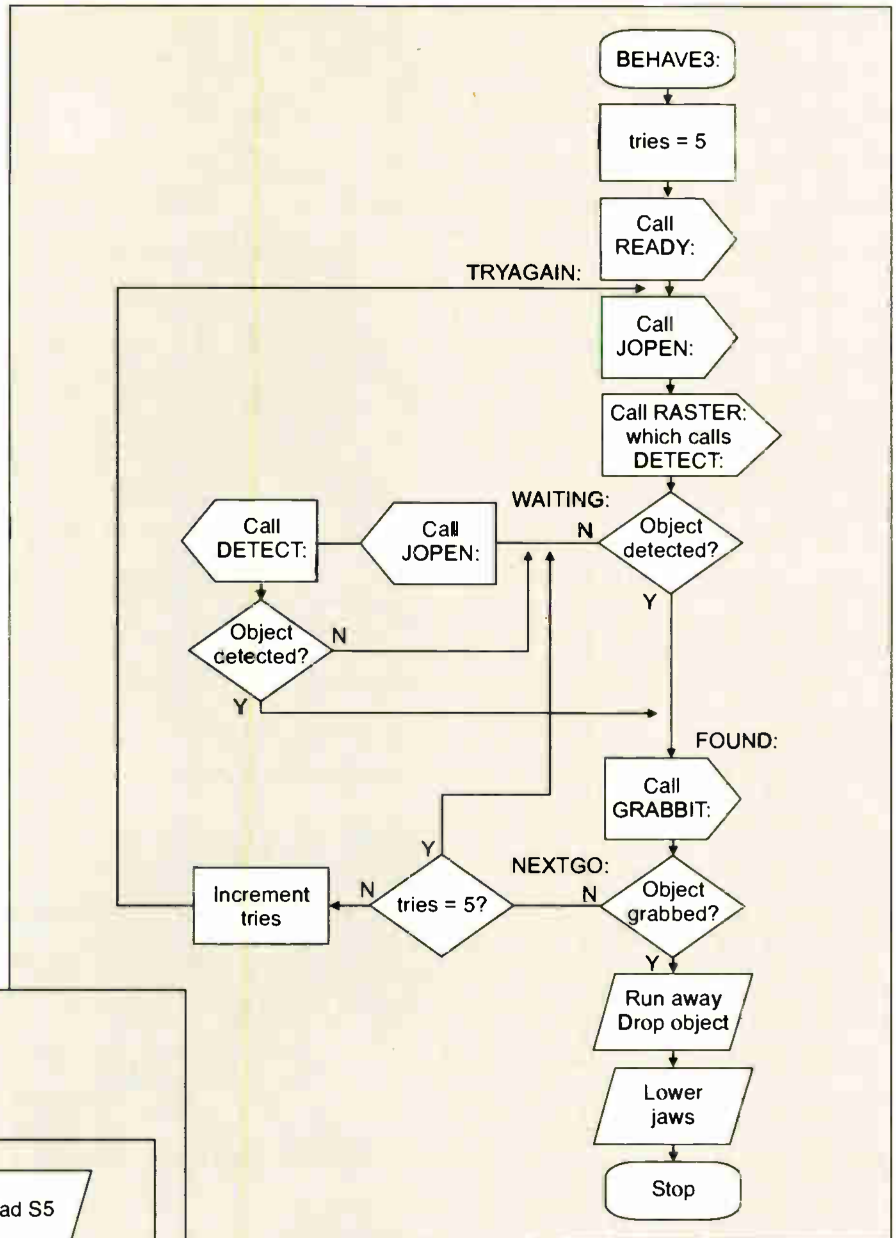


Fig.6.6. Flowchart of the Behave3: program

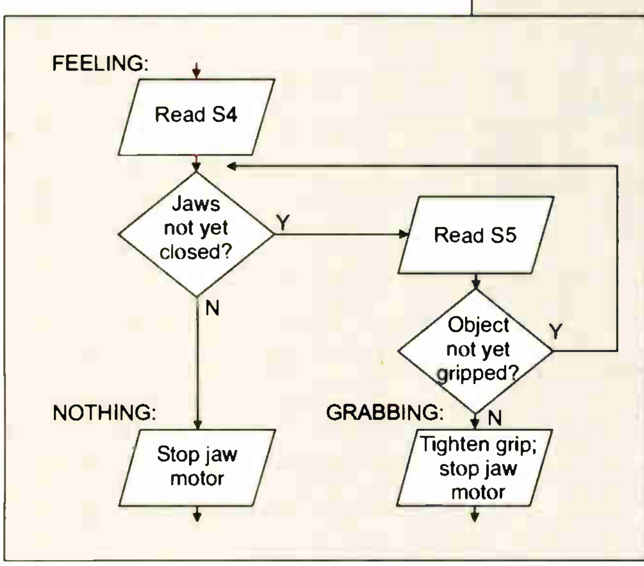
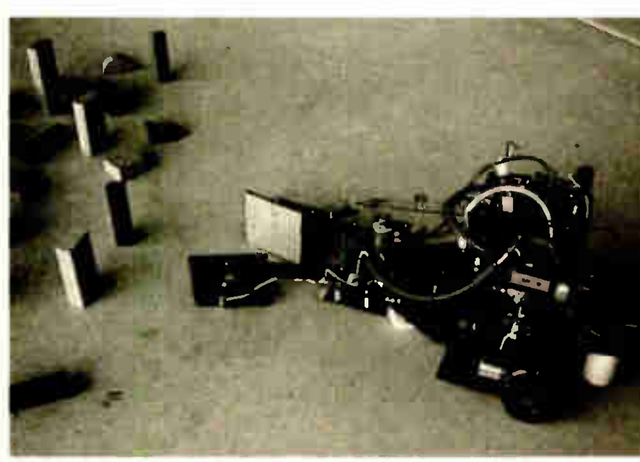


Fig.6.7. Flowchart of part of the Grabbit: subroutine

This program needs a large flat area. Scatter small objects (such as toy building bricks) in the central region of the area, about 10cm apart. Place SK-3 with its jaws facing the cluster of objects (see photo below) and switch on.

Seen from above, the grabber comprises a motor-driven gearbox and two arms. The upper arm in the photo is the pressure-sensitive arm



On the floor of the author's garage, SK-3 prepares to steal a brick

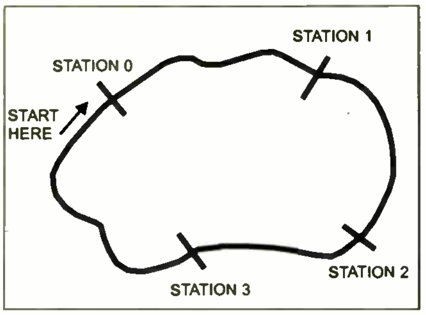
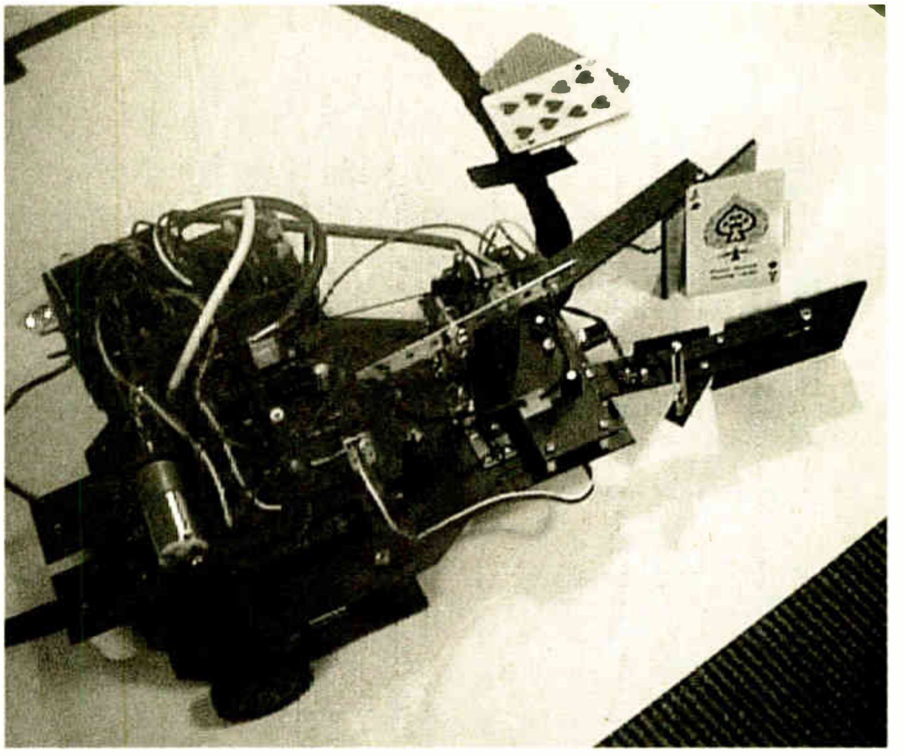


Fig.6.8. A possible path for the Behave4: program. Paint the path about 20-25 mm wide on white card, using black acrylic paint. Radius of bends should be at least 70mm. The stations are painted as transverse blocks



Smart Kart SK-3 about to "deal" an ace to a player's station at the gaming table.

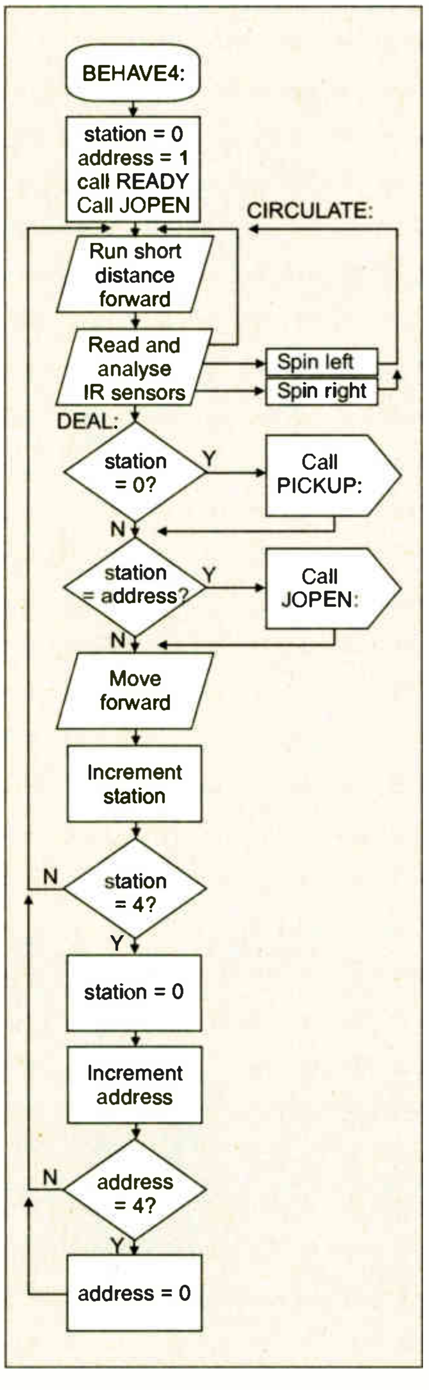


Fig.6.9. Flow chart of the Deal the Pack Behave4: program

Close-up of one of the two, front-mounted, infra-red line sensors.

Deal the Pack

Both Select switches S1 and S2 are turned on to enable the Deal the Pack routine. The program is based on the Line Runner With Stations program (Behave2:) described for SK-1 (Part 2). This uses the two infra-red sensors to guide the robot along a path that is a closed loop, see "line-runner map", shown in fig.6.8.

When running this program the robot behaves like a person dealing a pack of cards. When it is at Station 0 (the dealer's station), the robot is given a playing card and then distributes it to one of the stations, including Station 0. On successive rounds it drops a card at each station in turn.

The program (Fig.6.9) is the same as the line-follower up to the point at which the robot reaches a station. There, instead of the previous routine (**Break:**) we have a new one called **Deal:**. This uses two variables, **station** and **address**, to keep track of the robot's activities.

A lap takes the robot once round the track from Station 0 and back to Station 0. The **station** variable is the number of the station at which the robot is going to stop next. The **address** variable is the number of the station at which it is going to drop the card.

Let's Play

There are two simple rules for the Deal the Pack **Behave4:** program:

- Pick up a card when **station** = 0
- Drop the card when **station** = **address**

Assuming that SK-3 is circulating clockwise, it drops the card at Station 1 in loop 1, at Station 2 in loop 2, at Station 3 in loop 3 and at Station 0 in loop 4. Then it repeats.

The **Pickup:** subroutine calls **Ready:**, **Jopen:** and **Detect:**, waiting in a loop until an object is placed between the jaws. Then it calls **Grabbit:** to grasp the object. On returning from **Grabbit:** it does not check to find out if an object is grabbed. With a very thin object, such as a card, it is not possible to tell. So the robot relies on the operator to place the object accurately and check that it is firmly held.

To drop the card at the station the program simply calls **Jopen:**. The robot then moves forward a short distance to clear the station but, before proceeding to the next station, **station** and **address** are updated. They are ready to tell the robot what to do at the next station.

Using a painted path similar to Fig.6.8, place the robot on the path where it says Start Here. It should be facing forward, that is with its jaws facing away from Station 0. Run the program. Feed the robot with an object every time it comes to Station 0. It has an insatiable appetite!

Next Month

Next month, in part 7, our buggy gets into *Son et Lumiere* and PICs up the art of cybernetic singing and dancing!

READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

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

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★ LETTER OF THE MONTH ★

Locating GPS and Rugby

Dear EPE,

Although I won't be constructing the *Speed Camera Watch* (Jan '05), I have been interested in GPS (which it uses) for a long time. However, GPS instruments are too expensive for me to experiment with, so the latest article was very useful in pointing to an affordable module, and gave me a good start with a lot of the groundwork already done.

I took up electronics as a hobby when nearing retirement, after ten early years as an electronics engineer – it was all valves then – and thirty years teaching computer programming, and have subscribed to *EPE* since 1996. I had to learn about op.amps and transistors, and a lot of that came from *EPE*. I am also now a radio ham, licensed in 2000, and have built an Elecraft K2 as my HF rig, but its output goes to a loudspeaker driven by *EPE* audio amplifier circuits, and I used an oscillator from an *EPE* series to learn to send Morse.

My signal generator is from *EPE* Oct '96, and I have *Icebreaker* and *Toolkit TK3*. My hi-fi is turned on and off for recording programmes while I am out, by the radio-controlled clock from *EPE* Nov '97. My latest project was to adapt the receiver from a pair of wireless earphones to drive a loudspeaker instead, and, you've guessed it, it's an *EPE* audio amplifier that drives the speaker.

While I was still working, in the nineties, I heard of the Rugby transmissions and tried to find out about a receiver. One of the articles sent to me by NPL (National Physical Laboratory) was from long ago and written by one John Becker. I didn't build it but I learned a lot from it.

Harry Weston, via email

Thanks for this Harry. I've a feeling we shall see more designs that use the GPS Module referred to. Rugby – there's nostalgia, I had great fun with producing that design for EPE, *in the late 80s I think. It was built entirely around standard logic chips, even the receiver! My more recent one used a Maplin receiver module, and I fed its output into a PIC, which did all the decoding.*

More power to your continued enjoyment of us and your electronics!

A Shocking State

Dear EPE,

I realise that your publication is not aimed at electrical issues but I wish to draw attention to the Oct '02 *Circuit Surgery* section headed "A Shocking State". The remark that there are "plenty of low cost voltage testers available" will in my opinion only increase the risk of serious injury or death to members of the public who have little or no knowledge of the dangers.

The use of *non-approved* voltage testers for safe isolation of supplies is against all safety codes of practice, the inherent danger of multimeters is well known within the electrical trade, and the use of mains tester screwdrivers to check for the presence of lethal voltages is definitely not on. Any instrument that requires yourself to be part of the circuit under test is asking for trouble.

A vast number of these devices are purchased from unproven sources, i.e. bootfairs and market stalls, and are of unknown origin. Malfunction of these can cause the full mains voltage to appear at the metal end cap. The non-contact type, which operate on the presence of a magnetic field, can give false information.

There is a correct procedure for safe isolation which requires an approved voltage tester to GS38 standard, which must be proved to function both before and after checking the circuit in question. The obvious solution, however, is to leave it to the professionals, which from 1st January 2005 carries the force of the law, up to a point.

From 1st January *no person* may carry out the majority of electrical work on domestic premises without holding a particular self-certification qualification, unless such work is authorised by the local council's department who will come and test the installation afterwards, at cost to yourselves.

Failure to comply can result in a fine up to £5000, and this is to be extended to cover DIYers. Further information on domestic electrical work can be found initially at **www.partp.com.**

Martyn Briggs, Lecturer (Electrotech), Chelmsford College, via email

Circuit Surgeon Alan Winstanley replies:

Your point is taken about the use of cheap non-approved mains testing equipment, and we would always encourage readers to put quality first when choosing such items. There are, however, a number of low cost CE-approved testers available. (We agree, we don't like cheap insulated screwdriver testers either.)

Not only is it against accepted codes of practice to use non-approved electrical equipment, it is also illegal to sell or make available for supply any equipment that is not CE approved and suitably marked. Trading Standards officers are now well equipped to deal with this aspect.

There is still nothing to stop *EPE* readers from making mains-operated plug-in equipment, or making their own tests and checks on domestic wiring, or indeed making minor electrical repairs of their own. It would be a very sad day if it should be deemed illegal for a hobbyist to solder up a transformer and plug it into the mains.

Where necessary, *EPE* dispenses strong warnings to caution readers against making wiring modifications when they do not have competence, and they should consult a qualified electrician where in doubt. Readers have always been left to use their judgment about this and this formula has worked perfectly for 40-odd years.

Alan Winstanley

Electrical Installations

Dear EPE,

As one of the qualified jobsworth electricians mentioned in the letter from George Chatley (Feb '05) I would just like to add my voice to his comments. The Building Regulations have been amended to cover all electrical work carried out in a domestic property. They apply when building work is undertaken and the new *Part P* covers electrical work. These regulations require that:

1. Reasonable provision should be made in the design, installation, inspection and testing of electrical installations.

2. Sufficient information should be provided so that people wishing to operate, maintain or alter electrical equipment can do so with reasonable safety. Any major work carried out will have to be self-certificated by a competent person.

The work covered is major works involving rewiring or anything requiring a new circuit. Minor works like adding an additional light or socket or replacing accessories are not notifiable, but you will need to read the approved document to see what is covered. Any major work carried out which is subject to the provisions of *Part P* will have to be notified to the local authority and would normally have to be inspected by the local building control department.

But, to avoid the need for the building control department to appoint special agents, they will accept certificates of compliance from "Competent Firms", which means appropriately approved electrical contractors are able to certificate the work. Approved contractors have to be registered with an approved body like the NICEIC or ECA (National Inspection Council for Electrical Installation Contracting, and Electrical Contractors Association).

As most house-holders would not have any idea in regard to design or the regulations (BS 7671) which cover all electrical installation work, or even have the relevant test instruments required (which are expensive) for testing, you can see why they could not be called "competent".

Visit the NICEIC web site for further information **www.niceic.org.uk** and click on the *Part P* link. The main implication of this is that failure to comply with the requirement will be a criminal offence and that local authorities will have the power to have the work removed if it does not comply.

Can I just add that I have been reading your mag since the early 70s and have built quite a lot of projects over the years with some actually still in use. Keep up the good work.

Peter Goater, via email

Thank you Peter, that's useful info.

MORE ON REGS

Dear EPE,

Regarding George Chatley's letter, "Shorting-out DIY?", Feb '05, as a Qualified Electrical Engineer and now Practicing Handyman, I feel compelled to calm him, and hopefully enlighten your other readers to the law.

First of all, if you intend to do electrical work in your home, visit the government web site at:

www.odpm.gov.uk/stellent/groups/odpm_buildreg/documents/page/odpm_breg_033480.hcsp

And this next link will show you if you do, or do not need to notify:

www.niceic.org.uk/partp/notification.html

The new rules affect anyone doing electrical work in the home, including DIYers and should be read and understood. Nobody likes being told what to do, least of all me, who has been doing electrical and electronic installations and design and testing for 20 years, but there are always good reasons for changes in building regulations. Practically, the Building Regs have been changed to prevent the home owner from "cowboy" builders.

The rules will not stop you changing a socket or a switch or adding a bit of wire in the attic for your soldering iron. What they will do, however, is help to ensure that if anyone gets killed or injured by your or a cowboy's electrics, they will have some legal tool against you or that person for not following the regulations.

Having said that, I must point out that for any place containing water, i.e. bathroom, kitchen, utility room or outside, there are special requirements, zones and specifications for enclosures and positioning of equipment and cable and earthing. For these areas you are bound to get an electrical contractor, or you must contact your local building control department who will be pleased to advise you on a correct course of action. Visit **www.niceic.org.uk/** before you decide to do anything yourself.

From an electronics point of view, which is what I am interested in at home, there are British Standards for just about everything manufactured, to safe guard the public and users of equipment from injury or death. When I design anything electronic at home I try to make it in a way which would be able to be sold in a shop, especially if another member of my family is going to use it.

We should take the change in the electrical regs as a warning. As electronics enthusiasts we should all try to conform our electronics DIY projects to a reasonable safety and harmonious standard.

Terry Middlebrook, via email

Thank you Terry for your useful comments as well.

Mains Projects Safety

Dear EPE,

I notice in *PIC Electric Mk2* (Feb '05) that you again stress the safety procedures to be followed when building and testing mains powered circuits – this cannot be stated too often. However, we are all fallible and it is all too easy to forget whether the circuit is powered or not as we dive in with our multimeters, scope probes (and fingers!). Even having a low voltage l.e.d. to show the circuit is on assumes that the transformer, rectifier, etc, are working (and that the l.e.d. is the right way round!).

When I build any mains powered circuit I always build in a 230V neon across the mains lead at the first point where it enters the circuit or the enclosure. This ensures that I can tell at a glance if the circuit is live and has saved me from several nasty "belts" over the years. It only costs a few pence and could be a life saver.

Roger Redman, via email

Thanks for that Roger. My own view is that there is nothing to beat the sight of the mains plug's naked pins beside you on the workbench, then you know *it's unplugged! Useful though neons may be, even they can fail.*

Universal NiMH Charger?

Dear EPE,

How about a project for a universal NiMH charger? When I bought my Sony CyberShot digital camera, I got a charger and two Sony 2100mAh NiMH batteries in the box. Soon afterwards, I bought two (non-Sony) 1800mAh NiMH backup batteries. Although the Sony charger could charge them, they only lasted for two to three photo shots. I then bought a charger with four 2300mAh NiMH batteries. The problem with this charger is that it only shows that it is busy charging the batteries, but not when the charge is completed. NiMH batteries should not be overcharged, but with this new charger I have no idea if a set of batteries has been charged.

So now I have enough batteries, but I have to take along two chargers. Could *EPE* present a proper charger project that can charge AA NiMH batteries from, say, 1800mAh to 3200mAh?

Pieter Kruger, Bloemfontein, South Africa

Well readers – are any of you sufficiently expert in battery chargers that you might offer us your own design which would suit Pieter, and other readers too?

Speed Camera Watch

Dear EPE,

I am intrigued by the letter from Robert Talbot, Member of the Institute of Advanced Motorists, in the Feb '05 issue. I drive approximately 50,000 miles a year in the UK with my job and I can tell you not all speed cameras are located to be clearly visible nor are they all now yellow. If you get off the M1 at J24 and take the road out of Kegworth in Leicestershire towards the A6 to Loughborough, you will find a camera on the opposite side of the road on the exit of a sharp blind bend. So they do end up on blind bends.

Also, on the A1 southbound near Grantham, there is a camera a few yards behind a road sign! Were it not for the graduations on the road you would be unlikely to know it was there before you had passed it, especially in the dark and rain. I could go on.

Mr Talbot might have had a point had he referred to the (slight!) distraction that may ensue when using the electronic unit while travelling, but he is incorrect about speed camera practice.

Kevin Bell, via email

Thank you Kevin.

Challenging!

Dear EPE,

I refer to George Chatley's letter in *Readout* Jan '05 and take up arms and rush to John's Becker's defence. Perhaps George is picking just one small part of the whole spectrum of technology and saying you have no ideas in that small part. *EPE*, commendably, does not try to spread itself too thin, so it is easy to pick a part in the overall picture to which you have made no contribution.

To me your innovation is twofold, what I might call, to borrow from PIC terms, direct and indirect innovation. Direct innovation is the articles which are in their own right innovative, and there are plenty of those. Of course, the editorial policy is to maintain reader interest by publishing articles about projects which are do-able. Without reader interest, *EPE* dies and we would all be the losers.

Indirect innovation is what has mostly kept me coming to the table. I learn about PICs, for example, in tutorial type articles, which might or might not be direct innovation in their own right, but which spur me on to do my own innovative stuff, using the tools learnt from *EPE*. The knowledge thereby gained enables me to move quickly up a learning curve to do the things which are my prime interest.

Long live *EPE* and all the best to you for 2005.

John Waller, Plainfield, USA, via email

Thank you John. We too believe that people learn from studying how others tackle problems, even if they don't actually build the published designs.

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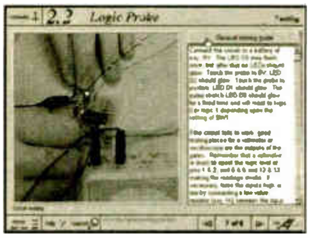
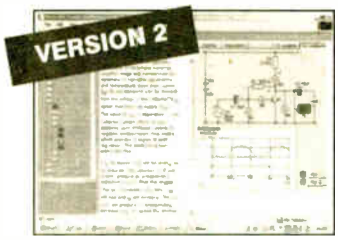


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

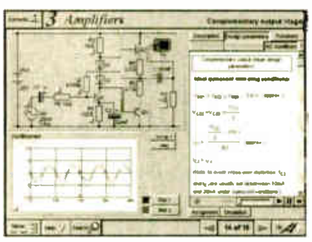
ELECTRONIC CIRCUITS & COMPONENTS V2.0



Circuit simulation screen

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

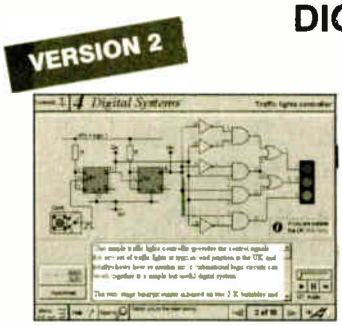
ANALOGUE ELECTRONICS



Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

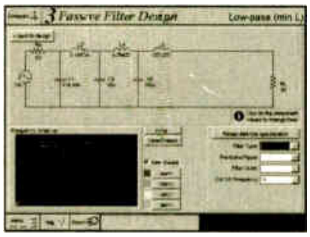
DIGITAL ELECTRONICS V2.0



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

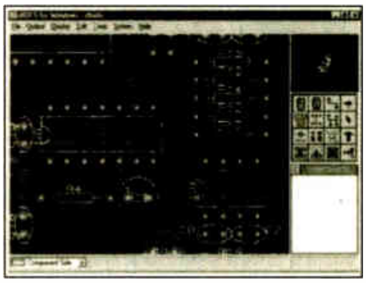
ANALOGUE FILTERS



Filter synthesis

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

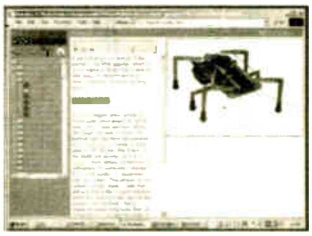
ELECTRONICS CAD PACK



PCB Layout

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

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

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

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	**£45 inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99 *plus* VAT**
Institutional 10 user (Network Licence)	**£249 *plus* VAT**
Site Licence	**£499 *plus* VAT**

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PICmicro TUTORIALS AND PROGRAMMING

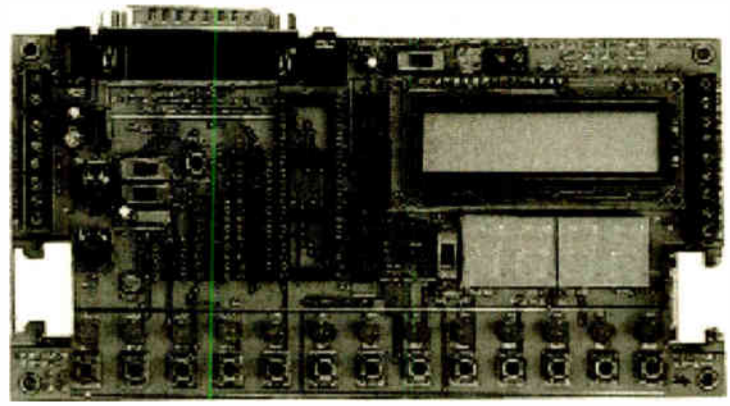
HARDWARE

VERSION 2 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. 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 – 13 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

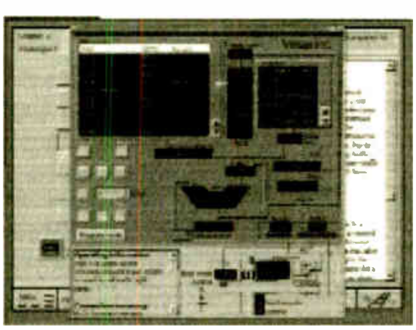
NEW V3

Suitable for use with the Development Board shown above.

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.



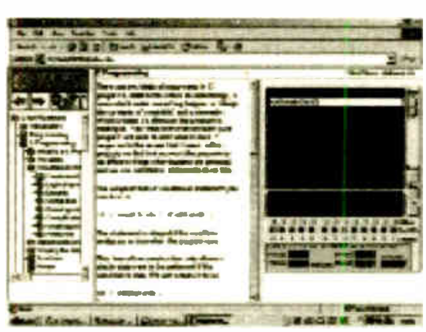
Virtual PICmicro

'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.

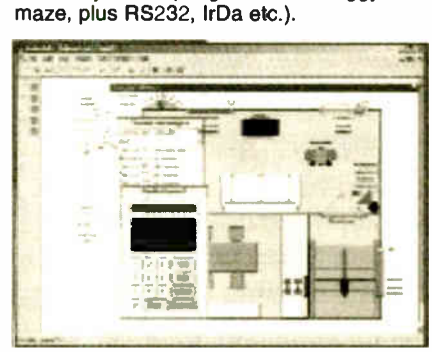
FLOWCODE FOR PICmicro V2

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 l.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:

(Order form on next page)

Hobbyist/Student	£45 inc VAT
Flowcode V2 Hobbyist/Student	£57 inc VAT
Institutional (Schools/HE/FE/Industry)	£99 *plus* VAT
Flowcode Professional	£99 *plus* VAT
Institutional/Professional 10 user (Network Licence)	£300 *plus* VAT
Site Licence	£599 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

THE subject of using a computer and a printer to produce professional looking front panels has been covered in previous *Interface* articles, and elsewhere in *EPE*. It is probably fair to say that the computer approach is by far the best. Whether you need to produce complete panels or individual labels, just about anything is possible with the aid of a PC, a printer, and some cheap graphics software.

Text can be tiny, huge or anywhere in between. Even a standard Windows installation has a wide range of fonts available, with many more available for little or nothing. With an inkjet printer you can even produce designs in full glorious colour.

If you have access to suitable equipment, it is certainly worth trying the computerised approach to producing front panels. However, not everyone has access to a PC and a printer, and some prefer a more hand-crafted method.

What alternative methods are available? The range of options seems to be somewhat reduced compared to a few years ago. This is probably due to the widespread use of computers in the graphic arts industry, and the consequent decline in the manufacture of traditional graphic arts materials.

Direct Approach

In days of yore, the two normal choices were high quality plastic panels made using a simple photographic process, or rub-on transfers applied direct to the front panel. The panel making systems could produce some top quality results that were very hard-wearing, but none of them are produced today. Dry transfers offered a cheaper and simpler solution to neat panels, but they are now increasingly difficult to obtain and expensive.

Many of the lettering sheets that are available from local stationers have quite large letters, at around 5mm to 12mm high. A letter height of around 2·5mm to 4mm is needed for labelling control functions, although a somewhat larger size can be used on larger projects.

Sheets of Letraset are still produced (see **www.letraset.com**), and some fonts are available in smaller sizes. These are professional products, and the letter heights are in point sizes (one point is equal to approximately 0·35mm). A point size of 10 is about right for labelling control functions, but 12 point lettering is also usable. Unfortunately, professional lettering sheets are expensive, although they are quite large and should last for many projects.

Assuming that suitable transfers can be obtained and provided due care is taken, it is possible to produce some quite professional looking results using this method. There is some skill involved though, as each letter has to be positioned very accurately. The smaller the lettering, the more precisely each letter has to be positioned. It is therefore advisable to use the largest text size that will not look out of place. A magnifier on a flexible arm can be very useful when building projects, and it is more than a little useful for an intricate task such as this.

Rub-Down

The transfers must be added before the controls and other components are fitted to the panel, so that there is a flat surface to work on. Ideally the panel should be removed from the case, but this is not possible with most types of case. If the panel cannot be removed, it is best to clamp the case in place so that you at least have a firm surface to work on. With a separate panel it is a good idea to fix it to the worktop using double-sided tape. This will prevent the panel from sliding around while you are trying to work on it.

A problem with rub-on transfers is that they tend to rub off again. Professional transfers are expensive but generally provide much better adhesion. No transfers will stick reliably unless the panel is clean and free from grease. Various cleaning fluids are available for this type of thing, but note that some of these dissolve or discolour some plastics.

It is essential to try any cleaning fluid on the back of a panel first, to check that there are no ill effects. Simply rubbing a panel thoroughly with a piece of kitchen towel should be sufficient unless it is heavily contaminated with grease or dirt.

Some Guidelines

Some transfer systems have guides that are intended to make it easier to get the letters aligned vertically, and some also help with the spacing between letters. These systems are not necessarily that helpful in practice, and when working on a small panel they can be difficult to implement at all.

In most cases it will be necessary to work "by eye", but it can be helpful to mark a horizontal guideline for each row of letters. However, make sure that you use something that does not permanently mark the panel and can be easily removed without damaging the lettering. Using a small piece of insulation tape as a guide is often more practical than using a pen or pencil to mark a line.

Neat results are dependent on getting each word placed accurately. Whatever method you use to label panels, this is something where being mathematical about the task often produces odd-looking results. The best position for each word is the one that looks the best, but where appropriate, make sure that the words in a row are of accurate vertical alignment. Again, a guideline marked on the panel will make this task much easier.

When judging the best position for each word it is more than a little helpful to temporarily place the control knobs on the panel. Remember that with some types of case the edges of the front panel are obscured once it is fitted into the main unit. The lettering must be kept reasonably well clear of any "no-go" areas of this type.

Bear in mind that some letters are wider than others. If a word has six letters it is not safe to assume that the centre line will be half way between the third and fourth letters. In the word "INPUT" for example, the "I" is narrower than the other letters. The centreline is not straight through the middle of the letter "P", but is just to the right of this.

The convention is to use only uppercase letters for labels, as this makes words easier to read, but you are allowed some artistic license. However, using only uppercase letters makes life easier because they are more uniform in width than the lowercase variety.

Fig.1. The Dymo Mini labeller on the left costs less than an electronic labeller such as the unit from Brother on the right, but the difference in cost is less than one might expect.

To the Point

Two common errors when applying dry transfers are to use a tool that has too sharp a point and to press too hard. Only moderate pressure is needed in order to transfer the letters from the backing sheet to the panel, and anything more can distort the letters. Using a tool that is too pointed will also distort the letters. A pencil with the point sandpapered to a well rounded shape will do the job quite well.

Dry transfers are not very hard wearing, and I suppose that this is also true of most other types of lettering. The simplest way of providing a protective covering is to spray the finished panel with a clear lacquer, or alternatively brush on some clear nail polish. Shops that sell art supplies have sprays that are intended for fixing pastel and charcoal drawings, and any of these should work well in this application.

Covering the whole panel with self-adhesive transparent plastic gives the ultimate in hard-wearing panels. Use a piece of plastic that is slightly too large and then trim it down to precisely the right size.

The main problem when using a plastic covering is that it can be difficult to get the plastic to lay perfectly flat at the first attempt. Small air bubbles can be pricked with a pin and pressed flat. Anything more major will require the plastic to be peeled off and a fresh attempt then has to be made. Unfortunately, some of the lettering is likely to come away with the plastic, ruining the panel. The thicker plastic materials give the best results and are easier to use, but they too can be difficult to obtain these days.

Labels

An easier approach to labelling panels is to make an individual adhesive label for each word, and then add them to the panel. With this method it is possible to add the labels once the project has been completed in other respects. In fact this is probably the best time to add them.

One way to make the labels is to use dry transfers on a self-adhesive plastic material. Actually, it is not essential to use plastic, and the material used does not have to be self-adhesive. Any good quality paper can be used provided it is quite thin. Any general purpose adhesive can be used to stick the labels in place, but Scotch Spray Mount is probably the best choice for this type of thing as it allows the labels to be easily repositioned.

By far the easiest way of making labels is to use a label making machine. The simplest type is the Dymo mini labeller, which has been produced in various forms for many years. The labels are produced on 6mm wide strips of self-adhesive plastic, which produces letters of just the right size for adding legends to projects.

The gadget itself costs under a fiver, and the tapes are quite cheap. On the down side, the quality of the labels is not very good. They are produced using a simple embossing system that produces quite crude results. This form of lettering is still better than nothing though. It is probably the best option for those who prefer something simple and straightforward at a "rock bottom" price.

Upmarket

Going slightly upmarket, the cheaper electronic labelling machines are capable of very high quality results. Like the simple Dymo labeller, they produce the labels on ribbons of self-adhesive plastic, but they mainly use a simple thermal printing process that produces very "crisp" results. The ribbons have various widths from about six to 20 millimetres. Some labelling machines only take the larger tapes, and are of little use in the current context. One that will take six or eight millimetre tapes is required.

A basic electronic labelling machine is unlikely to provide a wide range of fonts, but there are usually a few "frills" such as bold text, two-line printing, and the option of adding an outline around the lettering. An electronic labeller that has a Spartan specification should still be capable of producing good quality labels almost instantly.

The labels usually stick very reliably to metal and plastic panels, but this is something of a mixed blessing. Repositioning labels without making them a bit tatty at the edges can be difficult, because it is difficult to tear them away from the panel.

However, if necessary it only takes a few seconds to print out a replacement label. The ribbons are not particularly cheap, but the cost per label is very low since each ribbon should be sufficient to produce dozens or even hundreds of labels.

The difference in cost between a simple labeller and a basic electronic unit is less than one might expect, with some available for under a tenner. On the other hand, the difference in the quality of the results is vast. If you can afford the small additional outlay it is definitely worth buying an electronic labelling machine. You will probably find the labeller useful as a household gadget as well.

As pointed out previously, the tapes for electronic labellers can be quite expensive, so take this into account before buying a labeller that is not supplied complete with one or two suitable tapes. A couple of tapes could easily cost more than the labeller itself.

Stencil

Most stationers still sell stencils, and they are even available from some supermarkets. Together with a pen of the type designed to write on almost anything, a stencil can be used to mark lettering directly onto most plastic and metal panels. Using an ordinary fibre-tip pen and a stencil, it is possible to make paper or card overlays that can be glued to front panels. Marking the panel directly usually produces the most clearly defined lettering, because a plastic or metal panel does not absorb and spread the ink. Spreading of the ink can be a major problem when using some combinations of pen and paper.

Fig.2. The label from the Dymo Mini (top) is not as good as one from an electronic labelling machine (bottom). Results are adequate though, and can be improved if due care is taken when stamping the letters and handling the tapes

A problem with marking directly onto a panel is that the pen usually has a tendency to periodically dry up and stop writing. This is due to the spirit-based inks they use. Minimise this problem by keeping the top of the pen in place except when it is actually being used. On the plus side, the lettering produced using this method is remarkably resilient, and it is far tougher than lettering produced using dry transfers.

On the down side, this makes it difficult to remove a letter if a mistake is made. A solvent that will remove the erroneous letter is also quite likely to dissolve a plastic panel. Correcting mistakes on a card or paper overlay is not possible, so you have to get it right first time.

The biggest problem with stencils is that they are mostly available for lettering of about ten millimetres or more in height. At smaller sizes they become increasingly impractical due to the need for pens having ultra-fine tips.

Using stencils effectively requires a fair amount of skill, since getting the letters positioned accurately first time is far from easy. However, I have seen some very neat results produced using this method.

Fig.3. Using stencils it is possible to add lettering direct to a panel. Small lettering is not a practical proposition though

Special Feature

TK3 Simulator and PIC18F Upgrade

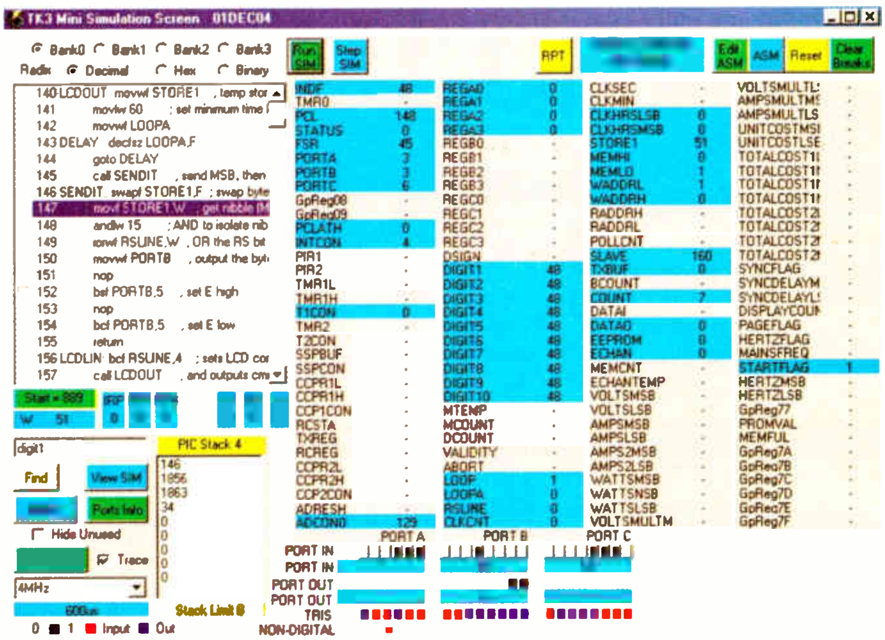
John Becker

Detailing the latest additions to EPE's PIC assembly and programming toolkit

THIS article describes the latest facilities that have been added to the author's *EPE PIC Toolkit TK3* PIC assembly and programming software, now released as version V3.00.

The first addition is a quite sophisticated Mini Simulator through which your own software routines can be put through initial testing procedures, allowing potential bugs to be eliminated prior to downloading the code to a PIC.

The second enhancement is the expansion of the assembly, programming and disassembly routines to allow members of the recently introduced PIC18Fxx2/xx8 family to be handled. These devices have more commands and abilities than the more familiar PIC16Fxx devices, but have significantly different assembly and programming requirements.



Mini Simulator

For some years the author resisted the temptation to write PC software which would allow a PIC's assembly code (ASM) to be tested in advance of sending its associated HEX file to a PIC. The main reason for resisting was that it was felt the writing of such a program would be highly time-consuming and difficult.

However, Richard Hinckley, in his *PIC Breakpoint* article of Oct '03, illustrated a technique for displaying on a PC screen the code values held by PIC registers in a semi-realtime situation. Impressed by the usefulness of this display, the author began wondering if a similar display might be used to show register value changes while the PC did the actual processing of the assembly code, rather than the PIC itself.

One hot day last UK summer, when it was more comfortable to stay indoors, a brief test program was written in which register values were displayed on screen in boxes similarly positioned as in Richard's *Breakpoint*. The results were encouraging, and more readily accomplished than had been anticipated.

So the tests continued, maturing into more specific functions, all related to the full suite of 30+ codes as recognised by a PIC16F device, such as the F84, F628 and F877 etc, which TK3 has long been able to handle.

Eventually, the Simulator reached the point at which many useful programming functions had been added, in addition to the basic step-by-step simulation. At that point, by chance *EPE* reader John Waller, with whom the author regularly email chats about PICs and other matters, expressed an interest in trying the Simulator with the software he was writing. This was for a model train semaphore signals controller he was developing.

There ensued a lively exchange of emailed ideas and Simulator code developments, effectively resulting in the software described below.

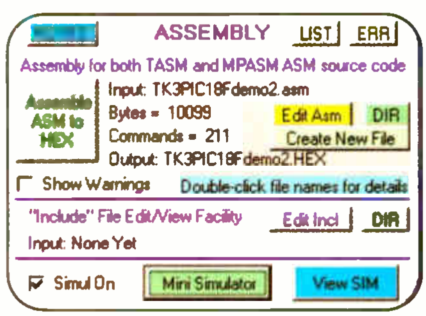
Preparing for Simulation

To use Simulation mode, the assembly (ASM) code that you have written is first assembled (through *TK3*) in the normal way, generating the usual HEX code. In doing so, though, it also generates another file having the same base name, but suffixed with .SIM. To this file are written the ASM commands, along with the HEX code values, and their command count addresses. These values are stored in the file in strict order of the same addresses as the PIC would see them. Also stored to this file are the equated register names and their address numbers.

Consequently, during simulation, all the branches, GOTOs and CALLS are to the same addresses as the PIC would see them, and the registers have the same values written to and read from them as when the PIC is running in real life. The Simulator thus allows a full check to be made of what is occurring as each command is processed.

When assembly has been completed, the actual HEX file is ignored at this time. Instead, the Mini Sim button on *TK3's* main screen is clicked, and the Simulator function is launched. This loads the SIM file, displaying the commands in a List Box, and storing the HEX codes to a memory array.

Simultaneously, any register values and their equated names actively used in the



ASM file are allocated in numerical register order to the main Sim screen area. Here there are 128 zones arranged in columns, numerically ordered from top to bottom, left to right.

The register names are shown to the left of each column, and their current values to their right. Any zone which does not have an allocated register name is allocated a default name, prefixed as GPReg (general purpose register), followed by its address number in hexadecimal (e.g. GPReg4B).

If the PIC in question has registers which are unavailable (e.g. register address 07 is unused in the PIC16F84), the name is shown as n/a (not available). Until register values have actually been set while running the simulation, their value boxes remain empty except for a hyphen symbol.

Bank Blocks

There can be more than 128 registers involved for any PIC, and any whose addresses are greater than 127 (remember that zero is an address in this context) are stored "behind" the screen, in numerical order in temporary storage arrays.

Any group of 128 registers and their values can be called up for display instead of the first 128 registers block by means of the Bank selection buttons at the top left of the screen. The buttons behave "exclusively" so that only one Bank can displayed at a time.

The selected Banks correspond to the allocated Banks for the PIC16Fxx family. Not all of these PICs have four Banks available, in which case, only those available can be selected. The PIC16F84, for instance, has only two Banks, whereas the PIC16F877 has four. Conversely, the 18F family have more than four banks (16 for the 18Fxx2/xx8 devices), and they can be selected in groups via another button when in 18F mode.

Note that when assembling an ASM file, unless it has the PIC type embedded in it (near the top of its code, in the form: LIST = P16F84) you *must* set the PIC type correctly via the usual *TK3* main screen option.

Running a Simulation

Two buttons, Run Sim and Step Sim, on the Sim screen allow the program to be cycled through each command in order, and its associated HEX command value processed accordingly. The numerical results of each command are displayed in the dedicated register boxes as appropriate.

Normally the register boxes are uncoloured, but become coloured (light blue) when they are accessed. This aids good visibility. Additionally, the captions in each box show in red while they are currently accessed, reverting to black when the next register is selected.

In Run mode, the sequence starts at the first command listed (or as selected), and the program automatically processes each command in order as it is encountered, amending values and branching to other segments of the code as instructed, as would a real PIC.

The main difference to a PIC is that you can stop the simulation at any point and examine the current status of the registers. To do this directly with a PIC, Richard's *PIC Breakpoint* program is needed.

The processing speed is also different. When Run mode is started, the program steps through the commands at a rate determined by the Sim program's internal timer interrupt.

When clicked to start running, the Run button's caption changes to Stop and its green colour changes to red. Click the button to stop automatic running.

Run mode is of particular benefit when it is the results of processing one or more code routines that are more significant than the immediate results of each command, as provided by Step Mode.

In Step mode, the process is identical to that in Run mode, except that each click of the Step button simply steps the simulation sequence on by one command, then waiting for the next click before stepping on again. This allows the results of each command to be examined at leisure.

Note that a particular line in the program is executed as soon as the simulation steps into it. For example, if you are simulating a timing loop, and you want to check a particular action occurs correctly when TMR2H reaches a particular value, then that value must be set into TMR2H *before* stepping into the line where TMR2H is read.

Selective Simulation

In either Run or Step mode, the starting point for the simulation can be set at any command. Alongside the Listed commands are small tick-boxes. To select any command as the start point, left-click on the selected command's box, then right-click at the same point. This action stores the starting point to memory, and is also confirmed in the small green box below the List screen. Clicking Run or Step now causes the simulation to start at that point.

Run mode can be terminated at any point beyond the start point (or even before it if commands there are branched to from a command further down the list). To select a stop (break) point, left-click on the required box, but do not right-click it.

When Run commences at the start point, the sequence of commands is processed until the break point is reached. Run mode then terminates and reverts to Step mode.

To repeat the simulation sequence from the designated start point, click the RPT button.

The start point can be changed in the same way as it was set. You may have several break points set simultaneously, each set by left-clicking on its tick box. When Run mode is again clicked following a break, the sequence then continues until the next break is reached, and so on. The break points only have significance for Run mode – in Step mode, each command is processed as an individual action.

Break points can be deleted by left-clicking on the ticked box. The tick changes state on an alternating cycle. It is important to note that it is the *box* which must be clicked, not the line itself. The latter *may* appear to work sometimes, but the tick behaviour can be erratic (a VB6 problem). Do not double-click a box.

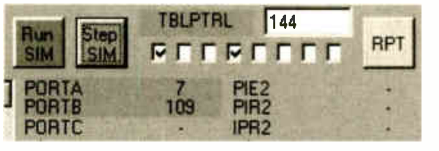
All start and break points can be cancelled by clicking on the Clear Breaks button.

Neither the RPT nor the Clear Breaks button affect the register values. To clear the registers back to zero (null) values, click the Reset button. This also resets the register box colours to neutral grey. Note that break points are unaffected by Reset.

By default, the register values are displayed in decimal. They can, though, be displayed in any radix, decimal, hexadecimal or binary. Three buttons below the Bank buttons select the radix mode.

Changing Register Values

Any displayed register can have its value changed manually when in Step mode. To do so, click on the register, at which a selection of other boxes appears at the top of the screen. The screen then displays the register name, its value in decimal in a text box, and as a binary value in eight tick boxes. Clicking any tick box changes its logic state and the resulting new byte is shown in the text box. Alternatively, you may change the text box value by keying in a new value, from 0 to 255. Values must be in decimal.



Clicking the register name to the left of the text box (or pressing Enter) causes the new value to be stored back to the selected register. At this point the Change option closes and is removed from screen. Clicking Run or Step also performs the same action.

Flag Bits

In addition to register values being displayed, so too are the Status register flag bits in their own boxes, below the List screen. The flags displayed are for the C, DC and Z bits (plus IRP, RP1, RP0 for non-18F devices, plus N and OV for 18F), with their status shown in binary (1 or 0).

These bits can be changed manually by clicking on them, causing them to alternate between states. The displayed value of these bits is responded to when the simulation is running.

W Register

The W register value has been allocated its own box, to the left of the Status flag bits. This is constantly updated while the simulation is in progress. It too may be changed manually, in the same way as for the other registers.

Tooltip Texts

Visual Basic 6 (VB6), in which this program has been written, allows "Tooltip Text Boxes" to be allocated. These are normally allocated with text at the time that the program is written. However, they can be given texts while the program is running and advantage of this has been taken. If you hover the mouse cursor over any register value box, that value will be displayed in a yellow box in decimal, hex and binary, irrespective of the radix mode selected.

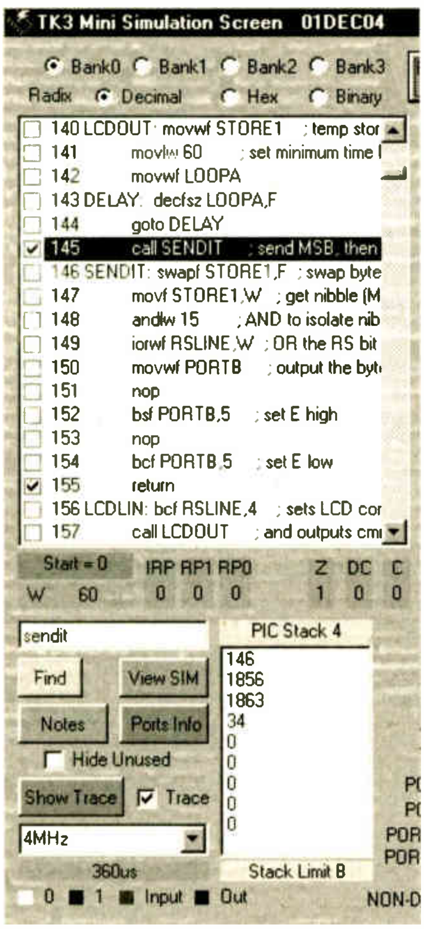
Hovering the mouse over any register name will cause that register's address to be displayed in hex. Hovering it over the flag boxes causes the full value within the Status register to be displayed in all three radix forms. Hovering it over the W box shows that value in all three radix modes.

Many other on-screen function buttons have Tooltip Texts, displaying a brief description of what that button does.

Furthermore, hovering the mouse over the List screen commands causes the full text of that line to be shown (within the length limits imposed by VB6); useful on the List screen when long command lines are truncated.

Word Find

A Find command button has been provided below the List screen. Above the button is a text box. Key in any word (or phrase) which might occur in the commands listed, click Find (or press Enter) and the routine will find it for you if it exists, highlighting the line in which it occurs. If it is not found, a message display will tell you so. Further clicking of Find will display other occurrences of the word until the end of the list is reached. Re-clicking Find will then start the search from the top.



PIC Stack

PICs have a Stack register which keeps track of return addresses when CALL commands are actioned. In the PIC16F family, this register cannot be read from or written to directly. It has a limit of eight addresses and can be inadvertently overwritten if this count is exceeded in a complex program having nested sub-calls. Such overwriting invariably causes a major program crash.

The Simulator keeps track of the Stack status and displays it in a separate list box a little below the command list box. The values shown are the addresses, in reverse calling order (last in, first out) and in decimal, to which the program jumps when a RETURN or RETLW command is performed. The values are one greater than the address from which the CALL was made.

When a return is made, the return address is "popped" from the stack, and return addresses below it are rippled back up the stack. This is a particularly useful facility as complex programs can generate many "nested" calls and unwary program writers can cause the stack to overflow, with the eighth address being lost, and consequent mayhem in the program!

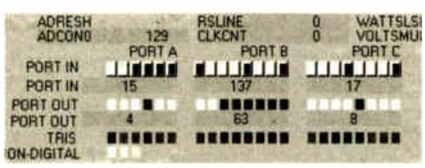
Ports

The Ports are different to other registers in that they are effectively two registers, one for data output to the world, the other for input from it, as determined by the setting of their TRIS (data direction) registers.

The basic function of a PIC16F Port pin is illustrated in the schematic drawing shown when the Ports Info button is clicked. Microchip state that: "Reading a port register reads the status of the pin, whereas writing to it will write to the port latch. All write operations are read-modify-write operations, so a write to a port implies that the port pins are first read, then this value is modified and written to the port data latch."

At the bottom of the screen, the PORT IN buttons in the first line represent the data logic levels available to be input when the relevant TRIS bit is set for input, alternating between High and Low logic when clicked, black or white respectively. In some respects they can be regarded as external switches connected to the pins. The blue boxes below them show the equivalent numerical value of the input logic bits.

The small PORT OUT boxes represent



the logic levels available to be output to the world from the data latch. The value is that determined by reads from the input pins and that set by data writes to a port (re-read Microchip's statement if this is not immediately clear). The data actually output is modified by whether relevant TRIS pins are set for input or output. The blue PORT OUT boxes show the equivalent numerical value of the data latch contents. On the main body of the screen, the register boxes for the Ports show the same data latch value.

The second-from-bottom line of boxes shows the TRIS bits, red for input mode, and blue for output mode.

With some PICs, pins can be selected for analogue or digital mode, as set by CMCON in an F628 for instance. For this to work, of course, the PIC type and configuration value must be included in the ASM file in the conventional manner (see discussion of 18F demo program later). When a simulation for such PICs is being run, an additional line of boxes at the bottom shows the analogue/digital status.

Missing Labels

Any Labels written into an ASM file are only repeated in the SIM file if they have a command associated with them. The SIM file is created at the same time as the HEX file and records only those statements for which a code value and address are given. Any line without such is ignored.

The SIM screen list box is arranged in strict numerical order of addresses as the PIC would see them and any additional lines would throw the program count correctness and Calls/Gotos/Returns etc would not be implemented properly. The only way round this is for you to add NOP at any label without a command where the label needs to be shown in the SIM list.

Command Timings

Each command actioned takes one or two PIC cycles (as listed in the data sheet), which occur at one quarter of the PIC's clock (e.g. crystal) rate. The simulator keeps track of the command cycles and displays them at the bottom left of the screen. By default they are in relation to a 4MHz crystal rate (1 cycle = 1 microsecond).

You may change this rate via the Combo box above the cycle counter display. The choices are 32768Hz, 3.2768MHz, 4MHz, 10MHz, 20MHz. No provision has been made to add to the choices. Click on the box's arrow and select from the list displayed. The choice is not stored for future recall when next the program is run, reverting to 4MHz.

Hide Unused

Normally, the screen displays all registers associated with a PIC Bank. You may "hide" unused registers by clicking on the Hide Unused tick box at the bottom left. Re-click to re-display them all.

Edit and Assembly Buttons

The Edit button calls up the same Edit facility as accessed via *TK3's* main screen, allowing the ASM code to be modified. Exiting the Edit function returns you to the Sim screen, where an ASM button is now shown. Click it to start code assembly in the normal way.

On completion of the assembly, that sub-screen offers the same options as usual, plus the option to re-enter the Simulation screen. (It has proved impossible to offer an automatic assembly entry from the Simulation screen following exit from Edit – as is provided via the main screen's function using the Enter key.) The Edit and Assembly buttons are hidden during automatic simulation (Run) mode.

Trace Button

The Trace tick box allows you to make a record of the commands actioned while in automatic Run mode. On starting the run, a file is opened (TK3Trace.txt) and each command actioned has its code line output to the text file, along with its address value. On stopping auto-run, the file is closed and can then be examined via the Show Trace button.

The recording always starts from the current line selected. The recording facility is not available when single-stepping a program, or when the Trace box is unticked. The record is always overwritten when a new run is started.

Simulation Inhibit

The simulation facility can be inhibited via the main screen. To the left of the Mini

Sim button is a tick box. Click the box to hide the tick, this also hides the Mini Sim button. Re-click the tick box to reactivate the option.

The benefit of turning off the Simul option is that it prevents .SIM files being created during the assembly process. If you are changing the ASM file name for each new version of that code (as is recommended, by using a suffix number for example), your disk drive could become "well-populated" by SIM files that you do not need. This inhibit option prevents SIM files from being created when you do not want them.

Simulating HEX Files

If you only have a HEX file for a particular program and wish to simulate it, first convert the HEX file to an ASM file via *TK3's* Hex Disassembly option. Then assemble the resulting ASM file to create the required SIM file). Remember that you must set the PIC Type for the PIC being disassembled.

Sim File Examination

The Sim file may be examined via the main screen or sim screen View Sim buttons. This is for information only and has no practical purpose.

Limitations

This mini simulator does not attempt to match the facilities of more sophisticated commercial simulators. It basically shows the behaviour of the commands in a program and the effects that they have upon the registers accessed. The following are not supported:

Interrupts
Access to Data Eeprom
PortB pullups
Sleep
Analogue inputs and other special I/O functions (e.g. RS232)
Timers, including WatchDog, with the exception that a mock creation of a TMR0 rollover is generated in response to the simulator's own internal timer

The program has a limit of 8000 PIC commands, 512 registers (4 Banks) for non-18F devices, and 4096 registers (16 Banks) for 18Fs.

All code changes must be made through the normal Edit/Assemble functions, they cannot be changed from within the simulator screen.

Whilst the simulator was originally designed for the PIC16F family, most aspects should also function with the 12F and 18F families. However, with the 18F family facilities, there are several other limitations, some known, others yet to be discovered.

Of the known 18F limitations (in addition to the 16F ones), table read and write commands (TBLRD, TBLWT) cannot (as yet) be processed correctly.

As a final comment on the simulator, it was originally written with the expectation that it would be used to check short code routines before implementing them into a larger program. Although it has been proved that some longer programs can be simulated, it is not guaranteed that all can be. If you wish to make helpful suggestions about improving this simulator, contact the author as stated later.

TK3 MPASM Link

Since early versions of *TK3*, an on-screen link to Microchip's MPASM assembler has been provided for those who have MPASM installed. This has been slightly upgraded in that *TK3* and MPASM can now exchange file names via two click-buttons. Using these buttons, any file name selected through *TK3* can be placed in MPASM's assembly program (via its .INI file, line 2), and vice versa.

Should you ever find that *TK3's* assembler cannot perform a less common function, but which is available through MPASM, don't hesitate to assemble your ASM code through MPASM. The HEX file created through MPASM is totally compatible with *TK3* and can be programmed into the PIC through *TK3* (provided *TK3* can handle the PIC type involved).

Similarly, any HEX file generated by *TK3* is believed to be totally compatible with any programmer designed for use with MPASM-type files. This is not necessarily true of ASM files created through *TK3*. *TK3* recognises a number of command structures (as used with the TASM dialect) which MPASM does not. Such differences are explained in the Notes files readable through *TK3*. To translate an ASM file having these different command structures to suit MPASM's requirements, use *TK3's* Conversion facility.

Disassembly Functions

TK3's Disassembly functions have also been enhanced with V3.00. These now allow a greater variety of methods through which PIC contents and HEX files can be examined and translated to "English".

PIC18Fxxx Family Facilities

FOLLOWING determined persuasion by a number of readers, in the summer of 2004 the author embarked upon the task of upgrading *TK3* to handle the fairly recently introduced PIC18Fxxx family. These have a host of extra facilities not offered by the more familiar 16F8x, 16F87x and 16F62x families. Malcolm Wiles will be formally introducing the 18F family to you next month.

In terms of *TK3*, the upgrade requirements were to add recognition of the extra commands, and to amend the programming algorithm to 16-bit instead of 14-bit. At first sight this appeared to be a straight-forward though lengthy upgrade.

Restructuring *TK3* to handle 18F commands as well as the existing 16F and 12F commands proceeded fairly readily, although it was soon recognised that splitting the Assembly routine into two separate functions would be preferable, avoiding many "IF 18F THEN ... ELSE ...END IF" statements.

By September, that split with all its implications and accessory routine procedure amendments had been finalised. Time to amend the Programming to send 16-bit as well as 14-bit hex values. Fortunately, it seemed, Microchip's datasheet had provided examples of the programming structures needed to send and read back 16-bit words to/from 18F devices. These were followed and tested.

Disaster – they did not work, or if they did they were unreliable in their repeatability. Browsing Microchip's data in all directions did not reveal solutions, but it did reveal documentation anomalies and ambiguities. Microchip's technical department were of no help, simply sending an automated reply to a querying email telling the author to browse their web site for information; which had already been done anyway, to no avail.

Battle Lines

By mid-October, the author recognised that this was a battle he might not win (not often that happens!). However, Malcolm Wiles, professional programmer and knowledgeable in the C language and its derivatives, provided the author with his C++ routines which *did* successfully program 18Fs.

Analysing Malc's commands clarified the Microchip ambiguities (although Malc too had earlier had trouble interpreting their published data in several areas). It also revealed a previously unknown problem with VB6, the software in which *TK3* is written. Any value written in hexadecimal form representing a two-byte decimal value of 32K or greater is translated by VB6 to a *negative* value comprising three bytes.

Many of the formatting commands required in the PIC programming routines are expressed in Microchip's documentation as hex values from 0000 to in excess of 7FFF (32767 decimal), well beyond VB6's "negative" boundary. Consequently, *TK3's* software, which sends decimal values in serial bit streams to the PIC, was sending the wrong format commands. Malc's software helped reveal this problem (C++ does not suffer the same value problem), as well as clarifying Microchip's requirements.

TK3 18F programming success was achieved in mid November! This included sending programming commands, configuration values and EEPROM data, and reading back data from all locations.

Following extensive bench and field testing, *TK3* with 18F facilities was released to the world in Jan '05 as V3.00! However, the current version should be treated as a "beta" version still under field trials. If you spot anything which is not as it should be, please tell the author via *EPE*.

This request particular applies to the 18F simulation which has had less opportunity to be tested "for real".

PIC18F Differences

As Malcolm will explain next month, there are several differences between 18F and 16F devices in the way in which code must be written.

Also be aware that MPASM (as at V3.50) no longer recognises the following shorthand commands when assembly 18F code:

CLRC, CLRDC, CLRZ, SETC, SETDC, SETZ, SKPC, SKPDC, SKPZ, SKPNC, SKPNDC, SKPNZ.

If you wish to use these valuable commands with MPASM, they must be defined at the head of your program. *TK3* continues to recognise them for all PIC types.

Example PIC18F Program

The program extracts in Listing 1 to 9 show examples of some 18F programming routines which you should find useful. They illustrate how an alphanumeric l.c.d. can be controlled by an 18F, and how this PIC's data EEPROM can be written to and read from. There are some other aspects which are also worth highlighting, including the use of FSR and INDF.

The demo is simply aimed at getting you started with 18Fs. The author finds the use of an l.c.d. is vital when debugging a program (irrespective of simulations) and so seems an essential first facility you might also need when writing for 18F. Similarly regarding EEPROM use, which is a facility the author often uses (partly as a debugging aid), so again seems an elementary tool to which you should have immediate access.

The full demo program from which these extracts have been taken is supplied with *TK3* Version V3.00 as file TK3PIC18FDEMO2.asm.

Listing 1

```
List P = PIC18F252, R=DEC;

include P18F252.inc


        __config H'300000', H'00'
        __config H'300001', H'22'
        __config H'300002', H'08'
        __config H'300003', H'00'
        __config H'300004', H'00'
        __config H'300005', H'00'
        __config H'300006', H'80'
        __config H'300007', H'00'
        __config H'300008', H'0F'
        __config H'300009', H'C0'
        __config H'30000A', H'0F'
        __config H'30000B', H'E0'
        __config H'30000C', H'0F'
        __config H'30000D', H'40'

A       equ 0

        CBLOCK
LOOP
LOOPA
CLKCNT
STORE
STORE
RSLINE
TEST
TEST2
TEST3
TEST4
        ENDC
```

List P Directive

Some of you may not be familiar with the List P directive as in Listing 1 line 1, **List P = PIC18F252 R=DEC**. This instructs the assembly program that the code which it is about to assemble is for a PIC18F252. Any PIC program can have a similar statement made at this point, detailing the intended PIC type. The assembler, whether *TK3* or MPASM etc, will then know which procedures it is to follow in order to correctly assemble the program for that PIC.

The directive **R=DEC** simply tells the assembler that any value encountered which does not have a prefix of, say, H', B', $, %, etc, is to be taken as a decimal value. It is worth noting that the author has never needed a radix other than decimal, and the statement can just be copied as shown for your own programs (or even omitted).

Include Directive

Line 2 has the statement **include P18F252.inc**. This tells the assembler it is to use the register equates values given in the Microchip "include" file for the same PIC type. This saves you having to key in your own list of the required special function registers (SFRs) and their allocated addresses (e.g. PORTB EQU xx, etc).

The "include" file name is prefixed by "P", followed by the PIC type. MPASM "include" (.INC) files for the entire PIC range can be downloaded from Microchip's website. They are also included with Microchip software such as MPLAB and MPASM. A selection of those for the PICs which *TK3* recognises are included with *TK3's* software.

Configuration

Next follow 14 configuration statements. The 18F family have more complex configuration arrangements than, for example, the 16F family with which you will be familiar. *TK3* has been given a dedicated config screen through which 18F config values are established. You click on the required functions you wish to set or reset, either through their allocated boxes, or via the List sub-screen and its tick boxes.

Having made your selection, click on the Copy Output button. This copies all 14 config values to the Windows clipboard. You then open the ASM text file for the program being developed and paste the values into it, which are correctly formatted in the style shown in Listing 1.

When the program is assembled, the config values are placed into the HEX file and automatically programmed into the PIC when the HEX code is sent to it. The config screen also allows you to readback config values from the PIC, and to send the values directly to the PIC, although there is rarely any need for the latter to be done separately.

It is stressed that you *must* have the 18F family datasheet in order to fully understand the functions of the config options.

Erasure and Code Protection

It is worth commenting that the program and data EEPROM contents of a PIC18F are automatically erased when the PIC is reprogrammed. Simultaneously, the config values are reset to their defaults, and all code protection values are cleared. Config can be written to or read from regardless of any code protection which may be on.

Access and Banked

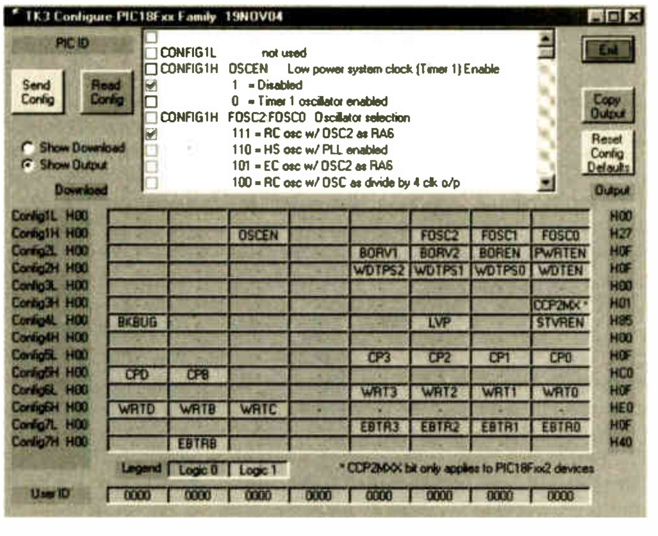
As Malcolm explains next month, PIC18F devices have Access and Banked addresses. Their function is somewhat analogous to using the BANK0/BANK1 (PAGE0/PAGE1) directives of the 16F family, but more subtle. Any command which causes a PIC register to be written to or read from should indicate whether that register is in the Access or Banked bank. This is done through *TK3* by the use of "A" or "B" as part of the command (MPASM also allows the use of the suffix ACCESS or BANKED, but *TK3* does not).

Normally you will only work with registers in the Access bank and so letter "A" will be the suffix, as is shown throughout Listing 1. If you omit to add the suffix, *TK3* will remind you, but assemble as though "A" had been used.

A full list of the 18F commands recognised by *TK3* can be read via the Show PIC Codes button at the bottom right of the main screen. The codes also show which suffixes are needed with each command, e.g. ADDWF requires f,d,a, in other words, it needs the file name, destination F or W, and the Access bit (A or B).

CBLOCK Directive

Recognition of the CBLOCK/ENDC directives is a fairly recent addition to *TK3*.



This is an MPASM structure which allows you to allocate your own named registers without giving them specific EQU XX values. The register names you want are simply listed following the CBLOCK statement. The list is terminated by the ENDC directive.

During assembly, each resister is given a consecutive address starting from the value given as part of the

CBLOCK statement. In the case of Listing 1, there is no value given, and the value is taken as zero (18F registers can start from 0, unlike 16F registers which typically start at H'0C' or H'20' depending on PIC type). For non-18F PICs, *TK3* allocates the relevant number even if it is omitted – unlike MPASM, which always treats an unspecified CBLOCK value as 0.

ORG and TRISx

As with other PIC families, the assembler/programmer must be told the PIC memory location (address) from which it must start to place the commands. With 18Fs, the first available working location is after the Interrupt location at H'18'. See the datasheet for details of the locations up to H'18'. *Do not* specify location 5 as the starting address for 18Fs, which is what you would probably do with 16F devices.

Unlike 16Fs, 18Fs do not require the use of BANK1/BANK0 directives when setting the TRISx values. They are simply set as shown in Listing 2 at the label START.

Listing 2

```
            org     0
            goto    START
            org     0008h
            retfie
            org     0018h
            retfie

START       clrf PORTA,A
            clrf PORTB,A
            clrf TRISA,A
            clrf TRISB,A
            movlw B'11000110'
            movwf T0CON,A
```

Timer 0

Timer 0 with the 18Fs is set similarly to the same timer in 16Fs, except that register T0CON is the one used to set the timer's prescaler ratio. The value shown in Listing 2 (B'11000110') sets the timer prescaler to 1:64.

PCL Counter and Tables

Accessing Tables though the PCL program counter (as required for 16F devices) is not needed with the 18F family. Instead, tabled values are read through the setting of table pointers and versatile TBLRD commands, and there is no limit to the length of tables. Examples of 18F table access are shown in Listings 3 to 5, where the tables are at labels TABLCD, MESSAG and MESSAG2. Malcolm will explain table use more fully next month. Apart from this change to any table use, alphanumeric l.c.d.s are controlled in same way as for other PICs.

It is still possible to use PCL for tables, but a crucial point to note is that 18F PCL behaves differently to 16F PCL. This difference requires a change to any loop which calls PCL-governed tables, in that the loop counter must be *doubly* incremented following each call to the table. If it were to be only singly incremented (in the more familiar manner) each line in the table would be accessed twice.

Double incrementing for PCL-accessed tables is essential in order to access each line both consecutively and incrementally. The loop count thus has to be twice the length you might normally expect, i.e. for an 8-line table access, a loop of 16 counts must be set. The knock-on effect is that tables are limited to 128 lines instead of the normal 256.

Malcolm stresses that it is preferable not to use PCL for 18F table access.

In Listing 3, the l.c.d is initialised to 2-line 4-bit mode, then a tabled 8-character message (MESSAG) is sent to l.c.d screen line 1. The routine is written to suit the standard l.c.d pinout order on *TK3*'s p.c.b.

Listing 3

```
LCDSET
        clrf    RSLINE
        movlw   UPPER TABLCD
        movwf   TBLPTRU,A
        movlw   HIGH TABLCD
        movwf   TBLPTRH,A
        movlw   LOW TABLCD
        movwf   TBLPTRL,A
        movlw   8
        movwf   LOOP,A

LCDST2
        tblrd*+
        movf    TABLAT,W,A
        rcall   LCDOUT
        decfsz  LOOP,F,A
        bra     LCDST2
        call    PAUSIT
```

Data EEPROM Writing

Next, for the sake of demonstration, values in the third table (MESSAG2) are sent for storage in the PIC's data EEPROM as in Listing 5. This is a subject which gave the author much grief many years back when he began investigating PIC16C devices, Microchip's datasheet then being erroneous.

The 18F datasheet in this respect is not totally explicit either, and a certain amount of experimentation had to be done before writing to the data EEPROM was successful. Reading from it was straightforward. But with both routines, knowledge gained from other PICs was invaluable for getting the 18F to function correctly.

When writing to the EEPROM, the value to be written is first placed in a temporary register (STORE, or other name of your choosing), the address at which the value is to be stored in the EEPROM is then loaded into W, and the SETPRM routine called. A somewhat "black-art" set of commands follows, which should be copied parrot-fashion into your own programs. All you need to concern yourself with is the loading of STORE and W. See Listing 6.

Listing 4

```
            ;LCD initialisation table

TABLCD      db B'00110011', B'00110011'
            db B'00110010', B'00101100'
            db B'00000110', B'00001100'
            db B'00000001', B'00000010'

            ; end initialisation table

MESSAG      db 'R', 'E', 'A', 'D', ' ', 'E', 'P', 'E'

MESSAG2     db 'H', 'I', 'J', 'K', 'L', 'M', 'N', 'O'

            org     H'F00000'
            de ' ','A','B','C','D','E','F','G','H','I'
            end
```

Listing 5

```
PRMMSG
        movlw   UPPER MESSAG2
        movwf   TBLPTRU,A
        movlw   HIGH MESSAG2
        movwf   TBLPTRH,A
        movlw   LOW MESSAG2
        movwf   TBLPTRL,A
        bsf     RSLINE,4,A
        movlw   8
        movwf   LOOP,A
        movwf   LOOPA,A

PRMMS2
        tblrd*+
        movff   TABLAT, STORE1
        movf    LOOPA,W,A
        rcall   SETPRM
                LOOPA,F,A
        decfsz  LOOP,F,A
        bra     PRMMS2
```

Listing 6

```
SETPRM      movwf EEADR,A
            movf STORE1,W,A
            movwf EEDATA,A
            bcf EECON1,EEPGD,A
            bcf EECON1,CFGS,A
            bsf EECON1,WREN,A
            bcf INTCON,GIE,A
            movlw H'55'
            movwf EECON2,A
            movlw H'AA'
            movwf EECON2,A
            bsf EECON1,WR,A

CHKWRT      btfss PIR2,EEIF,A
            goto CHKWRT
            bcf EECON1,WREN,A
            bcf PIR2,EEIF,A
            bcf EECON1,WREN,A
            return
```

Data EEPROM Reading

When reading the EEPROM, simply load W with the EEPROM address from which to read the data, then call GETPRM. See Listings 7 and 8. The routine is exited with W holding the value from the specified location. Again, copy the routine as it is into your own program.

Having placed eight extra values into the EEPROM (at its locations 8 to 15) in Listing 5, the first eight values (at locations 0 to 7 – set there as discussed next) are read back in Listing 7 and displayed at the right of screen line 1. The

Listing 7

```
            clrf LOOP,A
GETEEPROM   movf LOOP,W,A
            call GETPRM
            call LCDOUT
            incf LOOP,F,A
            btfss LOOP,3,A
            goto GETEEPROM
            call LCD21
            movlw 8
            movwf LOOP,A

GETEEPROM2  movf LOOP,W,A
            call GETPRM
            call LCDOUT
            incf LOOP,F,A
            btfss LOOP,4,A
            goto GETEEPROM2
            movlw ' '
            call LCDOUT
```

Listing 8

```
GETPRM      movwf EEADR,
            bcf EECON1,EEPGD,A
            bcf EECON1,CFGS,A
            bsf EECON1,RD,A
            movf EEDATA,W,A
            return
```

new EEPROM values are read and displayed on screen line 2.

Note in the full program the way in which the screen line is selected (call LCD21). It is suggested that you experiment with the table messages (but don't amend TABLCD), and those DB and DE-prefixed values at the end of Listing 4.

Embedded Data EEPROM Values

The DE-prefixed values at the end of Listing 4 are the values which the assembler loads into the HEX file for subsequent automatic placing into the PIC's data EEPROM, at locations 0 to 7 in this case. You will see the ORG value of H'F00000' – a very large value for a PIC you might think. Fortunately, it is not an address value as such, but merely a value which the assembler knows means that subsequent values are for the EEPROM.

Be aware that MPASM treats pairs of values in a DE line as a single value compacted into one word (two bytes), and individual DE values also as two bytes but with the second having a value of zero. *TK3* treats all data values as two bytes with the second as zero, and when reading the EEPROM this zero value is "unseen".

TK3 may have this function changed in a future version as it consumes more EEPROM than desirable.

FSR and INDF

The use of indirect addressing through FSR and INDF is also different with 18F devices. Practical examples are shown in Listing 9. For an understanding of the logic behind the commands, it essential to read the 18F datasheet, noting that there are several indirect addressing registers in addition (but similar) to those in the examples.

Listing 9

```
movlw 5                 ; load 4 consecutive registers
movwf TEST
movlw 6
movwf TEST2
movlw 4
movwf TEST3
movlw 8
movwf TEST4             ; this reg not accessed by routine below
lfsr FSR1,TEST          ; load FSR1 with address of 1st reg (TEST)
movf POSTINC1,W         ; read 1st reg and inc FSR counter
iorlw 48
call LCDOUT             ; show REG contents as decimal
movf POSTINC1,W         ; read 2nd reg and inc FSR counter
iorlw 48
call LCDOUT             ; show REG contents as decimal
movf INDF1,W            ; read 3rd reg but don't inc FSR counter
iorlw 48
call LCDOUT             ; show REG contents as decimal
movf POSTDEC1,W         ; read 3rd reg again and decrement FSR counter
iorlw 48
call LCDOUT             ; show REG contents as decimal
movf INDF1,W            ; read 2nd reg but don't dec/inc FSR counter
iorlw 48
call LCDOUT             ; show 2nd REG contents as decima
```

Obtaining TK3 V3.00

The software for TK3 V3.00, which includes the Simulation, 18F facilities and the demonstration program (TK3PIC18FDEMO2.ASM), is available via the *EPE* web site at **www.epemag.co.uk**. Click the usual Downloads button on the home page, and then access the PIC Microcontrollers path and select folder *Toolkit TK3*. Download all files within that folder into a new folder on your PC, under whatever name you choose. It is suggested that you do not delete the earlier *TK3* folder, just rename it.

Note that what used to be sub-folders named Disk 1 and Disk 3 have now been combined into one folder named Disk1-3. This holds the standalone (**Toolkit3.exe**) file, all the associated text files etc, and the *TK3* VB6 source code. The original Disk 3 held only the source code and is no longer required on its own (or available).

If you have not downloaded *TK3* before and do not have VB6 installed on your PC, you *must* use the files in folder Disk 2. These are Microsoft "runtime" files required for use with the standalone **Toolkit3.exe**.

Where files are zipped, unzip them all into the same folder holding the rest of *TK3's* files. Winzip is the suggested unzip facility, and should be part of any PC's software. If you do not have it installed, it may be download free from **www.winzip.com**.

Unless you are already familiar with PIC18F devices, wait until you've read Malc's introduction to them next month before putting them to use. There are certain other critical differences which you need to appreciate. You should also obtain the Microchip datasheet (DS39564) for the 18Fxx2/xx8 devices, from **www.microchip.com**. It is over 300 pages, but is essential to understanding the devices.

Acknowledgements

The author wishes to thank John Waller for the active field testing he did over several weeks with the Simulator and a PIC16F62x program he was working on, making many invaluable suggestions which were then implemented. John's project for a model railway signal control will be published in a few months time.

Malcolm Wiles is also warmly thanked for his invaluable help with getting *TK3* to program 18F PICs and for clarifying 18F table use. In places Microchip's documentation is less than clear and Malc clarified a number of points which, for some time, presented the author with seemingly insurmountable hurdles. Malc is currently offering advice on further improvements in respect of 18F devices. Updated *TK3* software embodying Malc's suggestions will be released when appropriate.

Malc's *Introduction to the PIC18F Family* will be published next month, in the April '05 issue.

Several other readers, too numerous to mention individually, have also assisted in various ways in the upgrade to *TK3 V3.00*. Very many thanks for your help too!

Don't forget that *TK3* now embodies Richard Hinckley's *PIC Breakpoint*, and several contributions by Andrew Jarvis to add more PIC types and associated software tools to *TK3's* repertoire. And Ian Stedman has contributed a *TK3* FAQ file which is in the *TK3* folder on the Downloads site. Joe Farr is currently developing a *TK3* interface for Proton+ Software. Thanks guys!

Practical example projects using 18F devices are in the pipeline.

If you wish to provide the author with feedback about *TK3*, you can do so via his *EPE* email address:

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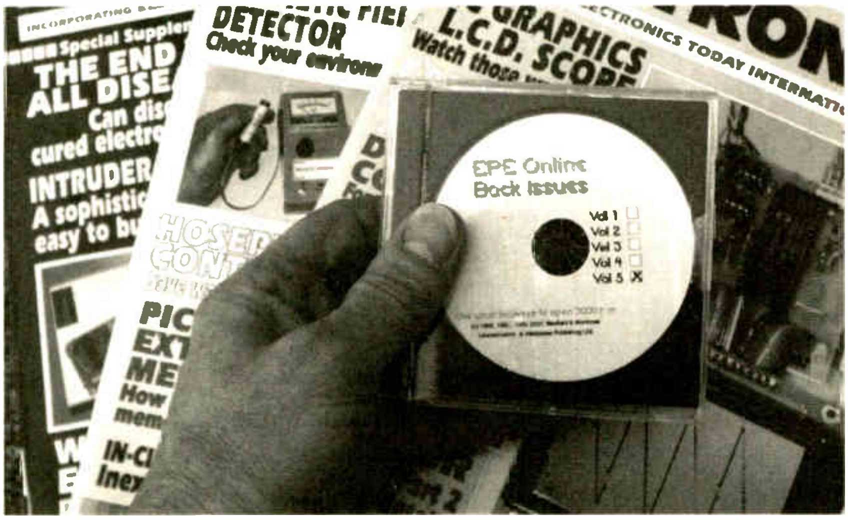

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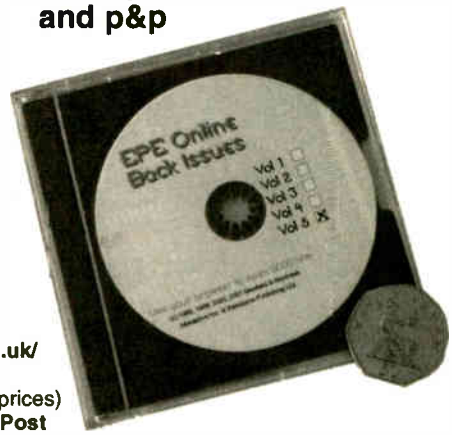

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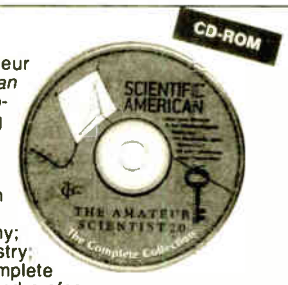

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With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
Richard Monk

FREE SOFTWARE

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There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.
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Ian Hickman

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S. W. Amos and Roger Amos

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Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.
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PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING
Robin Pain

To be a real fault finder, you must be able to get a feel for what is going on in the circuit you are examining. In this book Robin Pain explains the basic techniques needed to be a fault finder.
Simple circuit examples are used to illustrate principles and concepts fundamental to the process of fault finding. This is not a book of theory, it is a book of practical tips, hints and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialised.
The fundamental principles of analogue and digital fault finding are described (although, of course, there is no such thing as a "digital fault" – all faults are by nature analogue). This book is written entirely for a fault finder using only the basic fault-finding equipment: a digital multimeter and an oscilloscope. The treatment is non-mathematical (apart from Ohm's law) and all jargon is strictly avoided.
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Steve Money

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Ian R. Sinclair

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Owen Bishop

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Tony Thompson

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Project Building

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
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Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.
In fact everything you need to know in order to get started in this absorbing and creative hobby.
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Morgan Jones
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Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.
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Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.
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None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.
Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.
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R. A. Penfold
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There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.
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Theory and Reference

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Ian Sinclair
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Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.
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R. A. Penfold
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World Radio History

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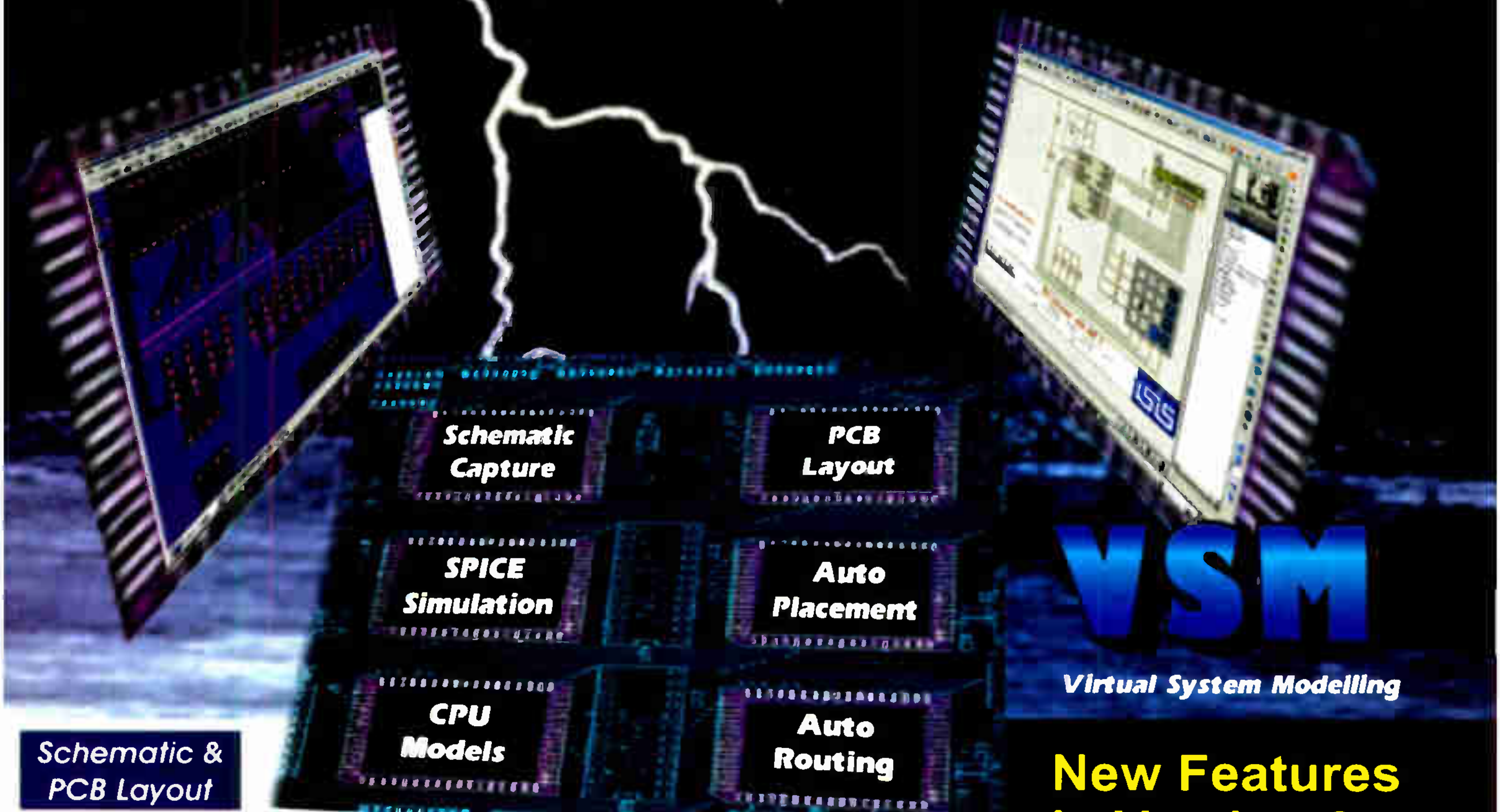

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