

THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL **ELECTRONICS**

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ELECTRIC MOBILITY BUGGY MONITOR

★ Speed ★ Distance ★ Temperature

PC-CONTROLLED BURGLAR ALARM – 2

Testing, driving, and optional keypad



MINI THEREMIN

Easy to build ★ Easy to set up ★ Easy to play



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PROJECTS ... THEORY ...
NEWS ... COMMENT ...
POPULAR FEATURES ...

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PIC & ATMEL Programmers

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

Programmer Accessories:

40-pin Wide ZIF socket (ZIF40W) £14.95
18Vdc Power supply (PSU010) £18.95
Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

NEW! USB & Serial Port PIC Programmer



USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.

Kit Order Code: 3149KT - £39.95
Assembled Order Code: AS3149 - £49.95

NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.



Assembled Order Code: AS3128 - £44.95
Assembled with ZIF socket Order Code: AS3128ZIF - £59.95

'PICALL' ISP PIC Programmer



Will program virtually all 8 to 40 pin serial-mode AND parallel-mode (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.

Assembled Order Code: AS3117 - £24.95
Assembled with ZIF socket Order Code: AS3117ZIF - £39.95

ATMEL 89xxx Programmer



Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.

Kit Order Code: 3123KT - £24.95
Assembled Order Code: AS3123 - £34.95

Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - £16.95
Assembled Order Code: AS3081 - £24.95



PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: VK8076KT - £21.95



PIC Programmer & Experimenter Board

The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: VK8048KT - £22.95
Assembled Order Code: VVM111 - £39.95



Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £8.95

USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.



Kit Order Code: VK8055KT - £20.95
Assembled Order Code: VVM110 - £39.95

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two & Ten Channel versions also available.



Kit Order Code: 3180KT - £44.95
Assembled Order Code: AS3180 - £54.95

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - £17.95
Assembled Order Code: AS3145 - £24.95
Additional DS1820 Sensors - £3.95 each



4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - £54.95
Assembled Order Code: AS3140 - £69.95



8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - £54.95
Assembled Order Code: AS3108 - £64.95



Infrared RC 12-Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - £47.95
Assembled Order Code: AS3142 - £59.95



Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic or direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - £24.95
Assembled Order Code: AS3153 - £34.95



Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).
Kit Order Code: 3164KT - £54.95
Assembled Order Code: AS3164 - £69.95



Hot New Products!

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

Bipolar Stepper Motor Chopper Driver

New bipolar chopper driver gives better performance from your stepper motors. It uses a dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase is set using an on-board potentiometer. Can handle motor winding currents of up to 2 Amps per phase. Operates from a DC supply voltage of 9-36V. All basic motor controls provided including full or half stepping of bipolar steppers and direction control. Synchroniseable when using multiple drivers. Perfect for desktop CNC applications.
Kit Order Code: 3187KT - **£29.95**
Assembled Order Code: AS3187 - **£39.95**



Shaking Dice

This electronic construction kit is great fun to build and play with. Simply shake and watch it slowly roll to stop on a random number.
Kit Order Code: VMK150KT - **£9.95**



Running MicroBug

This electronic construction kit is an attractive bright coloured bug-shaped miniature robot. The microbug is always hungry for light and travels toward it!
Kit Order Code: VMK127KT - **£9.95**



Video Signal Cleaner

Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations. You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: VK8036KT - **£19.95**
Assembled Order Code: VVM106 - **£26.95**



PC Interface Board

This interface card excels in its simplicity of use and installation. The card is connected in a very simple way to the printer port (there is no need to open up the computer). Likewise there is no need to install an extra printer port, even if a printer is to be used. This can be connected to the card in the usual manner. Connection to the computer is optically isolated, so that damage to the computer from the card is not possible.
Kit Order Code: VK8000KT - **£59.95**



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

Motor Speed Controllers

Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)



Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque

at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£21.95**

PC / Standalone Unipolar Stepper Motor Driver

Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£12.95**
Assembled Order Code: AS3179 - **£19.95**



Bi-Polar Stepper Motor Driver

Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer. Supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£17.95**
Assembled Order Code: AS3158 - **£27.95**



Bidirectional DC Motor Controller



Controls the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£17.95**
Assembled Order Code: AS3166v2 - **£27.95**

AC Motor Speed Controller (700W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or single phase 230V AC motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - **£12.95**
Assembled Order Code: AS1074 - **£18.95**
Box Order Code 2074BX - **£5.95**



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Top of the range. Complete self-contained electronics course. Takes you from beginner to 'A' Level standard and beyond! Contains all the hardware and manuals to assemble 500 projects. You get 3 comprehensive course books (total 368 pages) - *Hardware Entry Course, Hardware Advanced Course* and a microprocessor based *Software Programming Course*. Each book has individual circuit explanations, schematic and connection diagrams. Suitable for age 12+.
Order Code EPL500 - **£149.95**
Also available - 30-in-1 £16.95, 50-in-1 £21.95, 75-in-1 £32.95 £130-in-1 £39.95 & 300-in-1 £59.95 (details on website)



Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

Two-Channel USB Pc Oscilloscope

This digital storage oscilloscope uses the power of your PC to visualize electrical signals. Its high sensitive display resolution, down to 0.15mV, combined with a high bandwidth and a sampling frequency of up to 1GHz are giving this unit all the power you need.
Order Code: VPCSU1000 - **£289.95**



Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal Scope is well suited for educational use.
Order Code: VHPS10 - **£129.95 £119.95**
See website for more super deals!



www.QuasarElectronics.com

Secure Online Ordering Facilities • Full Product Listing, Descriptions & Photos • Kit Documentation & Software Downloads

Everyday Practical Electronics FEATURED KITS

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested down under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

3V to 9V DC to DC Converter Kit

KC-5391 £4.95 + postage & packing

Allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, this kit will pay for itself in no time. You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell.

- Kit supplied with PCB & all electronic components.
- As published in EPE Magazine June 2007



The Flexitimer Kit

KA-1732 £5.95 + post & packing

This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices and can be powered by a battery or mains wall adaptor. The kit includes PCB and all components.

- As published in EPE Magazine September 2007
- Requires 12-15VDC wall adaptor (Maplin GS75S £11.98)



Studio 350 High Power Amplifier Kit

KC-5372 £55.95 + post & packing

It delivers a whopping 350WRMS into 4 ohms, or 200WRMS into 8 ohms. Using eight 250V 200W plastic power transistors, it is super quiet, with a signal to noise ratio of -125dB(A) at full 8 ohm power. Harmonic distortion is just 0.002%, and frequency response is almost flat (less than -1dB) between 15Hz and 60kHz. Kit supplied in short form with PCB and electronic components. Kit requires heatsink and +/- 70V power supply (a suitable supply is described in the instructions).

- As published in EPE Magazine October & November 2006



Automotive Courtesy Light Delay

KC-5392 £5.95 + post & packing

This kit provides a time delay in your vehicle's interior light, for you to buckle-up your seat belt and get organised before the light dims and fades out. It has a 'soft' fade-out after a set time has elapsed, and has universal wiring.

Kit supplied with PCB with overlay, all electronic components and clear English instructions.

- As published in EPE Magazine February 2007



Recommended box UB5 HB-6015 £1.05

More Projects

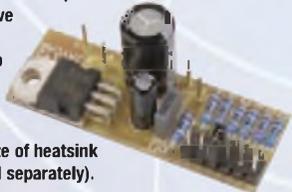
Versatile Regulated Voltage Adaptor

KA-1797 £2.35 + postage & packing

A very handy little kit!

A low-powered DC converter suited for many applications such as a peripheral computer power supply, powered speakers, modems, music/MIDI keyboards, etc. Just plug it's input into your PC's internal power supply cable and have

selectable regulated voltage out from 3 to 15VDC. Output current capability is around 1.5 amps depending on the size of heatsink used (heat sink sold separately).



IR Remote Extender MKII Kit

KC-5432 £7.25 + postage & packing

Operate your DVD player or digital decoder using its remote control from another room. It picks up the signal from the remote control and sends it via a 2-wire cable to an infrared LED located close to the device. This improved model features fast data transfer, capable of transmitting pay TV digital remote control signals using the Pace 400 series decoder. Kit supplied with case, screen printed front panel, PCB with overlay and all electronic components.

- Requires 9 VDC power (Maplin #GS74R £6.99) and 2-wire cable



LED Water Level Indicator MKII Kit

KC-5449 £10.25 + postage & packing

This simple circuit illuminates a string of LEDs to quickly indicate the water level in a rainwater tank. The more LEDs that illuminate, the higher the water level is inside the tank. The input signal is provided by ten sensors located in the water tank and connected to the indicator unit via-light duty figure-8 cable. Kit supplied with PCB with overlay, machined case with screen printed lid and all electronic components.



Car Kits

10A 12VDC Motor Speed Controller

KC-5225 £7.75 + post & packing

Use this kit for controlling 12V DC motors in cars such as fuel injection pumps, water/air intercoolers and water injection on performance cars. You can also use it for headlight dimming and for running 12VDC motors in 24V vehicles. The kit will control loads up to 10 amps, although the addition of an extra MOSFET transistor will double that capacity to an amazing 20 amps.

- Kit includes PCB plus all electronic components to build the 10A version.



High Range Adjustable Temperature Switch with LCD

KC-5376 £22.75 + postage & packing

This temperature switch can be set anywhere up to 1200°C, so it is extremely versatile. The relay can be used to trigger an extra thermo fan on an intercooler, a sensor near your turbo manifold to trigger water spray cooling, or a simple buzzer or light to warn you of a high temperature. The LCD displays the temperature constantly and can easily be dash mounted. Kit includes PCB with overlay and all electronic components with clear English instructions.

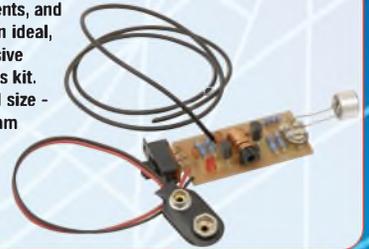


Mini FM Transmitter

KE-4711 £3.70 + postage & packing

This unit is a two transistor two stage transmitter that has the benefits of being VERY COMPACT.

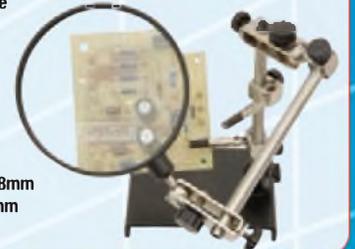
- The Jaycar kit contains PCB, 9V battery and all components, and makes an ideal, inexpensive beginners kit.
- PC board size - 45 x 22mm



PCB Holder with Magnifying Glass

TH-1983 £3.75 + postage & packing

With a 90mm magnifying glass, it also provides an extra pair of eyes. Infinitely adjustable for height and any working angle you may need. The two alligator clips provide secure support for boards as small as 32mm wide. Mainly intended for PCB assembly, this handy tool can be adapted for countless other uses in the workshop or around the house.



Base: 78 x 98mm
Height: 145mm

More Information? Secure Ordering?
www.jaycarelectronics.co.uk

NEW Jaycar Catalogue out this month - order on-line now.

www.jaycarelectronics.co.uk/catalogue

Project Kits

Theremin Synthesiser Kit

KC-5295 £14.75 + postage & packing

The Theremin is a strange musical instrument that was invented early last century but is still used today. The Beach Boys' classic hit "Good Vibrations" featured a Theremin. By moving your hand between the antenna and the metal plate, you can create unusual sound effects. Kit includes a machined, silkscreened, and pre drilled case, circuit board, all electronic components with clear English instructions.

- Required 9VDC wall adapter (Maplin #GS74R £6.99)



"The Champ" Audio Amplifier

KC-5152 £1.95 + postage & packing

This tiny module uses the LM386 audio IC, and will deliver 0.5W into 8 ohms from a 9 volt supply making it ideal for all those basic audio projects. It features variable gain, will happily run from 4-12VDC and is smaller than a 9 volt battery, allowing it to fit into the tightest of spaces.

- PCB and all electronic components included



Be one of the first to get our brand new colour catalogue. It's bursting with over 800 new products, all with PDS pricing and in full colour.



Starter Projects & Tools

Short Circuits Book and Parts

KJ-8502 £11.95 + postage & packing

This full colour 96-page book has over 100 drawings and diagrams. The projects are fun to build and relevant to the electronics scene in the new millennium. Included with the book, you get the baseboard, plenty of spring terminals and ALL the components required to build every project in the book, INCLUDING the bonus projects. Book measures 205 x 275mm



Precision Tools

Ideal for PCB work!

Both pliers and side cutters are made from quality tool steel and have soft padded handles that are spring loaded for comfortable long-term use.

6" Long Nose Pliers

TH-1887 £3.00 + postage & packing

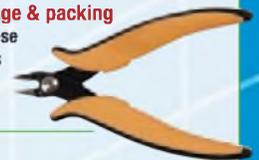
Precision, slim line long nose pliers that are ideal for working in confined areas. They have serrated jaws so you can get a firm grip on the item you're holding.



5" Angled Side Cutters

TH-1897 £3.00 + postage & packing

Ideal for fine PCB work, these cutters will easily cut leads flush with the board's surface.



Low Cost DMM

QM-1500 £2.25 + postage & packing

This full featured Digital Multimeter is perfect for the home handyman or young experimenter and will give years of reliable service. It features a huge 10A DC current range as well as diode and transistor testing functions. Also measures AC & DC volts and resistance. At this price you should buy two!



Battery Zapper Kit Mk II

KC-5427 £29.00 + postage & packing

This kit attacks a common cause of failure in wet lead acid cell batteries: sulphation. The circuit produces short bursts of high-level energy to reverse the damaging sulphation effect. This improved unit features a battery health checker with LED indicator, new circuit protection against badly sulphated batteries, test points for a DMM and connection for a battery charger. Kit includes case with screen-printed lid, PCB with overlay and all electronic components with clear English instructions.

- Suitable for 6, 12 and 24V batteries



NEW IMPROVED VERSION!

Solar Power Kits

Deluxe Solar Educational Kit

KJ-6694 £7.95 + postage & packing

A series of do-it-yourself experiments to acquire the basic knowledge of solar power. Includes solar cell module, musical unit, plastic lamp, motor accessories and plastic adaptors.



Solar Educational Kit

KJ-6690 £4.75 + postage & packing

A complete solar power kit including solar cell, motor, wire, clips, and booklet explaining the why & hows of solar energy.



How To Order

- ORDER ON-LINE
- ALL PRICING IN POUNDS STERLING
- MINIMUM ORDER ONLY £10

Post and Packing Charges

Order Value	Cost	Order Value	Cost
£10 -	£49.99	£5	£200 -
£50 -	£99.99	£10	£499.99
£100 -	£199.99	£20	£500+
	£40		

Max weight 12lb (5kg). Heavier parcels POA. Minimum order £10.

Note: Products are despatched from Australia, so local customs duty and taxes may apply.

How to order:

Call Australian Eastern Standard Time Mon-Fri
Phone: 0800 032 7241

Fax: +61 2 8832 3118

Email: techstore@jaycarelectronics.co.uk

Post: 320 Victoria Rd, Rydalmere NSW 2116 Australia

Expect 10-14 days for air parcel delivery

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or check out the range at

www.jaycarelectronics.co.uk

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For those who want to write: P.O. Box 107
Rydalmere NSW 2116 Sydney AUSTRALIA

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Electronics

PCB Production - Development

0.1" Copper Stripboard

Size	Tracks/Holes	£0 24
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	£2 75
390 81 x 60mm	2	£2 75
840 175 x 67mm	2	£4 86
740 175 x 55mm	1	£4 03
840 175 x 42mm	0	£3 08

Many other sizes available, also jump wires & matrix board



PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)

Clear Manual Film	£1 20
Clear Laser Film	£1 75
White HQ Laser Film	£4 62



Etch Resist Pens

"Dalo" Pen	£3 36
"Stagedler" Fine Pen	£0 96

Etch Resist Transfers

Seno mixed DIL pads	£2 24
Seno mixed RND pads	£2 24
Alfac mixed pads	£1 84
Transfer Spatular	£1 25

We carry the full range of Seno & Alfac PCB transfers, see our catalogue for full details.

Soldering Irons

We carry in stock a wide range of soldering iron and soldering accessories. Irons from 12 to 100 Watts.

20W 240V Basic	£3 74
25W 240V Ceramic	£7 14
30W 240V Basic	£4 68



Desolder Pumps

Basic 165 x 18mm	£2 85
Antistatic 195mm	£3 92
Antex Mini 198mm	£6 02
Antex Pro 210mm	£10 26

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, LED Temperature metering, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 420°C, Low voltage iron with Silicone cable. Supply: 240V, Iron: 24V 48W



Model 167-540 £41.66

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, Digital Temperature Indication, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 480°C, Low voltage iron with Silicone cable. Supply: 240V, Iron: 24V 48W



Model 167-570 £55.61

Digital Multimeter

Model: 121-120
Price: £11.47

A highly featured digital multimeter for professional use. Offers 30 ranges and 8 functions including temperature, capacitance, diode, continuity and hFE measurement. Large 3.5 digit LCD display with automatic polarity indicator. Supplied with shrouded test leads, K type temperature probe and shock proof rubber holster.



Technical Specifications

DC voltage 200mV - 1000V (±0.5%)
AC volts 2V - 700V (±0.8%)
DC current 2mA - 20A (±1.2%)
AC current 200mA - 20A (±1.8%)
Resistance 200 Ohms - 20M Ohms (±0.8%)
Capacitance 2000pF - 20µF (±2.5%)
Temperature 0°C - 1000°C (±1.5%)
Frequency 20kHz (±1%)
Max display 1999
Power supply 9V (PP3 battery)
Dimensions 88 x 173 x 40 mm

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	£98 75
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4 x 15W Tubes, 7 1/2 min timer	Model 332-004
330 x 260mm working area	£209 48



Chemical Processing

Low cost plastic tray £2 30
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 £169 58
Bubble etch Tank with heater & bubble pump Model 333-004 £208 48



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 Tungsten carbide reduced shank 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
Expo Zircon 12V drill, 3.8mm capacity, 11900rpm £14 20

Minicraft MX1 230V, 8000 - 21000rpm with chuck & collet, Model EPE270-390
Normal price £48 51



SPECIAL PRICE £31.02

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200ml Aero Duster	£5 13
250ml Cold Clean	£3 14
200ml Label remover	£3 52
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A range of single output regulated bench power supplies with variable voltage & current limiting. Features: Short circuit and "Foldback" overload protection, Metal case with on/off switch, outputs via Red, Black & Green (Earth) 4mm shrouded sockets.



Model: 461-550	0-30V 0-3A	£70.88
Model: 461-552	0-50V 0-3A	£81.00
Model: 461-554	0-30V 0-10A	£113.00

Panel Meters

High quality analogue panel meters, class 2, zero point correction, mirror scale and prewired for panel illumination. Meter size 46 x 60mm, Cutout size: 38mm

Range	Int Ω	All meters £5 89 each
0-50µA	6k5	6V Lamps £1 23 /pair
0-100µA	1k0	
0-500µA	430Ω	
0-1mA	200Ω	
0-10mA	2Ω6	
0-50mA	1Ω2	
0-100mA	0Ω65	
0-1A	60mΩ	
0-3A	20mΩ	
0-5A	12mΩ	
0-15A	4mΩ	
0-10V	10k	
0-15V	15k	
0-30V	30k	
±50µA	1k9	



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A high quality scratch resistant magnifying glass fitted to a balanced swivel arm and desk mount. An integral fluorescent tube provides illumination. Magnification: 3x Lens: 120mm Tube: 22W Daylight simulation



Model: 028-205 £28.80

PCB Production - Laminates

Copper clad - paper

Single sided low cost paper composite board	
100 x 160mm Board	£0 54
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220 x 233mm Board	£1 40
8" x 12" Board	£1 96

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Single & Double 1.6mm 305g/m²	
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160 x 233mm Single	£2 29
220 x 233mm Single	£2 88
8" x 12" Single	£3 98
100 x 160mm Double	£1 09
100 x 220mm Double	£1 25
160 x 233mm Double	£2 30
220 x 233mm Double	£2 90
8" x 12" Double	£4 05



Photoresist Coated

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

Size	Paper		Glass Fibre	
	Single	Double	Single	Double
4 x 6"	£1 47	£1 89	£2 17	£2 35
6 x 12"	£4 20	£5 04	£5 60	£6 23
9 x 12"	£6 30	£7 70	£8 40	£9 38
10 x 12"	£8 19	£10 01	£10 78	£11 83
12 x 12"	£8 26	£10 08	£10 99	£12 25
100 x 160mm			£2 38	£2 66
203 x 114mm			£3 01	£3 43
220 x 100mm			£3 08	£3 71
233 x 160mm			£4 83	£5 32
233 x 220mm			£6 83	£7 70

PCB Production - Chemicals

100ml Aerosol Photoresist spray, covers 2m²	£4 62
50g Powder developer, makes 1l	£1 09
500g Powder developer, makes 10l	£7 08
250g Ferric Chloride Pellets, makes 500ml	£1 68
500g Ferric Chloride Pellets, makes 1l	£3 04
2.5kg Ferric Chloride Pellets, makes 5l	£9 84
1.1kg Clear Fine etch crystals, makes 5l	£17 58
90g Tin Plating Powder, makes 1l	£11 58
200ml Aerosol Flux spray	£3 41
110ml Aerosol PCB Laquer spray	£3 54

Tools - Cutters & Strippers

We carry a wide range of specialist tools for the electronics industry including:

Side Cutters

130mm Low cost	£1 99
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Wire Strippers	
130mm Low cost	£2 30
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High quality ratchet crimping pliers for various terminals including Automotive, Data, Power and Data connections.

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Red/Blue/Yellow	£22 88
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Cable - Ribbon

7/0 127mm Grey ribbon cable on a 0.05" 1.27mm pitch with a red identifying stripe. Supplied by 305mm (11ft) or on full 30.5m (100ft) reels.

Size	per 305mm	per Reel
10 Way	£0 10	£5 80
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16 Way	£0 16	£8 58
20 Way	£0 20	£10 72
26 Way	£0 26	£13 94
34 Way	£0 34	£18 22
40 Way	£0 40	£21 44
50 Way	£0 50	£26 80
60 Way	£0 64	£33 22
IDC Crimp tool		£10 60



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£2 99ea £2 42 (10+)	



Tools	
Plastic punch down tool & cable stripper	£1 40
Professional punch down IDC & trim tool	£7 38



Outlets	
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2 Gang Plate (4 Mods)	£0 75
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2 Module Blank	£0 45

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Inventors wanted

One of the most rewarding aspects of editing an electronics magazine is hearing from readers across the globe. Your enthusiasm for the subject and boundless inventiveness help to keep *EPE* fresh and up to date. One way we try to support this is through our regular *Ingenuity Unlimited* (IU) pages. This is a venue for readers to showcase original ideas, novel concepts or circuits that are just plain fun. We are constantly surprised by the creativity of our readers and their 'unlimited ingenuity'.

We certainly don't expect something for nothing, and pay between £10 and £50 for material that is published, depending on length and technical/creative merit. Above all, we want to see novel applications and circuit designs, not just mechanical, electrical or software ideas.

IU really is open to *all* abilities. However, one thing we do insist on is that all submissions are typed or word-processed, with a brief circuit description (between 100 and 500 words) and, of course, you must include a full, clear circuit diagram with all component values/types. You don't need to explain every component decision, but do highlight the circuit's core operation and any critical sections.

FETs win prizes

Last, but not least, our friends at Pico Technology have generously agreed to support *Ingenuity Unlimited* with some very special prizes. Every year, Pico Technology will be awarding a PicoScope 3206 digital storage oscilloscope worth £799 for the best IU submission. The 3206 is a full-spec 200MHz analogue bandwidth, dual-channel storage oscilloscope, with built-in functionality to act as a spectrum analyser, multimeter and frequency meter – all topped off with a USB interface. In addition, a PicoScope 2105 handheld 'scope worth £199 will be presented to the runner up.

So what are you waiting for? We want your designs and ideas; whether it's a neat little 555 circuit that makes a sound like an elephant, a clever lighting dimmer or a USB-powered accessory for your PC. Perhaps you've found a solution to a common problem, or discovered an unusual use for a pressure sensor – all ideas are welcomed and taken seriously.

To enter, just send your circuit ideas to: *Ingenuity Unlimited*, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. (We also welcome submissions for IU via email: editorial@wimborne.co.uk) (Please note that submitted designs must be the reader's own work – and must not have been published or submitted for publication elsewhere.)

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PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it. A number of projects and circuits published in *EPE* employ voltages that can be lethal. **You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

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

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

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Las Vegas CES Show

Barry Fox takes a final look at new products on view at this year's Las Vegas Show

Short range radio

Westinghouse has been developing Pulse Link, an ultra wideband short-range radio link that can carry a high data load. Pulse Link can reliably carry 100Mbps over 13 metres, which is more than enough data for the highest quality HDTV. Not so fast, says Pioneer, when told that the future is LCD or OLED. Pioneer remains resolutely committed to plasma.

Pioneer's mantra is that 'black is the most important colour'. All LCD screens need a backlight, which leaks light into the room and makes blacks look grey. However, conventional plasma screens leak light too because the plasma cells must be kept electrically primed and ready to emit bright light.

Pioneer's engineers in Japan have now reduced cell idling emission to such low levels that the screen is invisible when idling, even in a pitch dark room. Also, there is no need for a backlight. Prototypes of Pioneer's next generation screens are just 9mm thin.

DualView

Texas Instruments is offering DualView – a projection system that can be used either to show 3D movies or games, to let two competing gamers see different scenarios on the same screen or to let mum and dad watch completely different programmes on the same TV.

A DLP digital mirror projector shows pictures at twice the normal frame rate, 120Hz for the Americas, 100Hz for Europe. The display is in fact two separate programmes in rapid alternation. Viewers wear LCD spectacles which work as light shutters, rapidly switching so that the viewer's eyes see different views or different programmes. Cost of the spectacles and control system is expected to add around \$200 (£100) to the price of a projector.

The CES demo showed a car racing game, with red car and grey car on the same track, but each player seeing only one car – so unable to cheat by obstructing.

Tracking rover

How highly do you value your dog? Zoombak is now selling a GPS tracker that hangs round its neck. GPS continually checks the pet's position and every 15 minutes Zoombak 'pings' the dongle by sending it a cellphone SMS text message. The

dongle replies to the ping with a message that gives the GPS position.

Zoombak's computers then compare the current location with whatever location has been registered as the dog's home. If the two don't tally, Zoombak sends the dog's owner a text message warning 'your dog is not where it should be'.

The same system can be used to keep track of your car, says Zoombak – for a one-off fee of \$200 (£100) and then \$10 (£5) a month.

Wireless charge

Many have tried, many have failed, to charge cellphones and PDAs without wires. Powercast of Pennsylvania claims to have cracked the problem, and was proving it with LED lamps in wireless stands that light up brightly when sat on a small charging pad like a beer mat.

Unlike other systems, Powercast uses a pure radio frequency field, with no magnetic component. A small IC, the size of a cellphone memory card, is stuck inside the device to pick up RF at 915MHz from the transmit pad and convert it to charging power.

Says John Shearer, CEO and founder: "We thought out of the box. Radio engineers usually want to tune very tightly to a broadcast station; but for power transfer I tried tuning the transmitter tightly and the receiver broadly. I went narrow on transmit and wide on receive."

XStream

XStreamHD wants to make blue laser video discs obsolete. For \$399 the subscriber will get a media receiver that downloads HDTV movies direct from a satellite, and a media server that stores them on a 500GB hard disk.

Actor Michael Douglas is backing the venture, but there is nothing yet available to buy or use and XStream President and Founder, George Gonzalez admits there are no firm deals with Hollywood studios to announce yet. "But you won't see a content issue" he assures. "All the top studios are very interested. We go live in October."

SanDisk cards

SanDisk is in 50/50 partnership with Toshiba to mass produce flash memory cards and now has a 30% share of the world market. Chairman and CEO, Eli

Harari likes to tell how some customers have put their cards through washing machines and still got their pictures back – SanDisk cards are used in aircraft black boxes too, because they survive crashes.

The latest 12GB Micro SD card is the size of a finger nail and has 50 billion transistors. "It will hold six Star War movies" says Harari. 'If each transistor were the size of an ant, and you put them head to tail, they would stretch twice round the world.'

As cards get smaller and store more, it becomes easier to lose more data. So SanDisk's latest tool is a flash memory USB stick called Titanium that can store 4GB of data but also has embedded software. Whenever the stick is plugged into a PC's USB port, it looks for any files that have been changed, steers the PC to an Internet site and stores the data on a remote server. If the PC or flash stick is stolen or damaged, the owner can go to the website and retrieve the lost data.

Dolby video

Dolby Labs became a household name by improving the quality of recorded sound. Now the company is hoping to improve the quality of video on LCD screens with a system called HDR, High Dynamic Range.

Instead of the usual fluorescent backlight, the new screen uses a matrix of 1300 bright white LEDs. The LEDs are individually controlled with an 8-bit code, while the LCD cells are controlled in the usual way, also with an 8-bit code. So this gives 16-bit very precise control of the grey scale between full black and full white.

CES moving?

And finally, don't believe what you read about CES leaving Las Vegas. We got a straight denial straight from the horse's mouth – Gary Shapiro, President and CEO of the Consumer Electronics Association, which has run the show since 1967. "We have no intention of leaving Las Vegas. We are not having talks with any other city. Las Vegas has more hotel rooms than any other US city and is planning more."

"We do have some concerns over hotel rates, though and we are working to reduce them. We used to be in Chicago and left in 1978 because it was so cold people would not leave their hotel rooms".

Li-Ion/Li-Polymer Chargers

Microchip has introduced the MCP73837 and MCP73838 dual-input, high-current Li-Ion/Li-Polymer charge-management controllers with automatic USB or AC adapter power source selection. The key facts are:

- Automatic selection of USB or AC power-source
- Up to 500mA charge current in USB mode, up to 1A charge current in AC mode
- Tiny 10-pin MSOP and 3×3mm DFN packages

Auto power-source selection from either a USB port or an AC adapter provides the user with increased flexibility for rechargeable battery applications. The USB charge currents (100mA or 500mA) are regulated to comply with USB power specifications, while the higher charge current (up to 1A) from an AC power source enables the MCP73837/8 devices to provide faster charging cycles. On-chip safety features, such as thermal regulation, cell-temperature monitoring and charge-timers result in safer, smarter and more efficient charger designs.

Standard parameter options available on the MCP73837/8 devices include voltage regulator outputs and safety timeout periods, as well as preconditioning current thresholds and current ratios, charge termination thresholds and recharge threshold ratios.

Microchip also offer the MCP73837/8 evaluation board (part number MCP7383XEVDIBC) to help designers evaluate the MCP73837/8 chargers in their designs. The board and samples are available at sample.microchip.com.

For further information, visit Microchip's Website at: www.microchip.com/MCP73837.

BFBS ON-AIR ACROSS UK

The British Forces Broadcasting Service (BFBS Radio) now provides the missing communications link for the British Forces. For the first time, BFBS Radio can be heard on-air in the UK via DAB Digital Radio in a trial of the service that started in January.

BFBS Radio has been broadcasting to the British Forces overseas since 1943. The Forces' station currently has bases in eleven countries. It plays a wide variety of music, has its own news service and specialises in on-air messages and requests between servicemen and women and their families. Now in a pioneering trial, the service is available across mainland Britain and can be received on any DAB digital radio.

"This completes the link," says BFBS Radio's Controller, Charles Foster. "Although we've been serving the British Forces community around the world for 65 years, we have relied on occasional links with the BBC and commercial stations or, more recently, the Internet, to keep the Forces and their families and friends at home in the picture."

Quentin Howard, Chief Executive of Digital One (the national commercial digital radio network broadcasting BFBS Radio to Great Britain) says: "We are delighted to be helping to connect British Forces personnel, their families and other listeners across the country who may share past and present links with the forces. If this trial of BFBS Radio proves popular and successful we would hope to be able to make the service permanent."

For further information, contact Simon Mundell on 0207 993 3006 or email simon@oneismore.com

Rugged Receiver Enclosures

RF Solutions has addressed the growing number of outdoor applications that require wireless remote control with the introduction of its new IP68 rated enclosures that provide protection against moisture ingress. The injection moulded ABS enclosures have been specifically designed to house a receiver module and an antenna. Three push-through areas on the underside of the enclosure provide access for power feed and other cabling and connectors.

A 4mm wall thickness provides a high degree of impact resistance and makes the enclosures viable for use in the most difficult and demanding environments. The new units are ideal for use in conjunction with their latest IP65-rated transmitter housing. The receiver enclosure's integrated card guide and retention system allows for a wide range of RF Solutions' PCBs to be accommodated, meaning that many wireless communication applications can be addressed using a single enclosure design. Overall dimensions of the new moulded plastic enclosures are 169 × 132 × 85mm (excluding the antenna).

Further information is available from RF Solutions, Dept EPE, Unit 21, Cliffe Industrial Estate, South Street Lewes, East Sussex, BN8 6JL. Tel: 01273 898000. Fax: 01273 480661. Web: www.rfsolutions.co.uk. Email: sales@rfsolutions.co.uk.

Real-time Logic Simulator

Reader Jari Komppa has told us that he is finishing up his project, Atanua, the real-time logic simulator. Atanua is designed to be a teaching/learning tool about logic gates and electronics.

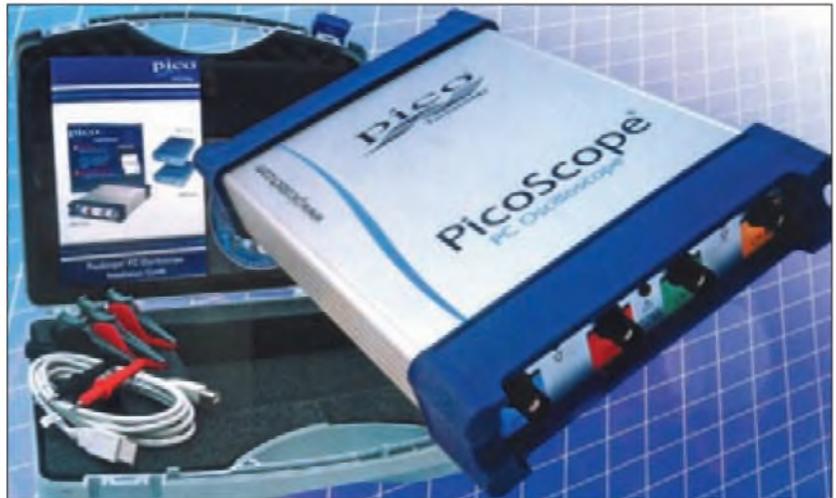
There are versions for Windows, Linux and OS X. Browse <http://atanua.org>.

DIFFERENTIAL 4-CHANNEL PC SCOPE

The PicoScope 3425 is a brand new PC oscilloscope from Pico Technology, featuring four differential inputs, 12-bit precision, 5MHz bandwidth and a high-speed USB 2.0 interface. A fully documented programming interface is included, with example programs in C, C++, Visual Basic, Excel and LabVIEW.

The PicoScope 3425's differential inputs allow you to measure signals that are not referenced to ground, removing the need for expensive differential preamplifiers and probes. Its maximum common-mode and differential ranges of 400V make it ideal for capturing power waveforms from switch-mode power supplies and motor inverters. It is also perfect for use in physics and biology laboratories, where its ability to reject common-mode noise allows it to pick up low-level differential signals from sensors. It has 12-bit resolution and a 20 megasample-per-second sampling rate, allowing it to capture extremely detailed waveforms, and its input impedance of over 10MΩ puts minimal load on the circuit under test. It is USB-powered and requires no external power supply.

The PicoScope 6 software included with the scope can show multiple views of the signal with different offsets and scales, in addition to a range of automatic measurements.



The scope's timebase range is 500 nanoseconds to 5 seconds per division, and with its deep memory of 512K samples it can capture 26 milliseconds of data at its top sampling rate. A high-speed streaming mode allows the scope to capture large data sets, limited only by the PC's memory, and resolution enhance mode can boost the scope's effective resolution to 16 bits. The software also has a spectrum analyser mode that can show frequency- and time-domain data at the same time.

Alan Tong, Managing Director of Pico Technology, commented that "Our PicoScope 3000 Series of scopes is already well-known for its high performance and ease of use. The PicoScope 3425 builds on that reputation, and opens up the benefits of PC oscilloscopes to a new class of users."

The PicoScope 3425 is available from local distributors, or direct from Pico Technology at www.picotech.com, for £975 + VAT and delivery.



A PC-Controlled Burglar Alarm System

This month, we complete the construction, describe the test procedure and give the 'driving instructions' for the software. We also describe the optional keypad module which can be used to arm and disarm the system.

Part.2: By TRENT JACKSON

HAVING COMPLETED construction of the alarm unit, it's time for the test procedure. At this stage, microcontroller IC1 should be out of its socket and the sealed lead acid (SLA) battery should be disconnected.

It's also a good idea to disconnect the display board from the main control board until the power supply has been fully checked out.

Here's the step-by-step test procedure:

Step 1: apply 16V AC power to the main controller board (but leave the SLA battery disconnected).

Step 2: set your DMM to read DC volts and measure the output from the 12V regulator (REG1). Anywhere from 11.5 to 12.5V is acceptable. Now, do the same for the 5V regulator (REG2) – its output should be very close to 5V.

If either of these readings is drastically low, switch off immediately and check for shorts on the PC board and for polarised components that may be the wrong way around.

Step 3: measure the voltage across the battery leads (ie, between Zener diode ZD1's cathode and diode D7's cathode). You should get a reading of 13.6 to 14V (this is the charging voltage).

If this checks out, connect the battery and repeat the last step. Depending on the amount of charge in the battery, you should get a reading in the range of 13 to 13.6V (a flat battery will give a lower reading).

Step 4: check that +5V is present on both pins 11 and 32 of the microcontroller's IC socket. If so, switch off, connect the display board, re-apply power and check that the mains power LED is lit (the other LEDs should all be off). Also, check for a +5V rail on the three righthand pins of the key socket connector on the display board.

Step 5: disconnect the power supply and plug the PIC microcontroller (IC1) into its socket. Take care to ensure that pin 1 is at upper right – see Fig.5 in Part 1.

Step 6: this step checks the basic operation of the two PC boards. First, connect a sensor (PIR or reed switch) to the input of Zone 1. As a default, the system assumes that NO (normally open) sensor contacts will be used. When the sensor is triggered, you should see the status LED for Zone 1 illuminate. This LED should then extinguish when the sensor is reset.

Repeat this test for the remaining seven zones, checking that their allocated LEDs respond accordingly.

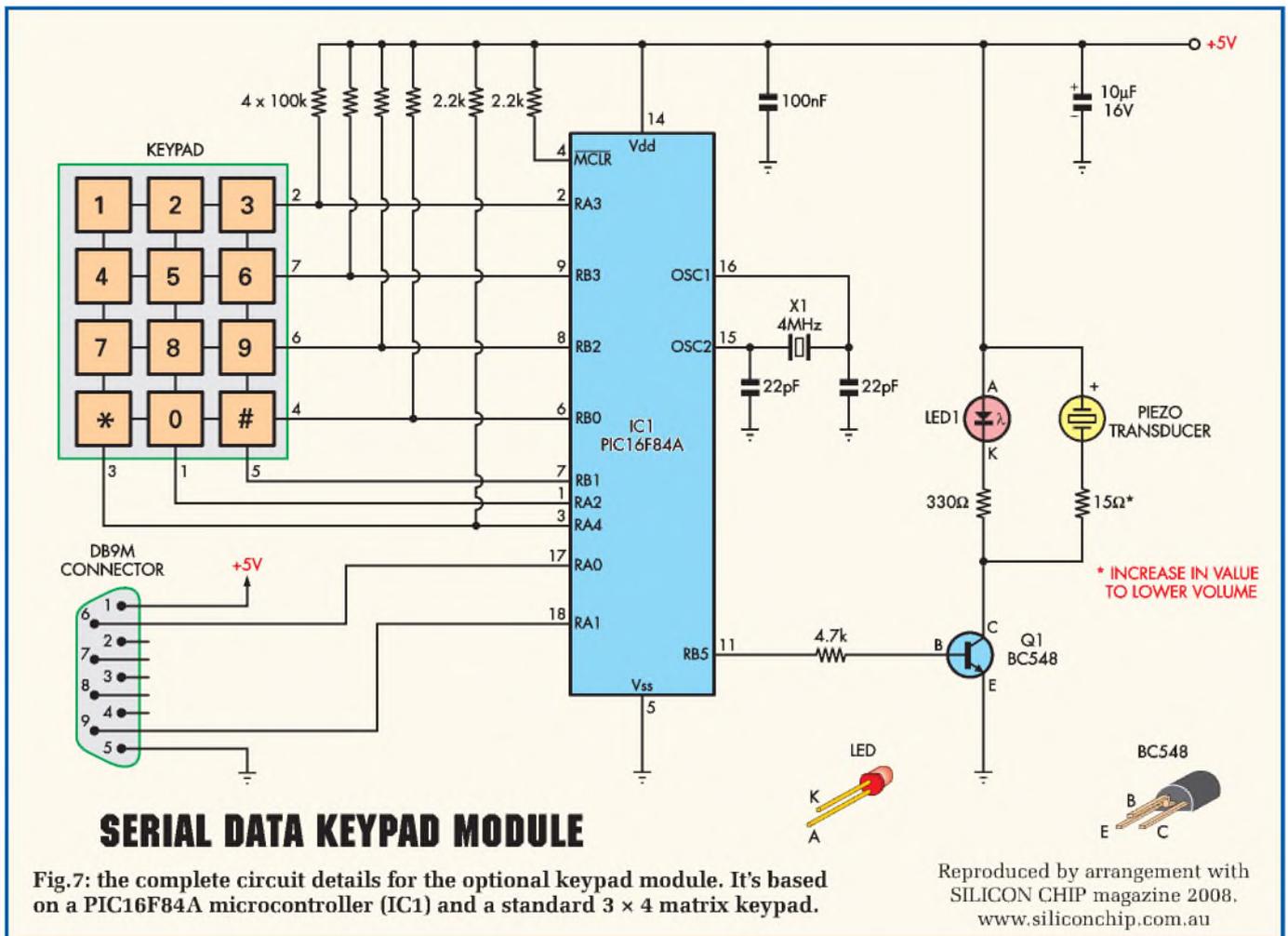
Step 7: it's now time to interface the system to your PC and test the various features. Connect it to the PC via an RS232 serial cable, then install and run the software. Refer to the large 'Driving The Software' panel for information on the various software interfaces.

Step 8: click on the 'Comms' setup button and select the serial port that's to be used. Now click on the button labelled 'Test'. If you have selected the correct port number, you should see all the LEDs on the front of the unit counting up in BCD (binary coded decimal). You should also hear the internal siren briefly chirping in synchronisation with the LEDs.

If this doesn't occur, check that the port is operational and valid. Double-check to ensure the integrity of your serial port cable and that the RS232 IC is installed the right way around.

Step 9: before proceeding to secure the system with passwords, check the door strike outputs. These are operated through the Arm/Disarm interface.

Using your DMM, you should be able to measure 12V across their



terminals when activated. Don't set the duration time for any given strike longer than it really needs to be. They draw high current and the power supply is quite modest.

Step 10: click on the arm button for zone 1. The internal siren should briefly chirp and the corresponding 'Armed' LED should light. Click on the disarm button and check that the LED extinguishes.

Step 11: secure the system with passwords and configure the entry/exit delays, siren duration times and auto-rearming features (if needed).

Step 12: this is the fun part – install the alarm into your premises and run the cables to all the sensors.

The keypad

The keypad is for those who don't wish to use a computer to arm and disarm the main alarm system. That way, you only need a PC for the initial system set-up and to define parameters and passwords.

A keypad is also useful if you want to use the system as a domestic house alarm and don't need the versatility offered by the Windows-based software. Alternatively, you can build the keypad for emergency use only – ie, to arm and disarm the system in the event of a blackout or computer malfunction.

In the latter case, the keypad also lets you do away with the 'Hard-wired Key', which can be rather inconvenient to use. If the power fails, just plug the keypad in and you're in business. Furthermore, the keypad can both arm and disarm the system, whereas the 'Hard-wired Key' can only disarm the system.

Up to four passwords can be defined via the Windows software, as shown in one of the screen grabs. However, you don't have to type in a password for all four – just leave them blank if you don't require them. Note that to access this feature, you need to be logged in as either an 'Owner' or 'Admin'.

These passwords are stored in the PIC microcontroller in the main alarm

unit (ie, in EEPROM) and must be four digits in length (numerals only).

The star (*) and hash (#) keys are used only to arm and disarm the system. To arm the system, just enter the 4-digit code and press *; to disarm it, enter the 4-digit code and press #. Easy!

If the code is correct, a short melody is played. However, if the code is entered incorrectly, then a short series of chirps will be heard. It's then just a matter of re-entering the correct code, but you only get five attempts, after which the system locks you out for 30 minutes.

By the way, this unit is quite universal and could easily be adapted to suit a host of other applications. It's not just suitable for used with the PC-Controlled Alarm.

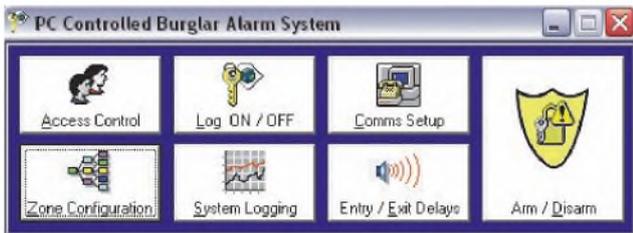
Another PIC

Inside the keypad module is – yes, you've guessed it – another a PIC microcontroller. This time, it's a 16F84A, which this is teamed with a standard numerical keypad and a handful of minor parts.

Driving The Software For The PC-Controlled Burglar Alarm

THE SOFTWARE for the PC-Controlled Burglar Alarm has been tested with Windows XP and Windows 98SE, but should also work with Windows 95, Windows 98 and Windows 2000. It has not been tested with Windows Vista. It's separated into seven main sections to make it easy to drive: (1) Access Control; (2) Log On/Off; (3) Comms Setup; (4) Zone Configuration; (5) System Logging; (6) Entry/Exit Delays and Arm/Disarm. The main GUI (graphic user interface) is shown immediately below.

The software assumes no security until an owner password is created. If you have just loaded the software and want to test the unit before finalising access settings, you can just go straight to the Communications Setup window to begin testing. Select the Comm port that you wish to use, then cover your ears and click on the relevant Test button (see GUI below right). The internal siren should sound and all of the LEDs on the front panel should start counting up in binary. If this occurs, then there's a good chance that your new alarm system is ready for installation. Before doing so, however, it would be a good idea to check that all the zones can be armed and disarmed.



THIS IS THE MAIN GUI for the Windows-base software. It's divided into seven sections (no confusing drop-down menus to explore), which makes it really easy to drive. Clicking on each of these sections brings up the other configuration panels shown on these pages, but first you have to define the various users and set-up access control, as shown in the GUI at the bottom of this page.

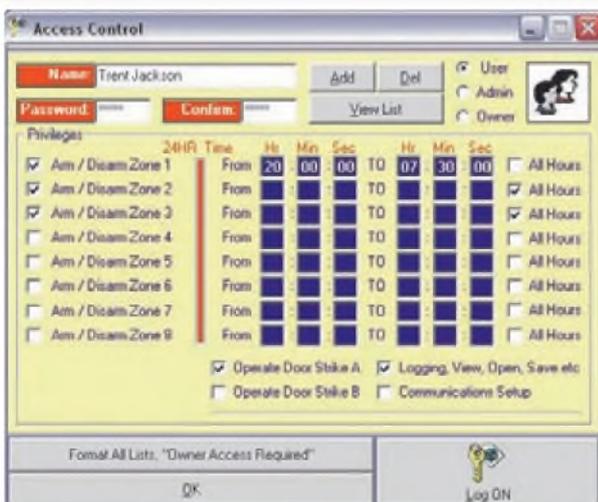
Once you have the system setup, you arm or disarm the system by simply logging on and clicking the Arm/Disarm section to bring up the GUI on the facing page. It's then just a matter of clicking the 'Arm' or 'Disarm' button for each Zone, as appropriate – or you can arm or disarm all zones simultaneously.



THE COMMUNICATIONS SETUP screen allows you to define the RS232 ports that you wish to use to communicate with the PC and the (optional) modem dialler. Make sure that you don't include any spaces in the phone number string. The two Test buttons help you choose the correct serial ports on the PC and to diagnose faults – see text.



PASSWORDS CAN BE alphanumeric, in which case you have to use a PC keyboard to log on. Alternatively, if the password has numerals only, you can enter it by clicking the numbers on the virtual keypad shown here.

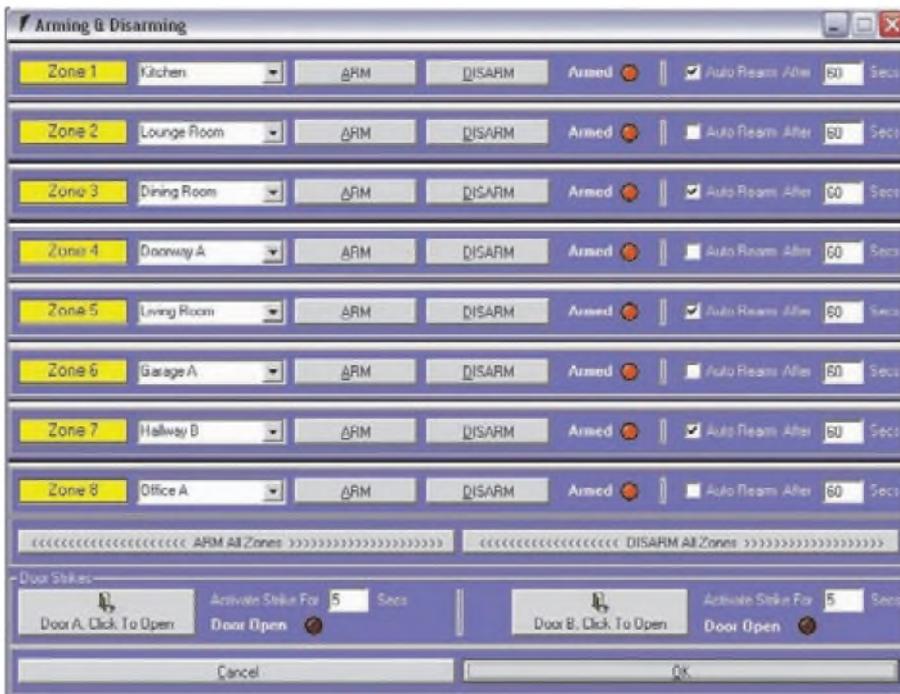


THE FIRST STEP IN SETTING UP THE ACCESS CONTROL for the system is to create an 'Owner' user name and password.

This is done by keying in a name and password, then selecting the 'Owner' option and clicking the 'Add' button. Doing that gives you control over the entire system. However, you cannot do much unless you log on. To do that, click the 'Log ON' button at bottom right and key in the password that you just set up.

If the password is valid you will be greeted with a MSG box that says 'Hi'.

You can create up to four 'Owners', eight 'Admins' and 16 'Users'. 'Owners' can create or delete other 'Owners', 'Admins' and 'Users', while 'Admins' can create and delete 'Users' only. 'Users' have defined access level privileges, most of which are self-explanatory.

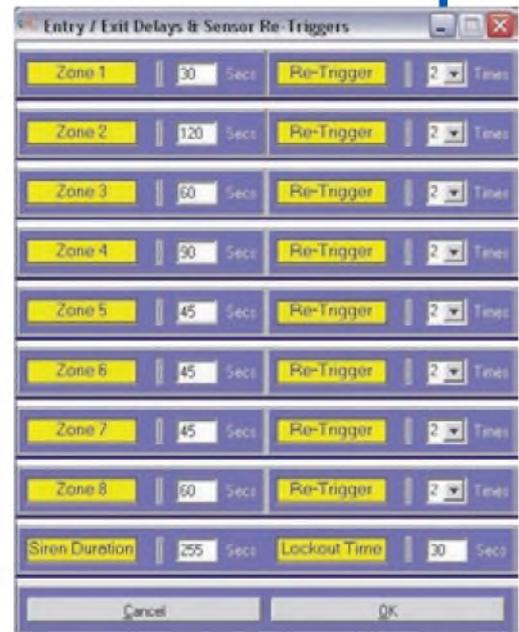


ABOVE: THIS IS WHAT THE 'ARMING AND DISARMING' GUI looks like. You need to have 'Owner' or 'Admin' access to modify these settings. Auto Rearm does exactly what it states – after a preset time, a zone that's been disarmed automatically rearms itself. This could be useful for monitoring an entrance way, for example, and keeping a log of people who have entered (or left) a building.

Note that you can give each zone a label value (eg, 'Kitchen', 'Lounge', etc). There are lots to choose from, so that you can easily identify zones. Clicking the 'OK' button saves any new settings.

The virtual red LEDs next to the 'Disarm' buttons clearly indicate which sectors have been armed. When you arm or disarm a zone, you will hear the internal siren briefly chirp to indicate success. You can also arm/disarm all zones simultaneously.

Finally, the 'Door Strikes' buttons at the bottom allow 'Owners', 'Admins' or 'Users' with defined access to operate the door strikes. Five seconds should be more than ample time for the strike to be activated, but you can adjust this value if you wish.

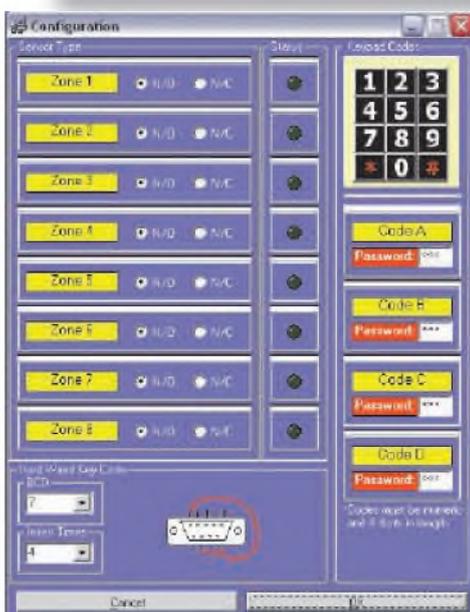


THE ENTRY/EXIT DELAYS GUI lets you customise the delay settings for each zone (0-255s). As with other settings, these delay times are saved in the PIC, so that the system can be operated without a PC if necessary after set-up (although you do lose features).

By default, a tripped zone is automatically rearmed 30 seconds after the siren times out. You can set the maximum number of 're-arms' to anywhere between 0 and 9, so that a zone will eventually be locked out after repeated triggerings (eg, to guard against a faulty sensor).

Check the noise pollution laws for your area before implementing this feature.

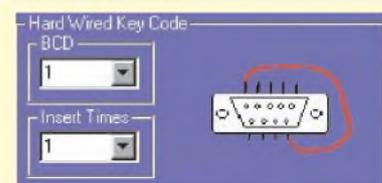
Set this value to 0 if you want each zone to be locked out immediately after it has been triggered.



THE CONFIGURATION GUI allows you to specify the sensors to be used for each zone – ie, either normally open (NO) or normally closed (NC). The status LEDs indicate the condition of each zone. When a zone is triggered, its corresponding LED lights up.

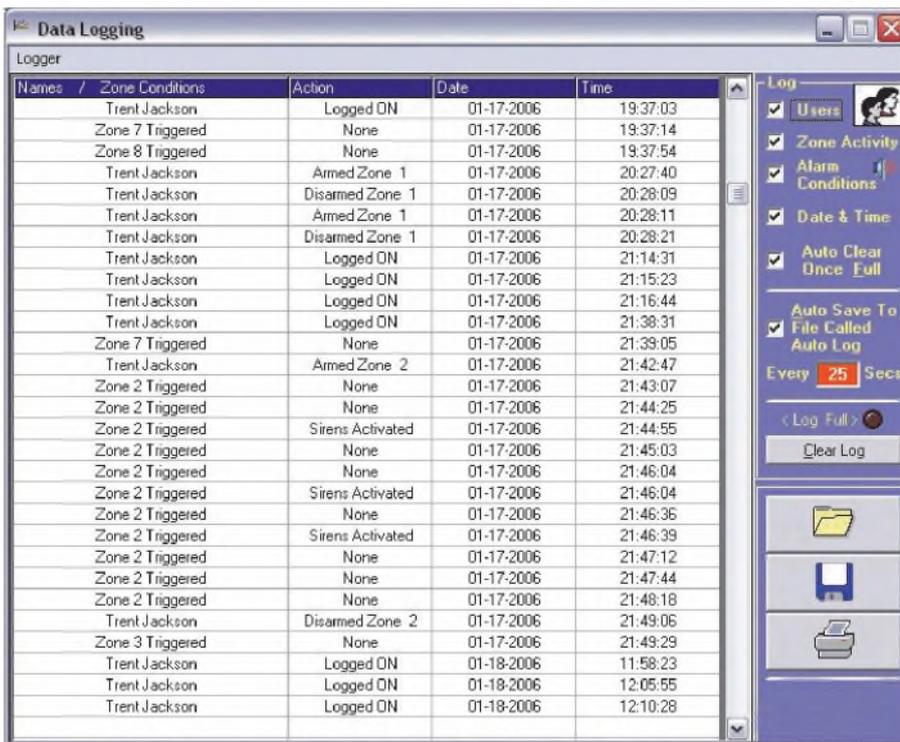
This GUI also allows you to set up the keypad codes and shows the configuration for the 'Hard Wired Key'. You simply select the BCD code and the number of inserts required and the accompanying diagram shows the wiring for the D9 connector.

Make sure that the system is plugged into your PC's serial port before clicking the 'OK' button, so that the settings are saved to the PIC's EEPROM.



THE WIRING DIAGRAM in the Configuration GUI shows you how to wire the Hard Wired Key for a given BCD code and number of inserts.

Construction Project



Names / Zone Conditions	Action	Date	Time
Trent Jackson	Logged ON	01-17-2006	19:37:03
Zone 7 Triggered	None	01-17-2006	19:37:14
Zone 8 Triggered	None	01-17-2006	19:37:54
Trent Jackson	Armed Zone 1	01-17-2006	20:27:40
Trent Jackson	Disarmed Zone 1	01-17-2006	20:28:09
Trent Jackson	Armed Zone 1	01-17-2006	20:28:11
Trent Jackson	Disarmed Zone 1	01-17-2006	20:28:21
Trent Jackson	Logged ON	01-17-2006	21:14:31
Trent Jackson	Logged ON	01-17-2006	21:15:23
Trent Jackson	Logged ON	01-17-2006	21:16:44
Trent Jackson	Logged ON	01-17-2006	21:38:31
Zone 7 Triggered	None	01-17-2006	21:39:05
Trent Jackson	Armed Zone 2	01-17-2006	21:42:47
Zone 2 Triggered	None	01-17-2006	21:43:07
Zone 2 Triggered	None	01-17-2006	21:44:25
Zone 2 Triggered	Sirens Activated	01-17-2006	21:44:55
Zone 2 Triggered	None	01-17-2006	21:45:03
Zone 2 Triggered	None	01-17-2006	21:46:04
Zone 2 Triggered	Sirens Activated	01-17-2006	21:46:04
Zone 2 Triggered	None	01-17-2006	21:46:36
Zone 2 Triggered	Sirens Activated	01-17-2006	21:46:39
Zone 2 Triggered	None	01-17-2006	21:47:12
Zone 2 Triggered	None	01-17-2006	21:47:44
Zone 2 Triggered	None	01-17-2006	21:48:18
Trent Jackson	Disarmed Zone 2	01-17-2006	21:49:06
Zone 3 Triggered	None	01-17-2006	21:49:29
Trent Jackson	Logged ON	01-18-2006	11:58:23
Trent Jackson	Logged ON	01-18-2006	12:05:55
Trent Jackson	Logged ON	01-18-2006	12:10:28

The data logger records all activity from people logging onto the system, as well as which zones have been triggered and the alarm conditions. To gain access to this screen you must have 'Owner', 'Admin' or set user-level privileges. Each time the software loads, the data log loads as well. It's then automatically saved at a specified interval. This arrangement means that you don't have to worry about power failures or having to manually save the logs each time you power down the PC. However, you still have the freedom to manually load and save logs. Up to 2000 samples can be stored, which should be more than enough.

A vital ingredient is the software that's programmed into the PIC. This software monitors the key presses and produces a serial data stream which is then fed to the PIC microcontroller inside the alarm unit. This in turn scans its passwords database and if it finds a match, allows access to the system.

The keypad is perfectly standard – you just press the digits, hit the hash key and the PIC microcontroller spits the digits out serially at 2400 baud.

Pressing the hash key inserts CHR\$(66) at the start of the data string,

while pressing the star key results in CHR\$(88) being sent first. This instructs the alarm to either disarm or to arm, respectively.

After the function BYTE, the 4-digit code follows in a plain ASCII format. A few minutes of experimenting will allow people with relatively modest PICAXE experience to interface it to their own projects.

Automatic resetting

Another feature of the keypad module includes automatic resetting if it's at idle. This simply means that if you

don't press in each subsequent digit in the code sequence within four seconds, then the system resets and you have to start over again.

This is done to ensure security – ie, it ensures that you have to key in your complete password every time you want to arm or disarm the system.

A piezo transducer and a red LED provide audible and visual indication of keypad activity. Each time a digit is pressed, a 'chirp' is produced by the transducer. Other sounds are also produced by the transducer, depending on the status of the keypad (eg, to indicate correct or incorrect codes).

In use, the unit plugs directly into the D9 female socket on the alarm to establish the communications link. In addition, a +5V rail to power the unit is also obtained from the D9 socket.

You can plug the unit into the D9 socket (and unplug it) with power applied. However, don't swap between the PC's serial port and the keypad port while the Windows-based software is running, otherwise the alarm system may lock up.

If it does, you'll have to reset the alarm by removing all power to it (including the back-up battery). Note: you can 'hot-swap' from the keypad to the PC and vice versa if the Windows-based software is showing the main menu GUI only, or is not running.

How it works

The complete circuit diagram for the keypad module is shown in Fig. 7. As stated, it's based on a PIC16F84A microcontroller (IC1) and a standard 3 × 4 matrix keypad. The keypad rows are monitored via ports RA3, RB3, RB2 and RB0, while the columns connect to ports RB1, RA2 and RA4.

The latter three ports (ie, to the columns) are all set as outputs and are switched at a rate of about 100Hz 'total cycle time' – ie, each port is toggled from high to low about 33 times a second.

Ports RA3, RB3, RB2 and RB0 (which monitor the rows) are all configured as inputs. These are all normally pulled high, to +5V via 100kΩ resistors, to ensure they don't 'float'. In addition, a 2.2kΩ resistor is connected to RA4 because this pin can sink but not source current.

In operation, IC1 pulls each of the columns low in turn and checks for key presses on the rows. For example, if RA2 is low and digit 5 is pressed, then RB3 port will be pulled low. IC1 decodes



There are just a few wire links inside the 'Hard-Wired Key' and the software shows you how to wire it. Note that when using this key, you must allow at least a one-second time frame between each insertion and withdrawal. If the time frame is too great, the system will lock out for a short period.

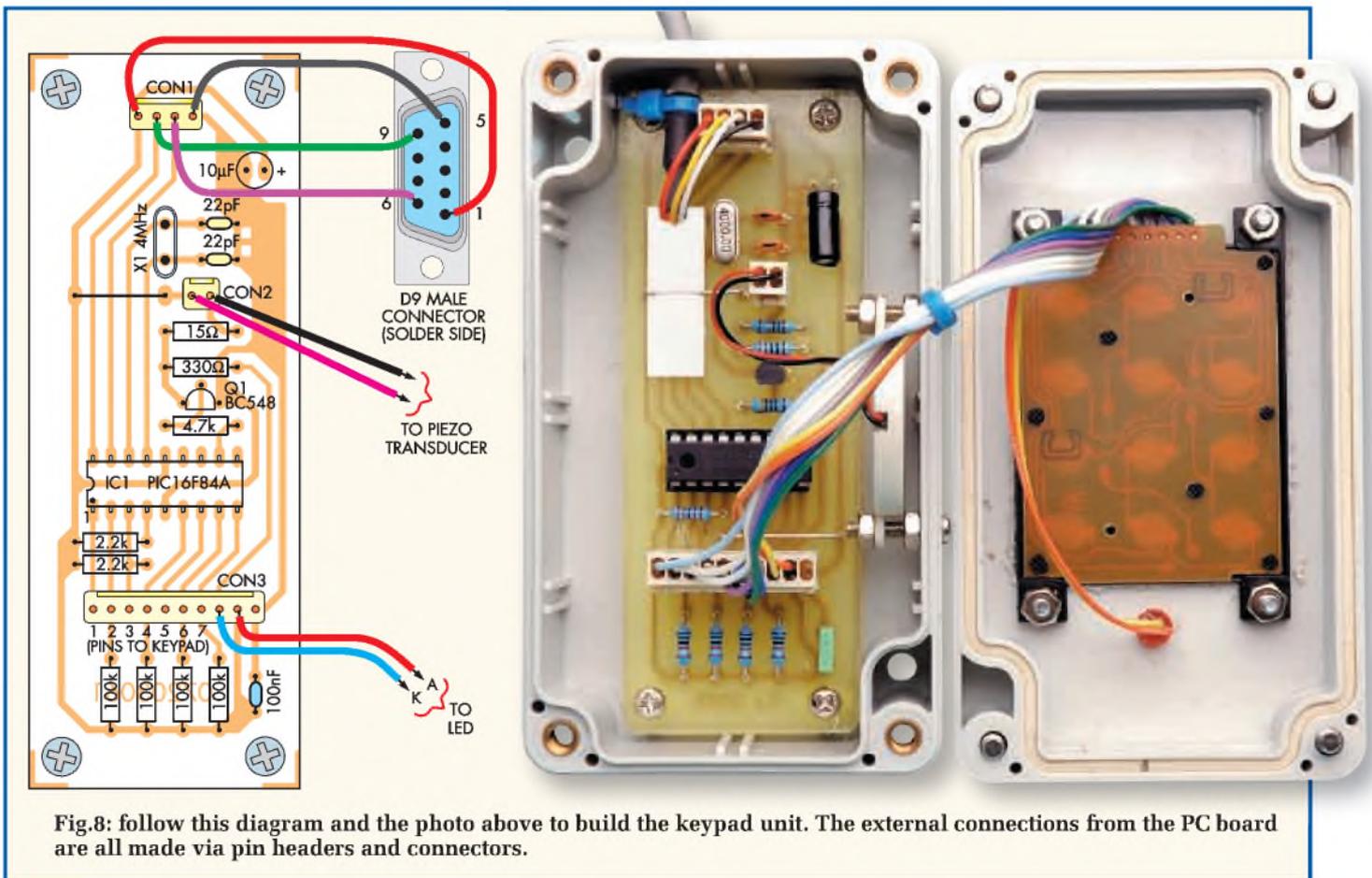


Fig.8: follow this diagram and the photo above to build the keypad unit. The external connections from the PC board are all made via pin headers and connectors.

these key presses and produces a digital data stream at its RA1 port.

This information is then fed via the D9 connector to port RC3 of the PIC microcontroller inside the main alarm unit. If the password is correct, RA0 on IC1 is briefly toggled high for about 200ms, LED1 flashes and the piezo transducer plays a short 'melody' to acknowledge that the correct code has been entered.

Note that there are two very distinct 'melodies' – one for a valid password and one for an invalid one.

LED1 and the piezo transducer are switched on and off via transistor Q1, which is in turn controlled by port RB5 on IC1, via a 4.7kΩ base resistor (this sets the base current to

just under 1mA). Assuming that the beta gain of Q1 is around 100, then the available collector current will be close to 100mA.

When RB5 goes high, Q1 turns on and so LED1 and the transducer also turn on. A 330Ω resistor limits the current through the LED to about 10mA, while a 15Ω resistor limits the volume from the piezo transducer.

Reset line and power

The MCLR pin of IC1 is pulled to the +5V supply rail by a 2.2kΩ resistor. This ensures that the microcontroller is reset when power is first applied.

The +5V supply itself is derived from a +5V rail on the keysocket connector

on the display board, inside the main unit. This connects to pin 1 on the D9 socket (note: you will have to make this connection inside the main alarm unit). A 10μF electrolytic capacitor and a 100nF MKT polyester capacitor provide a modest degree of filtering for the supply rail.

Finally, IC1 is clocked at 4MHz, as set by crystal X1. The two associated

Table 2: Capacitor Codes

Value	μF Code	EIA Code	IEC Code
100nF	0.1μF	104	100nF
22pF	NA	22	22p

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
4	100kΩ	brown black yellow brown	brown black black orange brown
1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
2	2.2kΩ	red red red brown	red red black brown brown
1	330Ω	orange orange brown brown	orange orange black black brown
1	15Ω	brown green black brown	brown green black gold brown

Parts List

- 1 PC board, code 668, available from the *EPE PCB Service*, size 104 x 38mm
- 1 IP65 ABS case, size 115 x 65 x 40mm
- 1 4MHz crystal (X1)
- 1 3 x 4 matrix numerical keypad
- 1 piezo transducer
- 1 D9 male connector
- 2 D9 female connectors
- 2 D9 backshells
- 6 M3 x 10mm screws and nuts
- 4 M3 x 5mm screws
- 1 18-pin IC socket (for IC1)
- 1 150mm length rainbow cable
- 1 1-metre length 4-core cable
- 2 small cable ties, 100mm
- 1 4-way SIL locking pin header and connector, 2.54mm (CON1)
- 1 2-way SIL locking pin header and connector, 2.54mm (CON2)
- 1 10-way SIL locking pin header and connector, 2.54mm (CON3)

Semiconductors

- 1 PIC16F84A microcontroller programmed with keypad.hex (IC1)
- 1 BC548 NPN transistors (Q1)
- 1 5mm red LED (LED1)

Capacitors

- 1 10µF 16V electrolytic
- 1 100nF MKT polyester (code 104)
- 2 22pF ceramic

Resistors (0.25W, 1%)

- 4 100kΩ 1 330Ω
- 1 4.7kΩ 1 15Ω
- 2 2.2kΩ

Software for this design can be downloaded free from the *EPE Downloads* site (access via www.epemag.co.uk). Ready programmed PICs for the main PIC (Part1) and the keypad PIC are available from Magenta Electronics (www.magenta2000.co.uk – see their advert

Keypad Advantages and Disadvantages

The keypad module was developed mainly to make it easier to disarm the alarm system in the event of a mains or PC failure, compared to using the hard-wired key. Unlike the hard-wired key though, it can also be used to arm the system. That means that you can do away with the PC and just rely on the keypad if that's more convenient.

There are some drawbacks to relying solely on the keypad, though. Basically, you lose the nifty access control features that the PC software has to offer. Four codes can be defined for the keypad, but they all provide full control over the system – the keypad either turns the whole system (ie, all zones) on or off.

Note that the independent zone entry/exit delays and the siren duration time are stored in the main system, so you don't lose these settings if you decide to rely on the use of the keypad after the initial set-up. There's just one thing to watch out for here – if you disarm the system using a PC and then rearm it using the keypad, the auto-rearm options will kick in (assuming they're set). This is because the PC sends a command to the alarm for auto-rearming when you click on the disarm button.

This command also includes the time duration before auto-rearm is applied (although this obviously only occurs if it's enabled). This is something to watch out for if you decide to use both the keypad and the PC.

22pF capacitors provide the correct loading on the crystal, to ensure reliable starting.

Construction

All the parts except the D9 connector, transducer and LED are installed on a PC board coded 668. It measures just 104 x 38mm and fits into a standard IP65 plastic case, size 115 x 65 x 40mm.

Fig.9 shows the parts layout on the PC board. It should only take you 10 minutes to assemble – you can install the parts in any order. Use a socket for microcontroller IC1 and take care to ensure that this IC and transistor Q1 are both oriented correctly.

Similarly, make sure that the 10µF capacitor is installed correctly. Table 1 shows the resistor colour codes, but it's also a good idea to check them using a digital multimeter.

Don't forget the wire link that's adjacent to the 4MHz crystal (X1). The crystal can go in either way around.

Boxing up

When the board assembly is finished, mount the keypad on the lid of the case – use the keypad module and front panel heading photograph as a rough guide to mark the cutout and the four mounting holes. The cutout can then be made by drilling a series of holes around the inside perimeter, knocking out the centre piece and filing the job to a smooth finish.

That done, the keypad can be fastened to the lid using four M3 x 10mm screws and nuts. The PC board can then be mounted in position. It's secured to the integral pillars in the case using four M3 x 5mm screws – see photo.

Finally, complete the construction by wiring the D9 connector, piezo transducer, LED1 and the keypad to their respective connectors and plugging them into the on-board headers.

Testing

Before testing, you need to open up the main alarm unit and connect a link between pin 1 of the D9 connector and one of the +5V pins on the key socket connector. This is necessary so that a +5V rail is applied to pin 1 of the D9 connector on the keypad module.

After that, it's simply a matter of connecting the keypad module to the alarm unit, setting up the password(s) in the software (via the configuration GUI) and trying it out.

That's it – your new alarm system is ready for action. **EPE**

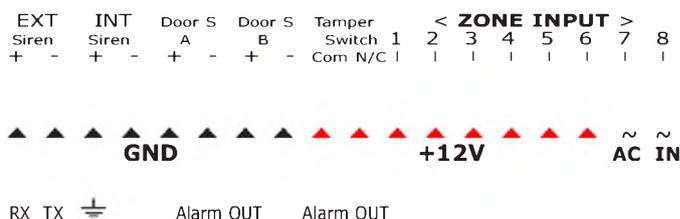


Fig.9: these labels can be cutout and affixed to the main board in the alarm system – ie, adjacent to the external wiring connectors.

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The best place to begin learning about microcontrollers is the PIC16F627A. This is very simple to use, costs just £1.30, yet is packed full of features including 16 input/output lines, internal oscillator, comparator, serial port, and with two software changes is a drop in replacement for the PIC16F84.

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and PIC18F2321 test PICs

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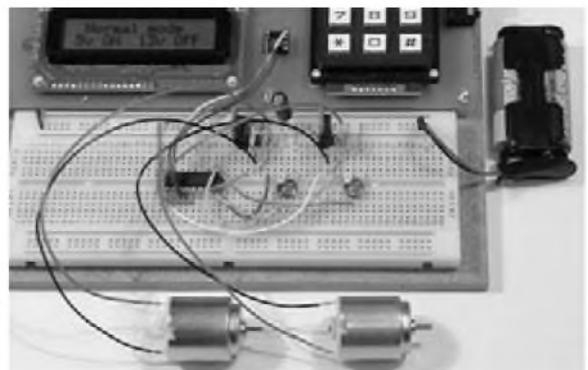
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Future Direction

Mark Nelson examines the trends that are directing the future development of electronics

There are those who claim the only certainty in life is death, although US Defence Secretary Donald Rumsfeld had a broader take on forecasting future developments. "I would not say that the future is necessarily less predictable than the past. I think the past was not predictable when it started," he asserted.

He amplified this on another occasion: "As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know."

More serious matters

Examine the last sentence closely and it makes very good sense. Too bad that people take him for a bit of a buffoon, but he is not alone in that respect. Let's leave the fatuity and ask a serious question – what's driving the direction that electronics is taking today? 'Advanced technology driver' is the jargon term that analysts use.

In the 1930s, arguably when electronics took off as an industry, the driver was domestic entertainment – radio receivers for the home, gramophones and a few tel-lies for the well-to-do. In the 1940s it was radio equipment for use in war and during the 1950s avionics was probably the focus of technology development.

Let's fast forward to the present day; until recently the personal computer was driving the industry, but right now it's the new generation of multi-function mobile phone handsets and smart phones or PDAs (electronic Filofaxes if you like). Miniaturisation is the emphasis, calling for advanced packaging and interconnect methods.

Right now, the race is on to make a single-chip mobile phone. In February, Texas Instruments revealed a quad-band GSM phone on a single CMOS chip, with all RF and baseband functions included. NXP, an independent semiconductor company founded by Philips, aims to be the first to offer a single chip covering all cellular standards, current, legacy and future up to Long Term Evolution by mid-2009.

Mobile migration

So where is this going? All decent mobile phones now have a camera by default and the specification is getting ever better. According to Telematics Research Group (TRG), the next must-have component in a mobile phone is GPS navigation,

which will in turn make web-enabled phones even smarter by providing users with location-specific information. TRG estimates that navigation-enabled mobile phones will begin to outsell dedicated personal navigation devices next year, with annual sales reaching more than 220 million by Christmas 2012.

Wireless will continue as the fastest expanding chip application during the next four years in the view of analyst Future Horizons. Interestingly, the next killer application is not necessarily TV to the mobile phone, says their guru Chris Ryan. Instead, he thinks this could be TV to the mobile video player, a gadget that has yet to make it to the truly mass market.

More ball lightning

It was just over a year ago that we last touched on the 'natural' electronic phenomenon of ball-lightning. The subject aroused a fair degree of interest then, so here are some further reports that have come to my attention on this mysterious subject.

First off is the news that scientists in the joint study group of Max Planck Institute for Plasma Physics and Berlin's Humboldt University have generated ball-lightning in the laboratory. To be absolutely precise, they have created ball-lightning-like plasma clouds taking the form of luminous plasma balls above a water surface. These have lifetimes of almost half a second and diameters of 10 to 20 centimetres, which is somewhat smaller than the natural phenomenon but an excellent start.

You may wonder why these researchers and an earlier team at St Petersburg both use electric discharges above water surfaces for their experiments. Prof Gerd Fussmann, head of the German study group, explains that this seems to be an essential ingredient. "It is probable that flashes of lightning and water must be interacting when ball-lightning occurs naturally," he states.

Don't try this at home

He explains that apart from the powerful capacitor bank needed to supply energy, the experimental setup is rather simple. A glass beaker filled with salt water contains two protruding electrodes, one of which is insulated from the surrounding water by a clay tube.

When a high voltage is applied, a current of up to 60A flows through the water for 0.15s. Flashover from the water enables the current to enter the clay tube, where it causes the water contained there to evaporate.

After the current pulse a luminous plasmoid consisting of ionised water molecules appears.

The facility can generate impressive 'ball-lightning' in every possible manifestation and colour about every five minutes. More information, including a (very) simplified circuit diagram and movies, is available at www.ipp.mpg.de/ippcms/eng/presse/pi/05_06_pi.html.

Returning from Berlin to Britain, a reader of this column has alerted me to Arthur C Clarke's book *Mysterious World*, which contains details of a fascinating incident at the small Scottish seaside resort of Crail in August 1968.

On the afternoon in question, Mrs Elizabeth Radcliffe was returning home from a walk along a concrete path near the seashore. She explains: "I looked up and saw what I thought was a sort of light, and almost instantaneously it turned itself into a ball, between the size of a tennis ball and a football. It crossed the path and changed colour slightly into the colour of the path. Then it passed over the grass and turned greenish, and, very quickly disappeared towards a cafe and went bang."

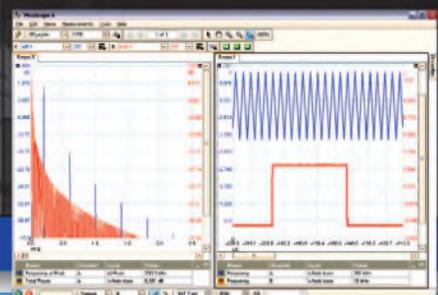
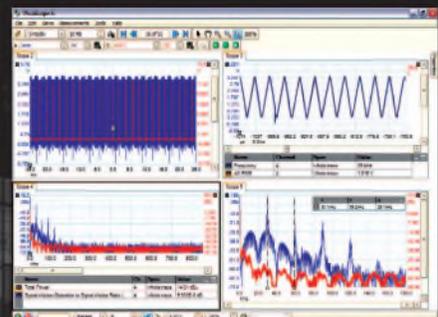
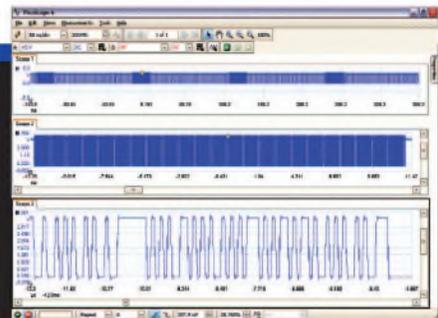
Hissing ball

Inside the cafe there was an awful disturbance; owner Mrs Murdoch and her customers heard terrible cracking sounds that increased all the time. The noise got louder and then suddenly there was one vicious crack. It seemed to go all through the hut, and the whole kitchen lit up with a luminous glare. Later, it was found that the thick cast-iron top of the stove had been split from end to end.

The café owner's daughter, Mrs Jean Meldrum, saw the ball of fire outside, describing it as a luminous orange in the middle, and pure white all round the side as it rolled right along the wall of the cafe. At a nearby caravan site, Mrs Kitty Cox was walking her two dogs and heard a tremendous clap of thunder. Then "this hissing ball came in front of me, trailing what looked like a copper ribbon two or three inches wide at the back of it. My dogs panicked, and I watched as it went past very quickly, hissing and whirring, and went right across into the sea."

Our reader adds that his father saw a glowing globe of light outside their living room window, late one night circa 1973. Like Crail, this was also in the county (or kingdom as it is called there) of Fife. He said it vanished with a bang and he could not explain it.

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PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

I SUPPOSE not every electronic project builder would agree with this, but assembling the electronics is usually the easy bit when building a project. It is often the mechanical side of construction that tends to be trickier. Admittedly, it depends on the project in question, and there are certainly some miniature projects that are about as easy as watch-making.

Shrinking projects

There are also projects that are difficult simply because they are very large, although modern electronic techniques have to some extent killed-off the mega-projects that were all the rage some years ago. Specialist integrated circuits and microcontrollers have reduced the average component count and simplified the electronic side of construction. Some technical know-how is needed in order to identify everything and fit it in the right place, and you have to master the art of soldering, but thereafter it should be largely 'plain sailing'.

The average size of projects may have shrunk somewhat in recent years, but the mechanical side of construction has not really become any simpler. Much of it is actually quite straightforward, and requires nothing more than a drill of some kind and a few drill bits. It is the few awkward components that provide the problems, and at least one of these features in most projects.

Trying to rush on and deal with these components as quickly as possible is definitely a mistake. If it takes longer to deal with one or two components than it takes to do all the other drilling and cutting, which it probably will, then it is best just to accept it as a project-building fact of life. Rushing things will usually result in a poor result that looks rather scrappy, and the awkward component might not fit into place reliably. Getting it badly wrong with some types of component can leave little option other than starting again with a new case.

Hole story

The components that cause problems are those that require something other than a round mounting hole of more than about 10 or 12mm in diameter. In other words, they need a mounting hole that cannot simply be handled by an ordinary drill and drill bit. With something like a panel meter, the main mounting hole is round, but far too large to be drilled in the normal way. Fancy switches, displays, some types of connector, and various other components require rectangular cutouts, or mounting holes having more complex shapes.

There are reasonably inexpensive tools that make it easy to produce large round holes, but anything other than round holes requires a fair amount of skill, and in some cases a fair amount of patience as well. The

basic technique is much the same for any large but non-circular hole, and it really just boils down to marking the outline of the mounting hole and then cutting it as accurately as possible 'by eye'.

There are several different tools that can be used to cut the hole, and the problem is eased by the fact that most cases and panels are made from relatively soft materials, such as aluminium or plastic. The same techniques can be used with steel, but even with thin panels it will take much longer.

Fretsaws and coping saws (Fig.1) are quite good for making small or large cutouts of any shape. The two types of saw are essentially the same, but a fretsaw is larger, giving it greater reach, so that it can be used to make cuts in the middle of large panels.

Since most electronic projects are quite small, a coping saw should be adequate in most cases. The elongated frame of a fretsaw tends to make it a bit unwieldy, and a coping saw is much easier to use. There are blades designed specifically for cutting metal and plastic, but practically any coping or fretsaw blade seems to cope with aluminium and plastic panels quite well. Work slowly when cutting plastic, or the blade might get hot, melt the plastic, and clog the blade.

Getting the needle

A slightly cheaper way of attacking larger cutouts, whether regular or irregular in shape, is to use a miniature round file. For obvious reasons, these are also known as 'needle' files. One of these files, or even a set



Fig.1. A coping saw is relatively inexpensive, but can be used to make cutouts of practically any size or shape. With practice, it is possible to produce very accurate results

of assorted shapes and sizes (Fig.2), is something that you should probably obtain sooner rather than later. Miniature files do not provide a quick means of making large cutouts, but they do at least equip you with a means of making practically any required hole, regardless of its size or shape. They are also useful for tidying cutouts and making small adjustments to them.

In the past, I have often recommended a type of needle file called an 'Abrafile'. These were available in various types, including one that fitted into a coping saw frame and, unlike a normal blade, enabled cuts to be made in any direction without rotating the saw. Unfortunately, these seem to be unavailable at present, but they are certainly worth considering if they become available again.

Another method of making cutouts is to use a sheet metal nibbler. Most of these are power tools that are expensive and intended for making large cutouts in fairly thick sheets of steel. The quaintly named 'hand nibbler' (Fig.3) is more appropriate in the current context, but the hand version of this tool is still only suitable for fairly large cutouts that have straight edges. They are



Fig.2. Needle files are often sold in sets containing a variety of shapes, but a round type is all that is needed for making cutouts. Other types can be used for tidying assorted holes.

mostly suitable for use with up to 18 or 16 gauge steel, and work equally well with aluminium and some plastics.

A nibbler lives up to its name, and cuts out a small piece of the sheet material each time it is operated. The nibbling should not cause any distortion of the panel, but some nibblers work better than others. A nibbler produced by one of the large tool manufacturers should be easy to use and give good results. A tool of this type has the advantage of cutting relatively quickly, but it follows from this that things can go wrong suddenly, unless due care is taken.

Practice makes...

Making cutouts in panels is one of those things that seems to be very easy until you try it yourself. Producing really neat and accurate results is quite tricky. It is certainly a good idea for beginners to practice using some scraps of sheet metal or plastic before starting work on the genuine article.

The work piece must be held securely in a vice or clamped to a worktop, and working accurately is probably easier if it is mounted vertically. This minimises problems with casting shadows on the work area, making it difficult to see what you are doing. Since the saw can only cut in one direction it will be necessary to stop and reposition the work-piece at some point in the proceedings. Reposition the work-piece before you start doing an impression of a contortionist!

Even if you are experienced and skilful at using saws and files, it is still advisable to cut just *inside* the line marking the required cutout. A file can then be used to carefully enlarge the cutout to precisely the required size and shape. With a little practice first, even those who are 'practically-challenged' should find that some quite neat and accurate results can be produced, provided the job is not rushed and due care is taken.

The importance of good accuracy is something that varies from one job to another. With something like a panel meter there should be no major problem provided the main cutout is not oversize to the point that it does not leave anywhere for the four smaller mounting holes. The front section of the meter can be relied on to cover a multitude of sins.

With other components, such as push-fit switches, there is virtually no margin for error. Make the mounting hole fractionally too small and it will not be possible to fit the switch in place. Cut the hole fractionally too large and the switch will be a loose fit, and may tend to fall off the panel. A useful approach with any push-fit component is to initially make the mounting hole slightly too small. It is then gradually enlarged until it can be clipped into place.

Short cuts

Making large cutouts can be a very slow process when using needle files, which usually have fine teeth. Using a coping saw or fretsaw is quicker, but not much.

There is a crude but effective way of speeding things up, and this is to drill a ring of closely spaced holes just inside the perimeter of the required cutout. The holes should be about 3 to 4mm in diameter and the gap between them should preferably be no more than about one millimetre. A needle file is then used to join up the holes and complete the cutout.



Fig.3. A hand nibbler can quickly cut through most thin sheet materials. A tool of this type is best suited to large cutouts having straight sides

The idea is to have most of the material removed by the drilling. Even though a large number of holes are required, the drilling does not take long if a small power drill is used. This leaves relatively little work to do with the needle file, and should greatly speed things up.

The cutout produced will probably have some rough edges, but this can be minimised by using a file having a diameter that is slightly smaller than the holes. Any roughness is not of great importance, as it should not take long to file the hole to a neat finish and precisely the correct size.

Cutting edge tools

Although it is not possible to produce holes of more than about 10 or 12mm in diameter using an ordinary drill and drill bit, there are tools specifically designed for making holes of much larger diameters. These are usually just called 'hole cutters', but there are actually several different types of tool within this general category. At one time, the chassis punch was the standard choice for holes up to about 40mm in diameter. Unlike most other methods of making holes in panels, a chassis punch usually produce extremely neat results with remarkably 'clean' edges.

A chassis punch requires a small guide hole to be drilled in the panel, and a bolt with the circular cutting blade attached is then fitted into this hole. A nut and a short metal tube are then fitted onto the bolt on the other side of the panel. The bolt is then tightened with the aid of an Allen key, forcing the cutting blade through the panel and into the tube, punching a hole in the panel. Chassis punches have waned in popularity due to their relatively high cost, and because a separate punch is required for each size of hole. They are now a less attractive proposition due to the much wider range of components in use.

Hole saws provide an inexpensive alternative to chassis punches, but only for larger holes, where they probably represent a better option. A hole saw is essentially a saw blade in the form of a ring, together with a mandrel that enables it to be mounted in a drill (Fig.4). A small central guide hole is required, but the drill bit is incorporated in the mandrel. The guide hole is

drilled first, and then the saw blade comes into action, cutting the main hole.

Most hole saws have relatively thick blades that remove quite a lot of material when cutting each hole, and they are designed for use at fairly low speeds. Even so, holes having diameters of around 25 to 65mm can be produced relatively quickly, and with quite 'clean' and neat results. As with chassis punches, a different tool is needed for each size of hole, but an inexpensive set of hole saws is adequate for most electronic project work.



Fig.4. A hole saw probably provides the quickest way of making large circular cutouts. They are often sold in sets that contain a useful range of sizes

A hole cutter that can accommodate a reasonable range of diameters is a more practical proposition. A single tool of this type can be set for precisely the required diameter with no compromises being required. Many DIY superstores sell hole cutters, or 'tank' cutters, as they are also known, that can cut holes from around 20 to 120mm in diameter. A tool of this type is a bit like a hole-saw, but with a single blade on the end of an adjustable arm, or two arms on opposite sides, with each one carrying a single blade. The arm or arms are adjusted to the appropriate length for the required size of hole.

These tools are usually very quick and effective, but only when used in the appropriate fashion. They are only intended for use in a hand-brace, or perhaps in a power drill that can be set for a very low speed. The holes produced are not always particularly neat, although they can be tidied up using a file.



Studio Series Stereo Preamplifier

Installing the modules in a case

Here's how to assemble your high-performance Studio Series preamplifier modules into a professional quality case!

By **PETER SMITH**

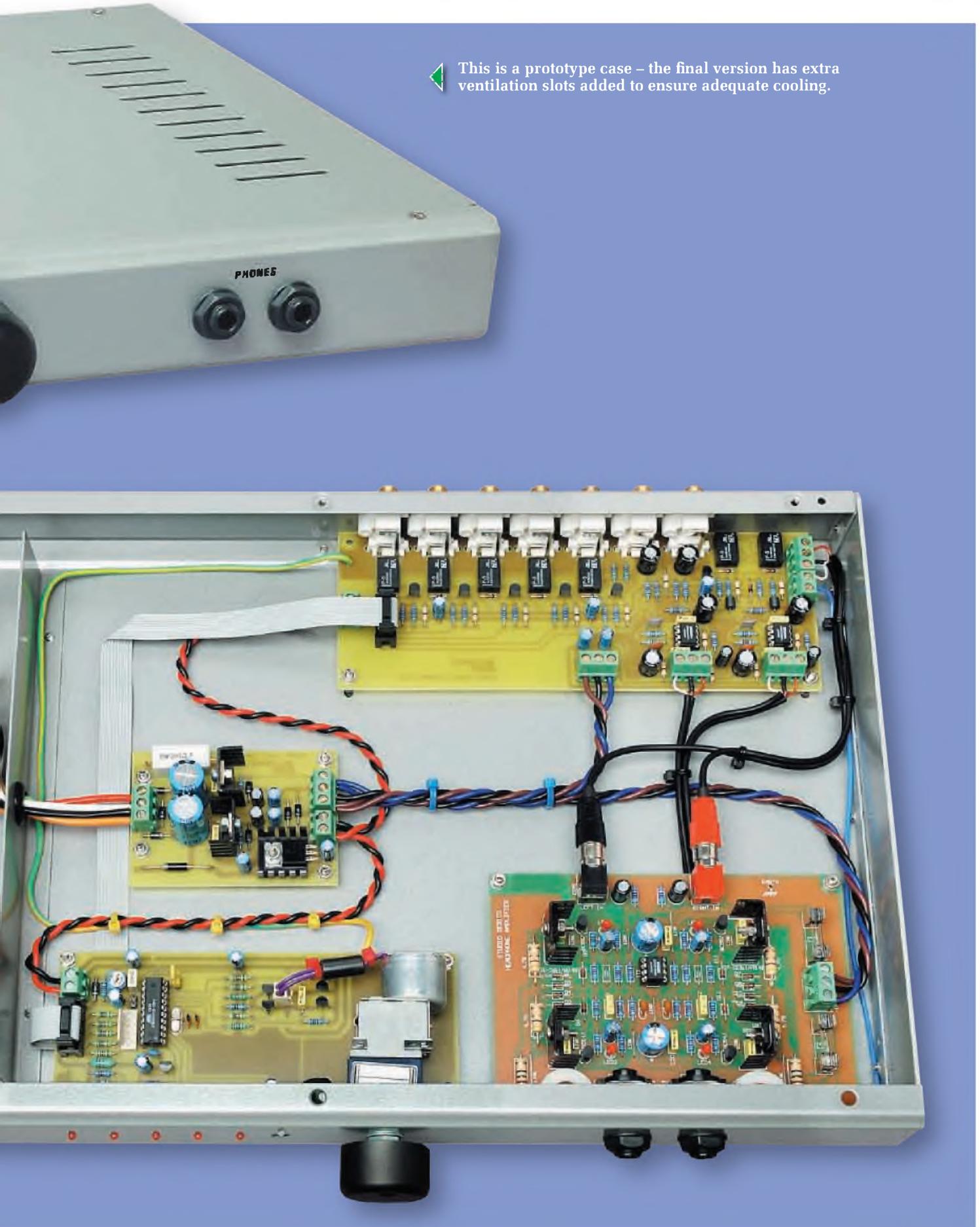
BACK IN THE FEBRUARY 2008 issue, we described a *Stereo Preamplifier* module that sets new standards in low-cost, high-performance, build-it-yourself audio. The module boasts a minimalist design that typically produces less than 0.0005% total harmonic distortion and noise. Five relay-switched RCA inputs and a headphone output simplify wiring and minimise audio signal degradation.

A matching *Stereo Headphone Amplifier* followed in the March 2008 issue. This has already proven quite popular and is undoubtedly the cleanest and quietest we've ever described. Although designed for use with the preamp, the headphone amplifier also works as a standalone unit and can be connected directly to the line output of a CD or MP3 player. It has the ability to drive headphones down to 8Ω impedance with low



Constructional Project

◀ This is a prototype case – the final version has extra ventilation slots added to ensure adequate cooling.



Constructional Project

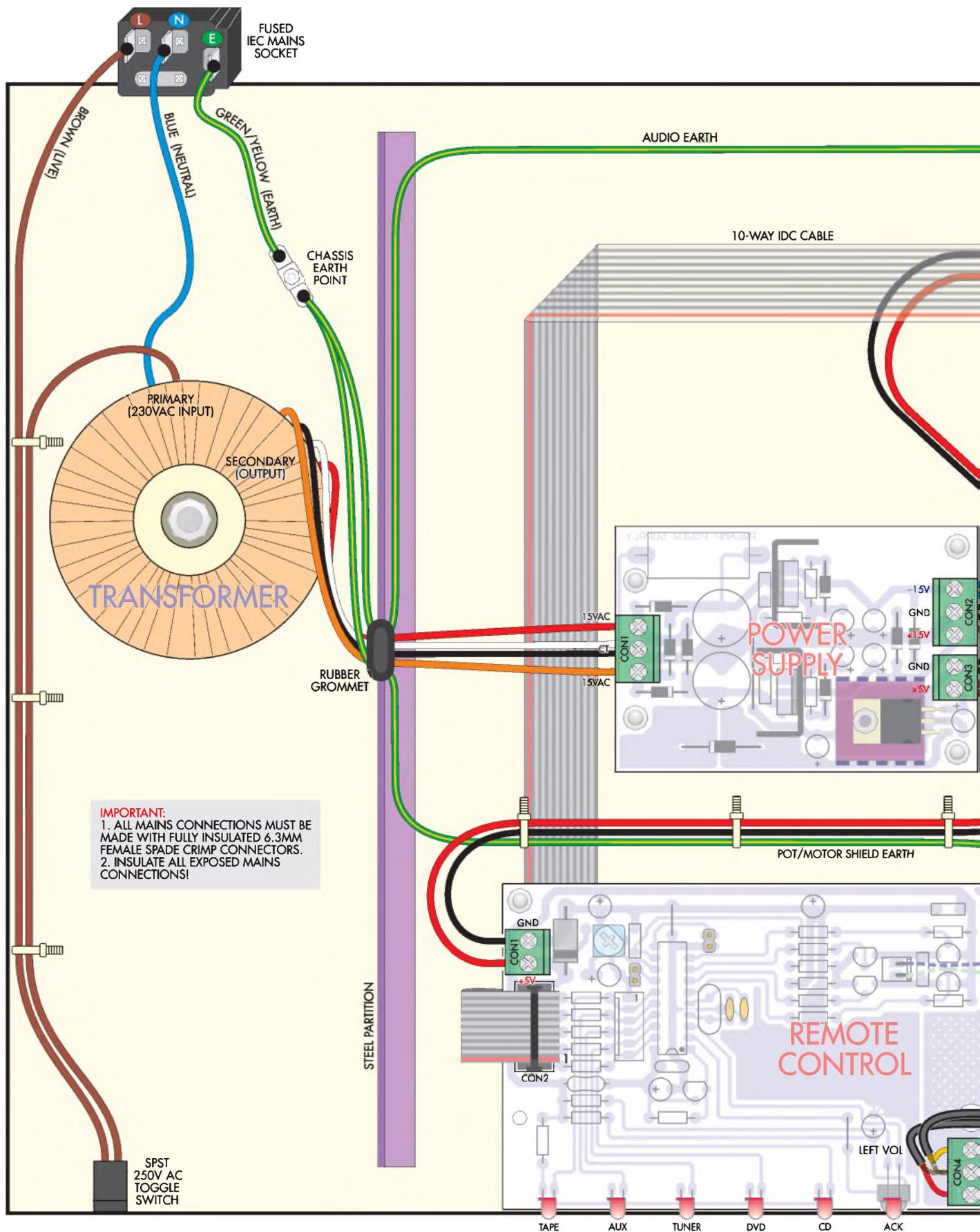


Fig.1: follow this basic interwiring layout to assemble the four modules in the low-profile case. Note in particular that all 230V AC mains terminations must be fully insulated and no low-voltage wiring is to be routed on the mains (left) side of the metal partition. The headphone amplifier is mounted on 10mm spacers, whereas all other modules use shorter 6mm types.

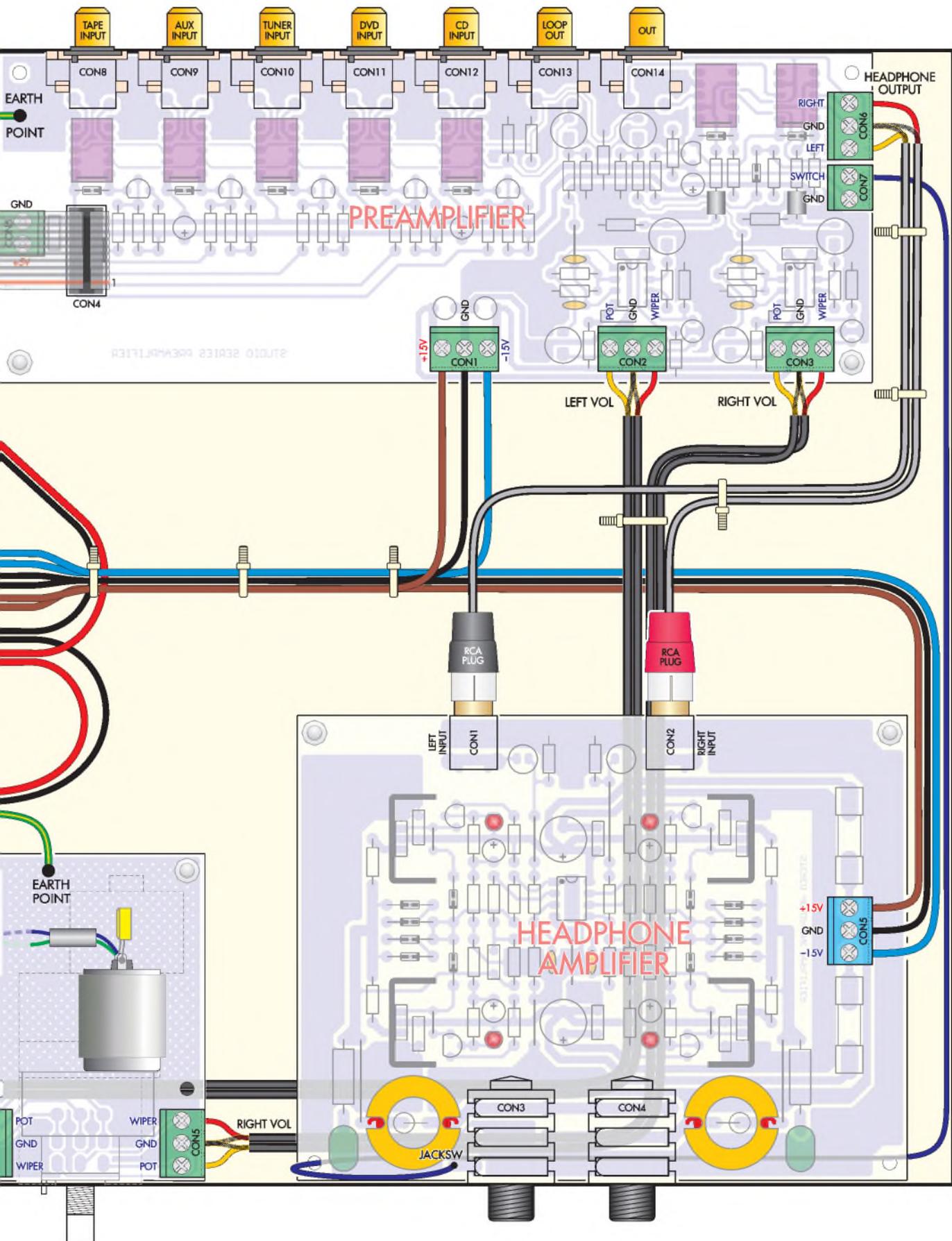




Fig.2: reproduced from the February 2008 issue, this graph reveals the extremely low total harmonic distortion and noise (THD+N) produced by the preamplifier module (the results are the same with the module both in and out of the case). This measurement was taken driving a 50kΩ load with a 600mV RMS input signal, but the results are virtually identical when driving a 1kΩ load.



Fig.3: here we're measuring from one preamplifier input to the headphone output. The 32Ω and 600Ω cases exhibit slightly higher THD+N than the standalone headphone amplifier measurements, as we're now using a smaller input signal to develop 200mW into 32Ω (ie, 382mV RMS) and 100mW into 600Ω (ie, 850mV RMS) – so noise (not distortion) becomes a larger overall factor.

distortion, while a second output socket allows connection of two pairs of higher impedance units.

Then in the last issue, we provided details of an *Infrared Remote Control* module to mate with the preamplifier. Using virtually any universal remote, this module allows you to take charge of the preamp from your lounge chair – an indispensable addition to any audio setup.

As promised, this month we wrap up the series by showing you how to install these modules, along with a low-noise power supply, into a low-profile steel case. You will need to provide an internal steel or aluminium divider partition for the 230V AC mains section.

Measuring up

So how does the assembled unit perform? Measured individually, the performance of the preamplifier and headphone amplifier modules remain the same as described in their respective articles. This indicates that the layout within the case works well, with no additional noise induced from the mains transformer.

The performance of the preamp input to headphone amplifier output is shown in Fig.3. As you can see, the 600Ω case in particular reveals slightly higher THD+N measurements than in the graph (Fig.7) published in March 2008. This is to be expected, as we're now using a considerably smaller input signal to develop our 100mW output – so noise (not distortion) becomes a larger overall factor in the measurements. Nevertheless, the results are excellent!

Cooling down

During testing of the completed assembly in a 1U rack type case, we were initially concerned about the temperature rise of the power supply module in high ambient temperatures. This issue was resolved by machining additional ventilation slots above and below the supply. We recommend that you do the same if you decide to construct your own case.

As noted in the headphone amplifier article, it's imperative that all

three of the voltage regulators are fitted with heatsinks. To maximise heat transfer, insulation pads must **not** be used between the regulators and their heatsinks. Instead, a thin smear of heat transfer compound is used on the mating surfaces before assembly.

Most important, note that without insulating pads, the heatsinks of the LM317 and LM337 regulators will be 'live'. After tightening the securing screws, make sure that they are sitting squarely in position, so as not to contact nearby components.

To maximise reliability, we also recommend that all of the electrolytic capacitors in the power supply module be upgraded to 105°C temperature rated types. Attention to these small details will ensure that your finished preamplifier provides long and reliable service.

Mains wiring

We'll start by hooking up the 230V AC wiring in the unit – see Fig.1. As shown, all the mains wiring is located in the partitioned-off area in the left-hand side of the case. In fact, this area is reserved exclusively for mains wiring.

Fit the toroidal mains transformer first, noting that the large flexible washer supplied with the unit must be installed between the transformer and chassis. Position the transformer so that the wires exit at the top, with

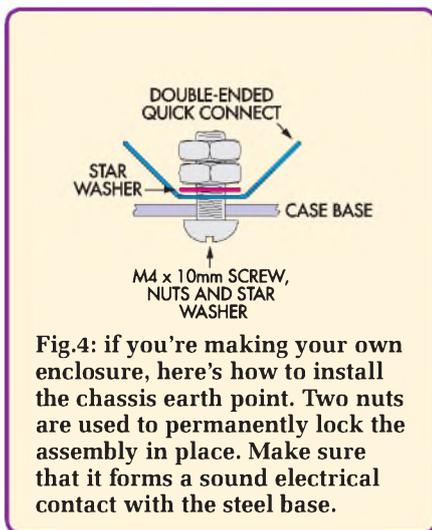


Fig.4: if you're making your own enclosure, here's how to install the chassis earth point. Two nuts are used to permanently lock the assembly in place. Make sure that it forms a sound electrical contact with the steel base.

the primary (brown and blue) wires nearest to the rear of the case – see Fig.1.

The secondary side terminations (possibly orange, black, white and red wires) can now be fed through the grommetted hole in the partition, ready for connection to the power supply board. Position all the wires so that there will be plenty of clearance to the lid when it is installed later.

A suitable chassis earth point, consisting of a double-ended 6.3mm spade lug, should be fastened securely to the base of the case. Position the lug approximately as shown and attach with an M4 × 10mm screw, shakeproof washer and two nuts – see Fig.4 for details.

Next, slip the mains rocker switch and IEC socket into their respective cutouts, noting that the earth pin side of the socket must be closest to the chassis earth point. You can now run and terminate the mains wiring. Use only 7.5A or 10A/250V AC mains-approved cable for all connections.

The active (Live) lead from the transformer should be long enough to extend forward to the switch, with an additional length of brown and yellow/green cable needed to complete the switch and earth point wiring, respectively. Use small cable ties where applicable to keep everything neat and tidy. Refer to Fig.1 and the photos for all the details.

Do not solder the wires directly to the switch or socket pins! These devices are not designed to withstand the high temperatures seen during soldering and may be damaged. Instead, terminate each wire end in a fully insulated 6.3mm female spade crimp terminal.

Note that a ratchet-driven crimping tool is required for this job. Low-cost automotive type crimpers are not suitable and their use will result in unsafe connections.

Once the mains wiring is complete, go back and check that each connection is secure and well insulated. If necessary, use heatshrink tubing to completely cover any exposed terminations. That done, use your multimeter to check for continuity between the earth pin of the IEC socket and any convenient point on the chassis that is devoid of paint, such as the countersunk screws in the side panels.

This test must be repeated later when the top panel of the case is fitted.

At that time, use your meter to check that the top and both side panels are earthed. If not, carefully remove the paint from beneath the heads of the retaining screws to ensure a reliable connection.

Module installation

The modules may be installed into the case in any order, although you may find it easier to leave the headphone amplifier until last. The audio cable passes beneath this module on its way to the remote control module.

To avoid hiccups, careful attention must be paid to the following key points:

- Adjustments to the lead bend of the LEDs and infrared receiver on the remote control module will be required to get everything in line. Ideally, the LEDs should all protrude through the panel by the same amount, while the body of the infrared receiver should just contact the rear of the panel.
- If the infrared receiver includes an external metal shield (see photo), then steps must be taken to ensure that it is insulated from the chassis. We suggest a short strip of ordinary insulation tape on the inside of the front panel, with a hole cut out to match the hole in the panel. *Do not* rely on the paintwork to provide insulation!
- All modules – apart from the headphone amplifier – are mounted on 6mm untapped spacers and held in place using M3 × 10mm screws, shakeproof washers and nuts. Use taller 10mm spacers for the headphone amplifier only.
- Although the preamplifier PC board has four 3mm corner mounting holes, only two of these are used to attach the PC board to the base of the chassis. The other end of the board is held firmly in place by the RCA phono sockets, which are attached to the rear panel via seven self-tapping screws. Similar mounting arrangements apply to the headphone amplifier and remote control modules – only the pair of holes furthest from the front panel should be used for mounting.
- For the three main modules, fit the base-mounting screws first, winding on the nuts so that they're only finger tight. Next, make sure that

each module is in firm contact with the front/rear panel and fit the nuts or screws on the pot shafts, jack sockets or phono (RCA) sockets, as appropriate. The idea is to tighten everything gradually, so that no stress is placed on board-mounted components.

- Don't tighten anything up just yet anyway – you'll almost certainly need to remove one or more boards to run cabling underneath and to get access to the terminal blocks for the audio cable wiring.

Low-voltage wiring

Now for the low-voltage wiring. First, trim the secondary leads of the mains transformer to the right length, scrape the insulating enamel off the ends and tin them with solder. You should have about 8mm of nicely tinned wire protruding from the spaghetti tubing. That done, twist one start and one finish lead of each winding together to form a centre tap and connect all three leads to the power supply module's AC input (CON1).

Before connecting anything to the output of the supply, power up and measure the three rails at the supply outputs (CON2 and CON3). Assuming all is well, the +15V, -15V and +5V rails should all be within ±5% of the rated values. Now switch the power off and physically disconnect the 230V AC mains lead to prevent any accidents while working on the interwiring.

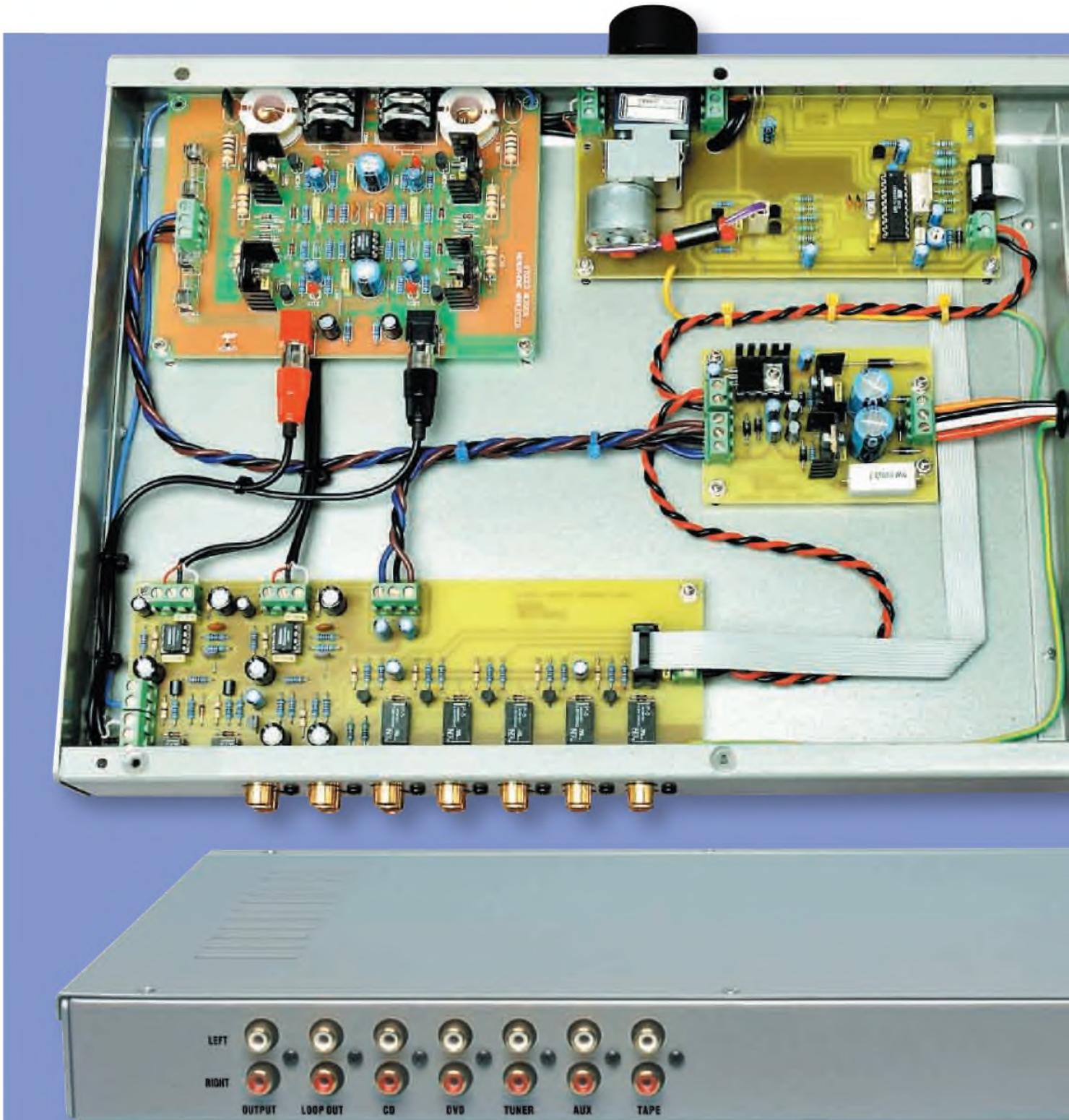
The ±15V and 5V cabling for the modules can be run next. Use heavy-duty, multistrand hook-up wire for the job and twist the wires tightly together to reduce noise and improve appearance. Ensure you use the exact connection arrangement shown, with each module having its own set of power leads back to the power supply outputs.

Prepare each wire end by stripping off about 10mm of insulation. Tin the bare ends with solder and then trim them to about 8mm in length. If you've done it right, you should be able to fit two wires into one terminal block hole.

Audio wiring

All audio connections are made using twin (figure-8) shielded cable. Run the cable between the volume pot and CON2/CON3 on the preamplifier module first, positioning it beneath the headphone amplifier. The 'left' volume cable should be fed through the large

Constructional Project



Top: the supply wiring to the various modules is twisted together to improve the appearance and reduce noise. Note the dress of the flat IDC cable between the preamp module and the control module. Bottom: the self-tapping screws that secure the RCA phono sockets should be tightened before the two chassis-mounting screws for this module.

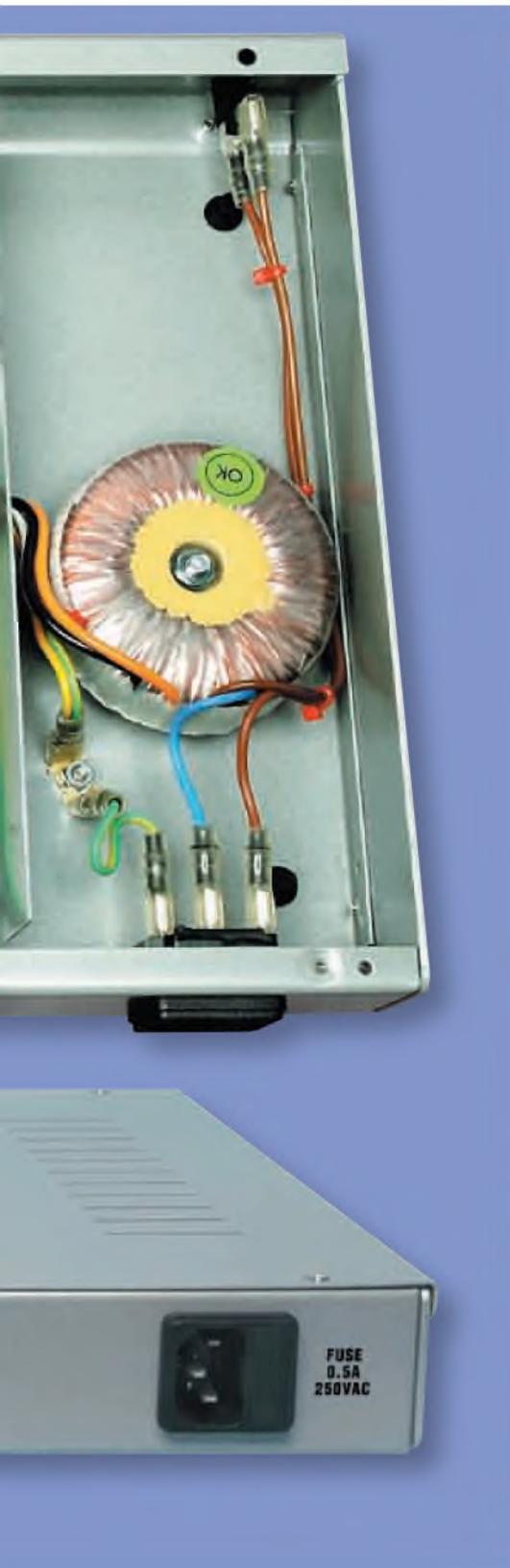
hole just to the rear of CON4 on the remote control board. We've labelled the terminal block connections WIPER, GND and POT to make identification easy.

To prepare each wire end for connection to its terminal block, strip off

about 18mm of the outer insulation, then twist the two shield wires tightly together and tin them with solder. An 8mm length of small heatshrink tubing can then be slipped over the shield wire to improve its appearance. Finally, strip

about 8mm of insulation off the red and white wires and tin these as well.

The connections to the headphone amplifier inputs are made with RCA phono plugs, so fit these to the cable ends first, before wiring the far ends



to CON6 on the preamp module. Finally, run a single, light-duty wire from the SWITCH terminal of CON7 on the preamp to the JACK SW pad on the headphone amplifier. This connection ensures that the audio

Additional Parts For Complete Preamplifier

- 1 1U type low-profile steel case, with internal divider
- 1 32mm black aluminium knob with grub screw
- 1 15V + 15V 30VA (or 20VA) toroidal mains transformer
- 1 SPST 6A 250VAC slimline rocker switch
- 1 snap-in fused male IEC socket
- 1 500mA 250V AC slow-blow fuse
- 1 240VAC 3-pin IEC mains power lead
- 1 6.3mm double-ended chassis-mount spade lug
- 7 6.3mm female spade insulated crimp connectors

Wire and cable

- 470mm heavy-duty red hook-up wire
- 470mm heavy-duty blue hook-up wire
- 470mm heavy-duty brown hook-up wire
- 940mm heavy-duty black hook-up wire
- 400mm light-duty purple hook-up wire
- 650mm figure-8 shielded audio cable
- 250mm 7.5A 250V AC brown wire for mains cabling
- 650mm 7.5A 250V AC green/yellow wire for mains cabling
- 40mm length of 3mm bore heatshrink tubing
- 2 10-way IDC cable-mount sockets
- 390mm 10-way IDC ribbon cable
- 14 small nylon cable ties

Mounting hardware

- 7 self-tapping screws (supplied with the RCA phono sockets)
- 8 M3 x 6mm untapped spacers
- 2 M3 x 10mm untapped spacers
- 10 M3 x 16mm pan head screws
- 10 M3 shakeproof washers
- 10 M3 nuts
- 1 M4 x 10mm screw
- 1 M4 shakeproof washer
- 2 M4 nuts

Note: the infrared remote control handpiece must be purchased separately. We used an Altronics (www.altronics.com) AIFA Y2E (Cat. A 1013) with the prototype, but almost any universal remote should be suitable.

signal is routed to either the RCA phono output or to the internal headphone output, as determined by the insertion and removal of a headphone jack.

Important: if the headphone jack switch isn't connected to the preamp board as described above, then you must insert a shorting link between the two terminals of CON7; otherwise, you'll get no signal from the RCA phono output (CON14)!

Grounding

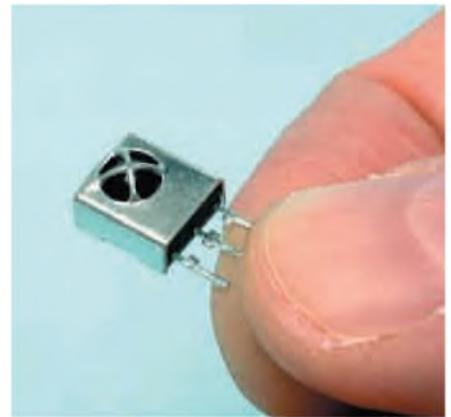
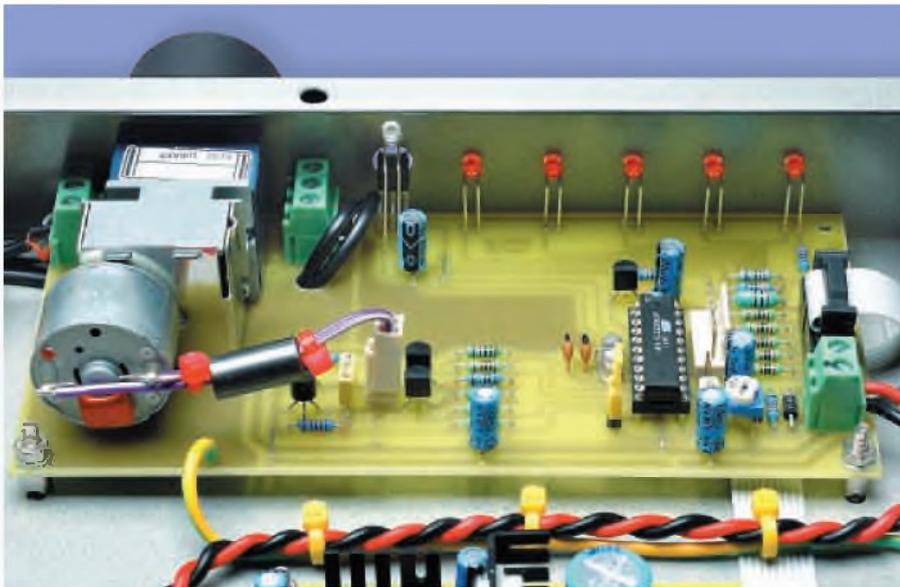
So far, you should have only one wire connected to the chassis earth point – the mains earth wire from the IEC socket. Now run an additional mains-rated green/yellow earth wire from the point marked 'EARTH' on the

remote control module to the chassis earth point. This solidly earths the body of the volume control pot to prevent motor hash or mains hum finding its way into the audio path.

Next, use your meter to make sure that mains earth is not connected to the 0V (GND) rail of the power supply. If it is, you'll need to find the source of the problem before continuing. Even though we intend to earth the audio input as the next step, it is very important that this occurs only via the provided earth point marked on the preamplifier board.

To correctly earth the audio ground, run a second wire from the chassis earth point to the pad marked EARTH on the preamp module, again using mains-rated green/yellow wire. Both

Constructional Project



If your infrared receiver module has a metal shield like this one, then be sure to insulate it from the front panel as described in the text.

the preamp, then try disconnecting the earth wire to the preamp module. **Never, ever disconnect the mains earth from the chassis!**

Well that's about it – enjoy listening to your new stereo preamplifier!

EPE

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The leads of the five red LEDs and the Acknowledge LED (we used blue) are bent at right angles, so that they go through their matching front panel holes. Similarly, make sure that the infrared receiver module lines up with its hole and is flush with the rear surface of the front panel.

earth wires should fit into a single spade crimp terminal to mate with the free end of the chassis-mounted lug.

This earthing method will reduce the chances of creating an audible 'earth loop' in your system, but success is not

guaranteed! For example, if your power amplifier also earths the audio signal, an earth loop will exist once the two are hooked together. This may or may not be a problem. If you notice more hum in your audio system after connecting

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mini Theremin

JUST MOVE YOUR FINGERS NEAR THE ANTENNAS OF THIS THEREMIN TO CREATE YOUR OWN ELECTRONIC MUSIC OR EERIE SCIENCE FICTION SOUNDS. IT'S EASY TO BUILD, EASY TO SET UP AND EASY TO PLAY.

Part 1: By JOHN CLARKE

Main Features

- External pitch and volume span adjustments
- Linear pitch change with hand movement over four octaves
- Linear volume control with hand movement
- Three sound variation controls
- Signal level adjustment
- Internal loudspeaker with headphone listening option
- Loudspeaker/headphone volume control
- Line output with muting switch for amplifier connection
- 12V DC operation from plugpack or battery

min



WHY are Theremins so popular? The answer lies in their great versatility and the uniqueness of the sound they produce compared to conventional instruments. Even relatively simple hand movements can lead to complex and engrossing performances.

Many Theremins produce only simple tones, but some Theremins – such as the unit described here – also allow adjustments to the tonal quality, so that the performance can be altered to suit the mood. Typically, the controls allow a range of sounds that can be varied from raspy-edged tones through to pure sinusoidal notes. The resulting sound can consist of smooth gliding tones (*glissandi*) or it can comprise separate notes (*staccato*) or a combination of both.

It really is a versatile instrument, only limited by the skill of the performer.

Controls

In order to play a Theremin, you must be able to accurately position your hands (and fingers) to produce the required tones. The more accurate

a Theremin is in producing the same frequency (or tone) for a given hand position (ie, distance from the antenna), the easier it will be to play. Similarly, the volume control needs to produce a consistent effect in response to hand movements.

The *Mini Theremin* described here has been designed to provide good consistency for both the pitch and volume ‘antenna controls’. In addition, two external controls have been provided (on the front panel) to adjust the pitch (Pitch Range) and volume (Volume Span) settings. These are required to compensate for any changes that may occur over long periods of time or because of temperature changes.

The linearity of the response to hand movements is another critical feature when it comes to playing a Theremin. It is also critical to ensure the same range of hand movement for each octave and that none of the octaves are compressed into a tight range (which would make playing difficult).

As a result, this unit has been designed to provide excellent linearity

when it is adjusted correctly. This has been made easier by a special test circuit that’s used when setting it up.

Tonal quality

Three further controls are included to adjust the tonal quality or ‘voice’ of the Theremin. The most popular ‘voice’ setting reproduces a cello sound at the lower frequencies, changing to a soprano voice at the upper frequencies. This tonal ‘voice’ creates an interesting backdrop against other instruments, such as a piano or violin.

If you are interested in hearing some fine Theremin performances, log onto <http://www.peterpringle.com/thereminmp3s.html>.

In operation, the ‘voiceing’ can be altered to suit using the waveform, symmetry and skew controls. Each control produces its own characteristic variation in the sound.

The waveform control varies the shape of the signal reproduced by the Theremin. At various settings, the unit produces waveforms that are somewhat triangular in shape, while at other settings it produces either squarer wave shapes or more sinusoidal waves.

Each wave shape has its own distinctive timbre. The squarer wave shapes produce a hollow sound, similar to that produced by a reed instrument. The more triangular waveforms are less hollow, while the sinusoidal shapes give a more neutral or purer sound.

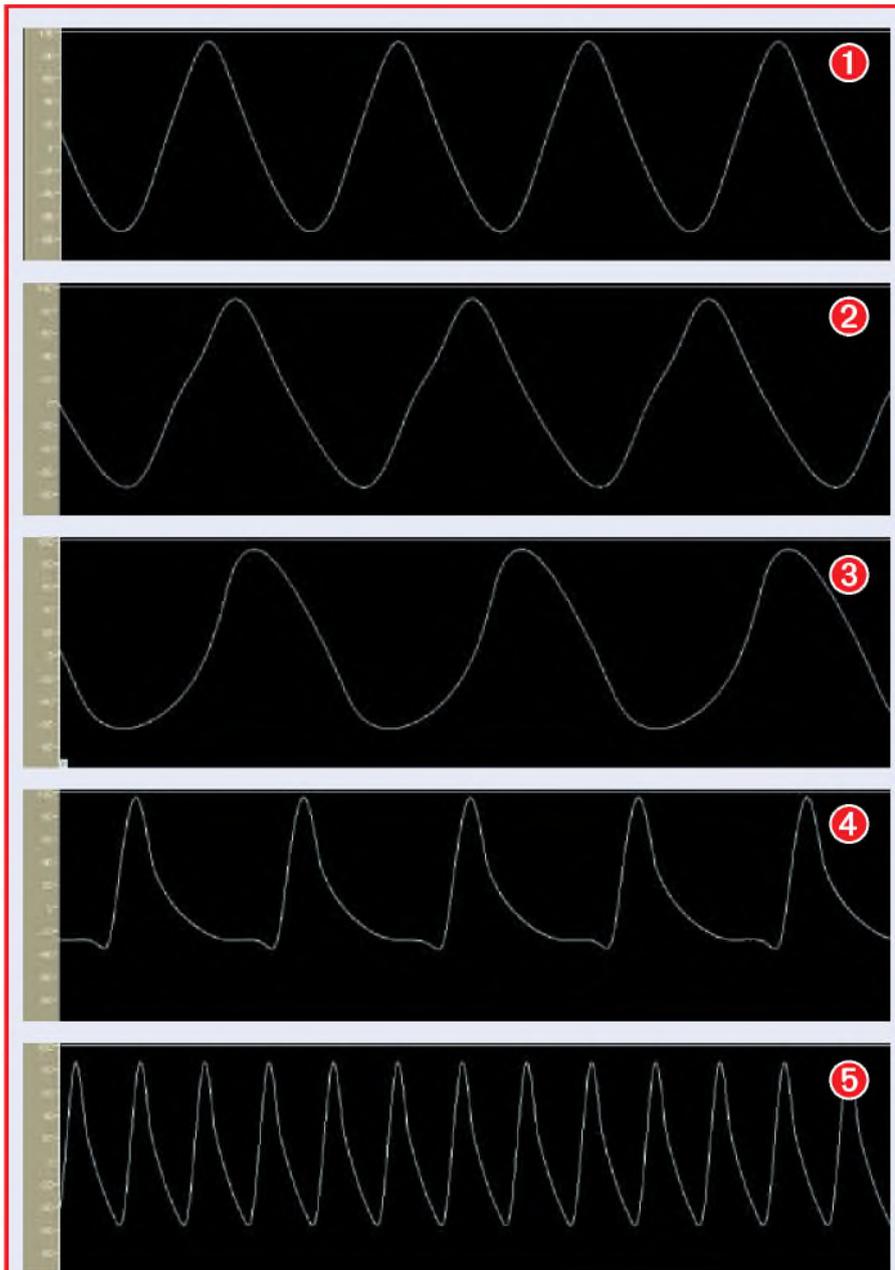
The symmetry control varies the shape of the waveform below the horizontal centre line. You can vary the waveform shape so that it is symmetrical above and below the centre line, or so that the lower half of the waveform becomes more rounded. This rounding produces a sound characteristic of a bowed instrument, such as the cello.

Finally, the Skew control varies the waveform from being symmetrical to asymmetrical (ie, more sawtooth in shape) about the vertical axis. An asymmetrical wave shape produces a brighter, richer sound.

Waveforms 1 to 5 show just some of the variety of waveforms that can be produced by this Theremin.

Note that all three tonal controls interact with one another, so that a whole array of

Constructional Project



Above: these traces show the variety of waveforms that can be reproduced by the Theremin. The top four traces are all at 100Hz and show what can be done with just the Waveform and Symmetry controls, with the skew control set to minimum. Waveform 1 shows the output when the Theremin is set to produce a sinewave. The next waveform (2) is more distorted, with a more triangle characteristic, while waveform 3 has a squarer wave shape. Waveform 4 shows what the Skew control does to the signal at around 100Hz. As can be seen, it becomes very asymmetrical about the horizontal and vertical axis, exhibiting a more sawtooth wave shape.

The final waveform (5) was obtained using the same settings that gave waveform 4, but at a higher frequency of 250Hz, making it more sinusoidal in shape. This characteristic occurs for all waveform shapes at the higher frequencies – a filter adjustment sets the threshold point where the tone becomes more sinusoidal.

subtle sound variations can be reproduced. These variations in the sounds are due to the harmonic content of the waveform. A pure sinewave comprises only the

fundamental frequency, and that is the only tone that you hear. If, for example, you play note A4, then you will hear a pure tone at 440Hz.

Harmonics

Waveforms that are not pure sine-waves include extra signals called harmonics. Harmonics are additional tones that are multiples of the fundamental frequency. So, for example, if you play note A4 again, but produce a square wave, you will hear the fundamental 440Hz plus multiples of that frequency.

Square wave harmonics are always odd and so you will hear the third harmonic ($3 \times 440\text{Hz}$ or 1320Hz), the fifth harmonic at 2200Hz and the seventh and ninth harmonics, etc. Note that the harmonic signal level is lower than that of the fundamental and diminishes with increasing frequency. In fact, in a square wave, the third harmonic is one third the level of the fundamental, while the fifth harmonic is one fifth the level, etc.

Triangle waves also have only odd harmonics, but the harmonic levels drop off much faster than the square wave harmonics. The third harmonic is only one ninth the level of the fundamental and the fifth harmonic is 1/25th of the fundamental's level.

When the wave shape is skewed about the vertical axis to produce a sawtooth shape, or if the symmetry is altered about the horizontal axis, then the harmonic content will include even and perhaps odd harmonics, depending on the waveform. Even harmonics are those that are twice the fundamental frequency, four times the fundamental, and so on. These even harmonics give a stringed-instrument sound effect and can enrich the sound produced by a square or triangle wave.

Gain control

The next control in the lineup is the gain control. This is included to adjust the audio output level on the Theremin's line output socket. It allows the output level to be correctly adjusted in response to different wave shapes.

In practice, the line level output signal is fed out via a 6.35mm mono jack socket. It can be switched on or off using the muting switch.

Monitoring

Normally, you would use the line output from the Theremin to feed an external amplifier and loudspeakers. However, the unit also features an internal amplifier and loudspeaker, which can be used for practice sessions (or as a foldback monitor during live

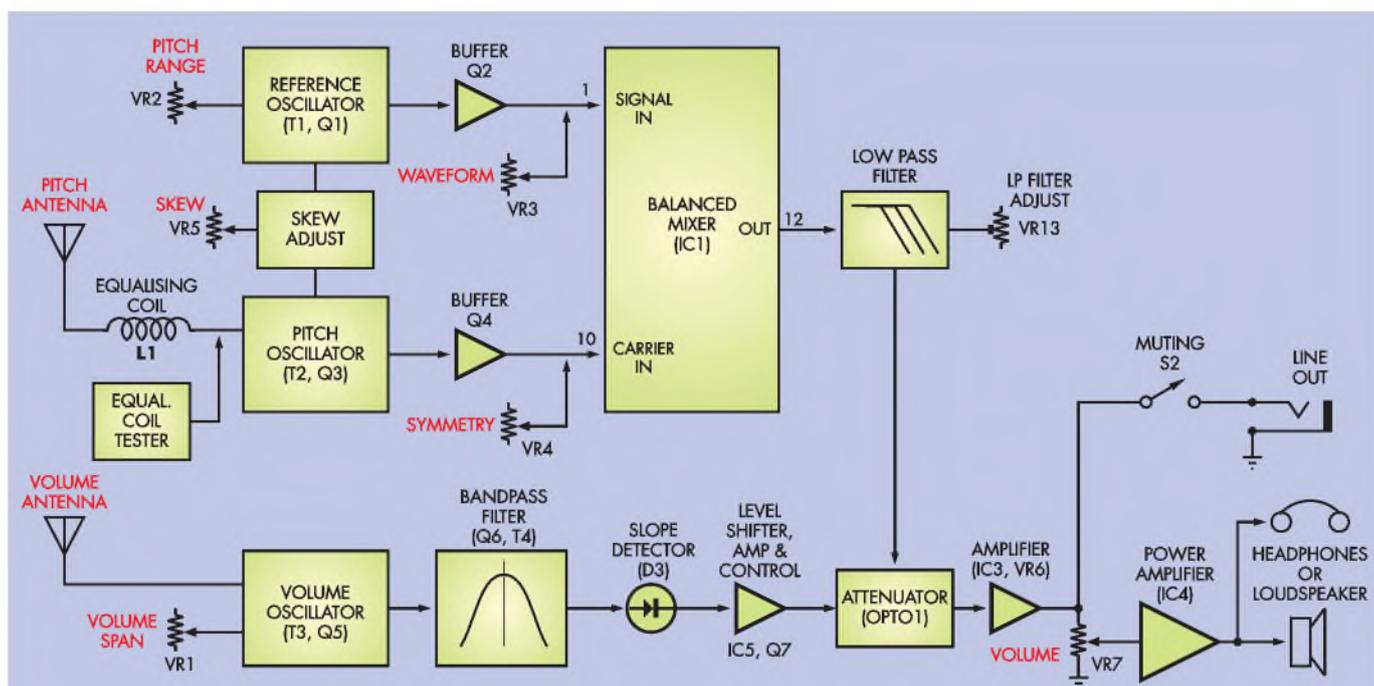


Fig.1: the Theremin is based on three virtually identical oscillators plus a balanced mixer (IC1). The mixer accepts the signals from the pitch and reference oscillators and generates difference signals to produce the tones. These are then fed to the output stages via a voltage-controlled attenuator stage (OPTO1).

performances). A headphone socket is also provided and this automatically disconnects the internal loudspeaker when the headphones are plugged in.

Presentation

As shown in the accompanying photographs, the *Mini Theremin* is housed in a plastic case, which in turn is mounted on a small camera tripod that serves as a desk stand. The pitch antenna sits vertically in the rear right-hand corner of the box, while the volume antenna lies nearly horizontally on the lefthand side of the box.

The controls are arranged along the front of the box, while the line output, headphone and DC supply sockets are on the righthand side, along with the power and muting switches. Circuit power comes from a DC plugpack.

Block diagram

Let's take a look at how the unit works, starting with the block diagram shown in Fig.1.

A balanced mixer (IC1) is at the heart of the operation. This accepts two signals: one from a reference oscillator (based on coil T1 and MOSFET Q1) and the second from a pitch oscillator (based on coil T2 and MOSFET Q3). The latter's frequency is controlled using the pitch antenna, which

is connected to the oscillator via an equalising coil.

Typically, both the reference and pitch oscillators are set to the same frequency, at about 455kHz. Any movement of the hand near to the pitch antenna will then alter its capacitance to ground and change the pitch oscillator's frequency.

In operation, the mixer produces several signals, depending on the incoming signals from the reference and pitch oscillators. These signals are: (1) the original reference oscillator signal (455kHz); (2) the sum of the reference and pitch oscillator frequencies; and (3) the difference between the pitch and reference oscillator frequencies.

When the two oscillators are at the same frequency (eg, 455kHz), then the sum of the two frequencies will be 910kHz, while the difference frequency will be close to zero. The mixer's output is then fed to a low-pass filter, which has a cut-off frequency of 3kHz. As a result, the 455kHz and 910kHz signals are filtered out, leaving only the difference signal.

In this case, however, there will be no output, since the difference signal is zero. However, when the pitch oscillator's output frequency is lowered by moving the hand closer to the pitch antenna, the difference between the

reference and pitch oscillators increases and we get an audible output. The lower the pitch oscillator's frequency, the greater the difference frequency from the mixer and the higher the tone fed to the amplifier stages.

For example, if the pitch oscillator is reduced to 454kHz, the difference frequency will be 1kHz and so we get a 1kHz audio output from the low-pass filter. If it goes down to 453kHz, we get a 2kHz audio output signal.

In practice, the difference signal from the mixer ranges in frequency from 65.4Hz to 2093Hz, which is equivalent to five octaves.

Equalising coil

The equalising coil in series with the pitch antenna vastly improves the linearity of any frequency changes with hand movement. Without it, these frequency changes would be very non-linear – very large hand movements would be required to produce pitch changes at the low-frequency end, while only minute hand movements would be required at the high-frequency end.

This 'compression' of the frequency range for hand positions close to the antenna is due to the way a tuned circuit works. The variations in capacitance with hand movement are linear with the distance from the antenna.

Origin Of The Theremin

IN 1919, A RUSSIAN PHYSICIST named Lev Termen (or Leon Theremin as he is called in the west) invented an electronic musical instrument called the 'Theremin'. At that time, the Theremin was innovative and unique in the musical world and was essentially the first electronic instrument of its kind. Playing it was also unique, the technique relying solely on hand movements in the vicinity of two antennas to control two electronic oscillators – one antenna to vary the pitch of the sound and the other to change the volume.

In operation, the pitch change afforded by the antenna is infinitely adjustable over several octaves, with the frequency increasing as the hand is brought closer to the antenna. An ear for pitch and fine hand control are essential requirements to become proficient at playing the Theremin.

To a large extent, the Theremin was made famous by recitalist Clara Rockmore. Born in Lithuania in 1911, she was an accomplished violinist by the age of five. She began to learn to play the Theremin after meeting Leon Theremin in 1927 and developed a unique technique for playing the instrument. This involved minute finger movements to capture and modulate the tone of the note and enabled her to play the instrument with great precision.

The Theremin was subsequently further developed and manufactured by the Radio Corporation of America (RCA) around 1929. This design consisted of a large box with an attached antenna and wire loop. The antenna provided the control for the pitch while the loop enabled the volume to be adjusted.

In practice, the pitch control antenna was mounted vertically while the volume loop sat horizontally, to minimise interaction between them. And of course, the circuit used valves.

General Electric (GE) and Westinghouse also made Theremins in the 1920s. However, the number of units produced was quite modest, with only about 500 units being made.

Today, the Theremin is hailed as the forerunner to modern synthesised music and was instrumental in the development of the famous Moog synthesisers. Because of its unique sound, it has been popular with music producers for both film and live performances. For example, it was used to produce background music in *The Ten Commandments* feature film by Cecil B DeMille. Its eerie sounds have also made it ideal for science fiction movies, including *The Day the Earth Stood Still* and *It Came From Outer Space*, and in thriller movies such as *Spellbound* and *Lost Weekend*.

In addition, bands such as the Bonzo Dog Band and Led Zeppelin have embraced the Theremin. The Beach Boys used an instrument similar to the Theremin – called an Electro-Theremin (also named a Tannerin) – in their famous *Good Vibrations* hit from the 1960s. The Electro-Theremin differs from the Theremin in that it incorporates a mechanical controller to adjust the pitch rather than hand movements relative to an antenna.

Many commercial Theremins are available on the market today, including the Etherwave series from Moog Music Inc, PaiA's Theremax and Wavefront's Classic and Travel-Case Theremins.

resonant frequency. However, this frequency shift will be much greater than the corresponding frequency change of the pitch oscillator. That is because the effect of hand capacitance (just a few picofarads) is far greater on the 12pF antenna capacitance than it is on the much larger 220pF capacitor in parallel with the pitch oscillator coil.

The overall effect is that your hand has a progressively smaller effect on the pitch oscillator as it is brought closer to the antenna. This introduced non-linearity counteracts the non-linearity inherent in the pitch oscillator and makes pitch changes much more linear for given hand movements.

Waveform shaping

The waveshape of the output is controlled using the waveform, symmetry and skew potentiometers (VR3 to VR5). Both the waveform and symmetry controls work by changing the DC bias levels on both the signal and carrier inputs of the mixer. A different bias voltage affects the wave shape that's applied to a particular input of the mixer and this changes the resulting output waveform.

Note that buffer stages (Q2 and Q4) are included in series with the outputs of the reference and pitch oscillators before the signal is applied to the mixer. These isolate the oscillators from the DC bias voltages at the mixer inputs, to prevent unwanted changes to the oscillator frequencies.

The Skew adjustment (VR5) varies the coupling between the pitch and reference oscillators, in turn varying their tendency to lock to the same frequency. When both oscillators are running close to the same frequency, increasing the skew control will cause the two oscillators to lock and so their output frequencies will be the same.

However, if extra hand capacitance forces the pitch oscillator to change, it will suddenly 'snap' to a different frequency. At the same time, the reference oscillator will continue to have an affect and so the resulting output waveform from the mixer will be 'skewed'.

Low-pass filter

As mentioned, the adjustable low-pass filter following the mixer output removes the higher frequencies from the mixing process, leaving only the difference frequency. Its frequency of roll-off can be varied from 3.3kHz

However, the frequency of a tuned circuit is inversely proportional to the square root of the capacitance. As a result, greater pitch variations occur for a given hand movement the closer one gets to the antenna.

Adding the equalising coil has the effect of reducing the hand movements required for the lower octaves and increasing the hand movements required for the upper octaves, so that the overall response is much more linear. When adjusted correctly, the resulting improvement in linearity is almost magical!

The equalising coil works by setting up a resonant circuit. The resonant frequency is set to be just below the 'at rest' frequency of the pitch oscillator and is based on the coil's inductance (about 10mH) and the capacitance of the antenna (about 12pF). The corresponding components in the pitch oscillator have an inductance of 560μH and a capacitance of 220pF (both inside coil T2).

Any hand movement near the antenna will increase its capacitance and thus cause a reduction in the

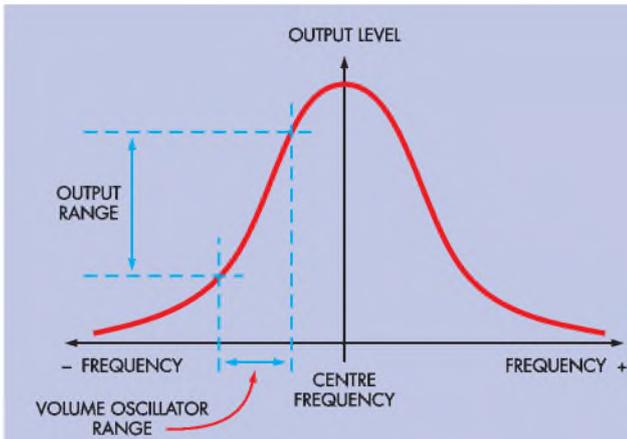


Fig.2: this graph shows the response of the bandpass filter. It reduces the signal level as the frequency of the volume oscillator decreases.

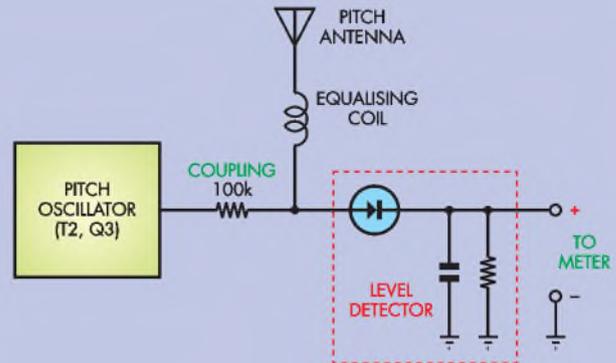


Fig.3: this is the basic arrangement for the equalising coil tester. It allows the pitch oscillator to be correctly adjusted so that the equalising coil and pitch antenna resonate, as indicated by a voltage dip on the output meter.

down to 592Hz, depending on the effect required.

Following this filter, the signal is fed to an attenuator and then to amplifier stage IC3. This stage has a gain of between two and seven, depending on the setting of Gain control VR6.

The output from IC3 then goes to the line out socket via muting switch S2. It also goes to power amplifier IC4 via Volume control VR7. The power amplifier then drives an internal loudspeaker or a pair of headphones.

Volume control oscillator

The volume oscillator is based on transistor Q5 and transformer coil T3. As with the pitch oscillator, its frequency varies in response to hand movement.

In operation, its frequency reduces as the hand is brought closer to the volume antenna. The resulting signal is then fed to a bandpass filter that rolls off signals above and below its centre frequency. Fig.2 shows the response shape of this bandpass filter.

The bandpass filter is set so that its centre frequency is above the frequency range of the volume oscillator – ie, the frequency of the volume oscillator is to the left (or lower frequency side) of the peak in the filter response curve. Therefore, as the oscillator's frequency decreases, the filter reduces the signal level.

The output from the bandpass filter is fed to a slope detector based on diode D3. This converts the signal to a DC voltage, which is then applied to a level-shifting amplifier based on IC5. In turn, its output controls the audio attenuator stage.

Equalising coil tester

Finally, we come to the equalising coil tester, which is attached to the pitch oscillator. This tester allows the equaliser coil to be checked with the pitch oscillator, to verify that its value is correct. Fig.3 shows the basic arrangement.

In operation, the pitch oscillator's output is lightly coupled to the pitch antenna via the equalising coil (L1). The oscillator frequency is then adjusted until the following level detector circuit detects the resonance, as indicated by a voltage dip on the meter.

Circuit details

That covers the basics. Now let's take a look at the complete circuit diagram for the *Mini Theremin* – see Fig.4.

The first thing to note is that all three oscillators (reference, pitch and volume) are virtually identical. Each oscillator is based on a junction FET (JFET Q1, Q3 and Q5) and a standard IF (intermediate frequency) transformer coil (T1 to T3), as used in low-cost AM radio tuners.

Each transformer includes a tapped primary winding and a parallel-connected capacitor to form a tuned circuit. Its corresponding JFET drives a portion of the primary winding (ie, between the pin 2 tap connection and ground), while the signal at the top of the primary is coupled to the gate (G)(which is self-biased) via a 68pF capacitor.

This arrangement provides positive feedback to maintain oscillation at the tuned frequency. In the case of the

reference oscillator, transformer T1 is tuned to produce an output frequency of about 455kHz.

Power for the circuit comes from a +8V rail and this is applied to transistor Q1's drain (D) via potentiometer VR2 and a 220Ω resistor. VR2 provides pitch adjustment by varying the drain-to-source current flow through Q1. This alters the gate-to-source voltage and thus Q1's gate-to-source capacitance. And this in turn alters the tuned frequency.

T1's secondary winding at pins 4 and 6 provides a low impedance output from the oscillator. This output is then further buffered using an amplifier stage based on JFET Q2, which is configured as a source follower. This buffering is essential to isolate the oscillator from the following stages, so that it is immune to any capacitance changes caused by varying the bias levels at the inputs to IC1.

The pitch oscillator is almost identical, the main difference being the use of a fixed 680Ω resistor in Q3's drain circuit. In addition, the pitch antenna is connected to pin 1 of transformer T2 via a 1nF capacitor and the equalising coil (L1).

The equalising coil test circuit is also attached to this part of the oscillator circuit during testing. In this case, the oscillator signal at pin 1 of transformer T2 (marked 'Test') is coupled into the pitch antenna via a 100kΩ resistor. This resistor ensures only minimal loading of the equalising coil and antenna-tuned circuit.

Diode D2 and the 10nF capacitor form a peak detector and this allows

Constructional Project

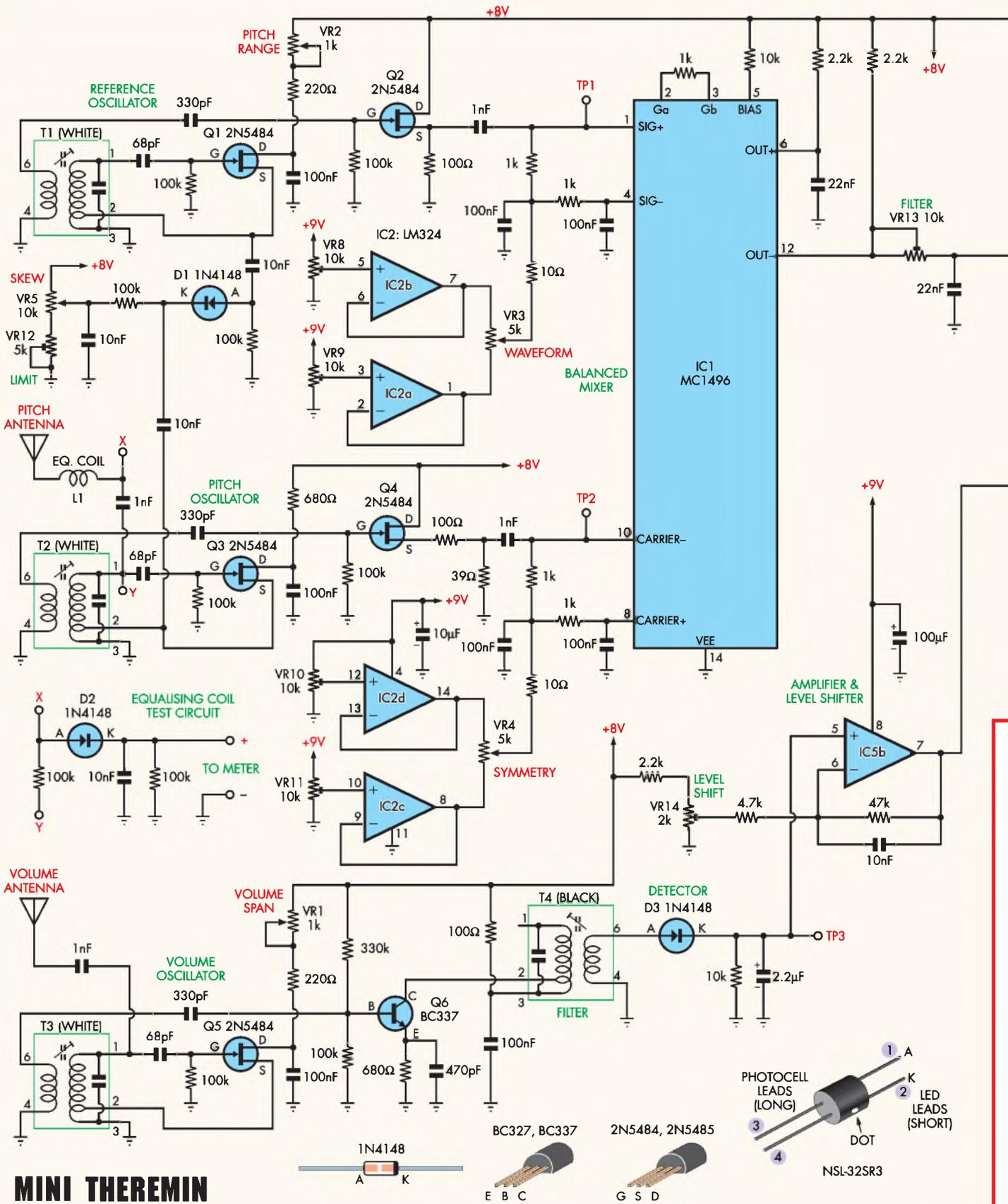


Fig.4: the complete circuit diagram for the Mini Theremin. Each oscillator is based on a junction FET (JFET Q1, Q3 and Q5) and a standard IF transformer coil (T1 to T3). IC1 is the balanced mixer – it produces the difference signal and feeds this to the audio output stages via an attenuator (OPTO1), in turn controlled by the volume oscillator and its following stages.

Parts List – Mini Theremin

- 1 PC board, code 670, available from the EPE PCB Service, size 188 x 103mm
- 1 plastic utility case, size 197 x 113 x 63mm
- 1 12V DC 450mA plugpack
- 1 190 x 105mm aluminium sheet (1mm thick)
- 1 100mm 4Ω 2W loudspeaker
- 2 high-quality stereo switched 6.35mm jack sockets, PC-mount
- 1 2.5mm PC-mount DC socket
- 2 SPST ultra-mini rocker switches (S1, S2)
- 1 mini tripod (Jaycar AM-4112 or similar)
- 1 mini heatsink, 19 x 19 x 10mm
- 1 M4 x 25mm nylon screw
- 1 M4 nut
- 9 M3 x 6mm screws
- 9 M3 nuts
- 3 4mm eyelet crimp connectors
- 4 4.8mm female spade connectors
- 7 plastic knobs to suit (do not use metal knobs)
- 20 PC stakes
- 1 400mm length of 0.7mm tinned copper wire
- 1 12m length of 0.25mm enamelled copper wire
- 1 250mm length of medium duty hook-up wire
- 1 green banana socket
- 1 11mm OD x 4mm ID x 2.5mm nylon spacer or similar (eg, 3 x M4 nylon washers)
- 1 300mm length of green hook-up wire

Transformers and ferrites

- 2 pot cores, 26 x 11.5 x 8mm (Jaycar Cat. LF-1060 or equivalent) (L1)

- 1 bobbin to suit above cores (Jaycar Cat. LF-1062 or equivalent)
- 3 low-cost 455kHz 2nd IF transformers (white slug) (T1 to T3)
- 1 low-cost 455kHz 3rd IF transformer (black slug) (T4)

Potentiometers

- 2 1kΩ 16mm PC-mount, linear (VR1, VR2)
- 3 5kΩ 16mm PC-mount, linear (VR3, VR4, VR6)
- 1 10kΩ 16mm PC-mount, linear (VR5)
- 1 10kΩ 16mm PC-mount, log (VR7)
- 4 10kΩ multiturn, top-adjust, trim-pots (code 103) (VR8 to VR11)
- 1 5kΩ multiturn, top-adjust, trimpot (code 503) (VR12)
- 1 10kΩ trimpot, horizontal (code 103) (VR13)
- 1 2kΩ multiturn, top-adjust, trimpot (code 203) (VR14)

Antenna Parts

- 1 375mm length of 16mm diameter plated steel or stainless steel tubing
- 1 125mm length of 16mm diameter plated steel or stainless steel tubing
- 2 chromed towel rail end brackets to suit above tubing
- 2 16mm ID plastic end caps
- 1 miniature tripod with ¼-inch mount
- 2 M4 x 10mm screws
- 2 M4 x 15mm screws
- 4 M4 nuts
- 1 ¼-inch tee nut

Semiconductors

- 1 MC1496 balanced modulator (IC1)
- 1 LM324 quad op amp (IC2)
- 1 TL071 JFET input op amp (IC3)
- 1 LM386 1W power amplifier (IC4)
- 1 7809 +9V 1A regulator (REG1)
- 1 7808 +8V 1A regulator (REG2)
- 5 2N5484 or 2N5485 JFETs (Q1 to Q5)
- 1 BC337 NPN transistor (Q6)
- 1 BC327 PNP transistor (Q7)
- 3 1N4148 diodes (D1 to D3)
- 1 1N4004 1A diode (D4)
- 1 NSL-32SR3 optocoupler (Silonex) (OPTO1) Farnell Cat. 369-2218
- 1 5mm red LED (LED1)

Capacitors

- 1 1000μF 16V PC electrolytic
- 1 470μF 16V PC electrolytic
- 3 100μF 16V PC electrolytic
- 7 10μF 16V PC electrolytic
- 1 2.2μF 16V PC electrolytic
- 1 220nF MKT polyester
- 8 100nF MKT polyester
- 1 47nF MKT polyester
- 2 22nF MKT polyester
- 6 10nF MKT polyester
- 4 1nF MKT polyester
- 1 470pF ceramic
- 3 330pF ceramic
- 3 68pF ceramic

Resistors (0.25W 1% carbon film)

- 1 330kΩ 2 680Ω
- 10 100kΩ 1 330Ω
- 1 47kΩ 2 220Ω
- 2 22kΩ 1 150Ω
- 4 10kΩ 3 100Ω
- 1 4.7kΩ 1 39Ω
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signal is AC-coupled to a 100kΩ resistor in series with the pin 3 input of amplifier stage IC3. This input is biased to 4.5V via the 10kΩ voltage divider resistors across the 9V supply and a second 100kΩ resistor. This allows the op amp to produce a symmetrical output voltage swing before clipping. The 4.5V bias supply is decoupled using a 100μF electrolytic capacitor to remove any signal ripple.

The signal level applied to pin 3 of IC3 is controlled by OPTO1, which is

an opto-coupled LDR (light-dependent resistor). This in turn is controlled by the volume oscillator and its following circuitry. As shown, the LDR is connected between pin 3 of IC3 and the 4.5V rail.

Normally, the LDR has negligible effect on the signal, because its resistance is considerably higher than the 100kΩ resistor at pin 3 of IC1. However, when current flows through the LED in OPTO1, the resistance of the LDR falls. This shunts the signal from pin 3 to the 4.5V rail.

In operation, the LDR's resistance has a range from about 25MΩ down to 60Ω, giving an attenuation range from 0dB to -64dB.

As discussed previously, hand movements over the volume antenna control the amount of attenuation. It works as follows. First, the signal from the volume oscillator (T3 and Q5) is fed to the bandpass filter, which is based on transistor Q6 and tuning coil T4. Coil T4 is tuned so that the output signal at its pin 6 decreases in level as the

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- | | |
|----------|--------|
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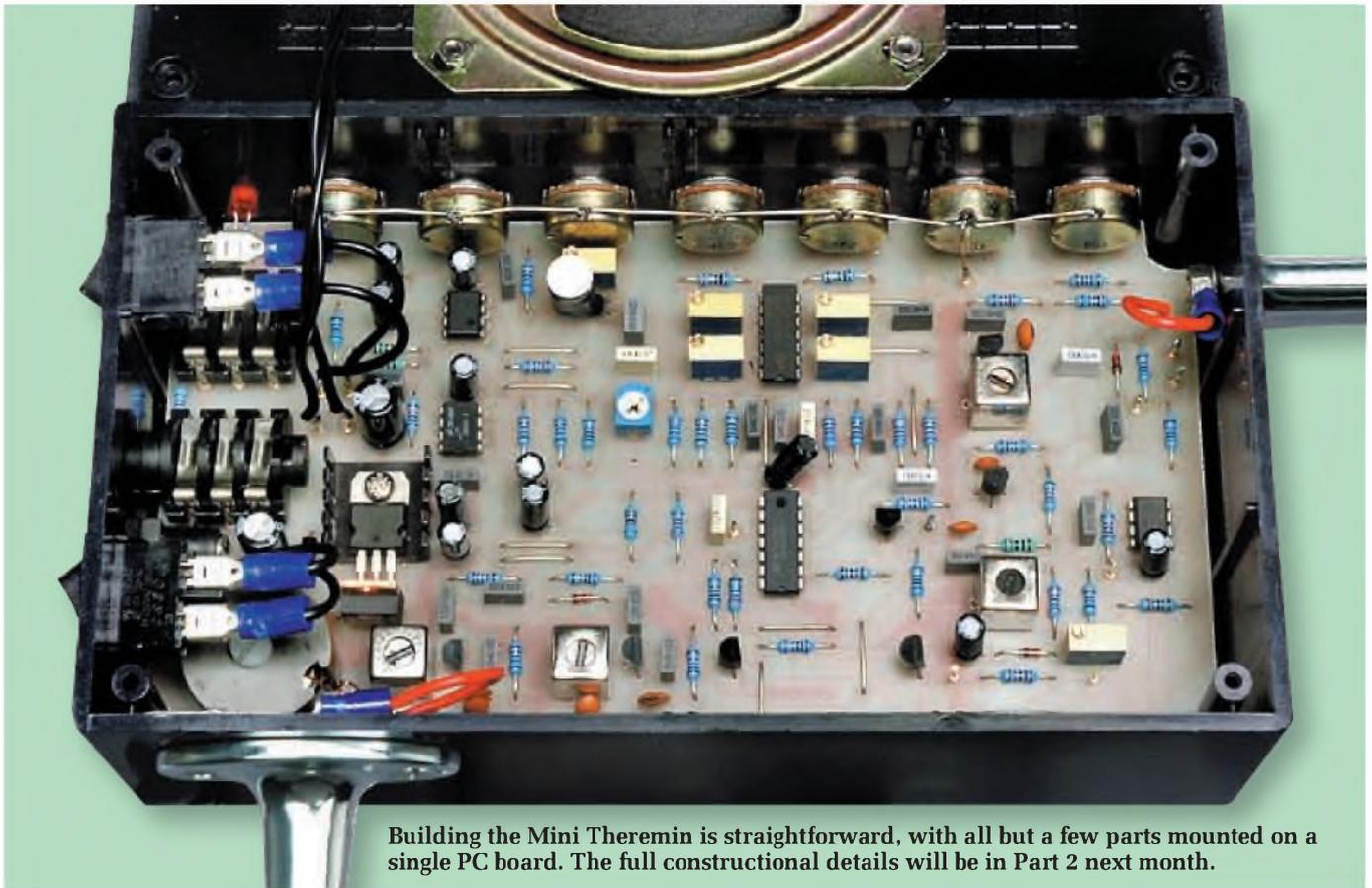
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Building the Mini Theremin is straightforward, with all but a few parts mounted on a single PC board. The full constructional details will be in Part 2 next month.

volume oscillator frequency decreases (ie, as the hand moves closer to the volume antenna).

Diode D3 rectifies this signal and its output is filtered using a $2.2\mu\text{F}$ capacitor to provide a DC voltage. The associated $10\text{k}\Omega$ resistor across the capacitor provides a discharge path, thus allowing the voltage across the capacitor to fall if the signal level falls.

This voltage is fed to IC5b, which is wired as a non-inverting amplifier and level shifter. Trimpot VR14 adjusts the output offset of the amplifier, so that it can be set to vary from about 8V down to nearly 0V with hand movement.

IC5b's output appears at pin 7 and drives PNP transistor Q7, which is wired as an emitter follower. This in turn drives the LED within OPTO1, via a 330Ω resistor. The anode side of the LED is connected to the 8V supply.

Note that there are two supply rails, 8V and 9V. Op amp IC5 is powered from the 9V supply, while the LED is powered from the 8V supply. The extra volt for the op amp is to ensure that IC5b's output can swing high enough to switch Q7 and the LED fully off.

Power amplifier IC4 is also powered from the 9V rail, while the more 'voltage-sensitive' sections of the circuit are powered from the 8V rail. This separation of supply rails ensures that IC4 can drive the loudspeaker at full power without affecting other parts of the circuit.

Op amp IC3 buffers the attenuated signal and also provides gain that can be varied from two to seven, depending on the setting of gain control VR6. The 10nF capacitor between pins 2 and 6 rolls off high frequencies to prevent instability.

IC3's output appears at pin 6 and is AC-coupled to mute switch S2 in series with the line output socket (CON1). The series 150Ω resistor serves to isolate IC3's output from the load connected to the line out.

IC3's output is also fed to volume control VR7 via a $10\mu\text{F}$ capacitor. From there, the signal goes to pin 3 of power amplifier IC4 via a 220nF capacitor. IC4 then drives the Theremin's loudspeaker or a pair of headphones, via a $1000\mu\text{F}$ capacitor and connector CON2. Plugging the headphones into CON2 automatically disconnects the loudspeaker.

Note that a Zobel network comprising a 10Ω resistor and 47nF capacitor is connected across IC4's output. This is done to prevent oscillation in the amplifier.

Power supply

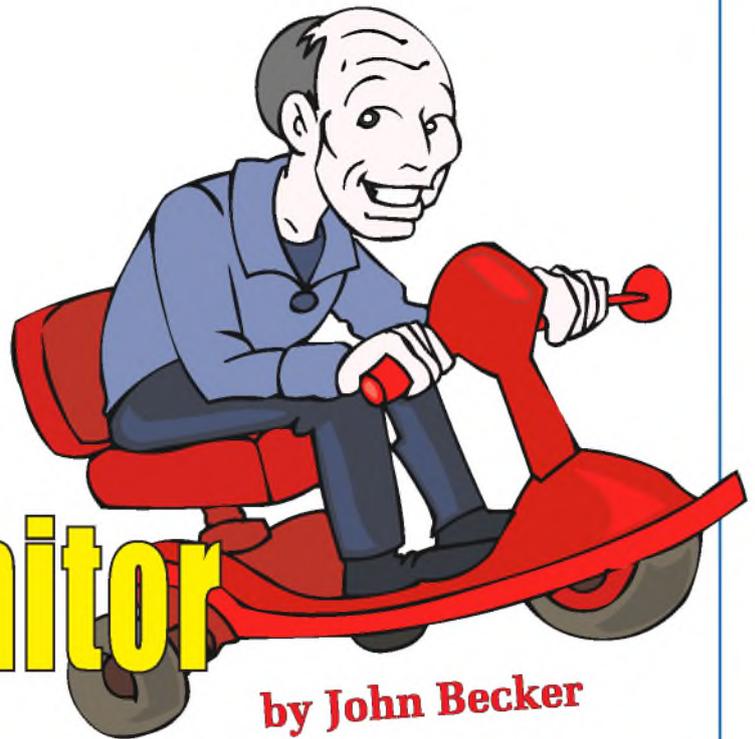
Power for the circuit is supplied from a 12V DC plugpack. This is fed to the circuit via power switch S1 and diode D4, which provides reverse polarity protection. LED 1 provides power on/off indication, while a $470\mu\text{F}$ electrolytic capacitor filters the supply rail before it is applied to three-terminal voltage regulators REG1 and REG2.

Regulators REG1 and REG2 respectively provide the regulated +9V and +8V supply rails. Their outputs are decoupled using two $10\mu\text{F}$ capacitors.

That's all we have space for this month. Next month, we will give the full construction details and describe the setting-up and adjustment procedures.

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Electric Mobility Buggy Monitor



by John Becker

Monitoring distance travelled (and other facts of general interest) by any small-wheeled vehicle.

HAVING recently had the misfortune to damage one of his feet, the author bought a battery-powered mobility buggy to help him get around while it mends. Within hours of using it for the first time, he immediately regretted that it did not have a distance-travelled meter.

The project described provides just that, and more – journey distance in miles or kilometres, elapsed time for journey, total distance ever travelled, current speed, and ambient temperature in Fahrenheit or Celcius.

Wheelies

The unit has been designed so that it can be readily set for wheel diameters from less than 150mm (six inches) to over 610mm (24 inches), making it suitable for virtually any small-wheeled vehicle, including golfing buggies and bicycles, having maximum wheel rotations of up to about 15 per second.

There is barely any mechanical assembly required, and the author's unit uses standard plastic plumbing

pipe with self-adhesive attachment. Electronically, the unit is PIC controlled, uses a magnet plus flux-gate rotation sensor, a temperature-monitoring IC, and a 2-line × 16-character liquid crystal display (LCD). It can be battery powered from about +7V to +15V.

Circuit diagrams

The main control circuit diagram is shown in Fig.1, with the rotation sensor circuit in Fig.2.

In Fig.1, IC2 is the controlling PIC-16F876A (or PIC16F876), operating at a rate of 3.2768MHz, as set by crystal



X1. The LCD is notated as X2, operated in 4-bit mode, with its contrast set by preset potentiometer VR1. The temperature sensor is an LM35CZ, notated as IC3, monitored via PIC pin RA0 used in analogue mode. The software is written for temperatures from 0°C upwards (the author does not intend to go out in sub-zero conditions!).

IC1 is a +5V 100mA regulator, which regulates the voltage supplied to the whole circuit, accepting the earlier stated battery voltage input range.

In the distance

S1 is the power on-off switch, it automatically causes the current distance travelled to be added to the total distance ever travelled when power is switched off. Normally, when the power is switched on, PIC pin RA3 is held high via switch S1b. When switch S1a/b is turned off, the S1b section removes the positive voltage from RA3, and resistor R4 pulls the pin low.

The software detects this and immediately goes into the mode which stores the current distance value, adding it to that previously stored. Due to the size of capacitor C1, the PIC has time to do this before the +5V power supply drops below the PIC's acceptable operating voltage.

In normal running mode, the previous total distance travelled can be shown by switching S1 (see below).

Switches S2 and S3 have multiple purposes, as will be discussed later, allowing wheel diameter setting, temperature adjustment, and recall of total distance travelled. Resistors R1 and R2 bias low PIC pins RA1 and RA2, to which switches S2 and S3 are connected.

The choice of whether distance and temperature unit values are expressed in miles or kilometres, and Fahrenheit or Celcius is controlled by the setting of the link wires notated A to D.



Previous total distance display. The K suffix indicating kilometres

Sensor circuit

In Fig.2, X3 represents the flux-gate sensor, the familiar and popular FGM-3 device from Speake Electronics (www.speakesensors.com). This detects the

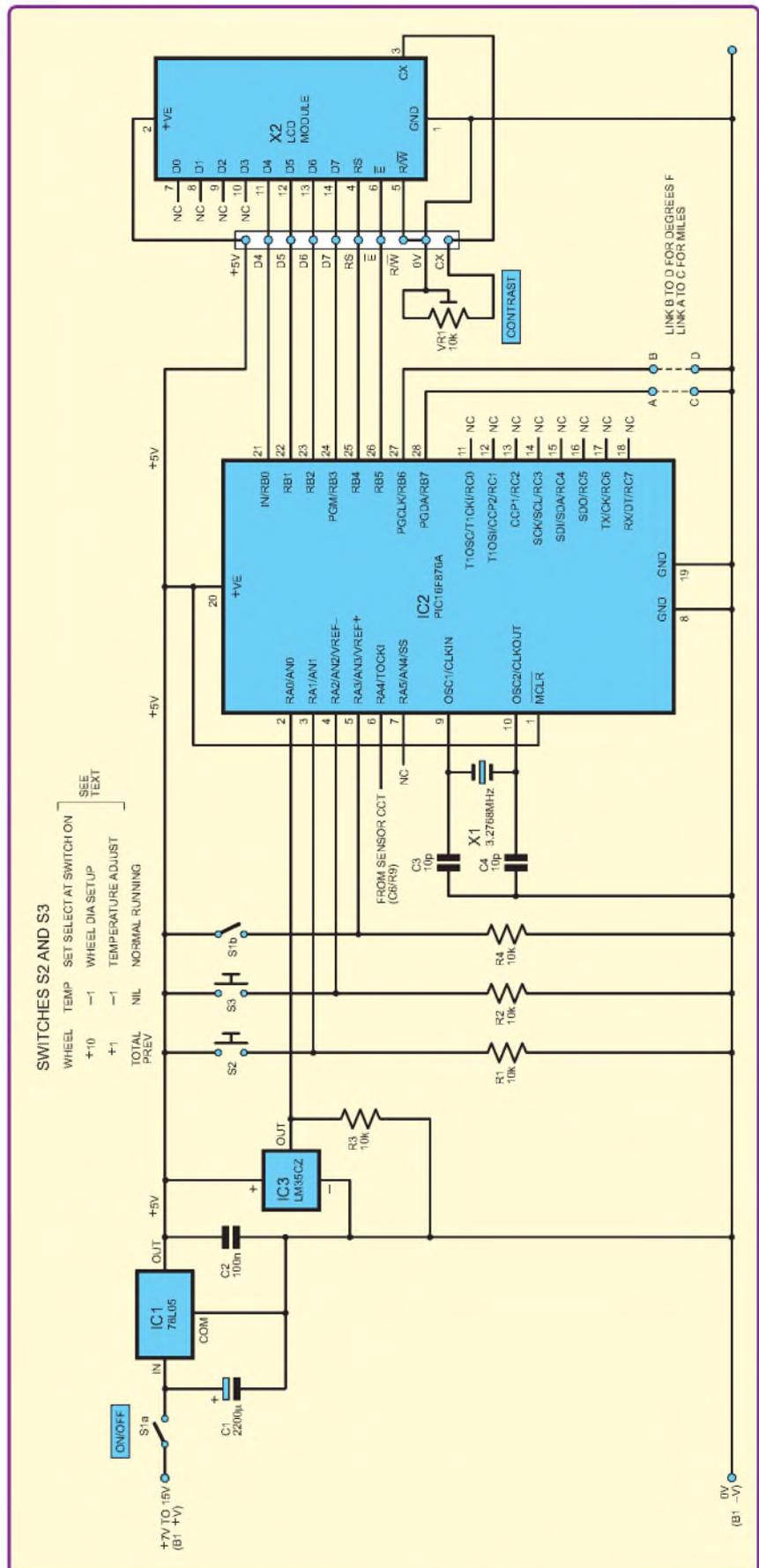


Fig.1: Main control circuit diagram for the Buggy Monitor

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passing of a magnet attached to one wheel of the vehicle. It outputs a frequency which varies in respect to the magnetic field that it detects.

A phase-locked loop device, type CMOS 4046, IC4, compares the input frequency with the internal frequency set by the combination of capacitor C5, resistor R6 and preset potentiometer VR2. The setting of the latter is not critical and is easily adjusted.

In response to the frequency comparison, IC4 outputs a DC voltage at pin 13, which varies according to how close the two frequencies match. Capacitor C6 and resistor R9 form a low-pass filter whose output swing is monitored by PIC pin RA4 (IC2), which has a Schmitt trigger input. That pin's resulting logic status is monitored by the PIC as trigger pulses caused by the magnet passing the sensor. (The technique is the same as that used by the author in his *PICagoras* bicycle distance monitor published in *EPE* April-May 1997).

PCB assembly

Details for the assembly and track layout of the printed circuit board (PCB) are shown in Fig.3. This board is available from the *EPE PCB Service*, code 669.

Assemble the board in order of ascending component size, starting with the single fixed link wire just above IC2. Use DIL (dual-in-line) sockets for IC2 and IC4. Temperature unit setting is: link B to D for degrees in Fahrenheit, or left unmade for degrees Celsius. Distance unit setting is: link A to C for distance in miles, or left unmade for distance in kilometres – the choice is yours. Ensure that polarity-conscious components, such as semiconductors and electrolytic capacitors are correctly oriented.

Before inserting IC2 to IC4, or connecting the LCD (X2) and sensor X3, check that when battery power is switched on, regulator IC1 outputs a voltage of +5V, within a few millivolts. Thoroughly check the assembly before applying power. When satisfied, insert the remaining ICs, noting that IC2 has to be pre-programmed with the software hex file.

Software notes

The software files are available for free download via the *EPE* Downloads site, access via www.epemag.co.uk. Pre-programmed PICs are available from Magenta Electronics

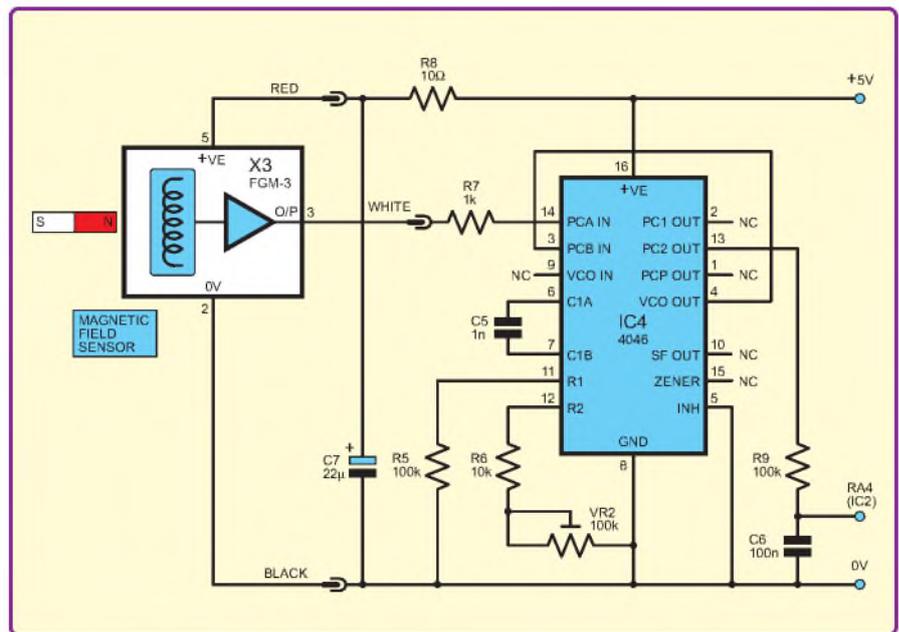


Fig.2: Circuit diagram for the flux-gate sensor section of the Buggy Monitor

Parts List – Electric Mobility Buggy Monitor

- 1 PC board, code 669, available from the *EPE PCB Service*, size 70mm x 50mm
- 1 plastic case, size 150 x 80 x 50mm approx.
- 1 FGM-3 flux-gate sensor (see text) (X3)
- 1 2-line 16-character (per line) alphanumeric liquid crystal display (X2)
- 1 3.2768MHz crystal (X1)
- 1 min. toggle switch, DPDT (S1)
- 2 single-pole min. pushbutton switches, push-to-make, release-to-break (S2, S3)
- 1 16-pin DIL socket
- 1 28-pin DIL socket
- 1 4-way SIL header pin strip
- 1 6-way SIL header pin strip
- 1 12-way SIL header pin strip
- 1 9V battery (PP3 type), with snap-on clips (B1)
- 4 self-adhesive plastic PCB stand-off pillars
- 2 3-pin DIN connector pairs (see text)

Length of coloured ribbon cable (for linking board to display module); length of plastic covered 3-core general purpose cable for linking unit to buggy; 22mm dia. plastic plumbing fittings etc to suit (see text); multistrand connecting wire; 1mm solder pins; solder, etc.

Semiconductors

- 1 78L05 +5V 100mA voltage regulator (IC1)
- 1 *PIC16F876A-04 microcontroller (or *PIC16F876-04), see text (IC2)
- 1 LM35CZ temperature sensor (IC3)
- 1 4046 phase-locked loop, with VCO (IC4)

Capacitors

- 1 2200μF radial elect. 16V (C1)
- 1 22μF radial elect. 16V (C7)
- 2 100nF ceramic disc, 0.1in pitch (C2, C6)
- 1 1nF ceramic disc, 0.1in pitch (C5)
- 2 10pF ceramic disc, 0.1in pitch (C3, C4)

Potentiometers

- 1 10kΩ min. round carbon preset (VR1)
- 1 100kΩ min. round carbon preset (VR2)

Resistors (0.25W, 5% carbon film)

- 1 1kΩ (R7)
- 5 10kΩ (R1 to R4, R6)
- 2 100kΩ (R5, R9)
- 1 10Ω (R8)

* Preprogrammed PICs are available from Magenta Electronics (www.magenta2000.co.uk)

– see their advert in this issue for contact details.

As supplied, the software has been set for a PIC16F876A device. The earlier PIC16F876 (without suffix) may be used by those who have PIC-programming facilities. First amend the ASM file near its start, with all references to PIC16F876A changed to PIC16F876, and then recompile the hex file.

The program was written in the TASM dialect, but it is compatible with MPASM-type assemblers.

Initial setting up

Once the unit has been completely assembled in the workshop, and before installing on the buggy, it's time to carry out some bench tests and setting up procedures.

The first job is to set the diameter of the wheel you wish to monitor, in millimetres. Before applying power, press and hold switch S2, then apply power via S1. This causes the program to go into wheel diameter setting mode. When you're ready, do so.

After the unit has been powered up, do not release S2. At this time, nothing may be shown on the LCD



Prototype model of the Electric Mobility Buggy Monitor

screen. Adjust Contrast preset VR1 until a reasonable image is shown (assuming that you have not made a

mistake in assembly and nothing appears – if so, switch off and re-check everything, then start again).

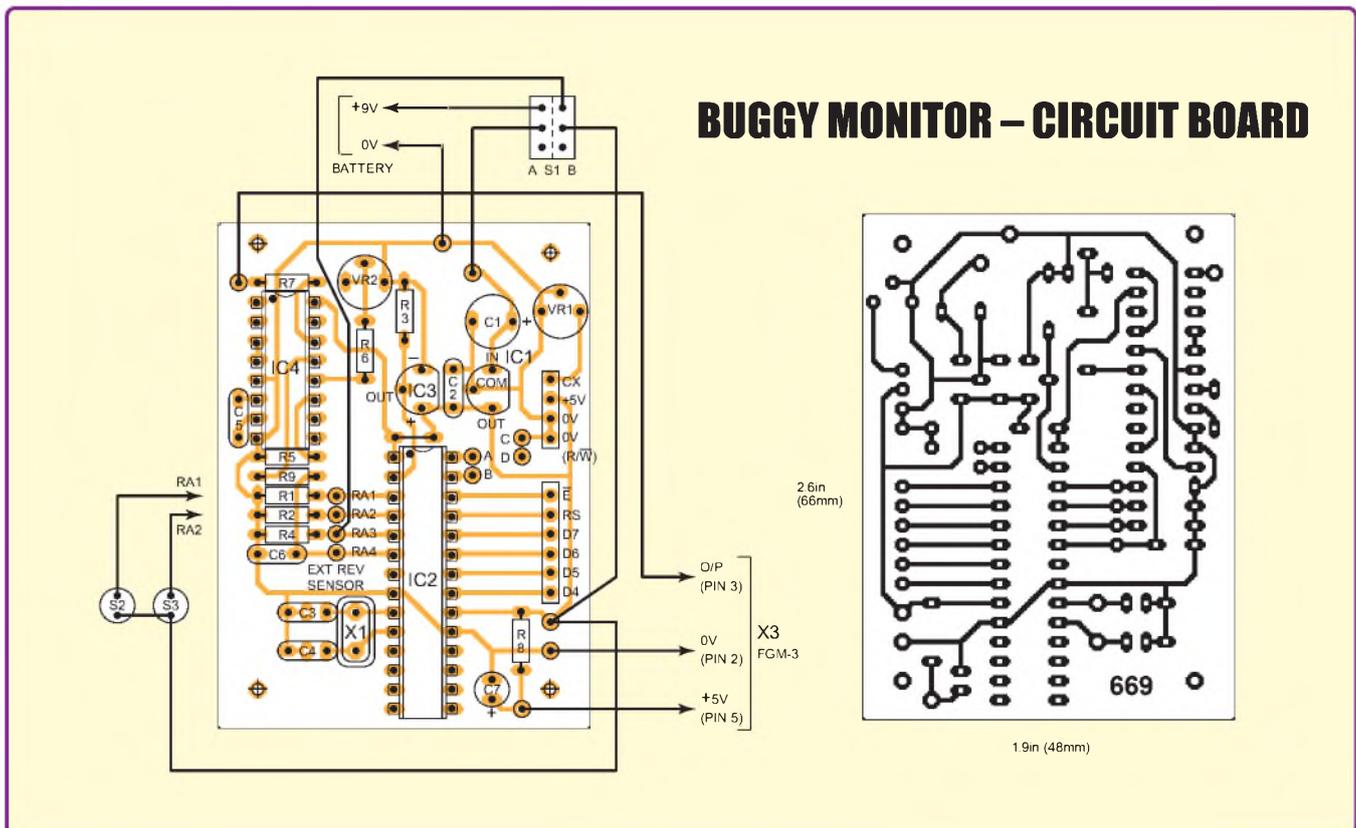


Fig.3: Buggy Monitor printed circuit board component layout, off-board wiring details and full-size copper foil master

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The image you should see first is that in Fig.4, telling you to release the switch.



Fig.4: Display contrast setting stored confirmation

When the LCD is at the correct contrast, release S2. After a brief pause, the image will change to that in Fig.5. This screen states which switches do what, ie pressing S2 next will increase the diameter value in steps of 10, pressing S3 will reduce it in steps of one.

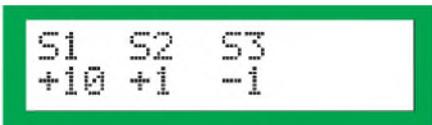


Fig.5: Switch function display

The screen then changes to that in Fig.6, which tells you the currently set diameter on line one, and on line two that you should wait for five seconds to store the value.

Now set the size you want using S2 and S3, increasing the displayed diameter value until it is the value needed. Then, pressing nothing further, allow about five seconds to elapse, after which that value will be automatically stored



Fig.6: Current wheel diameter setting

in the PIC's non-volatile memory, where it will stay (unless deliberately changed in the same way), even when power is switched off. Confirmation of the storage will appear on the LCD, as in Fig.7.



Fig.7: Confirmation of wheel diameter setting storage

The power must now be switched off before the unit can be switched on again for normal use. Having done so, wait a few seconds for the storage capacitors to discharge, then switch on again when you are ready.

In normal running mode, the wheel diameter is recalled from memory and the equivalent wheel circumference is calculated, for use when assessing the distance that the wheel turn counts detected represent. The LCD will show a display similar to that in Fig.8.



Fig.8: Normal running mode display

On the top line at the left are shown the hours, minutes and seconds that have elapsed since the power was switched on. To the right of the top line is shown the current wheel revolutions detected in one second.

On line 2 at the left is shown the current ambient temperature, in whatever units you have selected, C or F. In the middle of that line is the distance travelled since the unit was switched on, also in the units you have selected, K or M. On the lower line's right is the vehicle's current average speed, assessed every 10 seconds.

To prove that the revolutions detector is working, place the FGM-3 sensor on the workbench, away from any magnetic field. Now move a small magnet across and near the end of the sensor, varying the magnet's distance from the sensor until line one RHS shows a change from 0 to 1 or greater, depending on the frequency and speed of magnet movement.

After sufficient magnet movements, there will be a small change in the apparent distance travelled, and maybe the speed of travel. If necessary, adjust preset VR2 until a turns reading is shown on line one.

Roughly note the furthest distance apart that the magnet and sensor need to be in order to get a reading. It's about this distance apart, or less, that the mechanical positioning of the magnet and sensor will need to be on the vehicle. The distance will, of course, depend on the strength of the magnet.

In the prototype, a small magnet taken from a 'fridge magnet' produced a reading when the separation was quite small. A much stronger neodymium magnet measuring 20mm dia and 10mm thick (from RS Components) was used in the final unit. This also has a mounting hole which may prove useful with other types of vehicle.

Maths routines

It is worth commenting on the maths routines used for the software's various calculations. These were originally provided to *EPE* by Peter Hemsley, and the entire suite of routines is available via the *EPE* Downloads site. They include 32-bit routines for add, subtract, multiply and divide. They also include a binary-to-decimal conversion routine whose results are used in many of the LCD displays.

Each time a wheel rotation is detected, the wheel's circumference value is added to a counter. Every second, the program converts that value to decimal and displays the distance covered value on the LCD, to two decimal places, maximum 99.99. Both multiplication and division are also used in this process and quite large values can result, whether the conversion is for kilometres or miles, taking advantage of the 32-bit maths facilities.

Every second, the temperature value is read from the LM35 sensor. This varies at a rate of 10mV per degree Celsius and the ADC conversion value is auto-

matically displayed, with the decimal point in the correct place. The number of wheel rotations during the first second is shown on screen (prefixed by 'T/S' – turns per second).

Every ten seconds, the total wheel rotations in that period are multiplied by the circumference value, divided by ten, yielding the average current speed during that period, suitably converted for kilometres or miles, to one decimal place.

Temperature adjustment

It is possible that the initial range of the temperature value may be a bit too high or too low. If the value is known to be wrong, when compared against a good mercury-filled thermometer, it may be corrected, using a similar technique to that for setting the wheel diameter.

Switch off power, wait briefly for the capacitors to discharge, then with S3 pressed, switch on again and release S3. Adjustment is now made as before, S2 increasing the displayed value in steps of 0.1°C and S3 decreasing it in steps of 0.1°C (see Fig.5). The range of adjustment is ±12.7°C. Adjust the reading until it matches that shown by the thermometer. When satisfied, allow five seconds for the correct value to be stored in the EEPROM. Switch off when storage is confirmed (see Fig.9). Again, switch power off. The corrective value will now be taken into account by the display when power is re-applied.



Fig.9: Storage confirmation display

General installation

The method of mounting the complete assembly depends on the type of vehicle with which it is to be used. The author's buggy is a transportable version that disassembles for fitting into a car; a battery, seat, rear wheel and motor assembly, and the main 'chassis' with front wheels and steering. The sensor mounting had to take the assembly parts into account.

The magnet was slotted into one of the 'compartments' that make up the wheel hub, using Selotape 'Fixer Strip', double-sided self-adhesive strip with a foam-rubber type base. This was used to fix the magnet to the

wheel, and then another layer was placed above the magnet, to sandwich it and ensure that it could not be ejected.

The sensor assembly itself (see Fig.10) consisted of 22mm plastic plumbing tubing cut to just under the width of the buggy's rear wheel assembly. Using a right-angled bend, a downwards pointing section of pipe was pushed into the bend. The length of this was short enough to avoid being dislodged by grass, but long enough to hold the FGM-3 sensor within it.

An end cap was pushed over the lower open end of the tube, with a piece of Blu-tack holding the end of the sensor to prevent it vibrating – surprising how council-maintained pavements (sidewalks) can be so bumpy to such buggies with little wheels. Pedestrians don't normally notice such things.

Wall-mounting, plastic plumbing tube clamps then fixed the assembly to the buggy, again using Fixer Strip, used in good quantity, again for vibration reasons. It would, of course, be possible to bolt the clamps to the buggy if you don't mind drilling holes in it. The author's method causes no physical change to the buggy, and so does not affect the buggy's guarantee.

A thinnish three-core cable was then used to connect the sensor (see Fig. 11), passing through the tube, back to the display/control unit box. Connectors were inserted in the cable so that the rear buggy section could be detached as usual. The box on the author's assembly is not secured to the buggy, but is held in the front-mounted basket that is part of the buggy. It could be

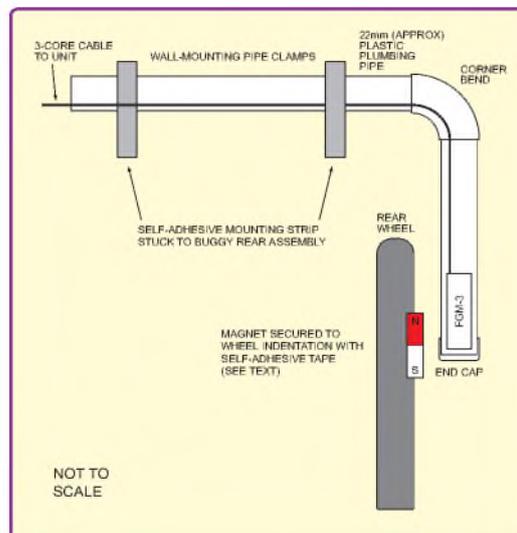


Fig.10. General assembly details of the flux-gate sensor and positioning of the wheel magnet

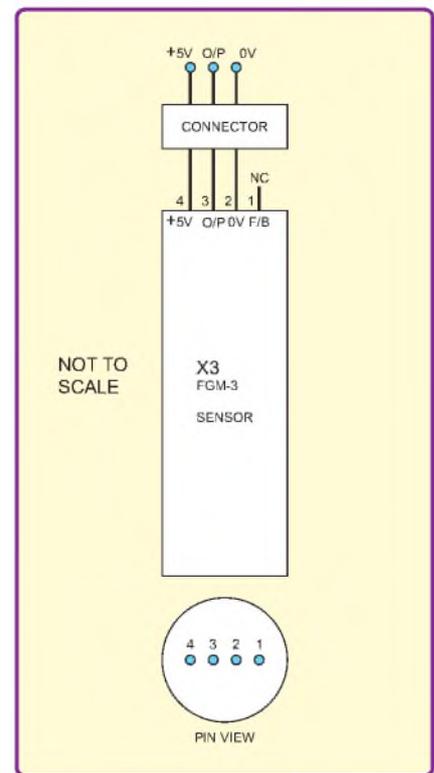


Fig.11. Flux-gate sensor connection details

mounted more firmly if wished.

The length of cable from the sensor tubing back to the box was secured along the buggy's main chassis, again using adhesive tape. Such things will wear out in due course, but it's simple enough to use more securing tape.

Other mounting methods

For other types of vehicle, other mounting techniques may be used. With the original PICAgoras, the sensor was mounted on the push-bike's front fork, with the magnet bolted firmly to the wheel spokes. It is imperative that the magnet should be mounted securely, as the torque forces generated by rotating wheels could cause an insecure magnet to fly off, causing damage or injury.

Finally

So now the author's natural curiosity is satisfied while out exploring, providing distance, time, temperature and speed values on the LCD. Not that speed really matters with a buggy which can only do about 4.5mph maximum, and normally does much less on bumpy surfaces! But with larger vehicles, such a reading will be of interest. With the author's push-bike, speeds of over 40 mph were reached – on a good day, downhill and a gale behind! **EPE**

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SP11 30 x 1N4001 diodes	SP151 4 x 8mm Red LEDs
SP12 30 x 1N4002 diodes	SP152 4 x 8mm Green LEDs
SP18 20 x BC182B transistors	SP153 4 x 8mm Yellow LEDs
SP20 20 x BC184B transistors	SP154 15 x BC548B transistors
SP23 20 x BC549B transistors	SP156 3 x Stripboard, 14 strips x 27 holes
SP24 4 x CMOS 4001	SP160 10 x 2N3904 transistors
SP25 4 x 555 timers	SP161 10 x 2N3906 transistors
SP26 4 x 741 Op Amps	SP164 2 x C106D thyristors
SP28 4 x CMOS 4011	SP165 2 x LF351 Op Amps
SP29 4 x CMOS 4013	SP166 20 x 1N4003 diodes
SP33 4 x CMOS 4081	SP167 5 x BC107 transistors
SP34 20 x 1N814 diodes	SP168 5 x BC108 transistors
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SP37 12 x 100/35V radial elect. caps	SP173 10 x 220/25V radial elect. caps
SP38 15 x 47/25V radial elect. caps	SP174 20 x 22/25V radial elect. caps
SP39 10 x 470/16V radial elect. caps	SP175 20 x 1/63V radial elect. caps
SP40 15 x BC237 transistors	SP177 10 x 1A 20mm quick blow fuses
SP41 20 x Mixed transistors	SP178 10 x 2A 20mm quick blow fuses
SP42 200 x Mixed 0-25W C.F. resistors	SP181 5 x Phono plugs - asstd colour
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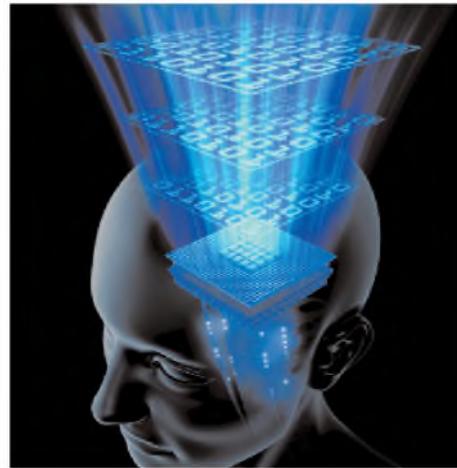
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Teach-In 2008

Part Seven – Using the additional memory banks, plus PCLATH

JOHN BECKER



PICs have more data memory available than is apparent at first glance. Under normal programming circumstances, the available memory with a PIC16F628 would seem to be 96 bytes, between h'20' and h'7F'. In this seventh part of *Teach In 2008* we look at ways in which additional PIC memory can be used for data storage and retrieval. We also look at PCLATH, the command that allows tables to be placed anywhere in the PIC's program memory area.

The PIC16F628 has four Banks, two of which were shown in Part 1 Table 1.2. They are all shown in the PIC16F628 data sheet. The first batch of registers in each Bank is associated with the device's Special Function Registers (SFRs), such as PORTB and TRISB. Some registers are common to each Bank (PCL, STATUS, FSR etc). Others, such as PORTB and TRISB, can be accessed through two Banks each, in this case Bank 0/2 and Bank 1/3 respectively.

Below each set of SFRs within the Banks are shown locations that can be used for data storage. With Bank 0, 96 bytes are available for data use, from h'20' to h'7F'. It is these 96 memory bytes, which will be familiar so far.

Normally, 96 bytes is adequate. The availability of additional memory though, can be highly beneficial with more complex programs. Study of the Bank tables shows that Bank 1 has 80 bytes of data memory (general purpose) available, and which are independent of those in Bank 0. Bank 2 has a further 48 bytes that are also independent.

However, the upper 16 memory bytes of all four Banks have a common root. Accessing any of these 16 bytes in any Bank automatically accesses those same locations in Bank 0 (h'70' to h'7F').

Before reading on, assemble the circuit in Fig.7.1, using the breadboard layout in Fig.7.2, and connect it to the Master PCB from Part 1. The switches are not used in the first demo.

Indirect addressing

When indirectly accessing the Banks through the use of FSR (File Select Register) and INDF (Indirect File register) 256 addresses can be accessed, either for the combined pair Bank 0 and Bank 1, or

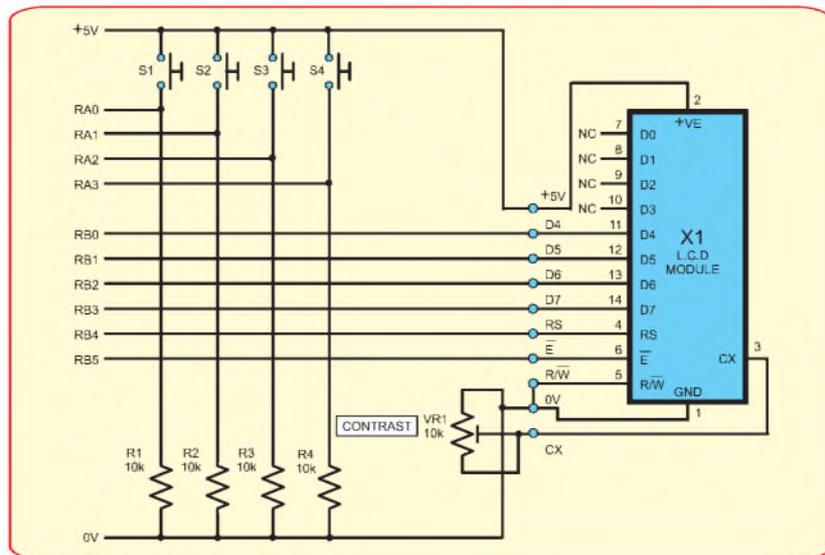


Fig. 7.1 Demo circuit for Part 7

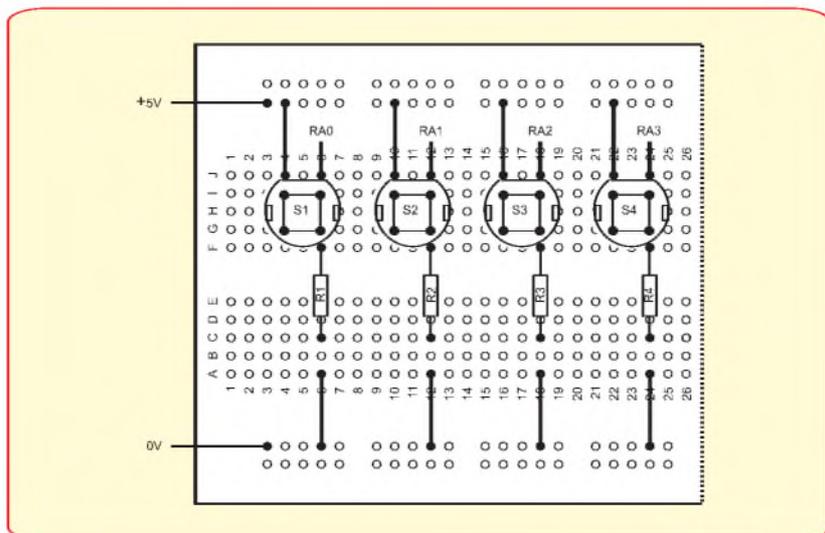


Fig. 7.2 Breadboard layout for Fig.7.1

the combined pair Bank 2 and Bank 3.

The selection of the Bank pairs is made through the use of STATUS bit 7, known as the IRP bit. Bank 0 and Bank 1 are

selected when bit 7 is low, Bank 2 and Bank 3 when it is high. Because the banks are paired in indirect mode, it is expedient to consider them as two blocks, BLOCK0

and BLOCK1, selectable by STATUS bit 7. As such, the command for block selection can also be defined at the head of the program. See Table 7.1, which includes suggested Block definitions.

Example codings

An example of a practical sub-routine for accessing the extra memory is illustrated in part through Listing 7.1 and Listing 7.2. The full source code for the routine is available via the *EPE* website at www.epemag.wimbborne.co.uk in the *TeachIn 2008* folder. The file is **TeachInG01.asm**.

For this example, we take the situation where the data source, a counter, is read and the resultant values stored in separate memory locations, using the three available Banks for the storage. There are many ways that the data could be acquired and stored in other situations.

The first batch uses the memory area following the main CBLOCK equates, commencing at MEMBANK0 and running through to the end of BANK0 at h'7F'. MEMBANK1 covers the 80 locations from h'A0' to h'EF'. MEMBANK2 covers the 48 bytes from h'120' to h'14F'. MEMBANK3 is not written to, just read, for reasons shown later. Note that Banks 1 to 3 are all equated as h'20', see the full ASM file.

In Listing 7.1 the counter is repeatedly incremented and stored in the memory locations for Banks 0 to 2.

At label SAMPLE1 the command for selecting BLOCK0 is first given, and the VALUE counter set to zero. Next, the PIC's address for MEMBANK0 is recalled through the command **movlw MEMBANK0** and the routine at GETBATC0 is called.

The address of MEMBANK0 is now placed into the FSR register, the value in the counter is then moved into W and stored in INDF, which is the location pointed to by the value in FSR. The counter is then incremented, as is the value within FSR. The counter is then checked to see if it is greater than the maximum Bank address available, in this case h'7F'.

If it is less than the maximum, a loop back to GETIT0 is made and the process repeats, without the VALUE counter being reset. If FSR is greater than the maximum, a return to the calling point is made. The process continues for BANK1, which covers the bytes between h'A0' and h'EF'. Note that the bytes between h'F0' and h'FF' are not written to – doing so would overwrite the same locations between h'70' and h'7F'.

The process then continues for the 48 bytes available in BANK2. On entry to this routine, the command BLOCK1 is given, to set the correct storage area. At the end of this routine, the block value is reset to BLOCK0.

On return, now to the calling point, the command **goto PART2** is given and the routines shown in Listing 7.2 are performed.

As shown in Listing 7.2, the values stored in the Banks are recalled, converted to decimal and output to the LCD. A short pause occurs between displaying each decimalised value.

At SHOWBANK0, first the Bank address is shown on Line 1, the BLOCK

Table 7.1

Bit 7	Block	Banks	Locations	Indirect Access	Address
0	0	0/1	h'00' to h'FF'	h'00' to h'FF'	
1	1	2/3	h'100' to h'1FF'	h'00' to h'FF'	#DEFINE

```
#BLOCK0 BCF h'03',7 ; clear STATUS bit 7 (IRP)
#DEFINE BLOCK1 BSF h'03',7 ; set STATUS bit 7 (IRP)
```

Listing 7.1

```
SAMPLE1      BLOCK0          ; set for Block 0
              clrf VALUE

              movlw MEMBANK0 ; get address of 1st batch in BANK0
              call GETBATC0   ; store values from counter

              movlw MEMBANK1 ; get address of 1st byte in BANK1
              iorlw 128       ; set bit 7 high (b'10000000' = 128 =
                              ; h'80')
              call GETBATC1   ; store values from counter

              movlw MEMBANK2 ; get address of 1st batch in BANK2
              call GETBATC2   ; store values from counter

              goto PART2

GETBATC0     movwf FSR        ; load FSR with value brought in on W
GETIT0       movf VALUE,W    ; simulated value to store into memory
              movwf INDF     ; store at address pointed to by FSR
              incf VALUE,F   ; increment simulation value
              incf FSR,F     ; increment address held by FSR
              movf FSR,W     ; is FSR greater than max for this Bank?
              xorlw h'80'    ;
              btfss STATUS,Z ; no, continue sampling
              goto GETIT0   ; yes, end of sub-routine
              return

GETBATC1     movwf FSR        ; load FSR with value brought in on W
GETIT1       movf VALUE,W    ; simulated value to store into memory
              movwf INDF     ; store at address pointed to by FSR
              incf VALUE,F   ; increment simulation value
              incf FSR,F     ; increment address held by FSR
              decf FSR,W     ; is FSR max for this Bank?
              xorlw h'F0'    ;
              btfss STATUS,Z ; no, continue sampling
              goto GETIT1   ; yes, end of sub-routine
              return

GETBATC2     movwf FSR        ; load FSR with value brought in on W
BLOCK1      movlw MEMBANK1 ; set for BLOCK1
GETIT2       movf VALUE,W    ; simulated value to store into memory
              movwf INDF     ; store at address pointed to by FSR
              incf VALUE,F   ; increment simulation value
              incf FSR,F     ; increment address held by FSR
              decf FSR,W     ; is FSR max for this Bank?
              xorlw h'50'    ;
              btfss STATUS,Z ; no, continue sampling
              goto GETIT2   ; return to BLOCK0
              BLOCK0        ; yes, end of sub-routine
              return
```

value is then set for BLOCK0, the address of MEMBANK0 is placed into FSR and the routine at SHOWVALBANK is called. In SHOWVALBANK, the data within the byte pointed by FSR is recalled, and placed into REGA0 in preparation for the decimalisation process, as discussed in earlier parts of *Teach In 2008*.

Before BIN2DEC is called, the current FSR address is temporarily stored in FSRSTORE, as the decimalisation routine also uses FSR, but for different purposes. Now BIN2DEC is called and the resulting decimal value is now displayed on Line 2.

Next, the value within FSRSTORE is also decimalised and displayed on Line 2 (not shown in Listing 7.2).

There follows a brief pause, allowing the displayed values to be easily seen before the process continues. The pause is caused by the routine at PAUSIT2. Its length maybe changed by altering the value set into CLKCNT.

After the pause, the value within FSRSTORE is recalled and placed back into FSR. FSR is then incremented and a return to the calling point is made. The value within FSR is then checked to see if the

Listing 7.2

```

PART2
SHOWBANK0    movlw '0'
              movwf BANKVAL
              call SHOWBANKVAL
              BLOCK0          ; set for Block 0
              movlw MEMBANK0  ; get address 1st byte of 1st batch
              movwf FSR        ; load FSR with value brought in on W
VAL0         call SHOWVALBANK
              movf FSR,W
              xorlw h'80'
              btfs STATUS,Z
              goto VAL0       ; no, continue sampling

SHOWBANK1    movlw '1'
              movwf BANKVAL
              call SHOWBANKVAL
              BLOCK0          ; set for Block 0
              movlw MEMBANK1  ; get address 1st byte of 2nd batch
              iorlw 128
              movwf FSR        ; load FSR with value brought in on W
VAL1         call SHOWVALBANK
              decf FSR,W
              xorlw h'FF'
              btfs STATUS,Z
              goto VAL1       ; no, continue sampling

SHOWBANK2    movlw '2'
              movwf BANKVAL
              call SHOWBANKVAL
              BLOCK1          ; set for Block 1
              movlw MEMBANK2  ; get address 1st byte of 1st batch
              movwf FSR        ; load FSR with value brought in on W
VAL2         call SHOWVALBANK
              BLOCK1          ; set for Block 1
              movf FSR,W
              xorlw h'80'
              btfs STATUS,Z
              goto VAL2       ; no, continue sampling
              BLOCK0

SHOWBANK3    movlw '3'
              movwf BANKVAL
              call SHOWBANKVAL
              BLOCK1          ; set for Block 1
              movlw MEMBANK3  ; get address 1st byte of 1st batch
              iorlw 128
              movwf FSR        ; load FSR with value brought in on W
VAL3         call SHOWVALBANK
              BLOCK1
              decf FSR,W
              xorlw h'FF'
              btfs STATUS,Z
              goto VAL3       ; no, continue sampling
              BLOCK0
              return          ; end of sub-routine

SHOWBANKVAL  call LCD1          ; set LCD for cell 0 line 1
              BSF RSLINE,4
              movlw 'B'
              call LCDOUT
              movlw 'A'
              call LCDOUT
              movlw 'N'
              call LCDOUT
              movlw 'K'
              call LCDOUT
              movf BANKVAL,W
              call LCDOUT
              return

SHOWVALBANK  movf INDF,W        ;get value from address pointed to
              ;by FSR
              movwf REGA0
              clrf REGA1
    
```

Listing 7.2 (Continued)

```

clrf REGA2
clrf REGA3
movf FSR,W          ; store FSR
movwf FSRSTORE
BLOCK0
call BIN2DEC
BSF RSLINE,4
call SHOWDIGIT8
    
```

maximum value has been exceeded. If not, the process repeats for the next stored byte.

If so, the next Bank values are recalled and displayed.

Note that 96 values from all four Banks are displayed. BANK0 quite correctly displays all the values sent for storage within it. BANK1 also shows the 80 bytes stored, but then shows the 16 values which are common to all four banks, which in this instance are those sent to BANK0. BANK2 shows the 48 bytes stored, then displays a sequence of zeros for unimplemented locations, followed again by the 16 common values. BANK3 again displays a sequence of zeros for unimplemented locations, followed once more by the 16 common values.

Also note that if assembling TEACHING01.asm your programmer may issue warnings that Equates have been duplicated. Ignore the warnings, as the apparent duplication is intended and is in connection with the Bank use.

PCLATH command

Earlier in the series, it was commented in passing that Tables can only be placed within the first 256 bytes of program memory (a page), and anything beyond that would not be accessed correctly, and could cause a program crash. It was said that there were ways round this using the PIC's PCLATH command, which we now explain.

A PIC's program memory scope varies from 2K to 8K bytes, depending on the PIC type, and is partitioned into 2048 (2K) byte-wide pages. Page boundaries are important when it comes to the use of Tables, and must be complied with for correct operation of the program.

Page allocation

Tables may be put anywhere in program memory space, once the operation of the PCLATH function is understood, and the table is wholly contained within a Page, as it always will be with the PIC16F628, which has eight sub-pages, being a 2048 program location device.

The program counter (PC) value is held in a 13-bit special function register, which can be regarded as having two parts – PCH (Program Counter High) and PCL (Program Counter Low), for the high and low bytes respectively. PCH resides in the upper five bits of the PC, whereas PCL resides in the lower eight bits.

PCL can be written to directly, as is done when normally accessing tables for example, and the response to amending PCL takes immediate effect. PCH, however, can only be written to via the lower five bits of special function register PCLATH. Writing to PCLATH, however, only takes effect when the CALL, GOTO or arithmetic operation involving PCL is performed.

It is worth noting that PCLATH is a write-only buffer. It is not safe to read PCLATH in order to, perhaps, do PC arithmetic.

Setting Program Counter

There are three ways in which the programmer can set a value into the program counter (PC):

- An instruction which carries out an arithmetic operation on the PC. The most commonly used such instruction is adding a value to the PC from the working register (W) when accessing a table, such as **ADDWF PCL,F** as you have seen when Tables are used

- A **CALL** or **GOTO** instruction which places the address of a label into the PC

- A **RETURN** instruction which places the contents of the stack top into the PC

Arithmetic operations

Arithmetic operations on the PC involve the W register and other 8-bit wide registers. It therefore follows that only PCL can be set with an arithmetic instruction. PCH remains at whatever value it holds at the time of the instruction.

It is possible to place a table anywhere in program space by setting PCLATH before the call to the table is made. The purpose of PCLATH is to set PCH for the call itself.

The operation code for **CALL** and **GOTO** instructions sets 11 bits of the destination address, which is all that is needed in 2K program memory devices. The additional bits are set from PCLATH bit 3 for 4K program memory devices, and bits 3 and 4 for 8K devices.

RETURN instruction

A **CALL** instruction pushes PCL and PCH values onto the PIC's stack. A **RETURN** instruction pops those PCL and PCH values and puts them into the PC, and no manipulation of PCLATH is required. It might be necessary, however, to set PCLATH after the return, as illustrated in the example program partly shown in Listing 7.3 and Listing 7.4. The full program is held in *TEACHING02.asm*.

The first line in Listing 7.3 sets PCLATH to zero. Then the loop at LOOP1 is entered, in which Port A is constantly read, waiting for one of the four switches, S1 to S4 in Fig.7.2, to be pressed.

When S1 is pressed, the routine at TEST1 is called. PCLATH is set with a value of 1 so that TABLE 1, held at the location pointed to by the command **org 300** (hex h'12C'), in Listing 7.4 can be correctly called. Note that the '1' set into PCLATH is the '1' in the lefthand nibble of the hex value. A value of 2 is now placed into W and TABLE 1 is again called.

In the usual way with calling tables, the value held in W is added to PCL, and the corresponding table line is actioned, in this case **retlw 12**. This places the 12 into W and a return to the calling point is made. Next, a call to **PREBINDEC** is made. This routine simply places the value of W into REGA1, clears REGA1 to REGA, and calls the **BIN2DEC** routine so that the value is decimalised.

Next, the LCD is set to display the next batch of data, starting at the left of Line 1.

Listing 7.3

```

                                clrf PCLATH                ; clear PCLATH

LOOP1                            btfsc PORTA,0            ; is S1 pressed?
                                call TEST1                ; yes
                                btfsc PORTA,1            ; is S2 pressed?
                                call TEST2                ; yes
                                btfsc PORTA,2            ; is S3 pressed?
                                call TEST3                ; yes
                                btfsc PORTA,3            ; is S3 pressed?
                                call TEST4                ; yes
                                goto LOOP1                ; no

TEST1                            movlw 1                  ;Set up for sub-page 1
                                movwf PCLATH
                                movlw 2                  ;Get 2nd line from
                                call TABLE1                ;1st table
                                call PREPBIN2DEC
                                call LCD1
                                bsf RSLINE,4
                                call SHOWPAGE

                                movlw 3                  ;Get 3rd line from
                                call TABLE1                ;1st table
                                call PREPBIN2DEC
                                call LCD21
                                bsf RSLINE,4
                                call SHOWPAGE
                                clrf PCLATH                ;Set up for page and sub-page 0.
                                return

TEST2                            movlw 2                  ;Set up for sub-page 2
                                movwf PCLATH
                                movlw 1                  ;Get 1st line from
                                call TABLE3                ;3rd table
                                call PREPBIN2DEC
                                call LCD1
                                bsf RSLINE,4
                                call SHOWPAGE

                                movlw 4                  ;Get 4th line from
                                call TABLE3                ;3rd table
                                call PREPBIN2DEC
                                call LCD21
                                bsf RSLINE,4
                                call SHOWPAGE
                                clrf PCLATH                ;Set up for page and sub-page 0.
                                return

; TESTS 3 AND 4 ARE SIMILAR

```

Then **SHOWPAGE** is called, in which the message 'TABLE' is output to the LCD, followed by the decimalised value held in **DIGIT9**. The line then displays 'JUMP', followed by the value held in **DIGIT10**.

In this instance, the value returned from the table call is 12. When decimalised, the lefthand value is '1', indicating the Table number, and the righthand value is '2', representing the Jump value. All the tables have values which are interpreted in this way.

In **TEST1**, **TABLE1** is again called to access the third line. The resulting value is then displayed on Line 2, similarly to Line 1. At the end of the routine, **PCLATH** is cleared and a return to the switch testing **LOOP1** is made.

Other switch presses call the corresponding routines, all of which are arranged in a similar manner to **TEST1**, calling the tables at varying locations within the PIC's memory.

Programmer's task

Every **CALL** and **GOTO**, and every arithmetic operation affecting the PC, requires that **PCLATH** contains the correct value for the operation concerned. Sometimes, for example, **GOTO** is used in a timing loop, which might have to allow for two additional **PCLATH**-setting instructions, and this loop might lie across a Page boundary.

Somehow these matters must be catered for in PIC programs. As with so much in programming, there are diverse opinions on which is the best technique. A useful strategy, for instance, could be:

1. Assign a functionality to each of the pages which minimizes **CALL** and **GOTO** instructions across page boundaries
2. If possible, provide buffer zones, with no instructions, near page boundaries
3. Write a first pass for the code, ignoring the need to set **PCLATH**; have it assembled and examine the listing

Listing 7.4

	org 300 ; h'12C'		org 1024 ;h'400'
TABLE1	addwf PCL,F retlw 10 retlw 11 retlw 12 retlw 13 retlw 14	TABLE4	addwf PCL,F retlw 40 retlw 41 retlw 42 retlw 43 retlw 44
	org 400 ; h'190'		org 2000 ; h'7D0'
TABLE2	addwf PCL,F retlw 20 retlw 21 retlw 22 retlw 23 retlw 24	TABLE5	addwf PCL,F retlw 50 retlw 51 retlw 52 retlw 53 retlw 54 retlw 55 retlw 56 retlw 57 retlw 58
	org 513 ; h'201'		
TABLE3	addwf PCL,F retlw 30 retlw 31 retlw 32 retlw 33 retlw 34		

4. Determine where CALL and GOTO instructions cross Bank boundaries, and where table calls (or other arithmetic operations on PCL) cross Page boundaries

5. Readjust tables so they are completely contained in a Page

6. Include PCLATH setting instructions where required

7. Repeat steps 4, 5 and 6 until no further corrections are required. You might have to try again if the process does not converge.

Practicalities

In practical terms, manual inspection and iteration during program development is at the very least tedious and time consuming.

At worst, it can be highly error prone. Each time a program is modified, you need to repeat the fix-up process, and on subsequent occasions the chances are that you have mostly forgotten how large chunks of the program work in detail.

Alternatively, every relevant instruction that might involve Bank boundaries could be preceded by PCLATH-setting instructions, whether they are needed or not. While it can be argued that it would be cumbersome and consume valuable program memory space to set PCLATH for every such instruction, there is a lot to be said for the brute force approach if programming space permits it, and there are doubts about where Bank boundaries might lie.

The use of PCLATH is essential in many larger PIC programs, and it is a command that you should familiarise yourself with through experiment. Perhaps the best advice is to use it in a fashion you feel comfortable with, and which you have proved through experimentation to be reliable. While evolving that technique, remember that you have to keep your wits about you again.

The use of extended memory and PCLATH is not suited to demonstration here via a simple program, needing a much larger concept to get stuck into. We hope to bring you an example later in the series.

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Circuit Surgery

Ian Bell



Ground and Earth Loops

This month we look at signal shielding and the associated problem of ground loops (also known as *earth loops*), prompted by a question from *Zapper* in the *EPE Chat Zones* forum (access via www.epe-mag.co.uk):

In my work I have done lots of building electronic and electrical control systems. As a matter of course I understand that when using screened cable, the earth connection should only be made at one connecting end. I do this automatically and suddenly asked myself, 'why?' Ground loop springs to mind. Could someone shed a light?

When two interconnected circuits, sub-circuits, or equipment are grounded at two separate points on a *ground bus* we have a situation known as a 'ground loop' (or earth loop), see Fig.1. The ground bus may be a circuit board track, the chassis of the equipment, point-to-point wiring, but perhaps, most commonly, it is the mains earth wiring connected at different outlets.

The most well known effect of ground loops is probably excessive *mains hum* in audio equipment (an audible 50Hz or 60Hz

tone and possibly harmonics thereof). Ground loops also cause banding effects on video displays and can be the reason for faulty behaviour in computers and computer-based equipment and peripherals.

In order for a ground loop to cause problems such as hum, a current has to flow in the loop to generate a signal that might affect the circuit or equipment concerned (I_L in Fig.1). For this current to produce voltage signals, which actually disturb the operation of the circuits, there must be some resistance in the loop wiring – for example, the screen resistance R_S , and the earth wiring resistance R_E , as shown in Fig.1. This is always the case, as all wiring has some resistance. However, ground loop effects can be minimised by using a very low resistance ground conductor.

Cable shielding

A good solution to ground loops is to avoid them by using a single grounding point (Fig.2). This is possible within equipment, but may be impossible when making connections *between* equipment. Of course, the loop can be broken by removing one of the earth connections, but this is potentially dangerous. Do NOT

remove an earth connection required for safety in order to solve a ground loop hum or other interference.

Shielded cables are often a source of ground loop problems, as *zapper* indicates, so it is worth taking a quick look at what cable shielding is about. Capacitively coupled interference (see Fig.3a) can be reduced using screening, which effectively grounds the interference coupling capacitance (see Fig.3b). Screening is implemented using coaxial (screened) cable to link to circuits.

Grounding a shielded cable at only one end (as he suggests) may be effective at breaking ground loops (Fig.4a). Unfortunately, this leads to more radio frequency interference, so connecting the screen at both end may be required (Fig.4b).

The shield should be connected *directly* to the mains earth, not via the circuit's signal ground. If this is *not* done (Fig.4c), then the ground loop induced currents flowing in the cable shield will also flow via the ground lines of the internal circuitry (eg via a circuit board track) and the effects will be worse. In general, cable shields carry unwanted signals to ground

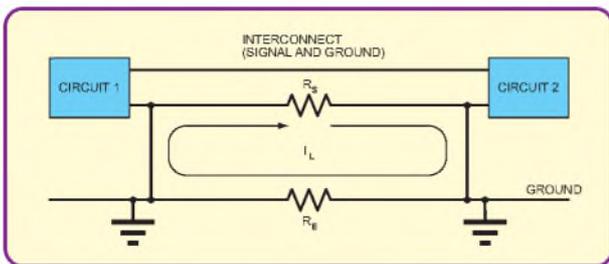


Fig.1. Conditions for ground loop problems

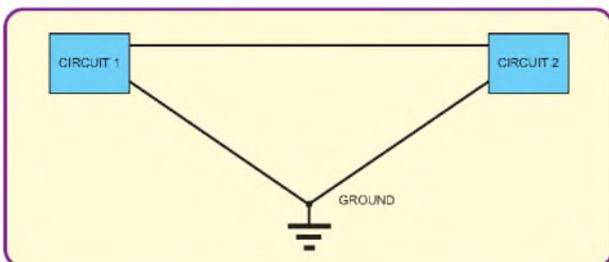


Fig.2. Avoiding ground loops

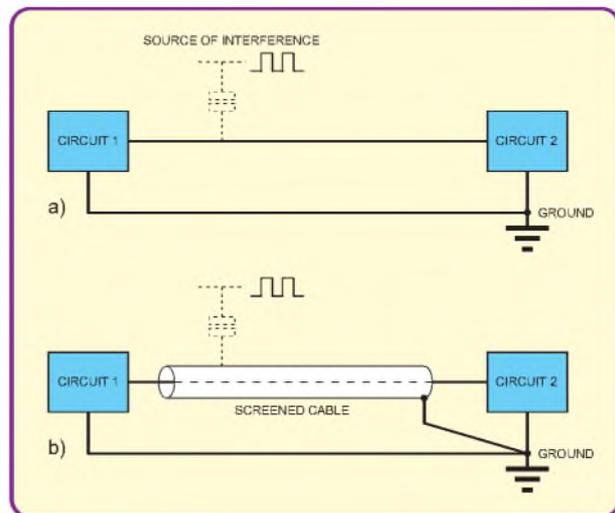


Fig.3. Capacitively coupled interference

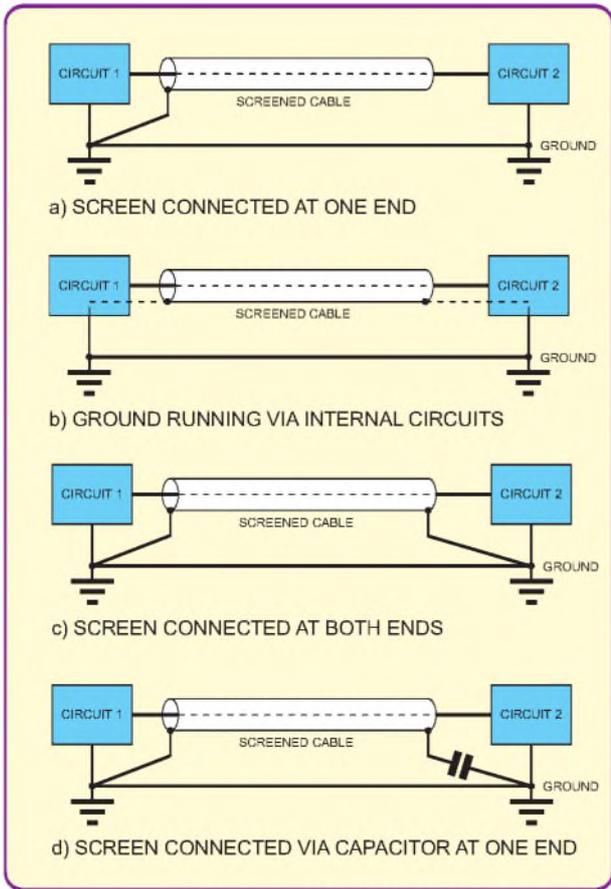


Fig.4. Various grounding options for screened cable

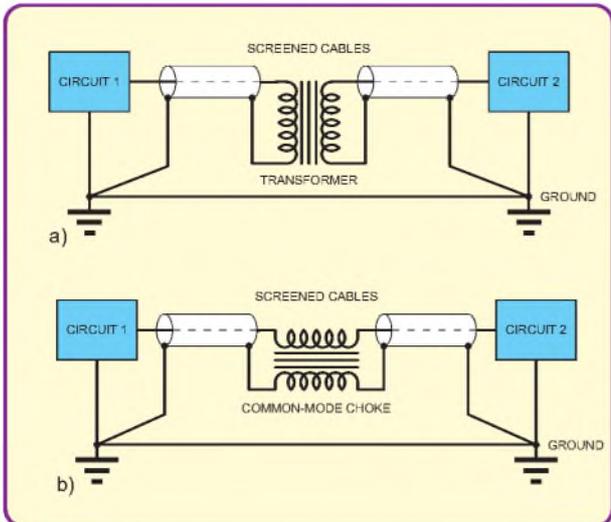
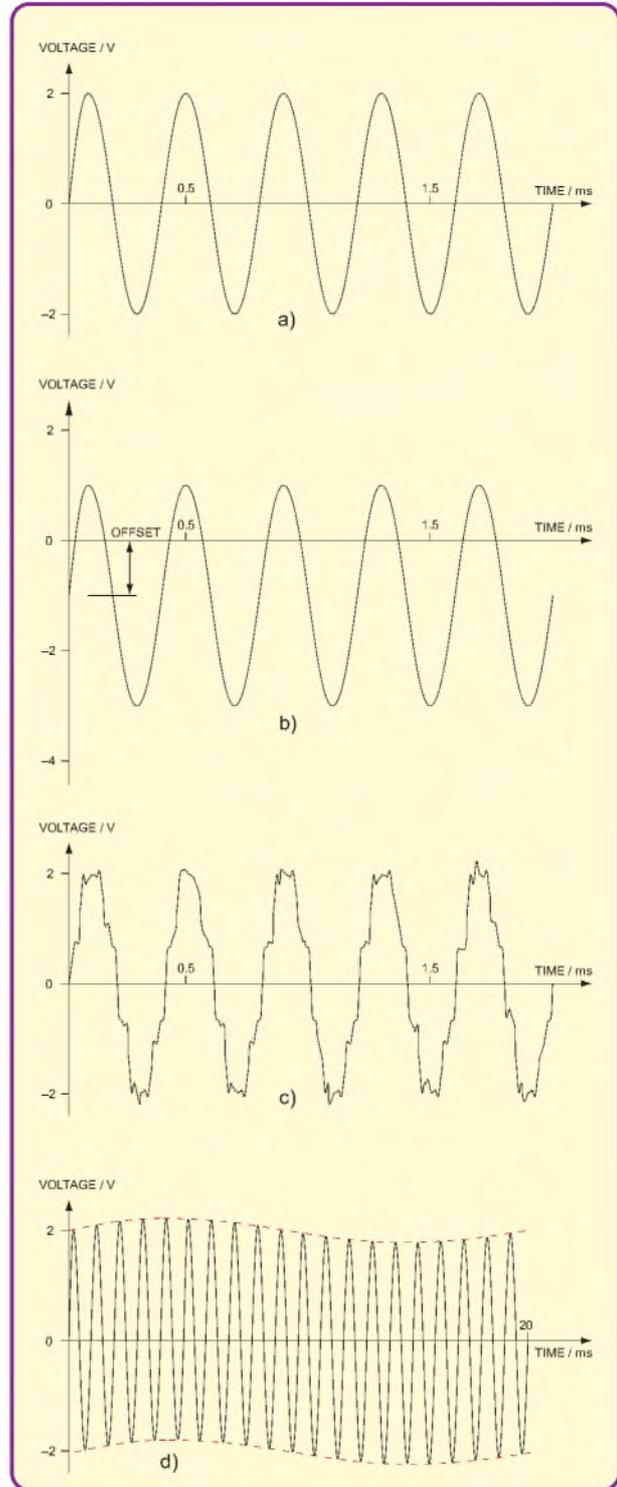
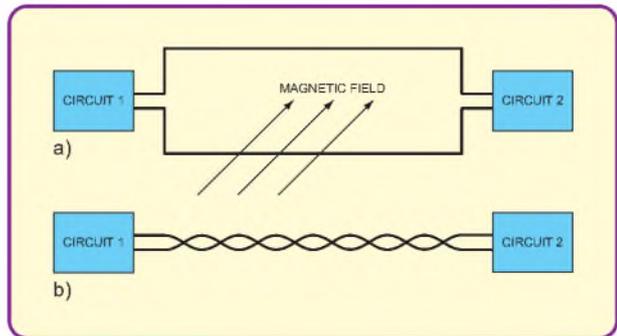


Fig.5. Breaking ground loops with a transformer and using a common-mode choke to block common-mode noise

Fig.6 (above right). Large wiring loops (a) make a circuit susceptible to voltages generated by magnetic fields. Reducing loop size (b) helps combat the problem

Fig.7 (right). Signals and noise. (a) A signal varying around 0V. The peak value is 2V and the peak-to-peak value is 4V. The frequency is 2.5kHz. (b) The signal from Fig.1 with a -1V offset. If you consider the signal rather than the offset, the peak value is still 2V peak, even though the signal 'peaks' at +1V and -3V. (c) Signal in Fig.1 with noise of a higher frequency than the signal. (d) Signal in Fig.1 with noise of lower frequency than the signal. This is about 0.2V peak of 50Hz mains hum. Note that the waveform is displayed over a longer period than Fig.1 so that the noise is more obvious to see



and should not share a path with signal grounds. Within equipment, grounds should be connected to a central point (often called the *star ground* or *star earth*), as shown in Fig.2.

Don't forget that your circuit or equipment may produce interference as well as be susceptible to it. Not grounding at both ends may mean that you cause interference elsewhere and fail to comply with electromagnetic compatibility (EMC) requirements.

However, connecting the screen at both ends may lead to very large currents flowing if the ground voltages are different at both ends. A possible compromise is to ground the screen via a suitable capacitor (Fig.4d); this prevents a ground loop forming at DC and low frequencies, but grounds the screen at high frequencies, reducing noise pickup and radiation.

Isolation

Another way of breaking ground loops is to use an isolation transformer, as shown in Fig.5a. This approach is popular for audio signals and audio ground loop isolators are readily available.

However, unless a sufficiently high quality transformer is used the sound quality may be degraded. This is because the effect

of the transformer on the signal is not uniform across the full range of frequencies present.

At video frequencies it is generally too difficult to produce an effective transformer and the preferred approach is to use a common-mode choke (Fig.5b). The choke passes DC and signals which are different on the two connections, but blocks common-mode signals. We will look at common-mode and differential signals next month.

There is more than one way in which unwanted signals can get into your system via ground loops. Differences in the local ground voltage can cause current to flow in the ground wiring, which produces unwanted input signals; the capacitance inherent in mains transformers can leak hum signals into the system. Unwanted signals can also be coupled magnetically into the ground loop.

Magnetic interference is worse when physically large loops occur in a circuit (see Fig.6a) and can therefore be reduced by avoiding such loops. This applies in general and not just to ground loops, where using twisted pairs of wires is an effective approach (Fig.6b). For circuit boards use a *ground plane* on one side of the board and for ribbon cables it is a good idea to make sure each signal has an adjacent return wire.

Shielding purpose

The purpose of shielding is to prevent unwanted signals (noise) being induced or coupled onto the signal we want. As we have seen, the shielding may also contribute to the noise problem if ground loops are created. Fig.7 shows examples of various forms of noise or error on a signal (Fig.7a). This may comprise: a DC offset (Fig.7b), random variations in the signal voltage (Fig.7c) or a signal of a very specific frequency, such as 50Hz/60Hz mains hum (Fig.7d).

The signals we have just seen are called *single-ended* because a single wire (other than ground) is used to carry the signal. Once such a signal has been affected by noise it is very difficult or impossible to remove the noise (eg by filtering) if its frequency or frequencies lie within the range of wanted frequencies.

For example, mains hum is within the audio range, so filtering it out will potentially remove part of the original signal too. This situation is worse if all the harmonics of the hum are present too (eg 100Hz, 150Hz, 200Hz, etc for a 50Hz mains).

Next month, we round-off our investigation in to 'ground loop' problems by looking at common mode and differential signals.

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FEATURES ● C For PICs – Part 3 ● Circuit Surgery ● Practically Speaking ● Techno Talk ● PIC 'N' Mix ● Net Work – The Internet Page

FEB '07

PROJECTS ● PIC Digital Geiger Counter ● Courtesy Light Delay ● Programmable Robot ● Charger for Deep Cycle 12V Batteries – Part 2
FEATURES ● C For PICs – Part 4 ● Techno Talk ● PIC 'N' Mix ● Interface ● Ingenuity Unlimited ● Circuit Surgery ● Net Work – The Internet Page

MAR '07

PROJECTS ● PIC Polyphonium – Part 1 ● Lap Counter for Swimming Pools ● IR Remote Checker ● SMS Controller – Part 1
FEATURES ● Techno Talk ● Practically Speaking ● PIC 'N' Mix ● Ingenuity Unlimited ● Circuit Surgery ● Net Work – The Internet Page

APR '07

PROJECTS ● Students' 20W Amp Module ● Star Power ● PIC Polyphonium – Part 2 ● SMS Controller – Part 2
FEATURES ● Ingenuity Unlimited ● PIC 'N' Mix ● Interface ● Visual C Training Course Review ● Circuit Surgery ● Net Work – The Internet Page

MAY '07

PROJECTS ● Energy Meter – Part 1 ● Bass Extender ● Caravan Lights Check ● SMS Controller Add-Ons
FEATURES ● Ingenuity Unlimited ● Circuit Surgery ● Practically Speaking ● Techno Talk ● PIC 'N' Mix ● Net Work – The Internet Page



JUN '07 – PHOTOCOPIES ONLY

PROJECTS ● Bat Sonar ● 3V to 9V Converter ● A Poor Man's Q Meter ● Energy Meter – Part 2.
FEATURES ● The Power of Mechatronics – Part 1 ● Using MPLAB – Part 1 ● Circuit Surgery ● Interface ● PIC 'N' Mix ● Ingenuity Unlimited ● Network – The Internet Page ● Techno Talk ● Free Mechatronics CD-ROM.

JULY '07 – PHOTOCOPIES ONLY

PROJECTS ● Lead-Acid Battery Zapper ● Video Reading Aid ● Minical 5V Meter Calibration Standard ● Digi-Flash Slave
FEATURES ● Ingenuity Unlimited ● Techno Talk ● PIC 'N' Mix ● Using MPLAB – Part 2 ● Circuit Surgery ● The Power of Mechatronics – Part 2 ● Practically Speaking ● Net Work.

AUG '07 – PHOTOCOPIES ONLY

PROJECTS ● V2 PC Scope – Part 1 ● RFID Security Module ● TwinTen Stereo Amplifier ● Printer Port Hardware Simulator
FEATURES ● Ingenuity Unlimited ● Techno Talk ● PIC 'N' Mix ● Using MPLAB – Part 3 ● Circuit Surgery ● The Power of Mechatronics – Part 3 ● Interface ● E-Blocks and Flowcode 3 Reviewed ● Net Work.

SEPT '07

PROJECTS ● Pocket Tens ● Flexitimer ● USB Breakout Box ● V2 PC Scope – Part 2
FEATURES ● Ingenuity Unlimited ● Techno Talk ● PIC 'N' Mix ● Using MPLAB – Part 4 ● Circuit Surgery ● The Power of Mechatronics – Part 4 ● Practically Speaking ● Net Work.

OCT '07

PROJECTS ● V8 Doorbell ● Inductance & Q-Factor Meter – Part 1 ● Standby Power Saver ● Build Your Own Seismograph.
FEATURES ● Interface ● Circuit Surgery ● Ingenuity Unlimited ● Techno Talk ● PIC 'N' Mix ● The Power of Mechatronics – Part 5 ● Banning The Bulb ● Net Work – The Internet Page

NOV '07

PROJECTS ● Vehicle Multi-Voltage Monitor ● USB Electrocardiograph ● Experimenter's Audio System ● Inductance & Q-Factor Meter – Part 2.
FEATURES ● Teach-In 2008 – Part 1 ● Techno Talk ● IFA Electronics Show Berlin ● Circuit Surgery ● PIC 'N' Mix ● The Power of Mechatronics – Part 6 ● Practically Speaking ● Net Work



DEC '07

PROJECTS ● MIDI Drum Kit – 1 ● PIC Speech Synthesiser ● A Charger For Your iPod or MP3 Player ● AVR ISP Socketboard
FEATURES ● Circuit Surgery ● Techno Talk ● Teach-In 2008 – Part 2 ● PIC 'N' Mix ● Interface ● Protecting Your Designs and Copyright ● Net Work – The Internet Page

JAN '08

PROJECTS ● MIDI Drum Kit – 2 ● Phone/Fax Missed Call Alert ● PIC Carillon ● Serial I/O Controller and Analogue Sampler
FEATURES ● Circuit Surgery ● Techno Talk ● Teach-In 2008 – Part 3 ● PIC 'N' Mix ● Practically Speaking ● Ingenuity Unlimited ● Net Work

FEB '08

PROJECTS ● Electromog Sniffer ● Low-Cost Intercooler Water Spray Controller ● Studio Series – Stereo Pre-amplifier ● Midi Drum Kit – 3
FEATURES ● Colossus and Pico ● Interface ● Teach-In 2008 – Part 4 ● Circuit Surgery ● Techno Talk ● PIC 'N' Mix ● Ingenuity Unlimited ● Net Work – The Internet Page



MAR '08

PROJECTS ● Studio Series – Stereo Headphone Amplifier ● Midi Drum Kit – 4 ● Fluorescent Tube Driver ● Multi Throttle Control For PC Flight Simulators
FEATURES ● Practically Speaking ● Teach-In 2008 – Part 5 ● Circuit Surgery ● Techno Talk ● PIC 'N' Mix ● Net Work – The Internet Page

APR '08

PROJECTS ● PC-Controlled Burglar Alarm System – 1 ● Studio Series – Remote Control Module ● PIC In-Circuit Programming Add-On ● Midi Activity Detector
FEATURES ● Teach-In 2008 – Part 6 ● Techno Talk ● Interface ● Circuit Surgery ● PIC 'N' Mix ● Net Work – The Internet Page

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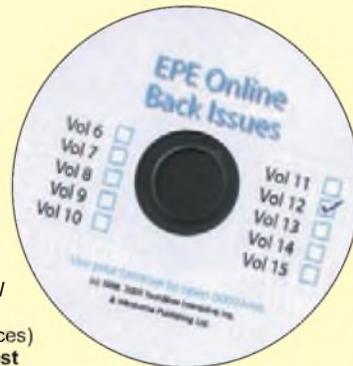
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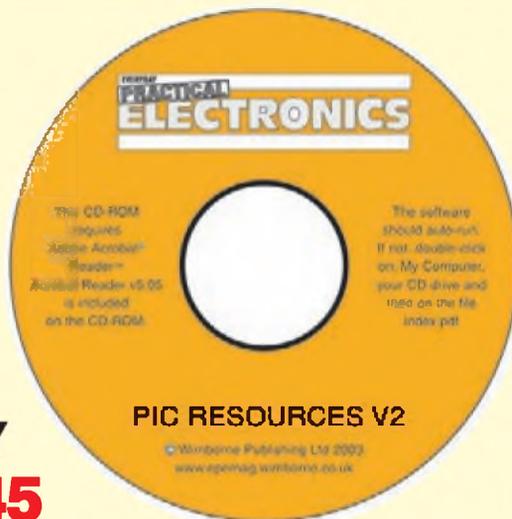
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★ LETTER OF THE MONTH ★

Techno Talk Jan 2008

Dear EPE,

Your *Techno Talk* '08 column starts 'Tin Whiskers - A new crisis in the electronics industry? Perhaps not.'

Don't kid yourself, this problem is real and it's happening right now. In fact, I witnessed this problem for the last five years without realising it up until a couple of years ago. For a living I repair Sky Digital boxes. These were first released by Pace in approx 1998; the first model, the 2200, was generally reliable.

A subsequent model, the 2400, was released about a year later and used a new concept in down-converting the LNB frequency, a solid-state tuner module based on a couple of ICs called the ZIF (Zero I.F.) tuner. Not long after the manufacturer's 12 month warranty ran out boxes started to fail, usually suffering from signal break up and intermittent no satellite signal having been received and stuck in stand-by.

The problem was traced to the failure of the ZIF tuner in every case. A new tuner would cure the fault, but was then a very expensive part to buy. I did some tests and traced the problem to the MAX2104CCM QPSK down-converter chip manufactured by Maxim semiconductors. I got Maxim in the UK to send

me a quantity of these chips from America and replacing this chip cured the intermittent faults.

The MAX2104CCM is a 48-pin surface mounted device and the underneath of the chip has a metal base, which not only provides an electrical connection for the RF ground plane but also the heat transfer point as this chip runs hot.

The soldering here was very poor and for a while I assumed this was the cause of the chip failure and I improved the heat-sinking with more solder paste before re-flowing. However, the chips continued to fail. Subsequent models of boxes manufactured by Amstrad started to drop like flies with the same signal-related problem, although these used a different ZIF chip, the CX24108-20CCM manufactured by Conexant.

Maxim semiconductors launched an investigation into the high failure rates of the MAX2104CCM and finally admitted, through a press release on their website, that the problem was caused by a growth inside the chip's package causing adjacent pins to short out intermittently. They stated that they have been unable to reproduce the failure mechanism in their laboratories, and were advising customers with failed chips not to desolder them from the PCB, as this could destroy

the failure mechanism, but to return the whole PCB for investigation.

This got me thinking, if heat could destroy the failure mechanism perhaps I could repair the faulty chip. If I heated the chip up to just above the solder melting point while it was still on the PCB, say 200°C, would this destroy the growth?

The answer is yes, it did and for a while I was repairing ZIF tuners without replacing any parts. However, this was short lived, because three months later the same chip was failing again.

It wasn't long before other chips started to fail in set-top boxes with alarming regularity. The 74LCX16244 and LCX16245 used in Panasonic and Amstrad will cause a box to be intermittently stuck in stand-by. The only good thing to come of this is a quicker diagnosis of an intermittent fault - if you heat up the chip and it cures the fault you have found the culprit! No test equipment required!

It's interesting that the germanium transistors have taken 25-30 years to manifest the problem, yet chips that run hot can fail after 18 months. My own theory is that heat accelerates the growth.

Michael Dranfield, Buxton, Derbyshire, via email

Navman and car supply problem

Dear EPE,

I have a Navman satellite navigation system for my car, which does not have an internal battery.

Consequently, when I start the engine the Navman switches off (drop in voltage I guess). This means I have to reprogram it, or call up the program if I have saved it as a 'favourite'. This is quicker than reprogramming, but it still has to be done with the engine running, which is not a good thing, and I guess I'll eventually run out of favourites' memory.

Does your mag have a circuit diagram for some form of 'dry cell' battery back up' that will maintain voltage to keep the Navman on when I cut the ignition or the voltage drops from starter motor loading? Or do you know of any company that make such a device, as I cannot build from the circuit but no doubt a local electronics wiz could. My local electronics shop (Dick Smith) cannot help.

**Anon, via email
New Zealand**

Alan Winstanley replied:

I am not aware of a published circuit, but you could ask for ideas in our forum at www.chatzones.co.uk, we have a number of readers in Australia and New Zealand.

Maybe a one Farad capacitor strapped across the supply (as used by car audio buffs)

would prevent the dip when switching on, but they are pricey.

The classic way of providing a battery backup is to use two rectifiers (eg 1N5401) in series with the battery pack and in series with the supply to the satnav. This stops the car battery discharging into the dry cells, but allows current to flow out of the battery pack, into the satnav.

The battery pack could be made rechargeable by using a simple constant current circuit. Some *EPE* readers may have some more ideas in the forum.

**Alan Winstanley,
via email**

FTDI, USB and VHDL

Dear EPE,

My readership has been off and on for the past few years, so this may have passed me by in a missed edition: I noted that the current projects still use a serial port, with the caveat that you may use a serial-to-USB converter.

Recently, I have come across FTDI (www.ftdichip.com) and their built-in USB converter to 3V3 TTL moulded lead, available through their webshop. They also provide free VCP and direct drivers, so existing software requires no further tweaking.

The good thing is you can personalise your lead using the also free MPROG software. Further study of their application notes will also allow you to get your own product name to appear in Windows device manager.

On a slightly different tangent, I noticed that Altera are now offering both their programming environment (Quartus) and their equivalent simulation environment (Modelsim) free for the MAXII range (www.altera.com/products/software/products/quartus2web/softwarwebmain.html). Previously this was a very expensive subscription.

In effect, you may write some VHDL and test it without going to any expense. 'Get you started' examples are very easy to find on the web. *Circuit Design with VHDL* by Volnei A. Pedroni is one of the best books I have read to get you going.

**Gary Cadman,
Northumberland, via email**

Thanks for that useful info Gary.

TK3 and PICKit2

Recently on the *Chat Zone* (via www.epemag.co.uk) reader Ian Stedman posted the following thread:

I like to use my TK3 PCB for PIC development work, but it does not support the PIC16F88 and PIC10F202 I currently use on some projects. I do have a PICKit2 programmer/debugger though, which supports these and many more devices. I made a simple adaptor to connect the two and put the instructions online here:

www.ianstedman.co.uk/Projects/TK3_PICKit2_adaptor/tk3_pickit2_adaptor.html

I hope some of you may find it useful.

Well done Ian, that's ingenious. Interested readers should browse your site.

Frequent CZ user Ed Grens (eagre) responded:

Ian – thanks. This is a very useful and well-described contribution.

Battery Zapper and more

Dear EPE,

Following on from the *Readout* letter about a blown fuse indicator for the *Lead-Acid Battery Zapper* – an indicator across a fuse is such a good idea that it's not new! The photo opposite, shows a dismantled fuseholder from the 1960s Hawker Siddeley-de Havilland Trident jet airliner. Note the 28V filament bulb in the head of the fuseholder, with a 330 ohm resistor across the fuse itself to allow enough current to light the nominally 80mA lamp through the faulty circuit after the fuse has blown.

Regarding the *USB Electrocardiograph*, UK component suppliers don't seem to acknowledge the concept of a 'low leakage' electrolytic capacitor (220µF, 50V, on the moving contact of gain switch S1) but Farnell lists the FM series from Panasonic and I see that the catalogue quotes leakage at '0.01µA max' which, if taken at face value, is more than an order of magnitude better than any other of the countless brands/types on offer (order 121-9481 at about a mere 32p + VAT – individually, no need to buy a quantity!). The lead pitch is the required 5mm.

**Godfrey Manning G4GLM,
via email**

Another useful contribution Gocfrey, thanks again.

Energy saving

Dear EPE,

Tony Jaques raises some interesting points in his letter 'What energy saving?' He is quite correct in saying that in winter months the effect of saving waste heat produced by lighting will be an equal increase in the energy used by the central heating system. However, there is another point to be considered.

The heat produced by the use of electricity requires that heat is first produced in a power station, then converted into electricity by means of a heat engine and a generator.

Carnot has shown that there is an absolute limit (dependent on the working temperatures of the engine) to the fraction of the input heat that a heat engine can convert to power. Assuming an input of heat at 500°C and a temperature of 0°C at which waste heat can be ejected to the environment (it is winter) this is about 65%. The rest of the heat goes up the cooling towers.

In practice, the fraction will be lower, probably under 50%. Thus the electrically produced heating from incandescent lamps will require twice as much energy as heating from an efficient domestic boiler.

**Sebastian Linfoot,
Oxford, via email**

Thanks Sebastian, such matters are never straght,forward.

RAM and Flash transfer

Dear EPE,

I found your *PIC n' Mix* in the Jan *EPE* very appropriate because I often use the large amount of available program (Flash) memory to augment limited RAM, when speed is not a problem. It certainly highlights advantages of using 18Fs in many circumstances.

However, I do not think that it was only possible 'for the first time' to transfer data between RAM and Flash with the 18Fs. It has



been possible for quite a while with a number of 16Fs, and I use this two-way procedure with my default 18-pin PIC, the 16F88. It is described in the 16F88 datasheet (DS30487B) pages 30 to 33.

To my mind, there is no reason to use a 16F84 or 628 when a 16F88 will do much more at no cost penalty.

Ed Grens, via email

Mike Hibbett replied to Ed:

Thanks for pointing that out Ed. I had a look at a number of the PIC16, 12 and 10 devices and didn't see Flash writing being available; clearly they have chosen a few 'select' parts to introduce this feature on before the 18F.

With so many devices available in the Microchip range it's often difficult to make a perfect choice of device for a project. I am often finding myself juggling features versus availability, and sometimes choose a part purely out of convenience – as I'm sure others do!

Mike Hibbett, via email

Electrosmog Sniffer

Dear EPE,

Regarding Thomas Scarborough's *Electrosmog Sniffer* of Feb 2008 issue, I have some questions:

1. He mentioned that coil L1 across the input and the output of the inverter IC1a is stabilising the output to about half of the supply voltage, though we know that a coil is like a short circuit for a DC voltage

2. How come it amplifies the ripples picked up by the coil to about 50 times?

3. The voltage induced across coil L1 terminals will be dependent on the frequency of the EMF since $E = N \cdot di/dt$. That is, after calibrating the meter, its reading will be valid only for one frequency of EMF at which the meter was calibrated?

K. Zack, via email

Thomas replied:

Q1. Yes indeed, the coil represents a DC short circuit – almost – yet there are ripples superimposed on the DC for the reason that the 'short circuit' is an inductor which is sensitive to AC – in this case EMF. This AC signal is then presented at a very high impedance input.

Q2. I was quoting a typical or 'ballpark' figure for such devices, where the input is at about half the supply voltage. In the circuit, it

will be more than 50 actually, due to feedback through the coil – a kind of regeneration.

Q3. Yes, certain inductances will ideally suit certain frequencies, especially when used as filters. In reality, though, when used as a pick-up coil, this does not significantly affect things – the same way that, for example, a radio coil will pick up mains interference as well as radio signals if suitable filtering is not present. If I had added the nuanced theory to my article, it would have considerably complicated it – and given me a headache trying to work it all out! This, bearing in mind that the design is not intended as a precision device, is simply a useful tool.

Thank you K. Zack for some observant questions.

Thomas Scarborough, via email.

Cold heat soldering irons

Dear EPE,

I've read Alans's on-line review of the Coldheat Soldering Iron (www.epemag.wimborne.co.uk/cold-soldering.htm). A quick question for you – while the results were disappointing for the average electronics hobbyist, with PCB connections all I would need it for would be soldering jack/jack and XLR/XLR plugs and sockets on amp and speaker leads. Would you consider it suitable for that purpose?

**Brian Read,
via email**

Alan replied to Brian:

Personally I wouldn't recommend a 'cold-heat' iron for this application because it's not controllable enough, the joints are highly inconsistent as a result and the tips are too fragile. The only job I would find it useful for is for melting an isolated already-existing solder joint, eg on a PCB, and using a reflow soldering technique to solder a tinned wire to it, or simple electrical repairs.

XLR connectors are expensive enough and in such a demanding application they would need a good quality joint, so in my view you would be far better using a traditional iron and a proper soldering technique. Unfortunately, in our market I have yet to hear from anyone who has had a good thing to say about these irons in electronics applications.

The best choice in my opinion are Antex mains pencil irons of say 15W or 25W, www.antex.co.uk or consider a gas-powered iron for portability.

**Alan Winstanley,
via email**

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

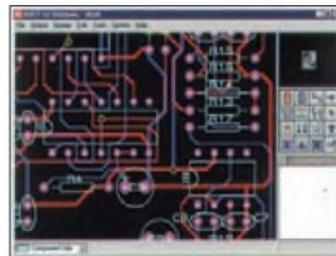


Logic Probe testing

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

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

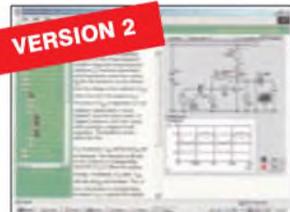
ELECTRONICS CAD PACK



PCB Layout

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

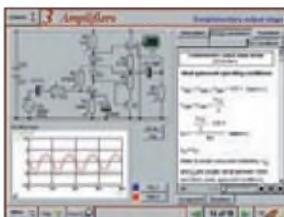
ELECTRONIC CIRCUITS & COMPONENTS V2.0



Circuit simulation screen

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

ANALOGUE ELECTRONICS

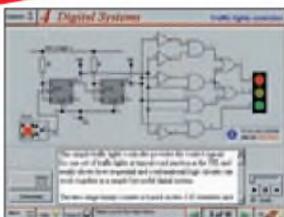


Complimentary output stage

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

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

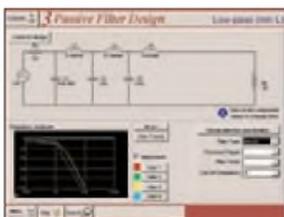
DIGITAL ELECTRONICS V2.0



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 op.amp filters.

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)

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

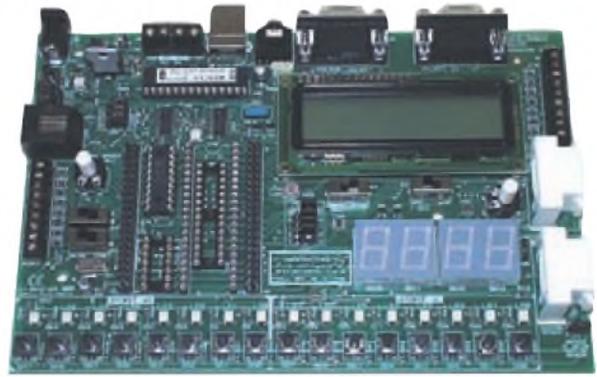
Hobbyist/Student.....	£45	inc VAT
Institutional (Schools/HE/FE/Industry).....	£99	plus VAT
Institutional 10 user (Network Licence).....	£249	plus VAT
Site Licence.....	£499	plus VAT

VERSION 3 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

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

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



£158 including VAT and postage, supplied with USB cable and programming software

SPECIAL OFFER

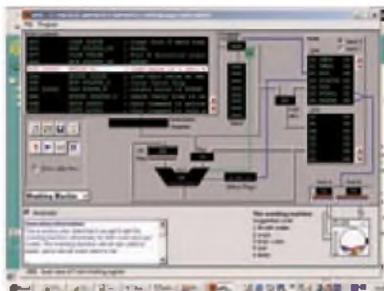
£40 OFF Buy the Development Board together with any Hobbyist/Student or Institutional versions of the software CD-ROMs listed below and take £40 off the total (including VAT) price.

SOFTWARE

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.

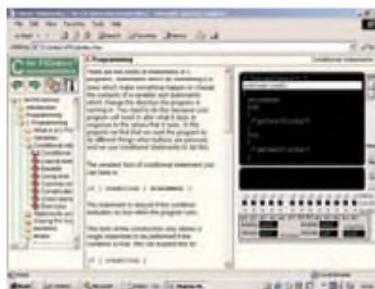


'C' FOR 16 Series PICmicro VERSION 4

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.



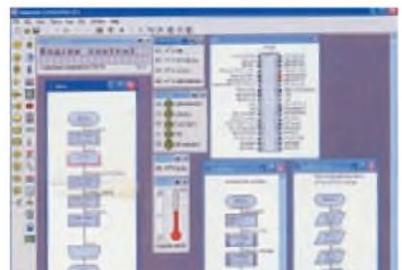
Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

FLOWCODE FOR PICmicro V3

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A Powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and I.c.d.s. The use of macros allows you to control these devices without getting bogged down in understanding the programming.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 3 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
- 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
- New features in Version 3 include 16-bit arithmetic, strings and string manipulation, improved graphical user interface and printing, support for 18 series devices, pulse width modulation, I2C, new ADC component etc. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

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

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Site Licence
Flowcode 10 user (Network Licence)
Flowcode 50 user (Network Licence)

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SPECIAL PACKAGE OFFER

TINA Pro V7 (Basic) + Flowcode V3 (Hobbyist/Student)

TINA Analogue, Digital, Symbolic, RF, MCU and Mixed-Mode Circuit Simulation, Testing and PCB Design

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TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

Customise presentations using TINA's advanced drawing tools to control text, fonts, axes, line width, colour and layout. You can create, and print documents directly inside TINA or cut and paste your results into your favourite word-processing or DTP package.

TINA includes the following Virtual Instruments: Oscilloscope, Function Generator, Multimeter, Signal Analyser/Bode Plotter, Network Analyser, Spectrum Analyser, Logic Analyser, Digital Signal Generator, XY Recorder.

Flowcode V3 (Hobbyist/Student) – For details on Flowcode, see the previous page.

This offer gives you two separate CD-ROMs in DVD style cases – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

Get TINA + Flowcode for a total of just £50, including VAT and postage.

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WHAT'S INCLUDED

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Runs in Microsoft Internet Explorer

*All circuits can be viewed, but can only be simulated if your computer has Crocodile Technology version 410 or later. A free trial version of Crocodile Technology can be downloaded from: www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.

Single User £39.00 inc. VAT.

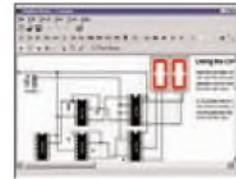
Multiple Educational Users (under 500 students) £59.00 plus VAT. Over 500 students £79.00 plus VAT.

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



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Over 600 images

DIGITAL WORKS 3.0



Counter project

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

ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

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Price £19.95 inc. VAT



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

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- Analogue Filters
- Electronics CAD Pack
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- Assembly for PICmicro V3
- 'C' for 16 Series PICmicro V4
- Flowcode V3 for PICmicro
- Digital Works 3.0

- Version required:**
- Hobbyist/Student
 - Institutional
 - Institutional/Professional 10 user
 - Site licence



PICmicro Development Board V3 (hardware)

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Net Work

Alan Winstanley



Sorry, new customers only

Last month we looked at the state of the current broadband market in the UK. The same pattern of falling broadband speeds and declining customer service could be repeating itself in other countries, as the trend steers towards slashing the price of this commodity service, with many ISPs needing to increase the volume of users, risking the all too familiar reduction of customer service from call centres that struggle to deal with hoards of customers all clamouring for support.

One Tiscali broadband customer was blisteringly furious at the way they mismanaged her change of address, citing a 45 minute delay holding for a call centre, repeatedly missing deadlines – a quoted ten-day changeover was still in limbo a month later. So she contacted another supplier (Swift Internet) who within 45 seconds (not 45 minutes) confirmed the status of her phone line, and a higher quality broadband was up and running within just two working days (with the added benefits of a fixed IP address too). Like everything, you get what you pay for, and if your choice just boils down to price then the service you receive will reflect that.

I highlighted my own experiences of Tiscali, who provided a totally faultless broadband setup and service back in 2005. Since then, download speeds have declined as more users climbed aboard, contention ratios have peaked and more users are dabbling with the likes of music downloads and streaming radio and TV services.

Tiscali is a key European ISP having a voracious appetite for customer numbers, gunning for the volume market partly by focussing on teaser subscription rates. Mercifully, they do not blitz us with mailshots or scores of unwanted CDs like AOL used to do, but their latest packages are causing not a little annoyance to some of its existing customers. The 'new customers only' package of unlimited (up to) 8Mbps broadband is just £8.49 (\$17) for the first three months then £14.99 (\$30) thereafter.

In effect, Tiscali newcomers receive over three months a year for free compared with loyal Tiscali Max subscribers locked into paying £18.50 (\$37) per month. One Max user reportedly tried to switch to the new lower price to be told bluntly by a Tiscali agent of the 'new customers only' policy, adding that they would be cut off if they tried to cancel the existing contract and re-apply at the lower rate.

A marketing mix

A classic marketing ploy to differentiate services and prevent customers from comparing like with like is to bundle in a range of add-ons, such as broadband TV (if available), free phone calls or discounted line rentals. However, when prices are pared to the bone, an 'everything is extra' stage is reached where one-off setup charges are levied again or wireless routers are charged separately, so it is always essential to compare tariffs and small print carefully.

Yet another Tiscali customer – this time in London – told me how delighted she was with her service, which is a flat

In the drive for volume numbers, city dwellers are the first to benefit when ISP's such as Tiscali install their own equipment into telephone exchanges.

rate all-inclusive package for £19.99, including line rental that was formerly payable to BT. It transpired that this is in a part of the UK where they have installed their own equipment in the telephone exchange: Tiscali claim to have been investing £60 million (\$120 million) in Local Loop Unbundling (LLU), which enables them to offer this flat rate, 'all you can eat' tariff that includes line rental.

As services continue to evolve in a highly price-sensitive market, providing us with broadband, streaming TV via ADSL or cable, inclusive phone calls, free routers or set-top boxes, eventually many of us will be able to buy an all-inclusive service with an 'all you can eat' pricing structure. In the meantime, suppliers' tariffs are deliberately complicated by differences in features such as line rental or free weekend calls. In regions where its attractive-looking all-inclusive local loop services are available, Tiscali requires a £30 setup charge; a monthly £19.99 fee seems attractive, but there is an 18 month lock-in. A comparison at <http://www.tiscali.co.uk/products/talk/package-comparison.html> shows how Tiscali claims their package will cost £389.82 (18 month's + setup) for broadband and voice calls against BT's £602.82.

Check it out

Here is a checklist of features to look for in today's market when shopping for a combined ADSL broadband/phone deal:

- Beware the lock-in period – how long is your contractual commitment?
- Is there an automatic renewal that locks you in for another year unless you cancel in time?
- Is there a usage limit on downloads? This affects TV/ radio/ video usage.
- Is there a one-off setup fee?
- Is free or premium rate telephone technical support provided?
- Is a free modem or (better) a wireless router supplied?
- Can you send your own domain-name email (From: *me@mydomain.co.uk*)? As an anti-spam feature, some providers don't permit domain names to be used without their prior approval.
- Do you receive any free web space?
- Is webmail available as well as POP3 downloadable email?
- Is line rental included?
- Are free evening and weekend voice calls available?
- Are 'favourite' or international calls bundled at a discounted price?

Today, it is as hard as ever to shop around for the best deal – so much choice and so many details to check first! You can check out specialist sites such as Broadband Speed Checker (see last month), uSwitch.com or other comparison sites that will help you to source a new provider in your country.

In forthcoming columns I will describe some simple tests to help you debug a troublesome Internet connection, also looking at some recent developments on TV available by broadband. You can email comments to me at alan@epemag.demon.co.uk.

DIRECT BOOK SERVICE

NOTE: ALL PRICES INCLUDE UK POSTAGE

Electronics Teach-In + Free CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole Teach-In 2006 series (originally published in EPE) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the Teach-In series, the book includes 15 CMOS-based simple projects from the Back-To-Basics series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the Teach-In series.

152 pages + CD-ROM Order code ETI £8.50



Circuits and Design

A BEGINNER'S GUIDE TO TTL DIGITAL ICs

R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the 'real world'.

142 pages Order code BP332 £5.45

PRACTICAL ELECTRONIC CALCULATIONS AND FORMULAE

F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Bridges the gap between complicated technical theory, and 'cut-and-try' methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements

256 pages Order code BP53 £5.49

MICROCONTROLLER COOKBOOK

Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages Order code NE26 £23.50

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF EPE OR GO TO THE SHOP ON OUR WEBSITE www.epemag.co.uk

EASY PC CASE MODDING

R.A. Penfold

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and its working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including: Electro luminescent (EL) 'go-faster' stripes Internal lighting units Fancy EL panels Data cables with built-in lighting Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube Digital display panels LED case and heatsink fans Coloured power supply covers.

192 pages Order code BP542 £8.99

ROBOT BUILDERS COOKBOOK

Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at <http://books.elsevier.com/companions/9780750665568> contains downloadable files of all the programs and subroutines, program listings for the Quaker and the Gantry robots that are too long to be included in the book.

366 pages Order code NE46 £21.99

NEWNES INTERFACING COMPANION

Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation.

Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems, Temperature, Light, Position and motion, Force, pressure and flow Part 2 – Interfacing, Number systems, Computer architecture, Assembly language, Interfacing, A to D and D to A conversions, Data communications, Programmable logic controllers, Data acquisition project Part 3 – Signal processing, Transfer function, Active filters, Instrumentation amplifier, Noise, Digital signal processing

295 pages Order code NE38 £31.00

Computing & Robotics

WINDOWS XP EXPLAINED

N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and Home editions.

The book was written with the non-expert, busy person in mind. It explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, Notepad and Paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; How to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

268 pages Order code BP514 £7.99

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS

Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various 'click-together' components supplied in the basic RIS kit. Explains in simple terms how the 'brain' of the robot may be programmed on screen using a PC and 'zapped' to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages – large format Order code BP901

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'water service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on

the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages Order code BP902 £14.99

THE PIC MICROCONTROLLER

YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION

John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages Order code NE36 £18.50

INTRODUCTION TO MICROPROCESSORS AND MICROCONTROLLERS – SECOND EDITION

John Crisp

If you are, or soon will be, involved in the use of microprocessors and microcontrollers, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors and microcontrollers. Assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern microc.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

222 pages Order code NE31 £22.00

Project Building

ELECTRONIC PROJECT BUILDING FOR BEGINNERS

R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

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.

135 pages **Order code BP392** **£5.49**

BUILDING VALVE AMPLIFIERS

Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

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.

368 pages **Order code NE40** **£22.50**

Theory and Reference

THE EMERGENCE OF BROADCASTING IN BRITAIN

Brian Hennessy

The beginning of any great enterprise should be recorded for posterity. Few knew that the *Children's Hour* "Uncles", Arthur, Jeff and Caractacus, were also the engineers who struggled by day to develop technical equipment – and would soon become Assistant Controller, Station Director and Organiser of Programmes for the BBC.

This is a very human account, from the dawn of radio to the attainment of a Royal Charter in the late 1920s. It tells of the struggles and frustrations of engineers in developing innovative equipment and of the great John Reith who battled with everyone to bring the BBC from a staff of four up to a Corporation of several hundred.

Brian Hennessy's book also describes the development of broadcasting equipment, the search for premises and looming bankruptcy before ending with the emergence of a firmly established Chartered Corporation – the BBC.

Meticulous research over many years, over a hundred photographs, plans and diagrams as well as interviews with many of those who were there at the time, make this a valuable and original work for those involved in media studies, for radio enthusiasts or simply for those interested in radio and the fascinating story of the emergence of broadcasting.

436 pages **Order code EBB** **£26.00**



PRACTICAL ELECTRONIC FILTERS

Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rhythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

188 pages **Order code BP299** **£5.49**

ELECTRONIC PROJECTS FOR EXPERIMENTERS

R. A. Penfold

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.

The subjects covered include: - Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

PRACTICAL FIBRE-OPTIC PROJECTS

R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include: - Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

STARTING ELECTRONICS, THIRD EDITION

KEITH BRINDLEY

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboarding layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equipped lab.

288 pages **Order code NE42** **£11.50**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR

R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

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.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£5.45**

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Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. Double-sided boards are NOT plated through hole and will require 'vias' and some components soldering both sides. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, Everyday Practical Electronics, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics (Payment in £ sterling only)*. **NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.** Back numbers or photocopies of articles are available if required – see the *Back Issues* page for details. **WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.**

Please check price and availability in the latest issue. A large number of older boards are listed on, and can be ordered from, our website. Boards can only be supplied on a payment with order basis.

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★ All software programs for *EPE* Projects marked with an asterisk, and others previously published, can be downloaded *free* from our Downloads site, accessible via our home page at: www.epemag.co.uk.

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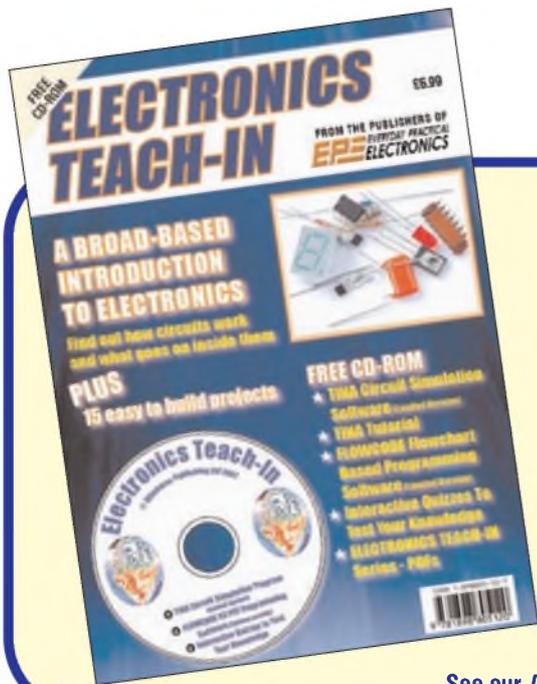
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EPE MONOPOLY MONEY

This fun project is the closest most of us will get to running a bank – see if you can do a better job than Wall Street!

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