THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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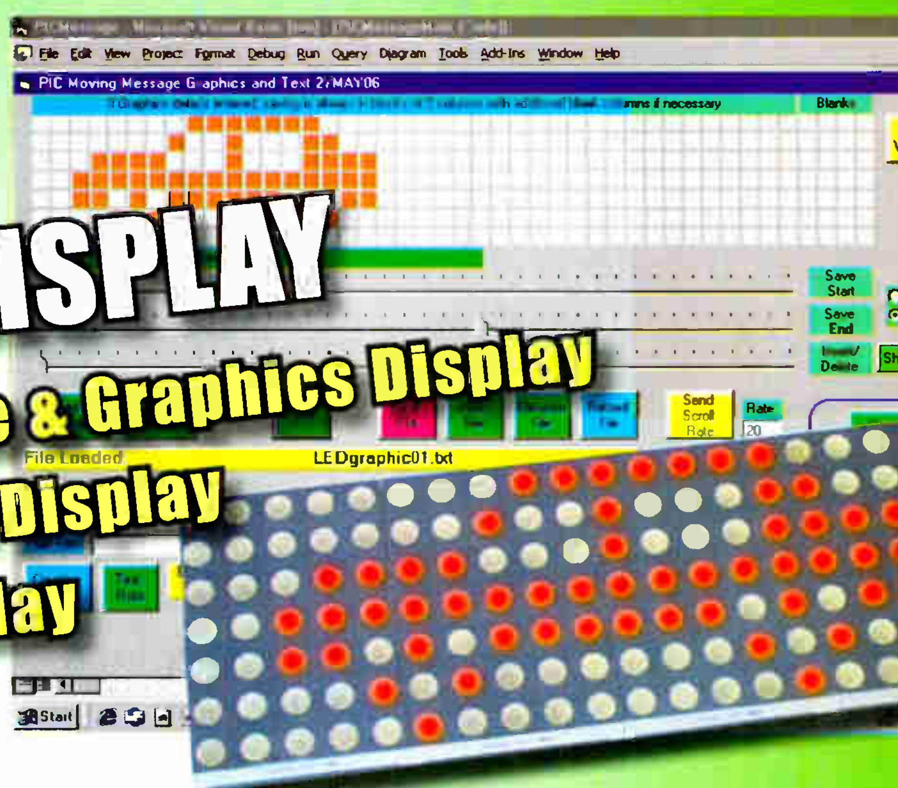

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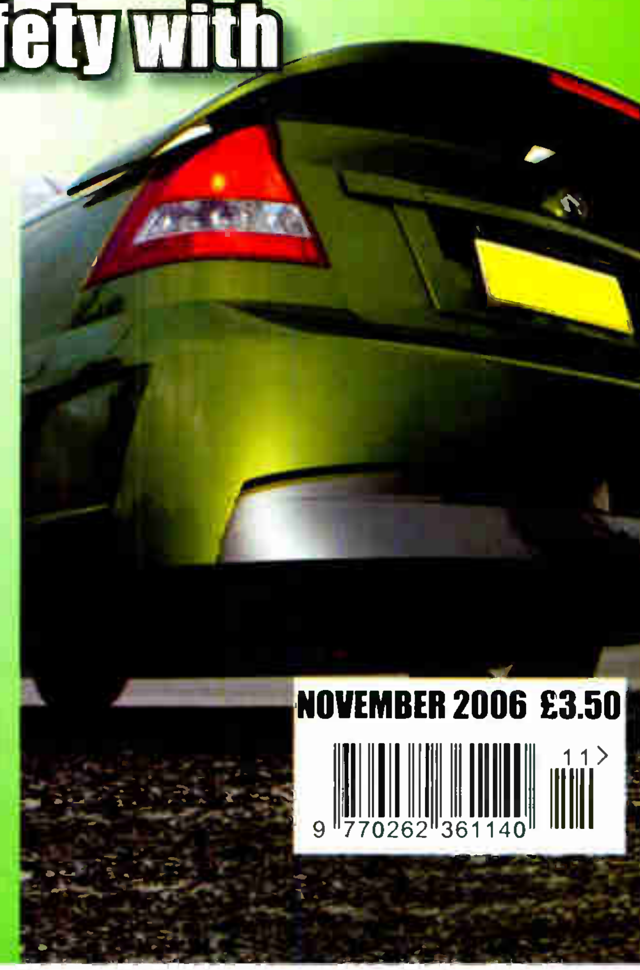

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World Radio History

NEW ELECTRONIC CONSTRUCTION KITS

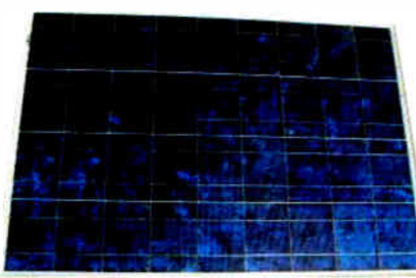
This 30 in 1 electronic kit includes an introduction to electrical and electronic technology. It provides conponents that can be used to make a variety of experiments including Timers and Burglar Alarms. Requires: 3 x AA batteries. £15.00 ref BET1803

AM/FM Radio This kit enables you to learn about electronics and also put this knowledge into practice so you can see and hear the effects. Includes manual with explanations about the components and the electronic principles. Req's: 3 x AA batts. £13 ref BET1801

This **40 in 1 electronic kit** includes an introduction to electrical and electronic technology. It provides conponents that can be used in making basic digital logic circuits, then progresses to using Integrated circuits to make and test a variety of digital circuits, including Flip Flops and Counters. Req's: 4 x AA batteries. £17 ref BET1804

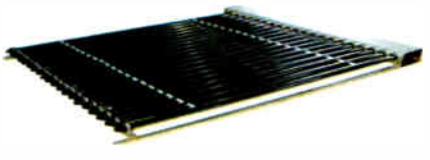
The **75 in 1 electronic kit** includes an nintroduction to electrical and electronic technology. It provides conponents that can be used to make and test a wide variety of experiments including Water Sensors, Logic Circuits and Oscillators. The kit then progresses to the use of an intergrated circuit to produce digital voice and sound recording experiments such as Morning Call and Burglar Alarm. Requires: 3 x AA batteries. £20 ref BET1806

SOLAR PANELS



We stock a range of solar photovoltaic panels. These are polycrystalline panels made from wafers of silicon laminated between an impact-resistant transparent cover and an EVA rear mounting plate. They are constructed with a lightweight anodised aluminium frame which is predrilled for linking to other frames/roof mounting structure, and contain waterproof electrical terminal box on the rear. 5 watt panel £29 ref 5wnav 20 watt panel £99 ref 20wnav 60 watt panel £249 ref 60wnav. Suitable regulator for up to 60 watt panel £20 ref REGNAV

EVACUATED TUBE SOLAR HOT WATER PANELS



(20 tube shown) These top-of-the-range solar panel heat collectors are suitable for heating domestic hot water, swimming pools etc - even in the winter! One unit is adequate for an average household (3-4people), and it is modular, so you can add more if required. A single panel is sufficient for a 200 litre cylinder, but you can fit 2 or more for high water usage, or for heating swimming pools or underfloor heating. Some types of renewable energy are only available in certain locations, however free solar heating is potentially available to almost every house in the UK! Every house should have one -really! And with an overall efficiency of almost 80%, they are much more efficient than electric photovoltaic solar panels (efficiency of 7-15%). Available in 10, 20 and 30 tube versions. 10 tube £199, 20 tube £369, 30 tube £549. Roof mounting kits (10/20 tubes) £12.50, 30 tube mounting kit £15

2kW WIND TURBINE KIT

The 2kW wind turbine is supplied as the following kit: turbine generator 48v three taper/ twisted fibreglass blades & hub 8m tower (four x 2m sections) guylines / anchors / tensioners / clamps foundation steel rectifier 2kW inverter heavy-duty pivot tower. £1,499

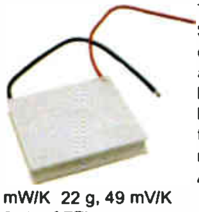
Other sizes available from 200 watts (£299) up to 20kW (£13,999) The 200w system is complete apart from 2x12v batteries and concrete for the tower. These low cost systems can provide substantial amounts of power, even in average wind conditions.

STEAM ENGINE KIT

The material in this pack enables you to build a fully functional model steam engine. The main material is brass and the finished machine demonstrates the principle of oscillation. The boiler, uses solid fuel tablets, and is quite safe. All critical parts (boiler, end caps, safety vent etc.) are ready finished to ensure success. The very detailed instruction booklet (25 pages) makes completion of this project possible in a step by step manner. Among the techniques experienced are silver soldering, folding, drilling, fitting and testing. £29.70 ref STEAMKIT Silver solder/flux pack £3.50 ref SSK

HOT AIR MOTOR (Stirling motor) This is an interesting metal based project for pupils aged 15 plus. The material pack will enable them to make a fully functional hot air motor. All the critical parts (piston, working cylinder, flywheel and coolers) have been pre-made and are ready for use. The detailed plans show all the important stages for the required metal working (Measuring with a vernier, sawing, silver soldering, drilling, marking out,thread making, silver soldering, sawing and filing, etc) At the same time the principles of the hot air motor are described in the wide ranging instructions. Technical data : Working cylinder stroke ø 12 x 10 mm Pressure cylinder stroke ø 13 x 11 mm

Unloaded speed approx. 800 rpm Size: Flywheel dia. 55mm Base 130 x130 mm With sinter smooth bearings and ready shaped cooler. £29.70 ref STEAMKIT2 Silversolder pack £3.50 ref SSK



Thermo **Peltier element**, large Size: 40 x 40 x 4,7 mmTechnical data of the Thermo element:Use as a Peltier element to cool or heat: will provide 33 Watts of heating or cooling, max temp difference between sides of 67°C, maximum output 15V 3,9 Ampere 150°C 3,5 Ohm 250 mW/K 22 g, 49 mV/K
£14 ref TEL1

Die cast illuminated microscope set in plastic carry case Includes a handy carry case with a 1200x magnification microscope. Contents include test tubes, magnifier glass and probe. Requires 2 x AA batteries (not included). ultra-compact, lightweight, easy to use and comfortable to hold. An ideal microscope for the beginner offering a good magnification range. £25.99 ref MAG1200

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HB10 One of our range of Stirling engines The Bohm HB10 Stirling engine is available in both ready built and kit form. The power comes from a small spirit burner, once lit just watch this amazing Stirling engine run. HB10 in kit form is £97.95 or £101.99 built. Many other models in stock. Order online at www.mamodspares.co.uk

Rapidos Mobile networking digital surveillance system. Plugs into USB port on computer, takes 4 cameras, NSTC or PAL, 352*288 res, 1-30 f/s MPEG4 & MJPEG, motion detection, pre and post recording, watermark, date, time and location markings, alarm notice via FAX, FTP or email, Modes- continuous record, motion detection record, sheduled record, time lapse record, dynamic IP, can send live images to your mobile phone. £109 ref RAPIDOS

HEAT PUMPS

A heat pump is a system that uses a refrigeration-style compressor to transfer heat from outside to inside, in order to heat offices or homes. Heat pumps can take heat from the air, water or ground. Ground source heat pumps are very efficient – in fact you will get 3-4 units of heat for every unit of electricity supplied to the heat-pump. Basic component parts of a GSHP:

1 A heat pump packaged unit: Water-Water type. (approx. the size of a small fridge) containing two cold water connections and two heated water connections.

2. The heat source which is usually a closed loop of plastic pipe containing water with glycol or common salt to prevent the water from freezing. This pipe is buried in the ground in vertical bore holes or horizontal trenches. The trenches take either straight pipe or coiled (Slinky) pipe, buried about 1.5 to 2m below the surface. A large area is needed for this.

3. The heat distribution system. This is either underfloor heating pipes or conventional radiators of large area connected via normal water pipes.

4. Electrical input and controls. The system will be require an electrical input energy, single phase is perfectly adequate for smaller systems. A specialised controller will be incorporated to provide temperature and timing functions of the system.

This type of installation offers many advantages.

a) The water-water heat pump unit is a sealed and reliable self contained unit.

b) There are no corrosion or degradation issues with buried plastic pipes.

c) The system will continue to provide the same output even during extremely cold spells.

d) The installation is fairly invisible. i.e. no tanks or outside unit to see.

e) No regular maintenance required.

Some tips

The efficiency of any system will be greatly improved if the heated water is kept as low as possible. For this reason, underfloor heating is preferred to radiators. It is vital to ensure that the underfloor layout is designed to use low water temperatures. i.e. plenty of pipe and high flow-rates. If radiators are to be used, they must be large enough. Double the normal sizing (as used with a boiler) is a good starting point.

5Kw (output) ground to air heat pump £1,099 ref HP5

9kw (output) ground to water heat pump £1,999 ref HP9

World Radio History

ISSN 0262 3617

PROJECTS . . . THEORY . . .
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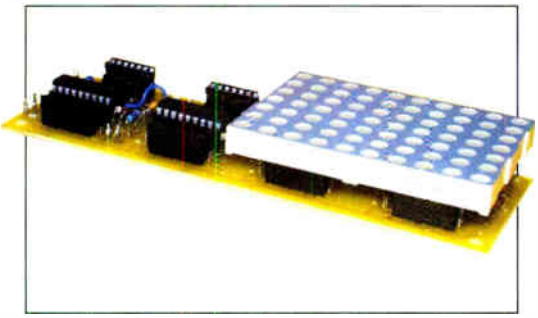

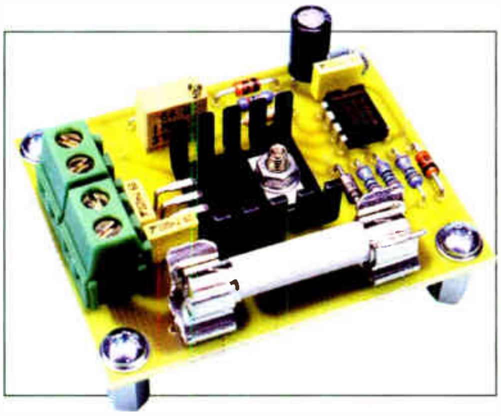

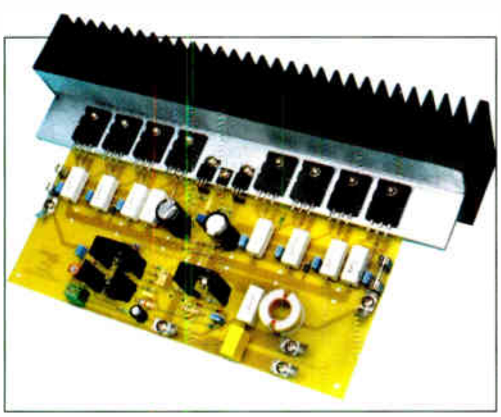

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Our December 2006 issue will be published on Thursday, 9 November 2006. See page 80 for details

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

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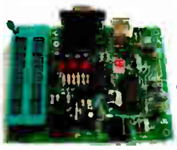
Leads: Parallel (LDC136) £4.95 / Serial (LDC441) £4.95 / USB (LDC644) £2.95

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 - **£37.95**
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 89xxxx 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**

ABC Maxi AVR Development Board

The ABC Maxi is ideal for developing new designs. Open architecture built around an ATMEL AVR AT90S8535 microcontroller. All circuits are embedded within the package and additional add-on expansion modules are available to assist you with project development.

Features
8 Kb of In-System Programmable Flash (1000 write/erase cycles) • 512 bytes internal SRAM • 512 bytes EEPROM • 8 analogue inputs (range 0-5V) • 4 Opto-isolated Inputs (I/Os are bi-directional with internal pull-up resistors) • Output buffers can sink 20mA current (direct LED drive) • 4 x 12A open drain MOSFET outputs • RS485 network connector • 2-16 LCD Connector • 3.5mm Speaker Phone Jack • Supply: 9-12Vdc

The ABC Maxi STARTER PACK includes one assembled Maxi Board, parallel and serial cables, and Windows software CD-ROM featuring an Assembler, BASIC compiler and in-system programmer.
Order Code ABCMAXISP - **£89.95**
The ABC Maxi boards only can also be purchased separately at £69.95 each.

Controllers & Loggers

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

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 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 - **£51.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Includes one DS1820 sensor and four header cables.
Kit Order Code: 3145KT - **£18.95**
Assembled Order Code: AS3145 - **£25.95**
Additional DS1820 Sensors - **£3.95 each**

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

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 - **£46.95**
Assembled Order Code: AS3140 - **£59.95**

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. Once programmed, unit can operate without PC. 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**

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 - **£11.95**
Assembled Order Code: AS3179 - **£18.95**

Bi-Polar Stepper Motor Driver also available (Order Code 3158 - details on website)

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: 9-18Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£19.95**

Bidirectional DC Motor Driver also available (Order Code 3166 - details on website)

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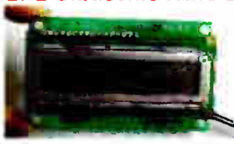
Hot New Kits This Summer!

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

EPE Ultrasonic Wind Speed Meter



Solid-state design wind speed meter (anemometer) that uses ultrasonic techniques and has no moving parts and does not need calibrating. It is intended for sports-type activities, such as track events, sailing, hang-gliding, kites and model aircraft flying, to name but a few. It can even be used to monitor conditions in your garden. The probe is pointed in the direction from which the wind is blowing and the speed is displayed on an LCD display.

Specifications

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

Based on the project published in Everyday Practical Electronics, Jan 2003. We have made a few minor design changes (see website for full details). Power: 9Vdc (PP3 battery). Main PCB: 50x83mm.
Kit Order Code: 3168KT - **£36.95**

Audio DTMF Decoder and Display

Detects DTMF tones via an onboard electret microphone or direct from the phone lines through an audio transformer. The numbers are displayed on a 16 character, single line display as they are received. Up to 32 numbers can be displayed by scrolling the display left and right. There is also a serial output for sending the detected tones to a PC via the serial port. The unit will not detect numbers dialled using pulse dialling. Circuit is microcontroller based. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£20.95**
Assembled Order Code: AS3153 - **£29.95**

EPE PIC Controlled LED Flasher

This versatile PIC based LED or filament bulb flasher can be used to flash from 1 to 176 LEDs. The user arranges the LEDs in any pattern they wish. The kit comes with 8 super bright red LEDs and 8 green LEDs. Based on the Versatile PIC Flasher, EPE Magazine Dec 02. See website for full details. Board Supply: 9-12Vdc. LED supply: 9-45Vdc (depending on number of LED used). PCB: 43x54mm.
Kit Order Code: 3169KT - **£11.95**

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

FM Bugs & Transmitters

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

MMTX Micro-Miniature 9V FM Room Bug

Our best selling bug! Good performance. Just 25x15mm. Sold to detective agencies worldwide. Small enough to hide just about anywhere. Operates at the 'less busy' top end of the commercial FM waveband and also up into the more private Air band. Range: 500m. Supply: PP3 battery.
Kit Order Code: 3051KT - **£8.95**
Assembled Order Code: AS3051 - **£14.95**

HPTX' High Power FM Room Bug

Our most powerful room bug. Very impressive performance. Clear and stable output signal thanks to the extra circuitry employed. Range: 1000m @ 9V. Supply: 6-12V DC (9V PP3 battery clip supplied). 70x15mm.
Kit Order Code: 3032KT - **£9.95**
Assembled Order Code: AS3032 - **£17.95**

MTTX' Miniature Telephone Transmitter

Attach anywhere along phone line. Tune a radio into the signal and hear exactly what both parties are saying. Transmits only when phone is used. Clear, stable signal. Powered from phone line so completely maintenance free once installed. Requires no aerial wire - uses phone line as antenna. Suitable for any phone system worldwide. Range: 300m. 20x45mm.
Kit Order Code: 3016KT - **£7.95**
Assembled Order Code: AS3016 - **£13.95**

Wide Band Synthesised FM Transmitter

PLL based crystal-locked wide band FM transmitter delivering a high quality, stable 10mW output. Accepts both MIC audio signal (10mV) and LINE input (1v p-p) for example hi-fi, CD, audio mixer (like our kit 1052) or computer sound card. Supply: 9-15Vdc.
Kit Order Code: 3172KT - **£19.95**
Assembled Order Code: AS3172 - **£32.95**

3 Watt FM Transmitter

Small, powerful FM transmitter. Audio pre-amp stage and three RF stages deliver 3 watts of RF power. Use with the electret microphone supplied or any line level audio source (e.g. CD or tape OUT, mixer, sound card, etc). Aerial can be an open dipole or Ground Plane. Ideal project for the novice wishing to get started in the fascinating world of FM broadcasting. 45x145mm.
Kit Order Code: 1028KT - **£23.95**
Assembled Order Code: AS1028 - **£31.95**

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Also available - 30-in-1 **£15.95**, 130-in-1 **£37.95** & 300-in-1 **£59.95** (details on website)

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A highly featured, high-precision digital multimeter with a large 4.5 digit LCD display. High accuracy (0.05%). Auto-zeroing, polarity selection and over-range indication. Supplied complete with shrouded test leads, shock-proof rubber holster, built-in probe holder and stand. Supplied fully assembled with holster, battery and presentation box. Features include:
Capacitance • Audio Frequency • Data Hold • hFE / Diode Test • Auto Power Off

Technical Specifications
DC voltage: 200mV-1000V • AC voltage: 2V-700V • DC current: 2mA-20A • AC current: 20mA-20A • Resistance: 200Ω-200MΩ • Capacitance: 2nF-20uF • Frequency: 20kHz • Max display: 19999

Order Code: MM463 - Was £44.95 **Now on sale at just £29.95!**
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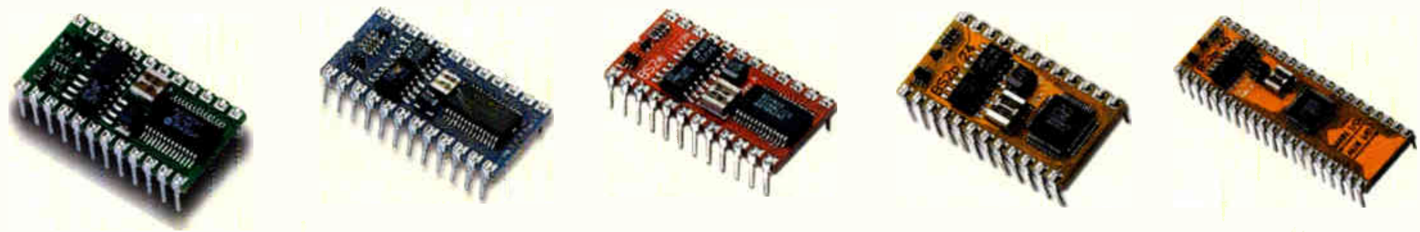

BS2-IC | BS2-SX | BS2E-IC | BS2P/24 | BS2P/40

Parallax BASIC Stamps - still the easy way to get your project up and running!


Serial Alphanumeric and Graphic Displays, Mini-Terminals and Bezel kits

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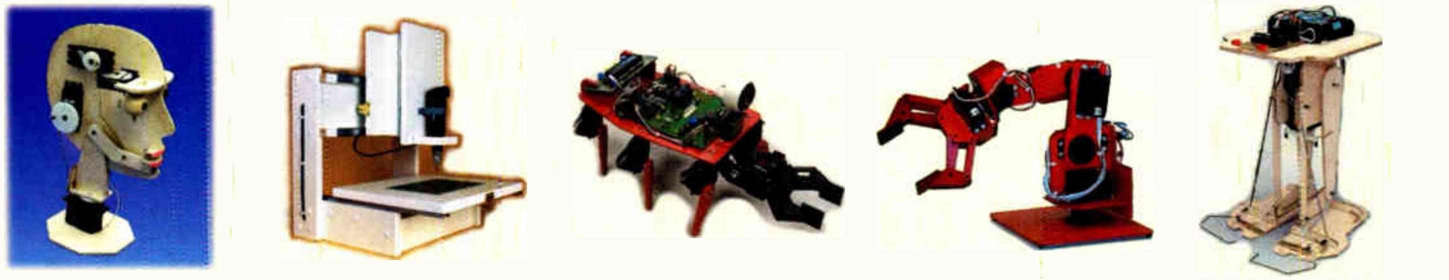

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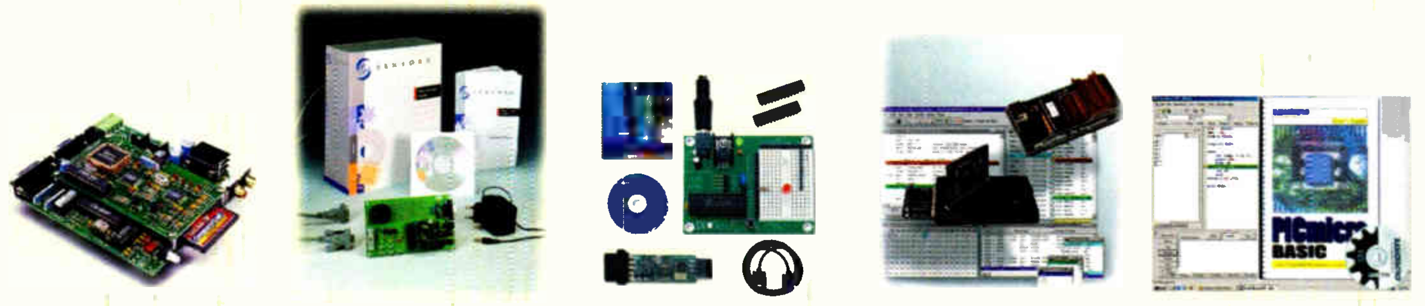

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World Radio History

EPE PROJECT PICs

Programmed PICs for EPE Projects
12C508/9-£3.90; 16F627/8 - £4.90
16F84/71/ - £5.90
16F876/877/ 18Fxxxx - £10.00
All inc. VAT and Postage

1kV/500V Insulation Tester

Super design. Regulated output and efficient circuit. Dual scale meter, compact case. Reads up to 200 Megohms. Kit includes wound ferrite transformer, drilled and punched case, meter scale, PCB & ALL components. (Needs PP3 battery).

KIT 848...£32.95

DUAL OUTPUT *TENS* UNIT

An excellent kit for this project based on the EPE March'97 Design. Our Full Kit includes all components, hardware and an improved Magenta pcb. All hardware and electrodes are included. Designed for simple assembly and testing, providing a high level controlled dual output drive.

KIT 866 .. £32.90
Inc. 4 electrodes

Set of 4 Spare Electrodes £6.50

EPE MICROCHIP P.I. Treasure Hunter

Stable Sensitive Pulse Induction detector. Easy to build and use. No ground effect - works in sea water. Detects Gold Silver, ferrous and non ferrous metals.

Kit Includes Headphones, coil and all Hardware

KIT 847 ... £63.95

Ultrasonic PEsT Scarers

Two Ultrasonic PEsT Scarers. **Kit 812** produces regular high level pulses of 32kHz. **Kit 867** produces Random pulses and can work with an optional slave unit to give two separate ultrasound sources. Both kits need 9V supply.

Kit 812 ... £14.81 psu . 3.99
Kit 867 ... £19.99 867 Slave **£12.51**

MOSFET MKII Bench PSU 0-25V 2.5A

Based on Mk1 design, with switching pre-regulator for high efficiency Panel meters for A and V. Toroidal transformer. Variable Volts 0 - 25 AND Variable Current limit from 0 -2.5A
Kit includes punched and labelled case. A classic and essential piece of test gear

Kit 845 ... £64.95

68000 Trainer Kit 621.. 99.95

Stepping & DC Motors

A range of motors for many applications:
Visit our website for more details
MD100 100 step Unipolar..... £9.99
MD200 200 step Unipolar..... £12.99
MD24 Type '23' size 200 step..£22.95

MAGENTA BRAINIBOT I & II

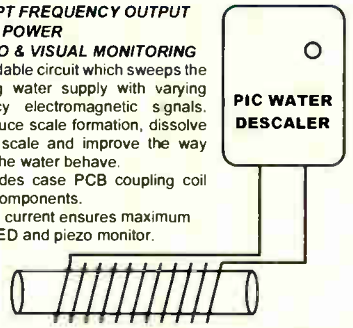
- Full kit with ALL hardware and electronics.
- As featured in *EPE* Feb '03 (KIT 910)
- Seeks light, beeps, and avoids obstacles
- Spins and reverses when 'cornered"
- Uses 8 pin PIC chip
- ALSO KIT 911 - As 910 *PLUS* programmable from PC serial port leads and software CD included.

KIT910..£16.99
KIT911..£24.99

PIC PIPE DESCALER

- ***SIMPLE TO BUILD***
- ***SWEPT FREQUENCY OUTPUT***
- ***HIGH POWER***
- ***AUDIO & VISUAL MONITORING***

An affordable circuit which sweeps the incoming water supply with varying frequency electromagnetic signals. May reduce scale formation, dissolve existing scale and improve the way salts in the water behave.
Kit includes case PCB coupling coil and all components.
High coil current ensures maximum effect. LED and piezo monitor.



KIT 868 .. £22.95 PSU £3.99

12V EPROM ERASER

A safe low cost eraser for up to 4 EPROMS or other UV erasable windowed devices at a time in 20 minutes. Operates from a 12 Volt supply (400mA). Ideal for mobile work -and in educational applications where mains voltages are to be avoided. Safety interlock prevents contact with UV.

KIT 790 ..... £29.90

PIC LCD DISPLAY DRIVER

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

- Learn how to drive the display and write your own code.
- Ideal development base for meters, calculators, counters, timers — just waiting for your application
- **Top quality display** with industry standard driver, data and instructions

KIT 860.£19.99

PIC STEPPING MOTOR DRIVER

PCB with components and PIC16F84 programmed with demonstration software to drive any 4 phase unipolar motor up to 24 Volts at 1 Amp. Kit includes 100 Step Hybrid Stepping Motor Full software source code supplied on disc. Use this project to develop your own applications. PCB allows 'simple PIC programmer' 'SEND' software to be used to reprogram chip.

KIT 863.........£18.99

8 CHANNEL DATA LOGGER

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

KIT 877.........£49.95

SUPER PIC PROGRAMMER

Magenta's original parallel port programmer. Runs with downloaded WINDOWS 95 - XP software. Use standard Microchip .HEX files. Read/Prog/Verify wide range of 18,28,and 40 pin PICs. Including 16F84/876/877, 627/8, (Inc. 'A' versions) + 16xx OTPs.

KIT 862. £29.99 Power Supply £3.99

ICEBREAKER

PIC Real Time
In-Circuit Emulator

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

KIT 900..£34.99
PSU £3.99

ICEbreaker uses PIC16F877 in-circuit debugger functions.

- Featured in *EPE* Mar'00 Ideal for beginners & experienced users. Windows (95 to XP) Software included

20W Stereo Amp.

EPE May '05 -- Magenta Stereo/Mono Module

Wide band Low distortion 11W / channel Stereo 20W Mono. True (rms) Real Power

Short Circuit & Overheat Protected. Needs 8 to 18V supply.

Latest Technology - Stable, Reliable, high performance IC with local feedback.

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

Magenta BrainiBorg

A super walking programmable robot with eyes that sense obstacles and daylight. BrainiBorg comes with PC software CD *(WIN95+ & XP)* with illustrated construction details, and can be programmed to walk and respond to light and obstacles on any smooth surface.

Kit includes all hardware, components, & 3 motor/gearboxes Uses 4 AA batteries *(not supplied)*.

KIT 912 ... £29.99 *(Kit with CD Rom & Serial Lead)*
KIT 913 ... £38.95 *(As 912 but Built & Tested Circuit board)*

EPE PIC Toolkit 3

As in EPE Apr/May/Jun '03 and on PIC Resources CD

- Magenta Designed Toolkit 3 board with printed component layout, green solder mask, places for 8,18, 28 (wide and slim), and 40 pin PICs. and many Magenta extras. Also runs with WinPic800 prog. Software.
- 16 x 2 LCD, PIC chip all parts and sockets included.
- Follow John Becker's excellent 'PIC tutorial 2' series.

KIT 880 ... £34.99 *(With 16F84 Chip)*
KIT 880 ... £39.99 *(With 16F877 Chip)*

OR Built & Tested £49.99 & £55.99

EPE TEACH-IN 2004

COMPLETE 12 PART SERIES FROM NOV03
All parts to follow this Educational Electronics Course. Inc. Breadboard, and wire, as listed on p752 Nov 03'

KIT920..£29.99

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

KIT921.£12.99

Reprints £1.00 per part.

BAT DETECTORS

Magenta's Super Heterodyne Bat detectors. Our best selling kit 861 now includes a drilled case and front panel label. The MkIIb and digital MkI are supplied built & ready to go

KIT 861 .. £37.99
Soft Zip Up Pouch for all 3....£5.99
MkIIb .. £49.95 MkIII .. £89.95

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World Radio History

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4049B	£0.29
4049UB	£0.17
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4051B	£0.23
4052B	£0.32
4053B	£0.22
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4082B	£0.28
4085B	£0.28
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4521B	£0.62
4526B	£0.40
4527B	£0.40
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74HC126	£0.46
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74HC133	£0.34
74HC137	£0.30
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74HC139	£0.31
74HC151	£0.33
74HC153	£0.30
74HC154	£0.94
74HC157	£0.22
74HC158	£0.23
74HC160	£0.64
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74HC162	£0.45
74HC163	£0.26
74HC164	£0.23
74HC165	£0.21
74HC173	£0.38
74HC174	£0.27
74HC175	£0.35
74HC193	£0.39
74HC195	£0.32
74HC240	£0.32
74HC241	£0.37
74HC244	£0.40
74HC245	£0.34
74HC251	£0.30
74HC253	£0.25
74HC257	£0.25
74HC259	£0.29
74HC273	£0.32
74HC299	£0.61
74HC365	£0.28
74HC367	£0.38
74HC368	£0.29
74HC373	£0.35
74HC374	£0.34
74HC390	£0.52
74HC393	£0.36
74HC563	£0.56
74HC573	£0.27
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74HC4049	£0.31
74HC4051	£0.50
74HC4052	£0.34
74HC4053	£0.22
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74LS08	£0.19
74LS09	£0.15
74LS10	£0.27
74LS11	£0.17
74LS12	£0.25
74LS14	£0.33
74LS15	£0.24
74LS20	£0.27
74LS21	£0.20
74LS26	£0.17
74LS27	£0.25
74LS30	£0.20
74LS32	£0.23
74LS37	£0.31
74LS38	£0.18
74LS40	£0.14
74LS51	£0.24
74LS73	£0.36
74LS75	£0.30
74LS83	£0.38
74LS85	£0.48
74LS86	£0.25
74LS92	£0.45
74LS93	£0.58
74LS107	£0.30
74LS109	£0.21
74LS112	£0.24
74LS113	£0.23
74LS114	£0.36
74LS122	£0.31
74LS123	£0.31
74LS125	£0.28
74LS126	£0.25
74LS132	£0.47
74LS133	£0.36
74LS136	£0.23
74LS138	£0.33
74LS139	£0.26
74LS145	£0.56
74LS148	£0.64
74LS151	£0.29
74LS153	£0.38
74LS156	£0.36
74LS157	£0.22
74LS158	£0.21
74LS160	£0.48
74LS161	£0.32
74LS162	£0.44
74LS163	£0.32
74LS164	£0.43
74LS165	£0.48
74LS173	£0.24
74LS174	£0.24
74LS175	£0.30
74LS190	£0.60
74LS191	£0.27
74LS192	£0.60
74LS193	£0.43
74LS195	£0.24
74LS221	£0.41
74LS240	£0.32
74LS241	£0.32
74LS243	£0.30
74LS244	£0.41
74LS245	£0.45
74LS247	£0.60
74LS251	£0.24
74LS257	£0.24
74LS258	£0.24
74LS266	£0.14
74LS273	£0.32
74LS279	£0.24
74LS283	£0.47
74LS365	£0.21
74LS367	£0.21
74LS368	£0.21
74LS373	£0.39
74LS374	£0.38
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7915	£0.22
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LM337T	£0.64
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LM338T	£1.10
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1N4004	£0.04
1N4005	£0.04
1N4006	£0.04
1N4007	£0.03
1N4148	£0.03
1N4149	£0.07
1N5400	£0.08
1N5401	£0.08
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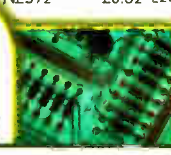

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World Radio History

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To C or Not to C

Regular 'Chat Zoners' (**www.epemag.co.uk** – click on Chat Zone) will no doubt recall the lively and informative discussions that took place a few months ago regarding programming languages for PIC programming. In essence, I think it was generally agreed that there is no 'right or wrong', but that a number of readers would like to be able to use 'C' instead of Assembly when they felt it was advantageous. With this in mind Mike Hibbett has produced a short series of articles on *C for PICs* which starts in this issue. It is not our intention to provide a full tutorial on C – there are plenty of books available that do that – rather Mike will look at the how and why of using C when programming PICs and how to use Assembly in line with C. We hope you find it helpful and informative.

Message Display

This month we also publish a new message display project from John Becker. Back in 1994 we published a similar project which used a Z80 CPU plus RAM and ROM and six other ICs for the control system alone. Now look at John's master controller – just two chips, a PIC16F828 and a MAX232 serial interface. How things have moved on in those twelve years.

The original design was also limited to 448 LEDs, while the new one can be built with over 4,000 LEDs if required – note that these LEDs are in 35 LED matrix (7×5) plug-in modules, thus avoiding too much soldering! The original design also needed an extra interface board to link it to a PC, something which is incorperated in the control board of the new design. No doubt this project will prove to be as popular as the original, which was still being requested many years after publication.

It is amazing to see just how long some projects last – it is not unusual for us to be asked for information on designs that are more than ten years old, we do however discourage this as components do go obsolete and we cannot provide technical back-up for projects over five years old.

Mike Kenward

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World Radio History

News . . .

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

IFA BERLIN

Barry Fox gives us a roundup of key news from the IFA

AT the recent International Funkausstellung, which began as a Radio Show in 1924, JVC revealed plans for a new 'True cinema' video projector which uses a wider than usual aspect ratio – 2.35:1 instead of 1.78:1 (16:9). Philips and Toshiba launched their rival blue laser disc systems, Blu-ray and HD-DVD.

Sharp promoted large screen Full HD LCD screens that do full justice to blue laser discs; so did Korean giants Samsung and LG, whose marketing strength has been increased by joint LCD production with Sony and Philips. Full HD is an unofficial name coined to describe a flat panel screen that gives higher definition than the HD-Ready screens. HD-Ready is an official logo from EICTA, the European Information and Communications Technology Industry Association.

Sharp's President Katsuhiko Machida estimates that current world demand for LCD screens is 42 million a year. Sharp is opening a new factory in Japan which is currently producing 90,000 panels a month, rising to 20 million a year by 2008. The new factory speeds panel production by replacing the traditional photo-masking process of depositing colour filter segments with modified ink jet printing.

Sharp's new screens play a clever trick to solve the problem of motion smear on LCD screens; they artificially reduce the switching response time from 6ms to 4ms by inserting a black 2ms segment at the end of each 6ms switching pulse. They also use a four-wavelength backlight, with an extra crimson red peak in the light source as well as the usual red, green and blue peaks.

DRM and Blue-ray

The Digital Radio Mondiale Consortium was sharing Digital Radio exhibition space with the manufacturers of DAB radios. The DRM system uses compressed digital code to put high quality stereo in AM broadcast channels. BBC World Service, Deutsche Welle and Radio Luxembourg are all broadcasting DRM tests. Radios from Roberts, Sanjean and Morphy Richards are already available, with a car radio coming soon from Kenwood that uses a DRM chip set developed by the Fraunhofer research institute in Germany.

The Blu-ray stand sported a very impressive collection of players from Sharp, Hitachi, LG, Samsung, Pioneer, Panasonic and Philips, with Sony and Dell laptops, and burner drives from Philips, Sony, Pioneer, Panasonic, and Samsung – with a 4× burner from Hitachi.

Philips is to launch a Media Center PC, the MCP9480i with Blu-ray drive. It will sell in Germany, the UK, France and Holland for $2500, starting late 2006 or early 2007. Universal plans eight titles on HD-DVD. Studio Canal of France will release 10 HD-DVD titles including *Basic Instict*, three *Rambos*, *Elephant Man* and the 1976 version of *King Kong*. Pathe and 2 Entertain promise just one title each. Eagle Vision is releasing a Pat Metheny music disc in three formats, DVD with DTS 5.1 Digital Surround, and Blu-ray and HD-DVD with 7.1 lossless DTS-HD Master Audio.

Watch ur PCBs

There is an innovative new service from PCB-POOL, which has over 18000 customers and is Europe's largest supplier of prototype printed circuit boards. For the past few years the possibility to track your order online has been among their services, but the company has spent the last 18 months developing a way to seriously increase the scope of their information.

Watch 'ur' PCB is the result, and with its help the customer doesn't just find out that their order has been processed, they can now actually watch the progress of their PCB through each manufacturing stage. Customers can now log into their personal account and view high resolution photographic images of their current order, whether that is drilling, exposure, tin stripping, UV curing, hot air levelling (surface finish), the customer can view their PCB as a large picture.

The advantage for the customer is that it is an easy and convenient way of monitoring the progress of their order. The images available are exact representations of what will be received. If there is a layout problem or a data issue, then the customer can discover this long before he has the board in his hands. The customer can react more quickly and send PCB-POOL new files for an immediate restart of production. The customer can plan in advance to remedy any errors, and prepare for re-design, therefore saving valuable time and money. If the board is perfect, they will know this long before the delivery, and can begin preparation for component assembly.

Using the Watch 'ur' PCB production monitoring service, the customer can have the pictures of the boards sent to him as a Zip file. On request he can even be informed by email whenever there is a new picture available to view. This means he'll miss nothing, and can archive all his PCB images for future reference.

For more information contact: Beta Layout Ltd (PCB-POOL), Tel: 0800 3898560. Email: sales@beta-layout.com Web: **www.pcb-pool.com.**

DipTrace PCB Software

Novarm's latest version of its DipTrace 1.23 PCB design software application package features a PCB layout module, a powerful auto-router, schematic capture and component/pattern editors, enabling board designers to develop their own component libraries.

Besides being very simple to learn, DipTrace has a very intuitive user interface and many innovative features. The board designer can instantly renew the PCB from an updated version of the schematic and keep existing placement, routed traces, board outline, mounting holes and other work.

DipTrace has a high quality automatic router, which can route a single layer (bottom side) and multilayer circuit boards, and there is an option to autoroute a single layer board with jumper wires, if required. Smart manual routing tools allow users to finalise the design.

Output formats are DXF, Gerber, N/C Drill and G-code. Standard libraries contain 50,000+ components.

Prices start at $145 for the DipTrace Lite (500 pins), and other versions are available. Also, there is completely free version available for students and hobbyists with 250 pins limit. It can be downloaded at no charge from the company's website.

Contact details: Novarm Ltd, Suite 19, #166 Rabochaya str., 49008, Dnepropetrovsk, Ukraine.

Web: **www.diptrace.com**

Email: atikhonov@diptrace.com

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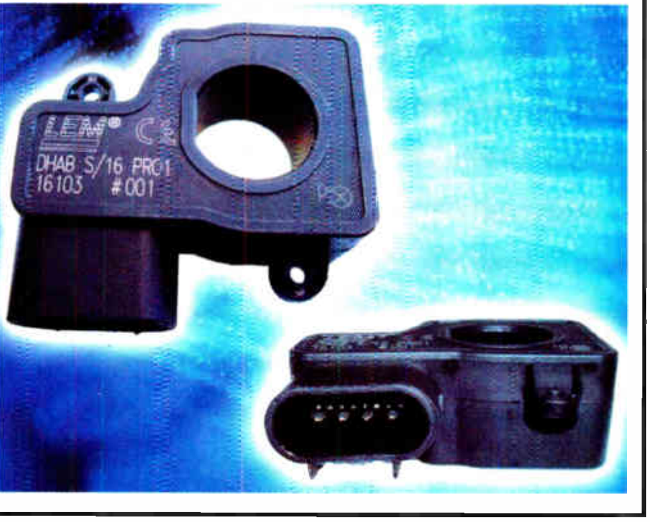
Automotive Current Sensors



LEM has introduced its first dual-range, non-intrusive current sensors for automotive applications. The key points are: dual measuring ranges to ±80A and ±600A; wide measuring range combined with high accuracy at low currents; sealed housing with a range of mounting options.

The sensors provide accurate, widerange current measurements in vehicle battery monitoring applications.

A DHAB Hall-effect sensor is fixed onto the battery cable of a car. Its two cores allow it to be used for two separate current ranges – one between ±20A and ±80A and the other between ±50 and ±600A. This enables full-range current measurements to be made in combination with highly-accurate measurements at lower currents.

The sealed housing of the DHAB sensors means that no potting is required. Panel and cable-mount versions are available to offer maximum mounting versatility.

For further information contact LEM UK Ltd, West Lancashire Investment Centre, Maple View, White Moss Business Park, Skelmersdale, Lancs WN8 9TG, Tel: +44 1695 712 560. Email: kwi@lem.com Web: **www.lem.com**.

MEDIA ENGINEERING

The University of Surrey has marked the launch a new range of degree programmes in Media Engineering with the opening of a purpose-built laboratory to provide students with access to professional quality audio-visual studio production facilities.

Integrating a traditional degree in electronics and computing with an understanding of modern digital systems engineering for music, video and computer graphics production, Media Engineering should appeal to anyone with an interest in music or film and an aptitude for problem-solving. Over the past decade digital technologies have revolutionised the music and entertainment industries. Media Engineering is a new range of degree programmes developed in response to industry demand for graduate engineers with the skills to develop digital technologies.

The Media Engineering Laboratory includes a television recording studio, with professional quality audio and video production facilities. Media Engineering students also have access to specialist test equipment for audio and video system design. This facility supports students in developing a practical understanding of the design and creative use of digital technologies for music, TV, film and games production.

Media Engineering offers excellent employment prospects in a diverse range of media-related industries. The School of Electronics and Physical Sciences has an excellent track record for graduate employment, with over 99 per cent employment in previous years. The UK is a world leader in the media production industries with numerous film post-production, broadcast and games companies located in London and the South East.

Browse: **www.eps.surrey.ac.uk/UG/Media**.

FTDI New Product

At the Embedded Systems Conference in Taipei, Taiwan, Future Technology Devices International Ltd (FTDI) announced the release of the Vinculum family of embedded USB Host Controller devices. They not only handle the USB Host Interface and data transfer functions, but also encapsulate the USB device classes as well. When interfacing to mass storage devices such as USB Flash drives, Vinculum also transparently handles the FAT File structure communicating via UART, SPI or parallel FIFO interfaces via a simple command set.

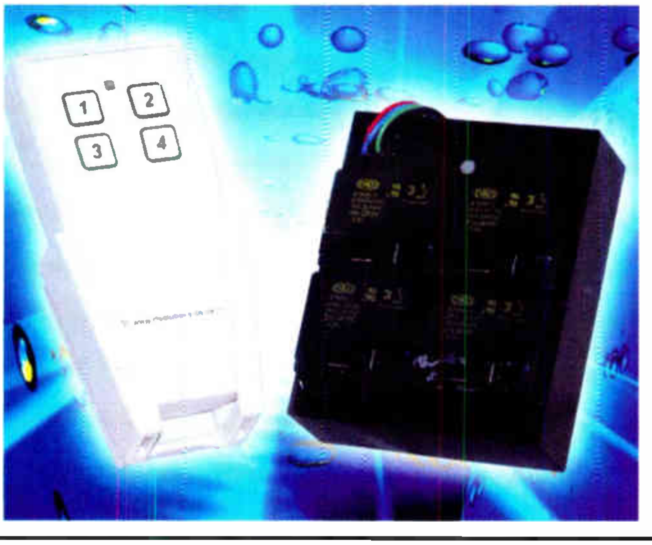
The initial product member of the family is the VNC1L device which features two USB ports which can be individually configured by firmware as Host or Slave ports.

Key VNC1L features include: 8/32 bit V-MCU Core; dual DMA controllers for hardware acceleration:

64K Embedded Flash Program Memory; 4K internal Data SRAM; two × USB 2.0 Slow/Full speed Host/Slave Ports; UART, SPI and Parallel FIFO interfaces; PS2 legacy Keyboard and Mouse Interfaces; up to 28 GPIO pins depending on configuration; 3.3V operation with 5V safe inputs; low power operation (25mA running, 2mA standby); in-built FTDI firmware easily updated in the field; LQFP-64 ROHS compliant package; multi-processor configuration capable.

Complete details for the Vinculum VNC1L are at **www.vinculum.com**. FTDI's full product line can be found on the main web site at: **www.ftdichip.com**. Contact: Future Technology Devices International Ltd, 373 Scotland Street, Glasgow G5 8QB.

Waterproof RF Modules



RF Solutions has addressed the growing number of outdoor applications that require wireless remote control with the introduction of its EMOD Series. Available as either a single or four-channel unit, the new waterproof radio remote controls are ideal for use in garden lighting, floodlighting and access control applications.

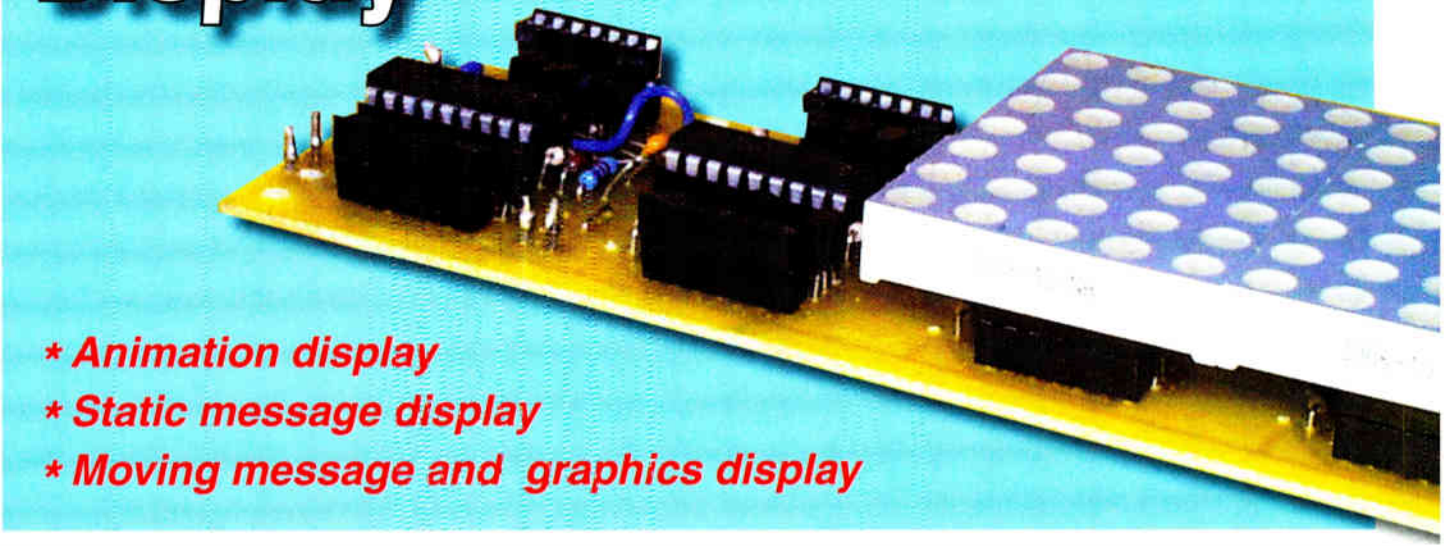
Housed in an IP68 rated enclosure, the robust resin encapsulated receiver features relay outputs with a 30A at 230VAC rating. 5mm spade connectors allow equipment to be connected quickly and easily. The receiver is able to operate from a supply voltage of either 12V or 24V.

Operating at the licence-free frequency of 433MHz and using a secure transmission protocol gives the EMOD Series reliable performance and a direct line-of-sight range of up to 100 metres. Up to seven transmitters can be configured for use with a single receiver using an 'easy learn' procedure. Each system is supplied ready to operate and is suitable for use between 0°C and +55°C.

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

World Radio History

Giant LED Message Display



Proclaim your message loud and clear in lights!

By John Becker

THIS Giant LED Message Display unit provides the following functions:

- Moving message and graphics display
- Static message display
- Animation display

It is in modular form and can be built pretty much to what ever size and format one prefers, as discussed later. It is PIC microcontroller controlled, programmable for its displays type and content from a PC computer.

Once the system has had the basic information sent to it, the system can be disconnected from the PC. The data is retained indefinitely even after switch-off, and can be recalled after switch-on again by means of three function switches on a master control box.

The PC provides the basic data via a serial connection (it is not designed for USB use) to a master PIC, which in turn stores the data, and passes on the information to a series of slave PICs, each of which controls an LED display module comprising a 5 × 7 matrix of LEDs. Each LED matrix module is 52mm high and 38mm wide. Its format is suited to displaying alphanumeric messages, graphics or animation displays, or a mixture all three.

Display formats

There can be up to 128 such display modules, each controlled by its own slave PIC. The display printed circuit boards (PCBs) are also modular and each holds four slave PICs and four LED modules. They have been designed so that they butt up against each other, allowing an overall display to be arranged linearly, or as a square or rectangle.

Each finished display PCB measures 152mm (6 inches) long, and so a fully linear arrangement of 128 LED modules would be 4.86m (16 feet) long! A more conventional rectangular arrangement of, say, 24 LED displays wide and five displays high, would produce a display measuring 91cm wide × 26cm high. The choice of arrangement is up to the user.

Previous message display

The last time *EPE* published an LED Matrix Message Display was in May-June 1994, by Julyan Ilett and Brett Gossage. This comprised 448 separate LEDs arranged on a single PCB in a 64 columns by seven rows format, measuring about 10.2cm × 58.4cm. The display was controlled by a Z80A microprocessor and peripheral devices.

Changes in technology now allow the use of PIC microcontrollers and LED display modules (saving an awful lot of LED soldering!). The use of PICs and LED

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modules also makes the overall control somewhat easier, as well as allowing for various modular arrangements.

Whereas the previous design used a mixture of in-built messages and a simple keypad plus a seperate PC interface for creating data, PICs allow for easy interfacing to a PC and its serial communications options, RS232 in this case, for the creation and transmission of data.

Slave controllers

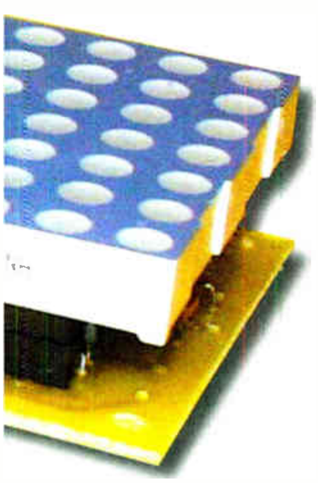
As with any LED, the current flowing through it must be limited. The maximum current allowed for the chosen LEDs depends not only on their characteristics, but also on those of the devices controlling them. The initial factor considered here is what current the PIC's control pins can source or sink. The maximum limit for the current sunk by any pin of a typical PIC is 25mA, and that provided as a source is 20mA.

Clearly, the anode current required by the LEDs must be greater than 20mA in order to provide adequate brilliance when seven of them in a column are all turned on. Consequently, the PIC's anode control lines must use a current-boosting interface to provide the needed current.

Referring to the Slave Control circuit diagram in Fig.2, transistors are used as the interface, one for each column, TR1 to TR5. These are used as emitter followers, their collectors jointly connected to a common power supply line. Current can flow through any transistor from its collector (c) to its emitter (e) when a control voltage and current are applied to its base (b), as provided by PIC pins RA0 to RA3, plus RA6, provided there is a path through the LEDs.

This path is completed when the cathode of any LED is connected to a current sink pin of the PIC, via a current-limiting resistor. PIC pins RB0, RB3 to RB7 and RA7 control these cathode paths. The choice of PIC pins has been dictated by the convenience of routing connections on the PCB.

The current flowing into each cathode controlling PIC pin is limited by resistors R1 to R7. Their values have been selected so that the total current flow cannot exceed the PIC's limits in the event of all LEDs in a column being turned on simultaneously. Normally, the cathode-controlling PIC pins are held high (logic 1) when the LEDs are to be turned off. To turn on an LED to which anode current is provided, the respective PIC pin is taken low (logic 0).



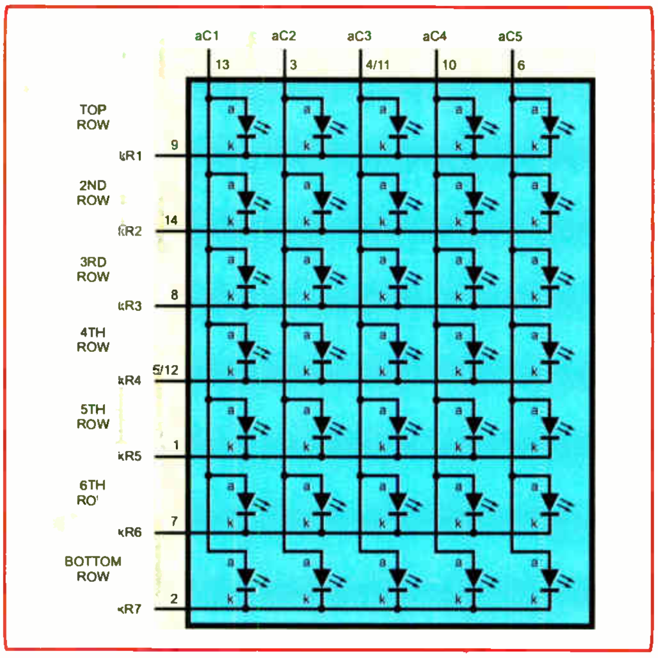


Fig.1. Internal structure of a 7 × 5 matrixed LED module

LED matrix modules

Before discussing any part of the control circuits, it is worthwhile examining first what it is that has to be controlled – the matrixed LED modules. As explained earlier, the type using 35 LEDs has been chosen. They are arranged in what is known as the *common anode* format, as shown in Fig.1.

The LEDs are internally connected so that there are five columns of them, each column having its own common connection to the anodes of the LEDs within it, aC1 to aC5 in Fig.1. The cathodes of each LED are connected so that seven rows are formed, which are each brought out as common cathode connections, kR1 to kR7. Any cathode-controlling code from the controller is applied to the cathodes of each LED in that row, but the LED only becomes active (lit) if the anode connection in the column to which it is connected is powered. Thus a single control byte of seven bits is required for the cathodes, and a single byte of five bits is required by the anodes.

Rate of change

The rate at which the columns and rows are activated is sufficiently fast that the eye does not perceive a noticeable flicker in the LED intensities. It is immaterial in which order the anodes

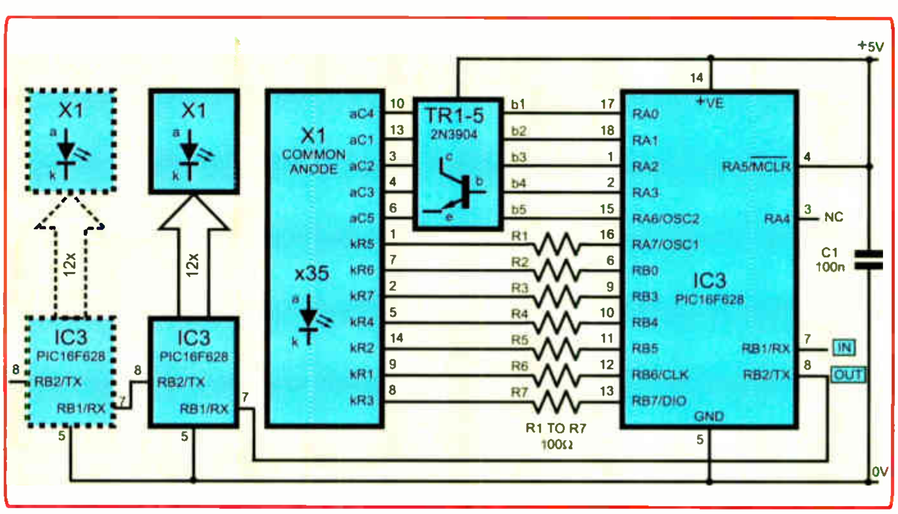


Fig.2. Circuit diagram for the slave control. Note TR1 to TR5's collectors (c) go to the +V line; the bases (b) to the PIC and emitters to display module

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are turned on, provided the applied cathode turn-on code is synchronised to change appropriately for each active column.

Each LED matrixed module and its controlling PIC are connected identically, and indeed these PICs are identically programmed. The PICs control their displays either from data held within their memory, or from data continually supplied by the master PIC, at a rate set by the user.

Each slave PIC operates at a clock frequency of approximately 4MHz, as generated internally according to the configuration code with which they have been programmed. They do not need an external clock control source.

There is inevitably a minor clock rate difference between each Slave PIC. This is normally of no consequence, but a synchronisation of the software routines within the PICs can be activated for animation display routines that need it. More on this later.

Master control

The circuit diagram for the Master Control is shown in Fig.3.

There are two devices in this circuit, the master control PIC, IC1, and an RS232 interface, IC2, for connecting to a PC. The RS232 device has featured in many *EPE* PIC projects and will not be discussed further here. Suffice to say that it allows the PIC and PC to 'talk to each other' bi-directionally, via connector SK1.

The PIC takes the user-generated message and animation data from the PC, using handshakes while doing so, at a baud rate of 9600. Moving message and graphics data is stored in its internal memory for use on request. Static and animation data is sent on to the slaves. In the case of static messages, all PICs receive the data serially, but only store it for future use if the data is not a blank space in the text, allowing animation or static data to be shown in that space if preferred.

The animation data is intended for use by specified PICs and displays in the chain of slaves. PIC address data is embedded in the code and only the PIC whose address corresponds will store that data for future use, it otherwise passes it to the next PIC, which does likewise, and so on until the required destination PIC is reached. There is no handshaking between PICs during

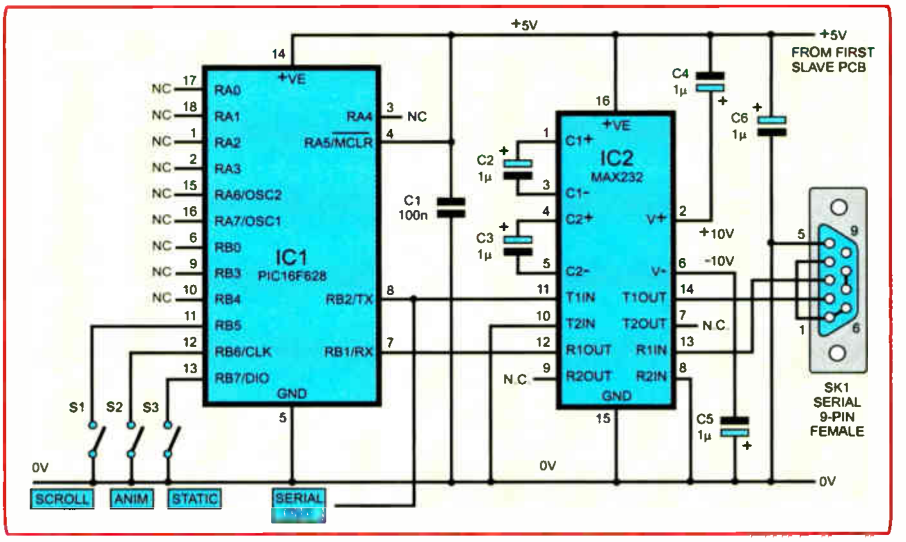

Fig.3. Circuit diagram for the Master Controller. The serial out is routed to the first slave circuit at IC3 pin 7

this process. The same, or different animation data may be sent to other PICs by their address codes, as told to the PC by the user.

Character map

Regarding the message text data, the codes sent to the master PIC by the PC are the ASCII codes for those characters, alphabetic, numeric and punctuation data etc. A table showing the data which can be displayed is shown in Fig.4.

Information about the columns and rows in which the data is used is held by the master PIC as a lookup table. In all cases, when a particular character is being processed by the master, it goes to the corresponding section of the table and allocates the specified row and column data as 8-bit byte values. There are five display columns used for each character, and thus five bytes are produced, plus an additional zero value byte to provide a space between each character/letter in moving message mode.

The font used in the displays is basically a copy of what would be seen on a normal alphanumeric LCD display. No provision to change it has been made. The data is held in file LCDMTX1.INC should you wish to examine it. Moving animation is dealt with similarly, except that the data has already been coded within the PC since look-up tables are not appropriate to what is essentially random data, as the graphics data depends entirely on what the user wants.

When running a moving message, sending it on to the slave chain, the master sends the five display bytes to the slaves with a user-selectable delay between each byte. On receiving each byte the slave shows that byte in the righthand column of the display, On receipt of the next byte, it transfers each of the column bytes to the next one to the left, and then stores the new byte in place of the previous one.

In doing so, the previous left-most byte of the first display is passed to the next PIC and its display. The process continues for each of the stored characters and their bytes, and then repeats. The result is a very effective repeating moving message display, traversing the display area right to left at the user's chosen rate.

<table>
<tr><td></td><td>0</td><td>@</td><td>P</td><td>'</td><td>p</td></tr>
<tr><td>!</td><td>1</td><td>A</td><td>Q</td><td>a</td><td>q</td></tr>
<tr><td>"</td><td>2</td><td>B</td><td>R</td><td>b</td><td>r</td></tr>
<tr><td>#</td><td>3</td><td>C</td><td>S</td><td>c</td><td>s</td></tr>
<tr><td>$</td><td>4</td><td>D</td><td>T</td><td>d</td><td>t</td></tr>
<tr><td>%</td><td>5</td><td>E</td><td>U</td><td>e</td><td>u</td></tr>
<tr><td>&</td><td>6</td><td>F</td><td>V</td><td>f</td><td>v</td></tr>
<tr><td>'</td><td>7</td><td>G</td><td>W</td><td>g</td><td>w</td></tr>
<tr><td>(</td><td>8</td><td>H</td><td>X</td><td>h</td><td>x</td></tr>
<tr><td>)</td><td>9</td><td>I</td><td>Y</td><td>i</td><td>y</td></tr>
<tr><td>*</td><td>:</td><td>J</td><td>Z</td><td>j</td><td>z</td></tr>
<tr><td>+</td><td>;</td><td>K</td><td>[</td><td>k</td><td>{</td></tr>
<tr><td>,</td><td><</td><td>L</td><td>\</td><td>l</td><td>|</td></tr>
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<tr><td>/</td><td>?</td><td>O</td><td>_</td><td>o</td><td></td></tr>
</table>

Fig.4. Character library available for use

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Power supply

The current capacity of the power source needed depends on how many display matrix modules are used. With all LEDs turned on, the displays each consume about 150mA. The voltage range of the power source is from 7V to about 9V DC. The 7V lower limit allows for the 2V 'headroom' needed by the 5V regulators used in the design. 9V still prevents the regulators from getting hot and thus needing a heatsink.

Although the transistors, TR1 to TR5, could handle a collector voltage of greater than 5V, there would be the danger of exceeding their 200mA limit. For the same reason, resistors R1 to R7 should not have values less than 100Ω. This value also prevents the current flowing into the PIC via the cathode lines from exceeding the PIC's limits.

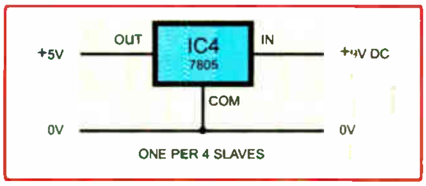


Fig.5. The +5V regulator circuit diagram. One per four slaves is required. It also powers the master circuit. The regulator appears on the first slave section on the PCB – see Fig.7

It is recommended that high-brightness LED modules are used to give good visibility in daylight without the need for high currents.

Each slave PCB, with its four PICs and displays, has its own on-board 5V regulator, shown in Fig.5 as IC4. The power supply should be connected to each regulator on the slave boards by wires radiating out from the power supply, in 'star' fashion. It would be unwise to serially connect the PCB supply lines to the PSU, as this could cause undesirable current and voltage spikes in the lines as the LEDs are turned on and off.

It would, in fact, be feasible to use just one regulator per two slave PCBs. The total maximum consumption for each board is about 600mA, with all LEDs turned on, consequently a 7805 regulator rated at 1.5A (rather than 1A) will cope well with the maximum possible current. It is highly unlikely anyway that all LEDs will be on together, unless you deliberately create that situation.

Parts List – Giant LED Message Display

Master Control

1 PC board, code 594 (Master), available from the *EPE PCB Service*, size 45.7mm x 35.6mm
1 plastic case, size and type to choice – see text
3 SPST toggle switches (S1 to S3)
1 9-pin D-type serial connector, female, plus cable – see text (SK1)
1 16-pin DIL socket
1 18-pin DIL socket
11 PC solder stakes

Semiconductors
1 PIC16F628 microcontroller, pre-programmed – see text (IC1)
1 MAX232 RS232 serial interface (IC2)

Capacitors
1 100n min ceramic (C1)
5 1µF radial elect. 16V (C2 to C6)

Mulitstrand connecting wire; mounting hardware to suit – see text; solder, etc

Slave Display

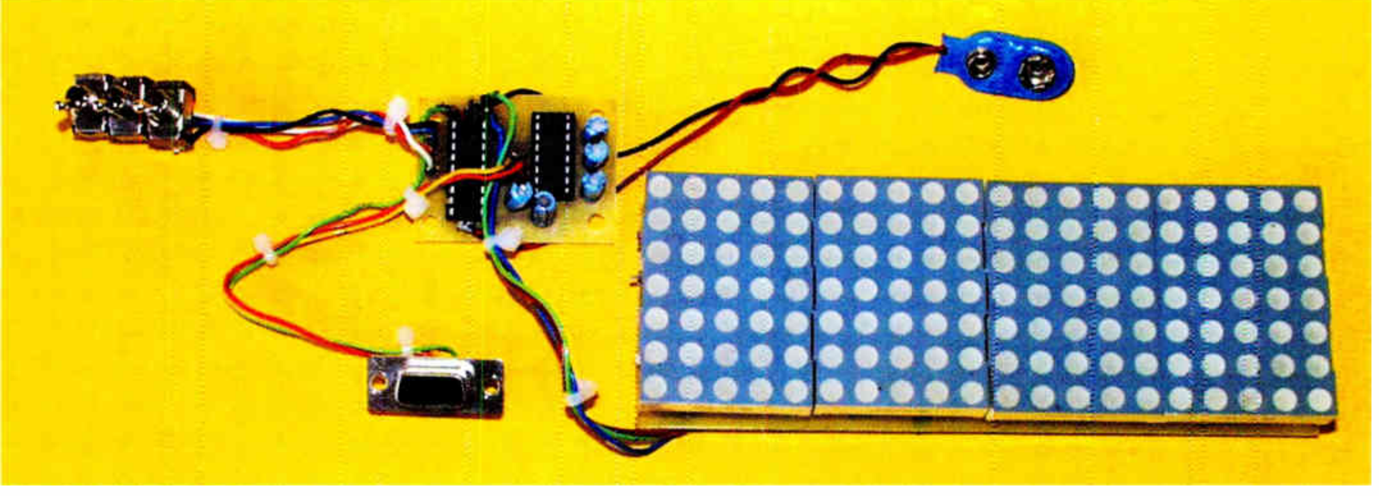
(one set needed for each display module, unless indicated)
1 PC board, code 595 (Slave) – four displays, available from the *EPE PCB Service*, size 150mm x 51mm
2 14-pin DIL socket – see text
1 18-pin DIL socket
1 2-inch, high-brightness, 35-LED matrix module – see text (X1)

Semiconductors
5 2N3904 NPN transistors (TR1 to TR5)
1 PIC16F628 microcontroller, pre-programmed – see text (IC3)
1 7805 +5V 1.5A voltage regulator – only one required for each group of four displays, see text (IC4)

Capacitors
1 100n min ceramic (C1)

Resistors
7 100Ω 0.25W 5% (R1 to R7)

Multistrand connecting wire; mouing hardware to suit – see text; PC solder stakes; solder, etc



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Construction

The Master control unit has its own PCB. The Slaves have one PCB for each group of four PICs and their displays. The assembly details for the boards are shown in Fig.6 and Fig.7 respectfully, along with their track layouts. These boards are available from the *EPE PCB Service*, codes 594 (Master) and 595 (Slave). As implied, you only need one master board, plus one slave board for each group of four displays.

There are no special concerns for the master board, but do take the usual care over component soldering, and observing the correct polarity of the components. Use DIL (dual-in-line) sockets for the two ICs, and note that they are static-sensitive. You should discharge static electricity from your body by touching the bare metal of any earthed item of equipment before handling any of the DIL ICs in this design.

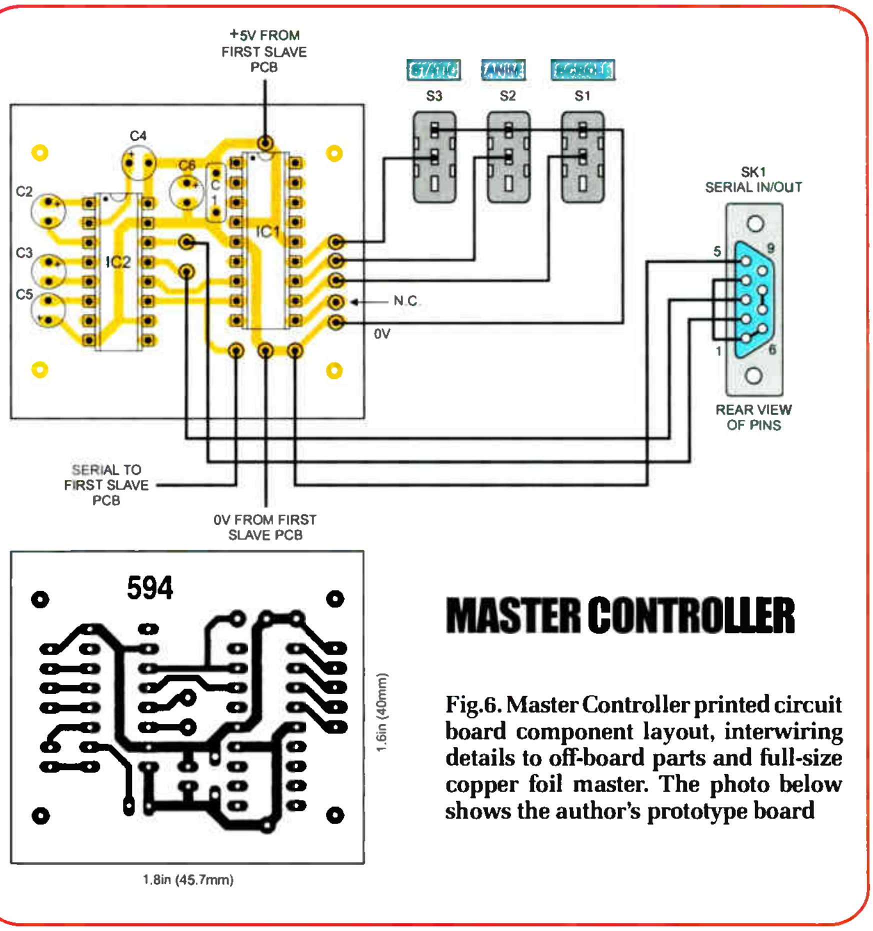
Display Slave PCB

With the slave board, all components are positioned below where the displays are mounted, and there are a number of link wires needed. Connect these first. Again use sockets for the PICs. Assemble each board in order of ascending component size. The pinouts for the transistors and regulator are shown inset. Note that the regulators are mounted on the *rear* of the PCBs because of their size.

The LED modules first need two 7-pin SIL sockets (cut lengthwise from a 14-pin DIL socket), and then a further 7-pin SIL socket plugged into each. This allows clearance of the components by the displays. Be very careful when inserting the displays that you do not bend their pins. Note that the displays are shaped at their sides, with their orientation as shown in Fig.7. The pin notations for the displays are given in Fig.8.

The board has been designed to be slightly smaller than the display area of the LED modules when mounted, to allow close mounting of the boards in the final display format that you choose. You will need to choose a material on which to mount the display boards, and suitably enclose them if preferred.

The master board can be mounted in any small plastic box of choice and adequate size. Holes must be drilled for the switches, serial connector SK1, and the connecting wires to the slaves. Note that this board takes its 5V power supply from the first slave board. The wires from the PSU to the slaves must be routed according to the needs of your layout, providing adequate securing, and also preventing the wires from becoming a trip hazard to other people.



MASTER CONTROLLER

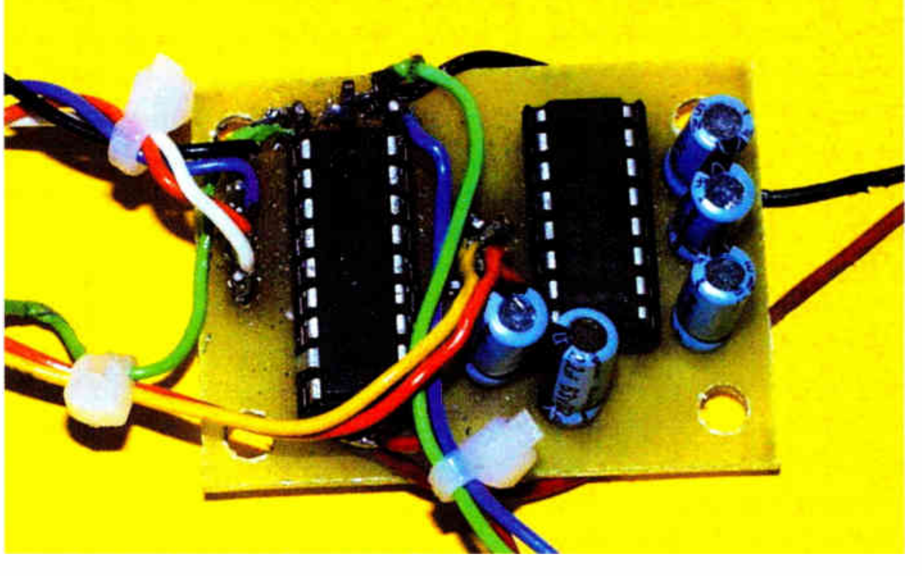
Fig.6. Master Controller printed circuit board component layout, interwiring details to off-board parts and full-size copper foil master. The photo below shows the author's prototype board

First tests

Software and pre-programmed PICs for this design are available as stated later.

On completion of the PCB assemblies, and without DIL ICs or LED modules inserted, connect the boards to the power supply. After switching on, check that +5V is present at the output of each regulator, IC4, and at the +VE connections of the sockets for the PICs and IC2, with the common (black lead) of the meter on the relevant 0V (GND) point.

If any corrections are required to your assembly, or when inserting or extracting PICs etc, make sure the PSU is switched off, and allow a few



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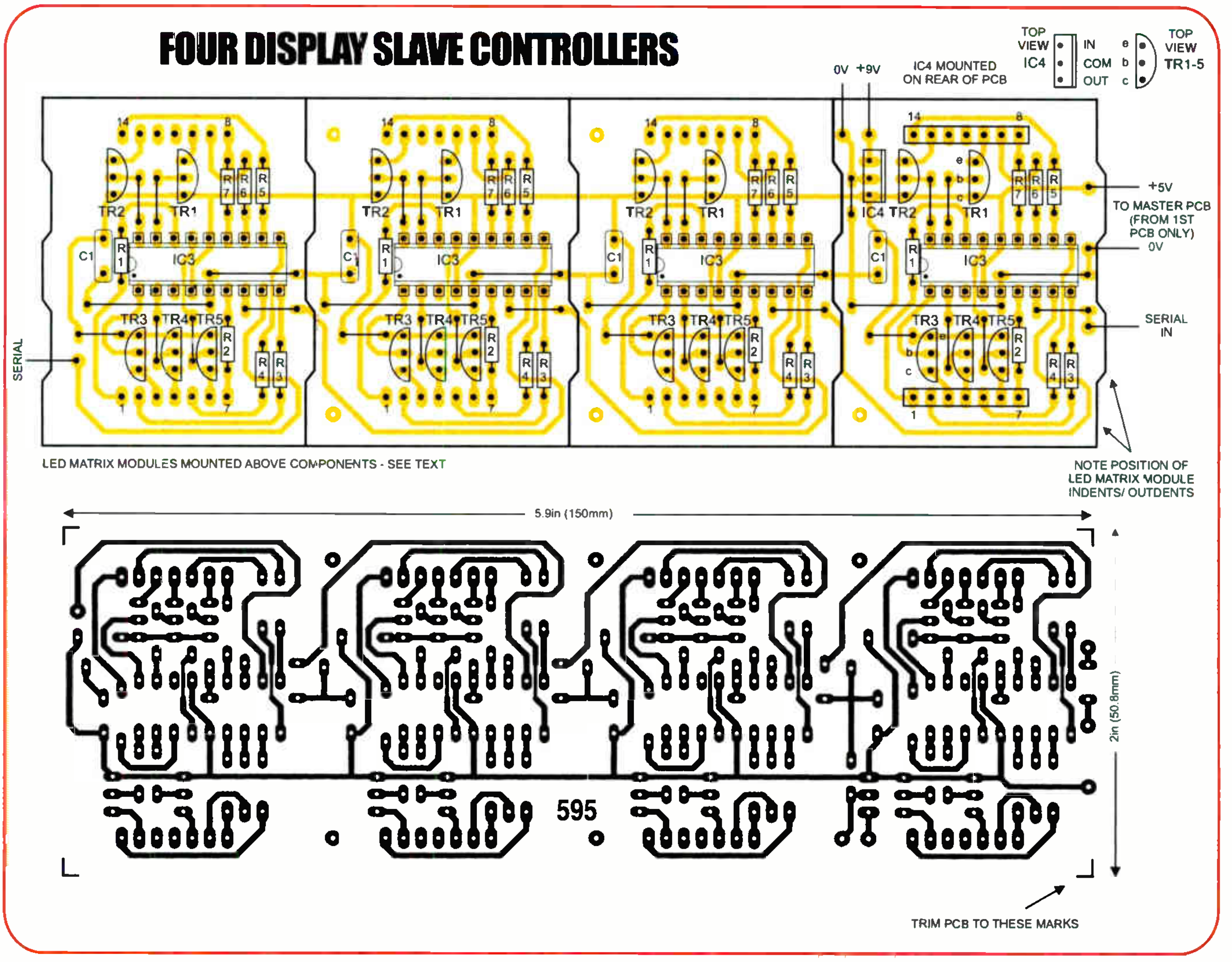


Fig.7. Printed circuit board component layout, wiring details and full-size copper master for four Slave displays. Note, the voltage regulator IC4, top right of PCB, is mounted on the underside because of its size. The 'notched' outline of the displays is also shown in this diagram

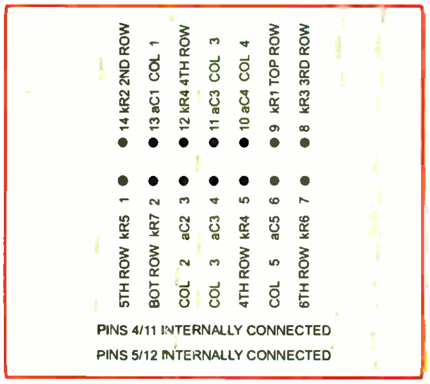
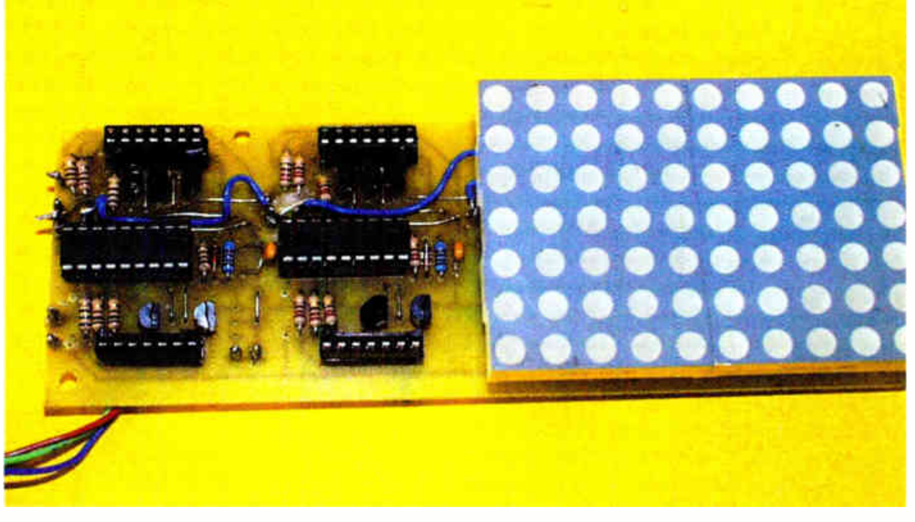


Fig.8. Pinouts for the LED matrix modules

seconds for its smoothing capacitors to discharge.

When satisfied with the first test, insert the pre-programmed PICs, RS232 chip IC2, and the displays, ensuring their correct orientation. Switch on S1 (Moving Message) and connect the power. Double-check the +5V power lines again.

On power-up, the master PIC reads the status of the switches and reacts accordingly, in this case, as S1 is switched on, by starting the flow of the moving message with moving graphics as programmed into the PIC's memory. Progressively, the moving message and graphics will flow from the master PIC and along through the slaves, being displayed as it progresses.



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The message is MIND THE CAR, followed by a simple caricature of a car, as copied from the header of the original 1994 article. The message and graphics are repeated indefinitely, at a rate built into the master PIC's program at this stage.

Switch off S1 to stop the message and clear the displays. Switch on S1 again to restart the message. No other switches will work at this time since no static messages or animation data have been sent from the PC yet.

Next check

Now check the power supply to the RS232 chip and its voltage outputs. There should be +5V on its pin 16, 0V on pins 15, 10 and 8. +10V should be present on pin 2 and -10V on pin 6, being generated internally by the device itself.

You can now connect the unit via a suitable standard modem serial lead (non-crossover) to whichever PC COM socket you prefer (as said earlier, the unit is not designed to run under USB).

Having obtained and copied the PC software into whatever hard-drive you prefer, including a partitioned drive, into a folder named as you wish. Double-click on the PICMessage.EXE file to launch it, during which a few working files are created. You will be told if the PC encounters any problems at this time.

Moving message screen

On completion of the setup, the blank Moving Message screen will be shown, similar to that in Fig.9, but without the graphics or text data.

At the top is a series of small boxes into which you put the graphics data by clicking on them. There are basically 40 boxes horizontally by seven boxes high, representing the LEDs in eight LED matrix modules.

On entry to the screen, all boxes are a uniform grey colour. Left-clicking the mouse on any box changes its colour to an orange shade. Clicking the mouse again on that box returns it to the grey colour. It would have been preferable visually if Visual Basic (VB6), the program in which the software is written, had allowed circular boxes to be clicked to change their colour, but it does not, so it had to be square ones, which do allow the facility.

Below the squares are three bargraphs. These allow you to choose the points between which data is to be saved, and to indicate where further boxes may be inserted if you wish, losing the equivalent number of boxes at the right. The buttons to the left below the bargraphs allow insertion or deletion of graphics data in the first column position.

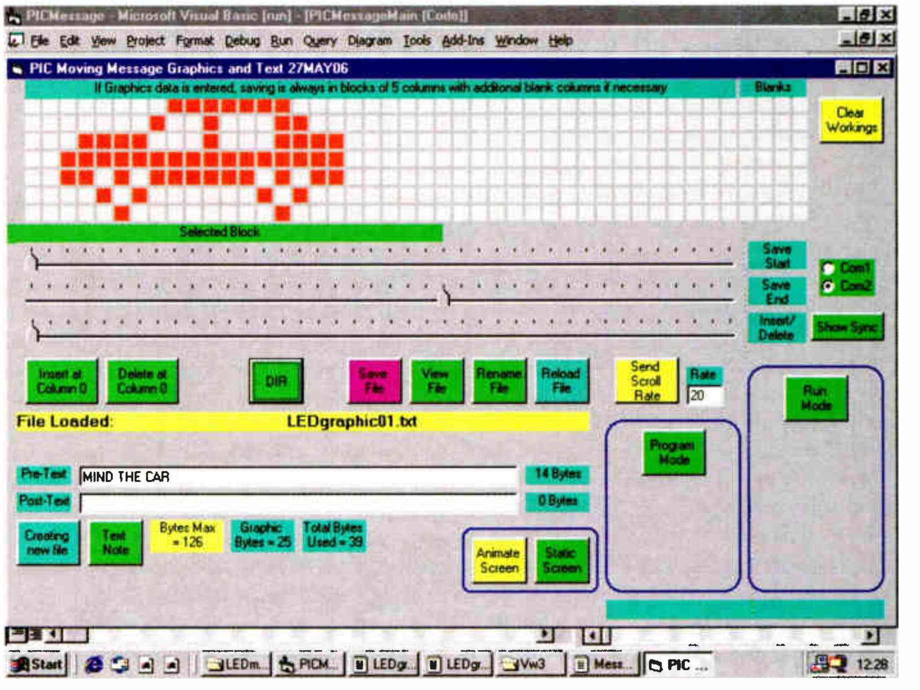

Fig.9. Main moving message screen, with author's test data

The chosen columns of graphics data are further confirmed by a green marker below the boxes, expanding or contracting as appropriate. Graphics data is saved in groups of five columns, corresponding to those in the displays themselves. At times, this means that the Blanks area at the right of the main boxes will be used to complete a group of five columns.

Also below the bargraphs are several other control boxes. More on these shortly. Below those is a horizontal box in which the name of any file loaded from the directory is displayed.

Below that are two boxes into which text can be entered. The upper box holds the message, if any, you would like to precede the moving graphic. The second holds the message, if any, you would like to follow the message. Either box can contain blank spaces (space bar) if you wish to do so.

Message length

There is a maximum total message length, including any graphics data, that can be handled by the master PIC. The limit is 126 bytes that it can store.

Alphanumeric and punctuation symbols, which are accessed through the master's font file mentioned earlier, take one byte each. Each column of graphics data takes another byte. The total number of bytes used for any message being built up is displayed in three boxes below the text boxes.

The remaining two bytes of the total 128 bytes that the master PIC's data memory can hold, are automatically taken up by the values for the total message length, and for the rate at which it is to be scrolled across the display area, as you set into the Rate box towards the right. The rate is automatically sent when the full data is sent, but it may also be sent when the message is running, immediately changing the rate of scroll. Click Send Scroll Rate to do so.

To save a newly created message file, click on the DIR button to open the Directory screen (Fig.10) which has an area near bottom in which you enter the file name you want to use, then click the Make File option. This creates the file by that name. It cannot overwrite previous files if file names conflict. You will be told of such conflict and another name can be chosen.

Having created a file, it is automatically opened in Notepad to confirm that it has been created. Close this file in Notepad's usual way.

Full details of the Directory screen's options can be read through its Notes file. The details will not be discussed now. There are several options available. Click again on the DIR button, select the file from the file names offered by double clicking on its name. This closes the DIR screen and opens the file into the LED Message screen routines.

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You can then save your new message into that file, by clicking the Save File button on the message screen.

You can be reminded of the process needed to create a new file by clicking the screen's Creating New File button.

Sending graphics and moving messages

To load and send a file's contents to the master PIC, ensure that switches S1 to S3 on the unit are switched off, then click DIR and select the file you want. Its contents will be loaded to the screen's graphics and text areas.

Plug in the serial cable to the COM port connector on the PC that you wish to use. Then on the program's main (moving message) screen click either the COM1 or COM2 "radio" button towards the top right, as suited to the COM port connector chosen. This choice is also stored to disk for future recall.

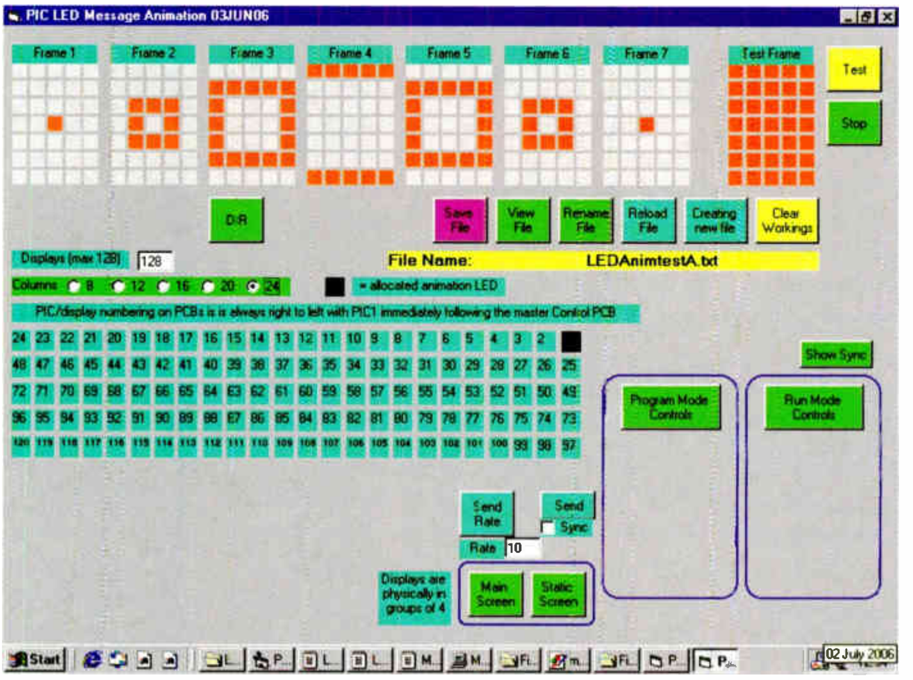

Fig.12. Animation screen, also with author's test data

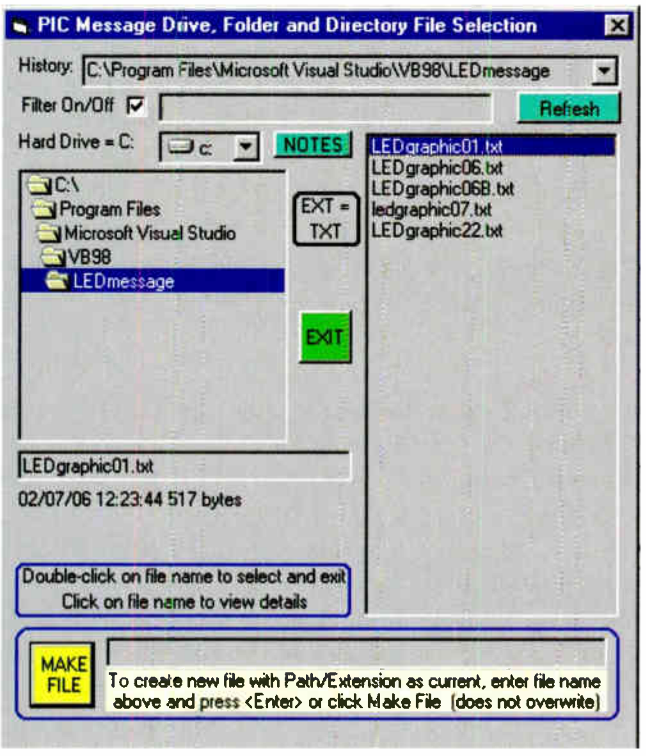

Fig.10. The directory screen

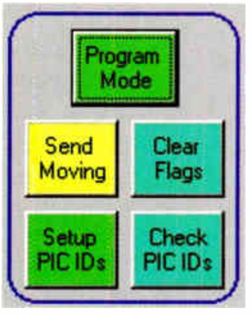

Fig.11. Program mode zone on moving message screen.

Now, with the PIC unit's power switched on and with the serial cable connected, first click on the Program Mode bottom towards the bottom right. This action alerts the master PIC to the fact that new data is about to come in.

It also causes four other buttons to be displayed (Fig.11). The only one that concerns you right now is the Send Moving button. The other three buttons are discussed later. Clicking this button causes the loaded data to be sent to the master PIC, which stores it.

Switch on S1 and the displays will start to show the message and any graphics data you have created. As before, S1 allows the message to be started or stopped.

Data facts

It is worth noting that sending a new message to the master PIC automatically overwrites the existing data. This means that the original moving car message will be overwritten the first time you use this option. Should you wish to reinstate the original programmed message, select file LEDgraphic01.txt via DIR and send that to the PIC.

Any file you have created can be amended, reloading it first and then re-saving. If you wish to rename a file, use the Rename Button, which provides the facilities. The View File and Reload File buttons cause those options to occur. In the case of the View File button, the file is opened through Notepad, through which you could amend it if you prefer, although understanding the graphics information will not be obvious at first glance.

If viewing a file in this way, note that the file length and scroll speed values are quoted at the top. It is probably unwise to amend the values here.

When creating graphics data, the Clear Workings button can be used to clear the screen of any data entered.

Ignore the Run Mode button for the moment, it will be discussed later.

Animation screen

Near the bottom right of the main (moving mode) screen are two buttons, Animate Screen and Static Screen. Click the Animate Screen button to display the screen through which animation data is created and sent to the PICs. The term *animation* in this instance means display data in a given LED display module which changes at a user set rate. It never changes LED module position.

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An example of animation is available via the DIR button. Click and select file LEDanimTestA.txt. When this is loaded, its data is shown in the seven groups of boxes at the screen's top (Fig.12). Each represents one 'frame' of animation data. Click the Test button to see the animation displayed on the PC screen in the far right display boxes. Click Stop to stop the display.

A similar action will take place on a selected LED module when data has been sent to its controlling PIC, at a rate of change as set via the Rate box near the screen's bottom, a value of 10 at the current time, but may be changed within its screen box by clicking the mouse on it and using the keyboard numeric keys.

Display module selection

The PIC to which the data is sent is selected via the blue boxes. These are numbered to correspond with the slave PICs in the display chain (which, as described later, will have their identities sent to them by the PC and master PIC.

The PIC and its display to which data is sent is indicated by the black square in amongst the blues, PIC 1 at present. Clicking any of the other blue blocks will cause that box to change colour to black, and return the previous black box to blue.

Display quantity selection

First, though, several pre-conditioning actions must take place. The PC must be told how many PICs there are in your chain. Cosmetically, and of no importance to the PC, the boxes can be re-arranged to the display format you have chosen, but only in a regular format of rows and columns.

In the Displays quantity box toward the upper left of the screen, enter the quantity of the displays you are using, from four to 128 is the range, in multiples of four. Then click one of the 'radio' options to select the number of displays in each column of your display format. The choices are 8, 12, 16, 20 or 24 columns.

The boxes will be re-arranged on screen to suit the selection, limited to the physical possibility of that arrangement, for example, selecting 12 displays and eight columns does not work, nor does eight displays and 12 columns! The screen will do what it can to meet your needs, blanking areas if the format is inappropriate.

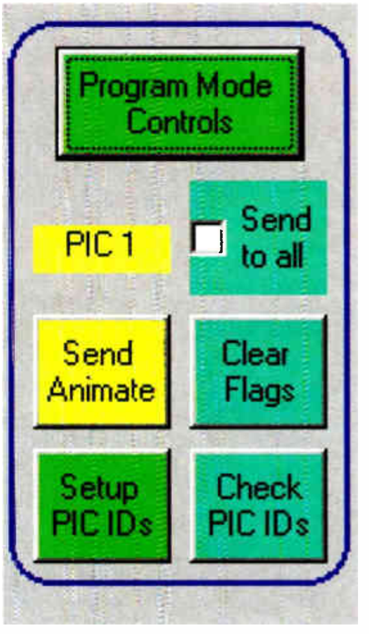

Fig.13. Program mode zone on animation screen

Having chosen a suitable display quantity and format, select the display you want to animate, the first display is suggested right now.

Slave PIC IDs

Next the slave PICs must be told in what order number they are. All are programmed identically by the same software and without identity. With power to the units switched on, click this screen's Program Mode Controls button to reveal several other buttons (Fig.13).

Click the Setup PIC IDs button. This sends a Setup command to the master PIC which initiates the process. It sends a Setup command to the first slave PIC, along with the ID value of 1. The first Slave PIC in the chain accepts this ID of 1 as being its own, and stores it in memory. It then sends the Setup command to the next PIC, incrementing the ID value to 2, and sending to the next slave PIC, which accepts it as its own ID and stores it. So the process ripples along the whole chain of slave PICs, for as many as there are, up to 128.

From then on all PICs now know their identities. And at the moment that they receive them, they output that value to the displays as a binary value affecting all five columns, which can be examined if you wish. At any time you may examine the IDs held by the slave PICs by clicking the Check PIC IDs button. (For reasons which cannot be determined, occasionally the PICs lose or have their identities corrupted, which then have to be re-sent by the PC. So it's worth checking them sometimes when using the Animation mode to send Animation data to selected slaves. Animation is the only mode in which IDs are used.)

With the IDs sent and the animation data loaded in the PC, ensure switches S1 to S3 are switched off, then click the Send Animate button to send the animation to the selected PIC. On receipt of the data, that PIC then shows the animation in action on its display, as you saw in the PC's test routine. The PC screen confirms which slave it has been send to via the display box above the button.

The same, or different, animation data may be sent to another PIC in the same way. It may also be sent to all slave PICs identically by first clicking the Send To All box to reveal a tick mark, and then click the Send Animate button. All slave PICs will receive the data and start to display it. The tick mark can be turned off by clicking its box again.

If data has been sent to all PICs identically, the small display box shows a value of 255.

Your own animation sequence can be created in a similar way to creating graphics, clicking on the PC's display boxes to create the frames sequence you want. Larger animation spanning two or more displays can be created by allocating different data to adjacent PICs, vertically or horizontally. You are always limited to the use of seven frames.

Non-moving symbols can also be created similarly, allocating identical data to each of the seven frames.

Data is saved to a file in the same manner as with moving messages, first creating a named blank file, loading it, and saving the data into that named file.

Synchronisation

If the animation data has been sent to all slaves. It will be seen that eventually they go out of synchronisation with each other, as their respective clock rates are not precisely matched, as explained earlier.

Synchronisation can be achieved by clicking the Sync box to reveal a tick prior to sending the data to the slaves. Sync can also be turned on or

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off by clicking the Sync box to hide or reveal the tick, on an alternating cycle. Sync can be changed while running by clicking the Send button above the tick box.

The status of the sync flag can be checked by clicking Check Sync on the main screen. The display is binary 8 for sync off, and binary 9 for sync on.

The rate at which the animation takes place can be changed while the displays are running by amending its box value and then clicking the Send Rate button.

Static message

Click now on the Static Screen button at the bottom of the Animation screen to enter the Static Screen, shown in Fig.14.

Again, there is the selection of displays quantity and arrangements available, but this will have been set to the same format as used for animation when you entered the Static screen. Similarly, such change as you make here will be repeated if you go back to the Animation screen.

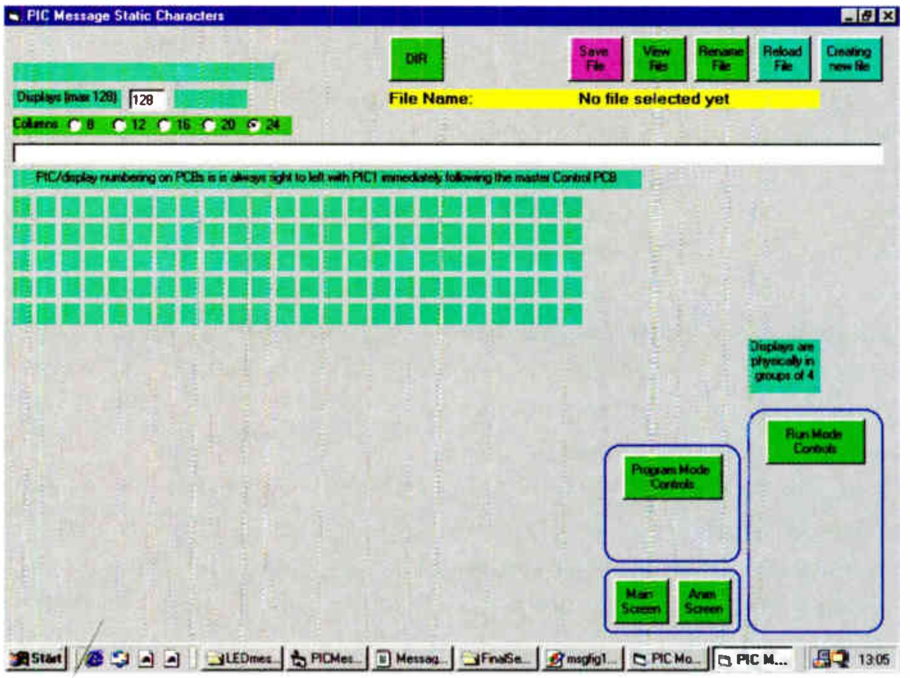

Fig.14. Static message screen, without additional data

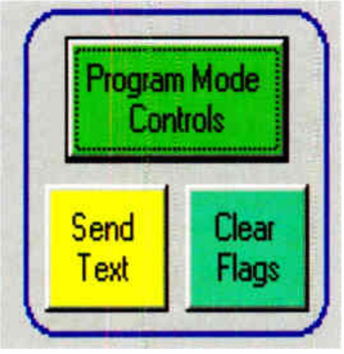

Fig.15. Program mode zone on static message screen

To create a static message, enter the message into the text box provided. Create a named file, load and save into it as before. Reloading that file, the message will be displayed back in the text box and in the blue boxes where it can be examined. The boxes are not numbered on screen as you can arrange the text as you want it and sent to as many displays as implied by its length.

To send the loaded message to the slaves, ensure the unit's switches S1 to S3 are switched off, and click the Program Mode Controls button (if it was not last clicked in a previous screen), to reveal just two buttons now (Fig.15). Click the Send Text button to send it, whereupon the slaves will display it.

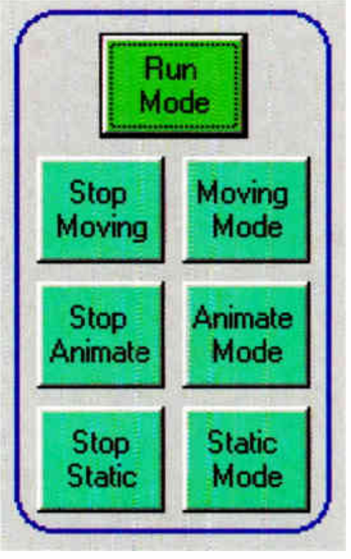

Fig.16. Run mode zone – common to all screens

Static points

A few points to note about static messages. First, they are normally shown in place of animation or moving data. The exception to this is in respect of blank spaces in a static message. The slaves do not regard the blanks as having data, consequently, animation can be sent to the slaves so that it occurs in those blank displays.

Secondly, the act of sending static data to the slaves overwrites the existing moving message in the master PIC's memory. However, that moving message data can be re-sent to the master following the sending of the static data. This restriction is imposed by the master using the same program routines to send static data to the slaves as it does to store and send moving messages.

Mode selection

There is a choice of methods by which to select moving or static messages, or animation displays. Normally, with the PC unplugged from the unit, the selection is made via switches S1 to S3, each respectively turning its selected mode on or off. S1 for moving message, S2 for animation and S3 for static message.

The same selection can be made from the PC. Click the Run Mode button on any of the three mode screens. This reveals six buttons (Fig.16) while hiding the buttons in the Program Mode area. The function of the buttons is marked and is the same as that for the switches.

Note that there is no communication between the PC and master PIC in this context, and so the PC does not know the setting of any switch. All this means is that the PC's buttons may not respond as expected until the other associated button has been clicked. The PC's control then overrides the switches. The switches may still be used after the PC has selected the mode.

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All three modes may be run concurrently, the appropriate display appearing on a particular LED module. For example, if animation data has been sent to some displays, but not others, those others will show the moving message, it 'passing behind' the animation displays unseen. Similarly, if a static message has been sent with spaces in it, those spaces will show the moving message as it scrolls along, again 'passing behind' the used static displays. A mixture of all three modes is possible.

When static and animation data are sent to the slaves, a 'marker flag' is internally set within the PIC's memory. When the static or animation buttons or switches are used, only those PICs whose data type is appropriate to the button or switch will show that data, or terminate the mode if already active.

The control codes are 0 for normal moving message only, 1 for animation and 2 for static. There is one only flag in each PIC and so only one mode code is ever active in it.

When static or animation data is sent to the slaves, the flag is always changed to the current code type if the destination PICs are intended to accept the latest data.

In connection with this, the flags may be totally cleared in all slaves by clicking the Clear Flags button in the Program Mode box of any PC display.

Message over and out

That then is the overall nature of this message display unit. Over to you now to enjoy making use of it and its facilities, let us know how you find it.

Finally, a warning. If you think about making changes to the software, beware that it is highly complex, probably the most complex project software on which the author has worked. So many factors are interlinked, more so than may appear at first sight. You make changes entirely at your own risk. Make sure you have a backup copy before you start!

Note also that Joe Farr's Serial Interface software, available from our Downloads site, must be installed if you wish to run the PC program under VB6.

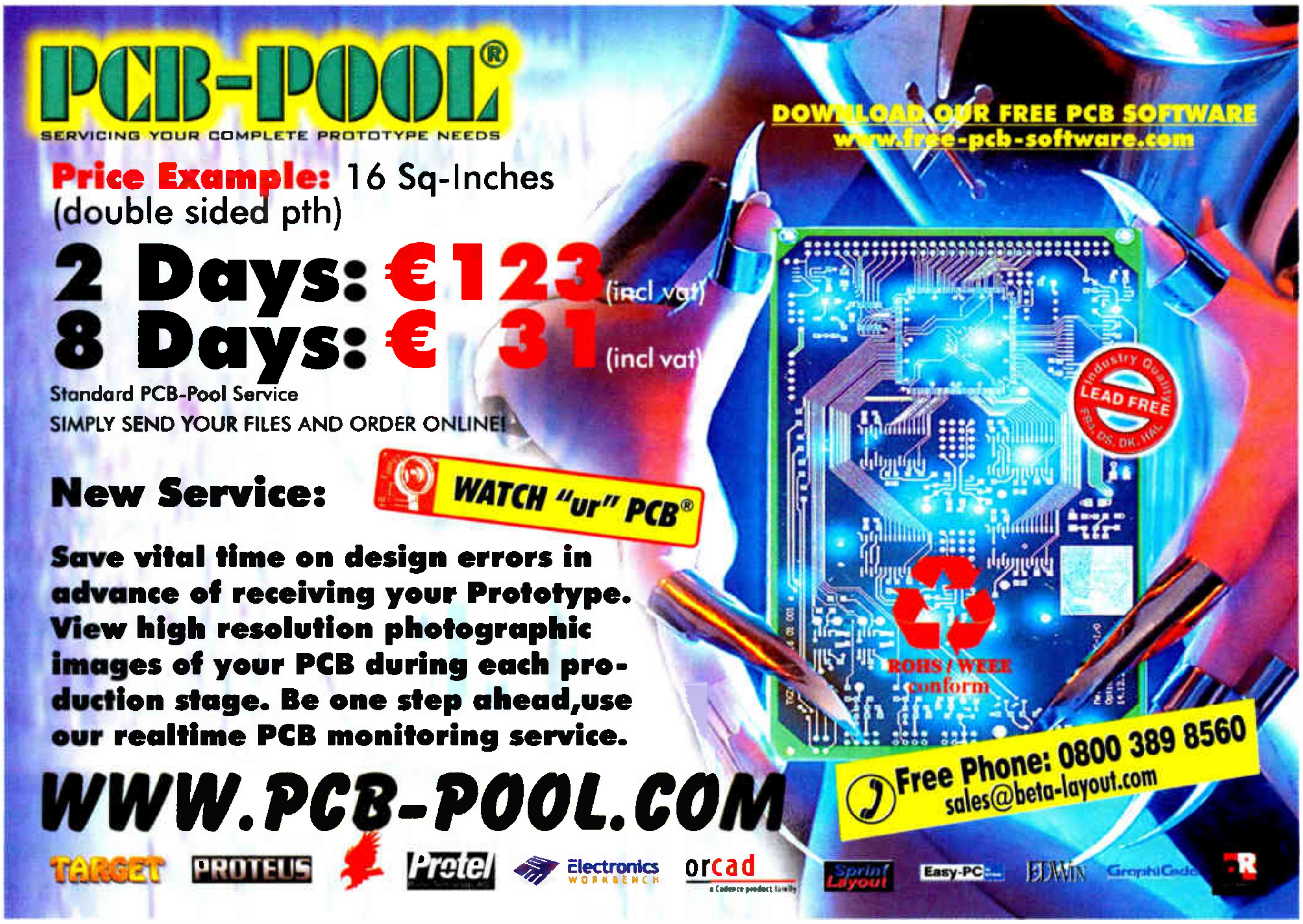
Hopefully, you will not wish to make changes and enjoy using the design at it is.

And just in case you're thinking of such – it is illegal in the UK to have an illuminated message in your car's rear window. So resist the temptation to tell that other driver to stop climbing up your exhaust pipe! *EPE*

Resources

Software, including source code, is available for free download via the *EPE* website at www.epemag.co.uk. Pre-programmed PICs are available from Magenta Electronics Ltd, contact details as in their advert in this issue, prices on request. Ask about quantity discounts.

There are a few other example test data files that can be examined through the Directory mode of the various screens.



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TECHNO-TALK MARK NELSON

Day Of The RFIDs

Applications now abound for RFID radio indentification tags, which is good, but they have acquired a scary image problem as well. Should we be afraid, very afraid? Mark Nelson thinks not.

THE last time we discussed RFID here (June 2005) the technology was no longer a solution looking for a problem but by no means mainstream technology. Today you can find RFID chips concealed in your dustbin. Worse still, the tiny tags can be cloned, compromising their use in passports and other security applications. No wonder civil liberties activists are alarmed, with industry professionals having their work cut out defending the technology.

So what's all the fuss about? First a quick reminder what RFID tags are. RFID stands for Radio Frequency Identification Device and involves a technique in which small identity labels or tags fixed to larger objects can be 'read' by radio means from a distance. Some people call them radio barcodes and given that RFID tags are used a lot in commerce, it's quite a convenient analogy.

But whereas barcodes are read optically, these RFID tags are activated by low-power radio waves, causing them to announce their identity to special reader devices. The system is ideal for tracking and identifying goods and other objects, whilst the tags are durable, cheap, small and (whisper it quietly) easy to conceal.

Spy Chips and Dodgy Dustbins

One of their first applications was in stores of a leading British supermarket chain and this was when the controversy first became public. Privacy campaigners claimed the tags' purpose was to identify shoplifters stealing Gillette razor blades, which happen to have a high value for their extremely pocketable size. Tesco, the company in question, claimed the tags, applied to high-value items in 10 shops, were used only as part of its distribution process. This did not stop privacy groups from labelling them 'spy chips', fearing the tags might be used to track errant customers.

The muck really hit the fan over the August bank holiday weekend, however, when Sunday papers revealed that half a million electronic spy 'bugs' had been planted secretly in British dustbins. "Were it not so pernicious and intrusive, the tale of eco-bugging in suburbia would be the stuff of comedy. Instead, it is yet more worrying evidence of the nosy nanny state Britain is fast becoming," thundered the *Mail on Sunday*.

It emerged that hundreds of thousands of wheelie bins around the country were being fitted with special microchips to monitor the amount of waste discarded by householders. Local authorities argued these were necessary to gather data about rubbish disposal habits and could be used to settle disputes over bin ownership. Others feared the information could be used to fine people who exceeded the limits on the amount of non-recyclable rubbish that they put out and pondered the ethics of removing the tags to avoid the monitoring.

Grand Debate

There's no doubt that the stealthy way the technology has been introduced has led to considerable confusion and resentment and this has not been helped by loud voices from those with axes to grind. Although 999 people out of 1,000 are probably unaware, the European Union has recently held an online public consultation on the subject at **www.rfidconsultation.eu**. Its purpose, the website says, is to ensure that the growing use of radio frequency identification devices boosts the competitiveness of Europe's economy and improves the quality of life of its citizens, whilst safeguarding their basic rights.

"We need to ensure that RFID technology delivers on its economic potential and to create the right opportunities for its use for the wider public good, while ensuring that citizens remain in control of their data," said Information Society and Media Commissioner Viviane Reding in July, even if you or I had never heard of her back then.

RFID technology is big business of course, so much so that the European Union is spending 7.5 million Euro on promoting it. Its advantages over conventional barcodes are very clear, as Ian Neild, disruptive technologies manager of BT's research, technology and IT operations business BT Exact, explains. "The need to develop new RFID technologies is vital for the retail industry: where barcodes fail, is by either not giving enough information or by working only in line of sight. By contrast, RFID tagging uses radio waves, so line of sight isn't as important an issue and the amount of data it can carry is much larger," he states.

However, his (and others') enthusiasm may need to be tempered temporarily until some serious security issues have been sorted out. Three separate reports earlier this year revealed that RFID tags have flaws that could put their deployment at risk. Two were relatively trivial, such as the allegation that viruses written into tags could infect companies' computers or that the tags themselves could be disabled by overloading them with data in a Denial-of-Service attack. More worrying was the claim made at the August *DefCon* security conference in Las Vegas that information in RFID tags could be copied and used to clone corporate access cards, e-passports and other badges that were supposed to establish people's unique identity.

Hobby Applications Too?

Turning our attention to matters more benign, do RFID tags have hobby applications? Ian Morton of MERG (**www.merg.org.uk**) reckons they do. MERG is an international collection of hobbyists who promote the application of electronics (including computers) to all aspects of railway modelling. Digitally coded control systems are widely used now for running model trains more realistically and Ian is convinced that RFID tags could play an important role in this process.

One scenario he describes is where an electronic reader at the exit from a yard of sidings could identify the locomotive or a particular set of rolling stock to compare this against a schedule and display the train's identity on the control panel. In the autumn issue of *Modern Railway Modelling* magazine he sets out the full detail of his scheme, which is both high-tech and down-to-earth. Ian states confidently, "I am sure that standards for model railway RFID will appear eventually, probably once a major player in the market produces something that people start to use."

Cheap As Chips

Without agreed standards or commercial equipment, the immediate take-up will be limited, he suspects. Another factor is the cost; this equipment is not yet as cheap as chips and until mass production makes tags cheap enough to implant in chocolate wrappers or crisp packets, there may be a lack of interest among hobbyists.

Currently, perhaps the cheapest starting point is the RFID evaluation kit available for around £70 from Mannings (Southport) Ltd (**www.rfidshop.com**) but prices could plummet before too long. Researchers at BT Exact are examining how producing tags could be made cheaper, with 'printable electronics' as one possible solution.

Ian Neild has the last word: "If you don't require the processing complexity of an Intel Pentium processor, printable electronics could prove the best option. Instead of loading an inkjet printer with colour ink, you use silicon oxides with conductive and non-conductive inks, and so 'print' your tagging components cost-effectively."

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Multimedia cards have serious storage capacity for PIC projects

IN previous *PIC n' Mix* articles we have discussed interfacing to large capacity flash memory ICs, some with capacities up to a few megabytes. With the advent of digital cameras and multimedia consumer electronics however, the cost of removable flash memory cards has steadily reduced to the point where they have become cost effective for use in small hobby projects. This month we look at hooking up some serious storage capacity to our projects.

Numerous Card Formats

There is a plethora of card formats available – Compact Flash, SD-Media, MMC, Memory Stick; the list goes on. Some have a proprietary interface which is closed to hobby developers, but some, such as Compact Flash, SD-Media and MMC are more open and the specifications are available from manufacturers' web sites.

For only a few times the price of a small EEPROM it is now possible to get huge capacities on a memory card – up to 4GB! And as it is removable, you can move it between different embedded projects.

By far the most interesting aspect however, is the ease at which, with just a little additional software, data can be stored in a format recognisable by a PC. Then it becomes a trivial task to exchange data between your project and a PC, which opens up many exciting opportunities. We will discuss how to do just that in next month's issue. For now we will look at the low level interface.

MMC Cards

For this article we have chosen MultiMedia Cards (MMC) because they are cheap, readily available, easy to interface to and compatible with SD-Media cards. The connectors for them are also relatively cheap and easy to solder to. Fig.1 shows the typical wiring required to communicate with a card in SPI mode. As you can see from the figure, only six connections are required. To all intents and purposes we treat the card as an SPI connected IC.

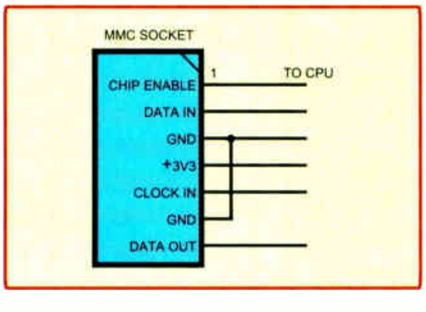

Fig.1. Connections to an MMC

SPI is a serial IC to IC communication protocol, similar to the I²C bus and in many ways a lot simpler (especially if you want to 'bit bash' communications from your microcontroller). Most of the PIC range of processors supports this protocol in hardware, allowing simple code to support very high data rates – up to 100 times faster than I²C!

In this article we will use the PIC18LF2420 processor (which supports SPI in hardware) to demonstrate the features of MMC, and the example code is available in the download section of the *EPE* website (see References). The code should run on any of the PIC18F series that support SPI but will also run on any PIC processor with minor modification. Interfacing to an MMC card is not complex, but understanding how to configure and use the card can be a little daunting. The details are difficult to understand from the datasheets alone but 'hopefully' we will demystify the subject, and provide you with a set of routines to include in your own projects.

While the datasheets for MMC cards are formidable, after reading and re-reading it becomes clear that using them does not have to be complicated. The complexity is there when you need to squeeze the highest performance/reliability out of the device. It's a pity that specification writers do not add a 'get you started' section to these specifications, as you find in product manuals. Perhaps it's not considered 'professional'.

Minor grievances aside, at least the specifications are available and easily downloaded from the Internet. We have used the Sandisk card specification (see the References for a download link) and a Kingston memory card. The MMC format is a well defined standard and the differences between the card manufacturers' products will not affect us.

The cards can be purchased from a wide variety of online memory stores (we picked our 256MB card up from **picstop.co.uk** for less than £8) or even from local high street electrical stores. If you do order a card online it is worth investing in a cheap USB card reader if you intend to exchange data with a PC at a later date. To connect the card to your project you will require a special socket, which are available from companies like Farnel for less than £1 (part number 9186182).

These cards have a wide operating voltage range, from 1.6V to 3.6V – ideal for a low powered project, but it does limit your choice of microcontrollers to those that can operate at 3.6V. Thankfully, there are many in the PIC range. Alternatively you can use a resistor divider on outputs from the PIC, and power the MMC card from a separate 3.3V regulator.

How MMCs Work

So, to the main task: how do these cards work? Besides the large block of flash memory, the cards implement a very simple controller that is responsible for handling initialisation, identification and control commands from the host processor. You cannot just power the device up and read from it as you can with an EEPROM memory IC. Thankfully, when communicating with these cards in SPI mode the 'instruction set' and procedures for setting up the card are simplified, and are summarised in Fig.2.

Commands typically consist of five bytes: the command, a four-byte parameter, and an optional check byte. Check bytes are not used by default once the card is initialised, and for simplicity we will not enable them. They provide a basic confirmation that communication with the card was not corrupted and would not normally be necessary.

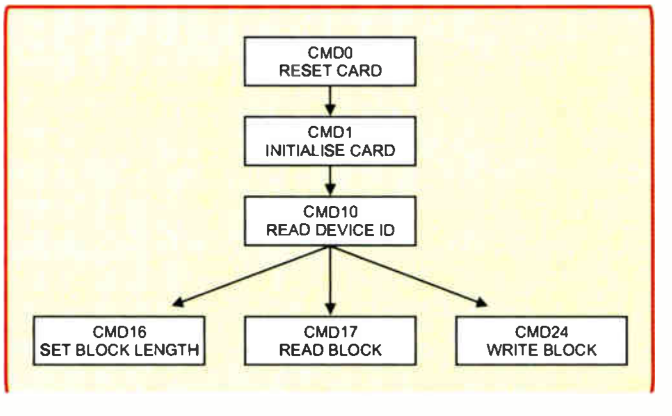

Fig.2. Instruction set summary

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Most commands return a response message, which in SPI mode must be clocked out of the card by sending it 0xFF bytes (this is probably one of the most confusing aspects of SPI communications; it's not a specific requirement of MMC cards). The details of the parameters are covered in the specifications and example source code so we will not cover them here, but concentrate on the sequence of commands.

When the card powers up you must send a CMD0 command to reset the card back to its idle state, then follow it with CMD1 to initialise it (see Fig.2). The latter command can take some time to complete; issue the command repeatedly until the response indicates initialisation has finished.

Once initialisation has completed there is a final mandatory command that must be issued: CMD10, retrieve card identification. This returns a 16-byte response, CID, that identifies the manufacturer and card type. This information can be useful in identifying the amount of memory on the card.

Reading and Writing

Having issued CMD10 and extracted the CID, you are now free to read and write to the flash memory. The read and write commands, CMD17 and CMD24, take a 32-bit (four-byte) address parameter. This means that up to 4GB of data can be addressed, if your card contains that much flash memory. A read can start at any address and you may read as many bytes as you wish with the single command; just keep writing 0xFF to the card to latch out further data bytes.

Writing is a little more complicated. Internally, the memory of the card is organised in groups of 512 bytes, called sectors, to mimic the memory allocation on hard disks (more on this next month). When you write to a sector the card first erases it and then writes your data. Now this is fine if you want to transfer 512 bytes at a time, but sometimes this is not convenient – maybe you want to update a single byte, or you just do not have the available RAM to buffer 512 bytes. To accommodate this there is a command, CMD16, which can be used to set the 'buffer block size'. This command will determine how many bytes are read or written by commands CMD17 and CMD24.

One important detail when setting the block size to a value other than one: always set your starting address for a read or write to a multiple of the block size. So for example, if set to 512 bytes, your read/write commands should be set to start from 0, or 512, or 1024, or 1536 etc.

The example code demonstrates the use of two block sizes, 512 and 1.

SD Media Compatible

Those few commands are all that is necessary to read and write data to an MMC card, and as MMC is a subset of the SD media format, they should be compatible with that format too. There are many other commands that can be used which allow for protection and faster multi-block writes, but what we have presented here should be sufficient for most needs. Your only problem now is to invent uses for such a large storage capacity! Data loggers, audio (for record and play back perhaps), the options are only limited by your imagination.

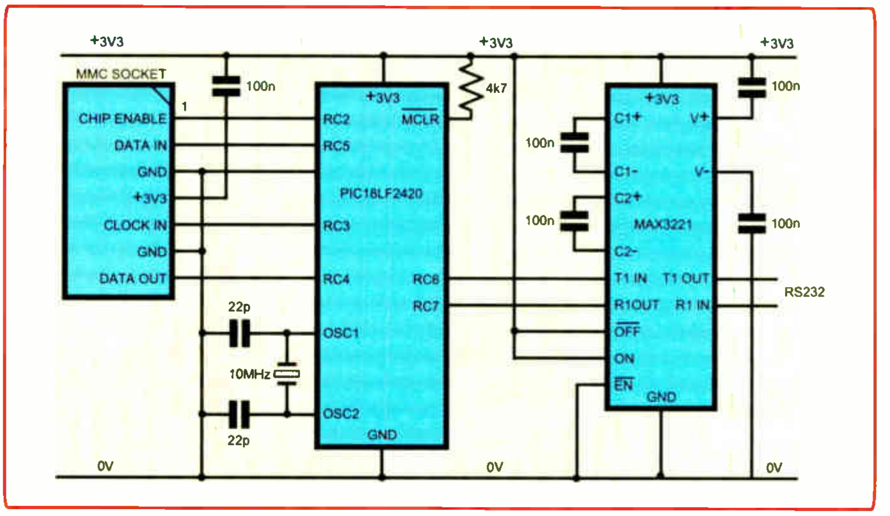


Fig.3. An example MMC use circuit

The example source code for this article is once again based around the 'bootloader' code from a previous *PIC n' Mix* article. It simplifies development since you can hook up an RS232 interface to the TX and RX pins on the processor (PORTC,6 and PORTC,7) and simply download revised code through the serial interface. The MMC card functions are held in **MMC.INC**, and the low level SPI routines in **SPI.INC**. Both hardware and software ('bit-bashed') SPI routines have been implemented; simply change the line

```
SPI_MODULE_MODE     EQU
SPI_USE_HW_MODULE
```

to

```
SPI_MODULE_MODE     EQU
SPI_USE_BIT_BASHED
```

if you want to use 'bit-bashed' SPI communications.

The file **APP.INC** is the 'glue logic' that demonstrates how the MMC functions can be used, and presents a simple user interface over the serial port. You can communicate with the program using a terminal program like Hyperterminal at 9600,n,8,1.

Fig.3 shows a complete example circuit that can be used with the example software. As you can see, the interfacing requirements are minimal – the RS232 interface is more complex!

Transfer Rates

There is a problem with this setup if you want to move the data over to a PC. If you have an RS232 interface then even at 115200 baud, transferring large amounts of data over a serial link will take a ridiculous amount of time. One day to transfer 1GB! If you have a USB interface on your design this is not an issue, but if not another way to transfer data is called for.

Fortunately, 'Media Card' readers for PCs are now very cheap and make an ideal means for transferring data from a card onto a PC. The readers do require data to be stored in a format similar to that on a hard disk, however, and this adds some more complexity to your code. It does open up huge possibilities for sharing data between a PC and your projects and so we will pick up on this next month.

References

MMC card specifications:
http://www. sandisk.com/Oem/Manuals/

Example code:
http://www.epemag.wimborne.co.uk/downloads.html

Author: **mike.hibbett@gmail.com**

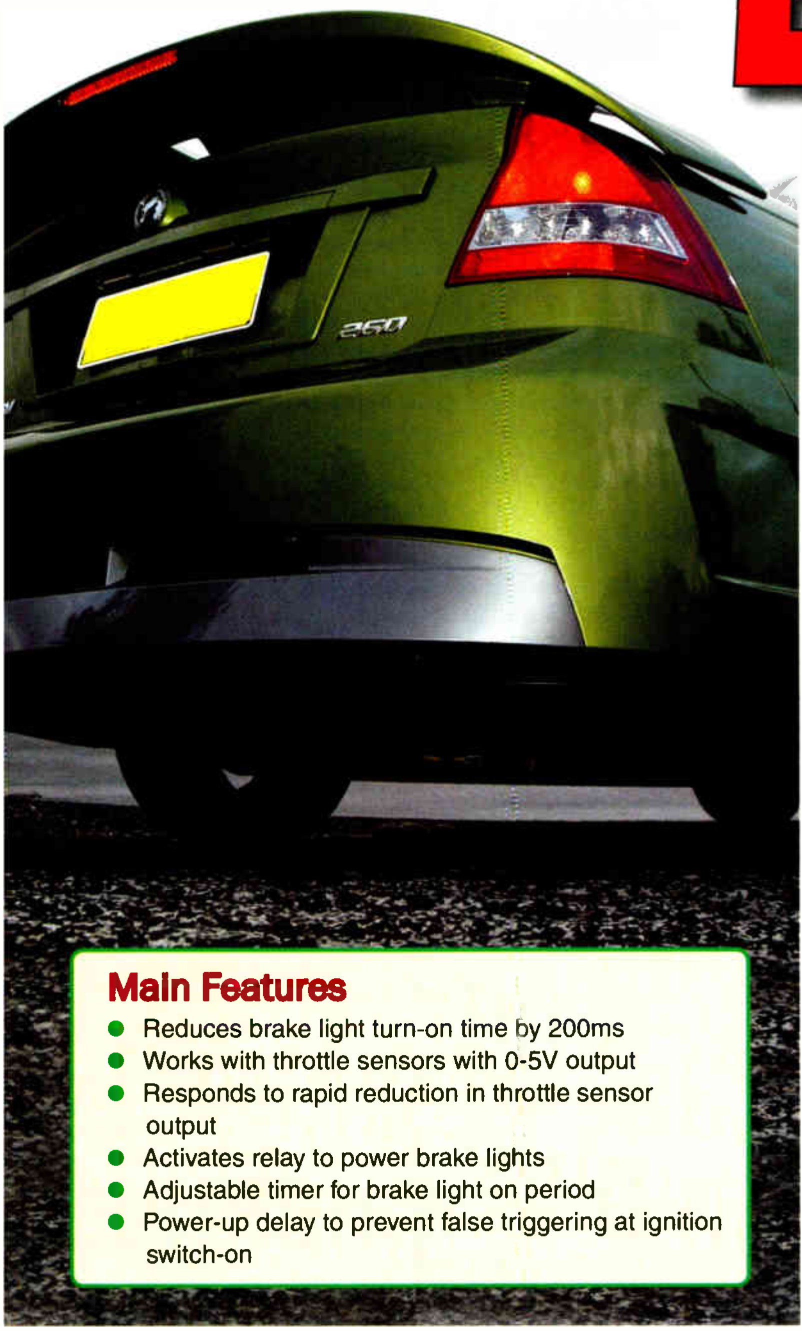
World Radio History

Increase your driving safety with

QuickBrake

Are you concerned about the risk of a rear end collision when driving in traffic? With QuickBrake, your brake lights come on faster than you could ever apply them, giving you literally metres more safety.

Words by Julian Edgar
Design by John Clarke



Main Features

- Reduces brake light turn-on time by 200ms
- Works with throttle sensors with 0-5V output
- Responds to rapid reduction in throttle sensor output
- Activates relay to power brake lights
- Adjustable timer for brake light on period
- Power-up delay to prevent false triggering at ignition switch-on

LED brake lights, as opposed to filament bulbs, can provide the following driver with as much as 200ms earlier warning . . . that's 5.4 metres at 60mph. But with QuickBrake you can do even better than this and provide another 200-250ms earlier warning! By combining LED brake lights with QuickBrake, you can give at least 400ms earlier warning that you're stopping – that's 10.8 metres at 60mph. It's a brilliant technique that we've not seen anywhere else – even in new cars.

Think about what occurs during an emergency stop. You're driving along, mind dwelling on all things interesting – including the other traffic – when you suddenly realise the cars ahead are stopping abruptly. You rapidly lift off the accelerator and then transfer that foot to the brake pedal, quickly jabbing down on it. But 'rapidly' and 'quickly' are relative terms – in

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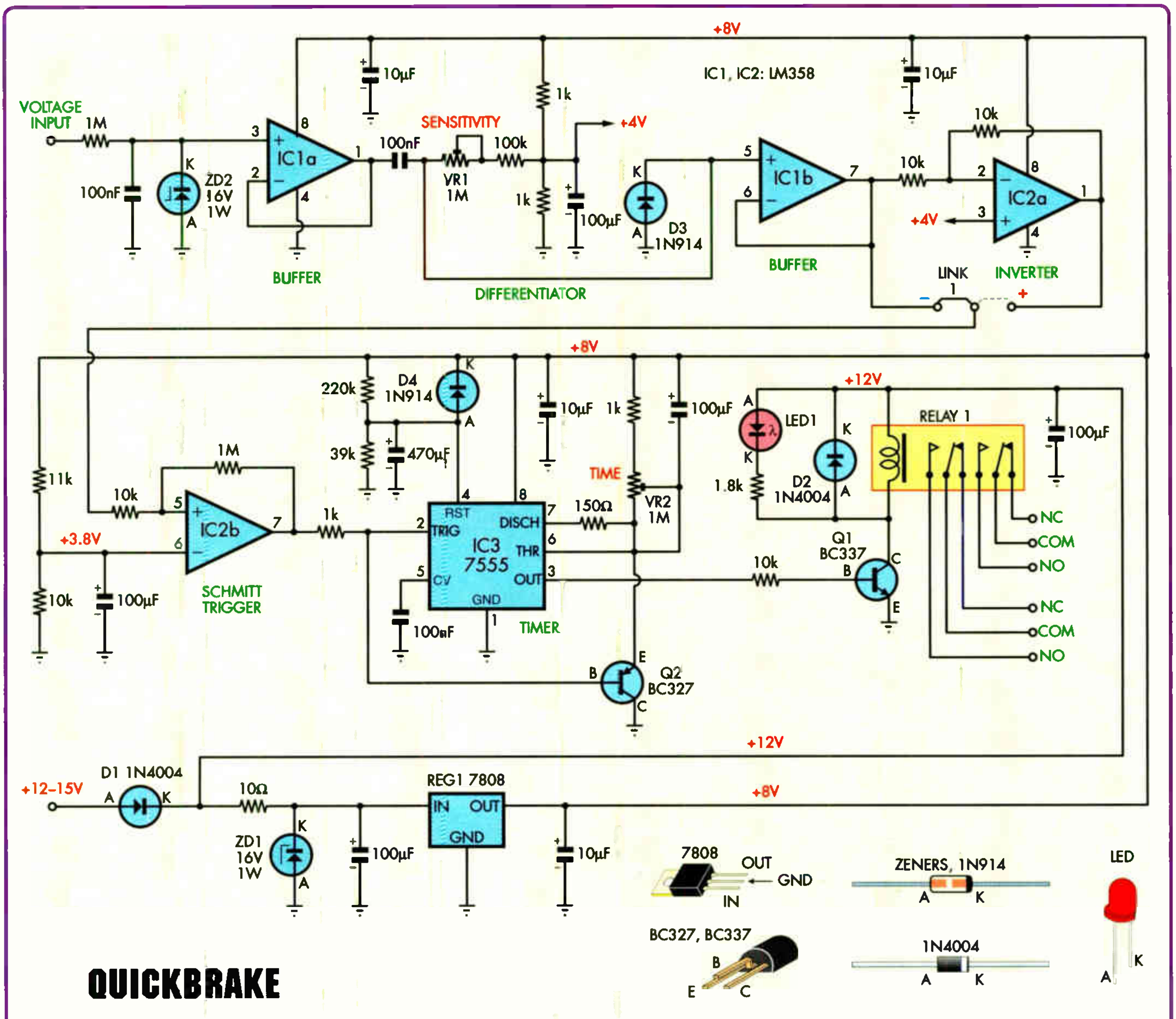

Fig.1: the circuit monitors the car's throttle position sensor and if a rapid negative transition occurs, the 7555 timer is enabled to briefly activate the relay and the car's brake lights.

fact it takes about a quarter of a second (250 milliseconds) from the time that you start to lift off the throttle to the time the brake pedal is pushed and the brake lights come on.

But why wait that long before illuminating the brake lights? There's no logical reason – only the engineering tradition of turning on the brake lights with a brake pedal switch.

So why not trigger the brake lights when you rapidly lift your foot off the throttle? 'Oh that won't work', you say. Well, why not? With a little circuitry, you can sense the speed of the throttle movement quite easily, just by tapping into the throttle position sensor. Then, if you have the circuit detect a rapid reduction in voltage from the throttle sensor (as happens when you're about to stop in a hurry), you can use a relay to switch on the brake lights. Finally, a timer could be used to hold the relay on to cover the time between the throttle closing and the brake light switch being activated.

This is just what our QuickBrake circuit does. And it's just uncanny watching a car fitted with the project simulate an emergency stop. The brake lights come on 'soooooo' fast that you suddenly realise that the pause between deceleration and braking that normally occurs is quite clearly able to be seen, even from outside the car.

QuickBrake can be very handy when you're plagued with a 'tailgater' too. If someone is following you much too closely, just lift off the accelerator quickly and the brake lights will come on for a brief period, without you even having to touch the brake pedal. Nifty, huh?

PC board module

As shown in the photos, QuickBrake is a small PC board module measuring 105 x 60mm. It uses the engine management system's throttle position sensor output to monitor the movements of the throttle.

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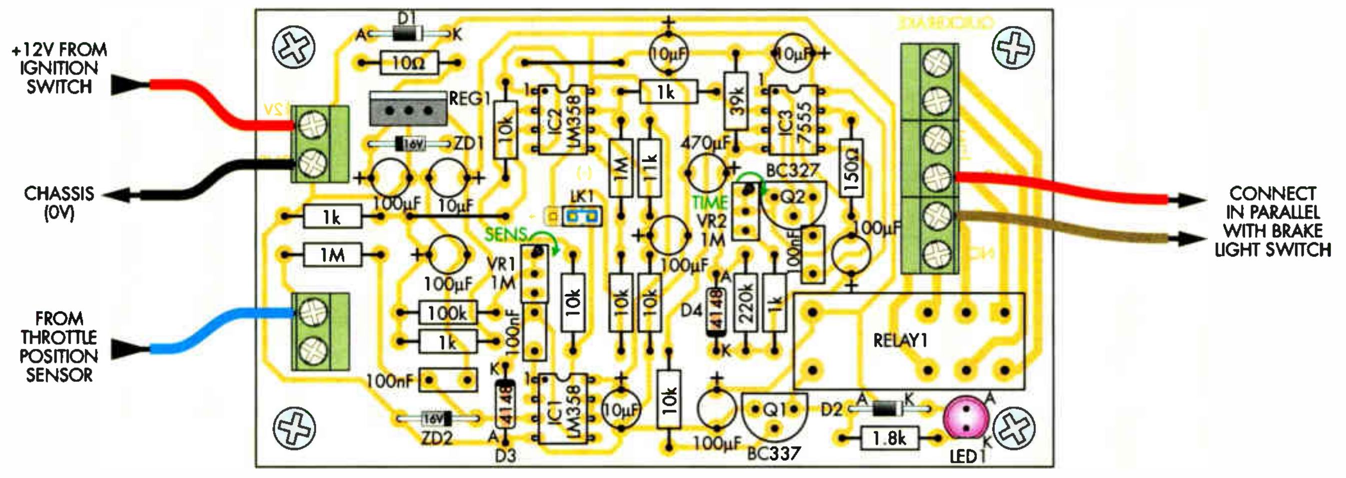

Fig.2: this diagram shows where each of the components is placed on the PC board. Also shown are the connections you need to make when installing QuickBrake in your car. The input signal to QuickBrake is derived from the throttle position sensor output. The Normally Open and Common contacts of the relay are wired in parallel with the brake light switch. Ignition-switched power and an earth connection finish the wiring.

In operation, it is designed to work with throttle position sensors with an output voltage that varies within the range of 0-5V. *If your car does not have engine management or it uses a throttle position switch (rather than a potentiometer), QuickBrake cannot be used.* You have been warned – you need to check this point out, *before* you start buying the components.

Circuit description

Fig.1 shows the circuit of the QuickBrake which is based on four op amps (in IC1 & IC2) and a 7555 timer. In effect, the circuit is designed to detect the rapid change of voltage from the throttle position sensor and then close a relay for a brief time. The relay switches on the brake lamps for a pre-determined time. In the meantime, if the driver's foot hits the brake pedal, the brake lights will stay on. If not, the brake lights go out when the relay drops out.

So let's look at the circuit in more detail. The DC voltage from the throttle position sensor is fed to a low pass filter consisting of a 1MΩ resistor and 100nF capacitor and then to op amp IC1a, which is connected as a unity gain buffer. From there, it goes to a differentiator consisting of a 100nF capacitor, trimpot VR1 and a 100kΩ resistor.

A differentiator can be thought of as a high pass filter – it lets rapidly changing signals through but slowly changing signals are blocked. Putting it another way, if the rate of change of the signal is greater (ie, faster) than the differentiator time constant (RC), the signal will pass through to op amp IC1b, which is another unity gain buffer, and then via link LK1 to IC2b which is connected as a Schmitt trigger stage.

The output of IC2b connects to pin 2, the trigger input of IC3, a 7555 timer. When IC2b briefly pulls pin 2 of IC3 low (as it does for a sudden reduction in throttle sensor signal), IC3's pin 3 immediately goes high, turning on transistor Q1 and RELAY1. This turns on the brake lights.

At the same time, IC2b's brief negative pulse turns on transistor Q2 which pulls the negative side of a 100µF capacitor to 0V and this fully charges this capacitor to 8V. From this point, the 100µF capacitor discharges via trimpot VR2 and the series 1kΩ resistor. This means that the negative side of the 100µF rises until it gets to about +5.3V, whereupon pin 3 goes low and transistor Q1 and the relay are switched off.

The timer period of IC3 can be set from around 100ms up to 110 seconds, using VR2. In this QuickBrake application, the timer is set to quite a short period, typically less than 500ms.

Diode D2 is connected across the relay coil to quench spike voltages generated each time transistor Q1 turns off. Q1 also drives LED1, via the 1.8kΩ series resistor and this lights

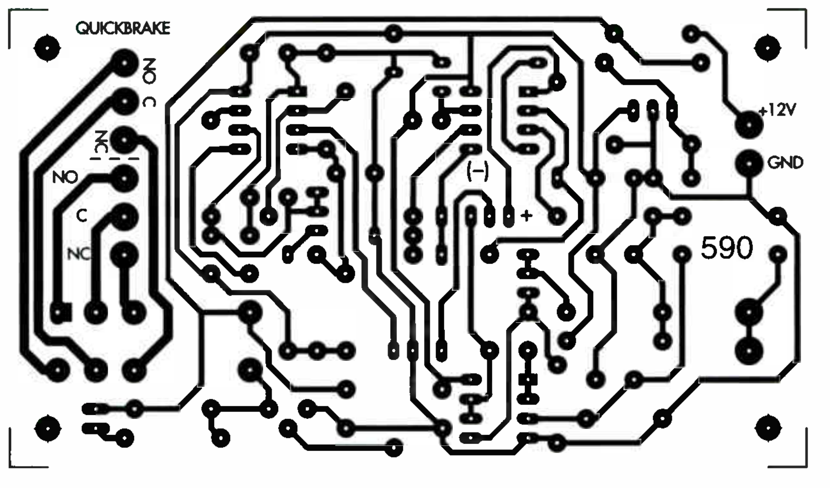

Fig.3: check your PC board against this pattern before installing any parts.

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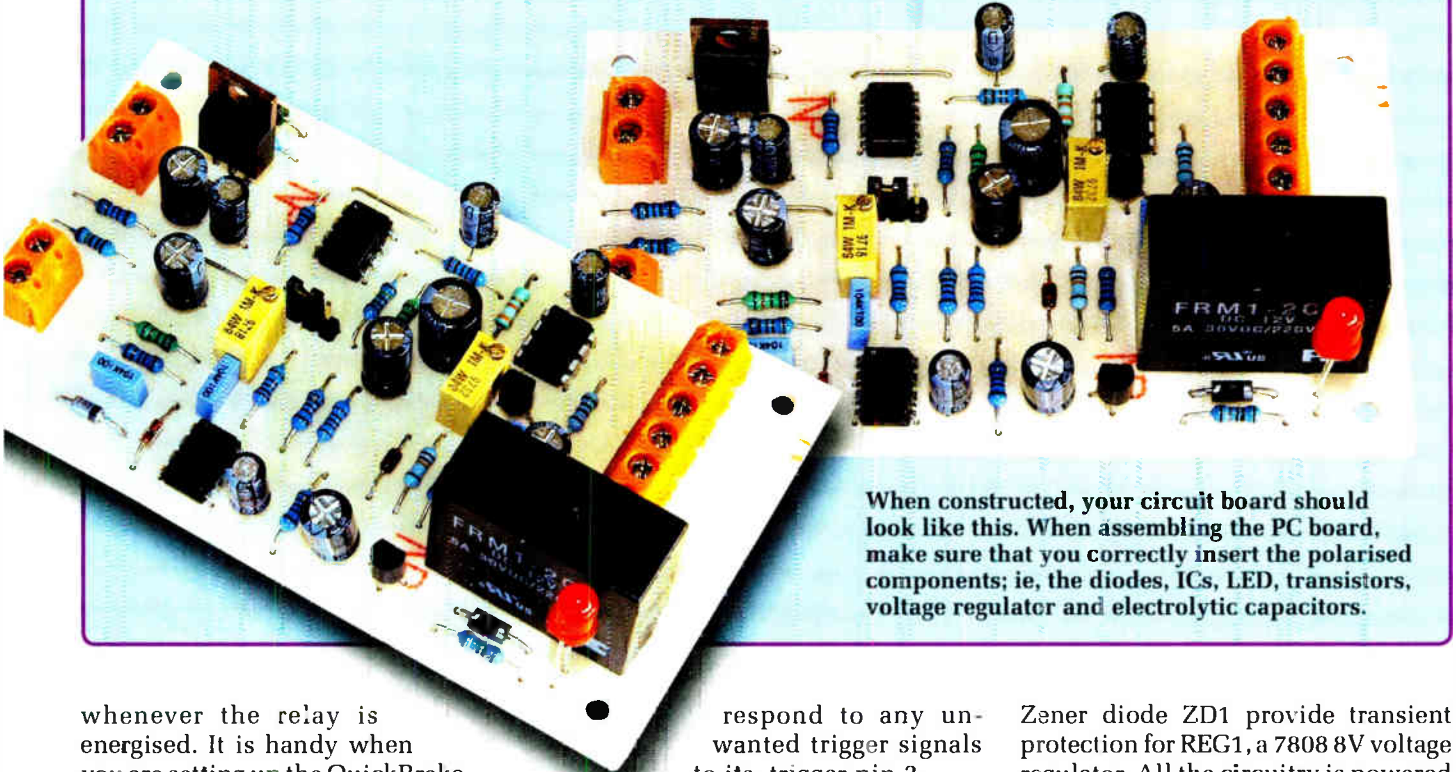

When constructed, your circuit board should look like this. When assembling the PC board, make sure that you correctly insert the polarised components; ie, the diodes, ICs, LED, transistors, voltage regulator and electrolytic capacitors.

whenever the relay is energised. It is handy when you are setting up the QuickBrake circuit on your car.

Power-up delay

Pin 4 of the 7555 (IC3) is used to provide a power-up delay. When the car is first started, we don't want the QuickBrake responding to any unpredictable changes in signal from the throttle sensor; we want all circuit operating conditions to have stabilised before QuickBrake starts operating. Therefore, pin 4 of IC3 is connected to a network comprising a 470µF capacitor, diode D4, and 39kΩ and 220kΩ resistors. Initially, the 470µF capacitor is discharged and so pin 4 is low, effectively disabling IC3 so it cannot respond to any unwanted trigger signals to its trigger pin 2.

IC3 is enabled (ie, begins to operate) when the 470µF capacitor charges to around +0.7V via the 220kΩ pull-up resistor. This is after about two seconds. The 39kΩ resistor prevents the 470µF capacitor from charging above 1.2V and this allows it to discharge quickly via diode D4 when power is removed from the circuit (ie, when the engine is stopped). This is important so that QuickBrake is properly disabled if the engine is immediately restarted.

Power for the circuit comes from the car battery via diode D1 which gives reverse connection protection. The 10Ω resistor, 100µF capacitor and Zener diode ZD1 provide transient protection for REG1, a 7808 8V voltage regulator. All the circuitry is powered from REG1, with the exception of the relay and LED1.

Construction

All the circuitry of QuickBrake is on a small PC board measuring 105 x 60mm and coded 590 (see *EPE PCB Service* page). The component overlay diagram is shown in Fig.2.

Install the resistors first, checking the values with your multimeter as you install each one. Use 0.8mm tinned copper wire for the two wire links. Make sure that you insert the polarised components the correct way around. These parts include the diodes, ICs, LED, transistors, voltage regulator and electrolytic capacitors.

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	1MΩ	brown black green brown	brown black black yellow brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	39kΩ	orange white orange brown	orange white black red brown
❑	1	11kΩ	brown brown orange brown	brown brown black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	1	1.8kΩ	brown grey red brown	brown grey black brown brown
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown

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Parts List

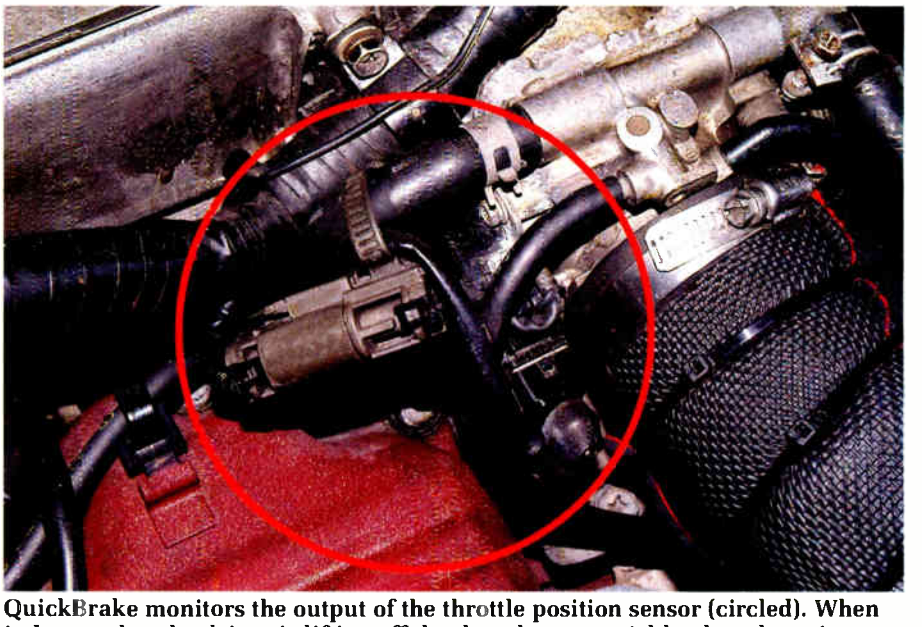
1 PC board, code 590, available from the *EPE PCB Service*, 105 x 60mm
5 PC-mount 2-way screw terminals with 5mm pin spacing
1 12V PC-mount DPDT 5A relay
1 3-way header with 2.54mm spacing
1 jumper shunt with 2.54mm spacing
1 50mm length of 0.8mm tinned copper wire
2 1MΩ multi-turn top-adjust trimpots (VR1,VR2)

Semiconductors
2 LM358 dual op amps (IC1,IC2)
1 7555 CMOS 555 timer (IC3)
1 7808 3-terminal voltage regulator (REG1)
1 BC337 NPN transistor (Q1)
1 BC327 PNP transistor (Q2)
1 5mm red LED (LED1)
2 16V 1W Zener diodes (ZD1,ZD2))
2 1N4004 1A diodes (D1,D2)
2 1N914, or 1N4148 diodes (D3,D4)

Capacitors
1 470µF 16V electrolytic
5 100µF 16V PC electrolytic
4 10µF 16V PC electrolytic
3 100nF MKT polyester

Resistors (0.25W, 1%)

2 1MΩ	5 10kΩ
1 220kΩ	1 1.8kΩ
1 100kΩ	4 1kΩ
1 39kΩ	1 150Ω
1 11kΩ	1 10Ω



QuickBrake monitors the output of the throttle position sensor (circled). When it detects that the driver is lifting off the throttle very quickly. the relay trips, illuminating the brake lights. A built-in timer then covers the period before the brakes are actually applied.

The relay and the screw terminal strips can be installed last.

Note that there is a trap in the installation of the two trimpots. They can go in either way but they must be installed as shown in the diagram, with the adjustment screw closest to IC2 and IC3 respectively. If you install the trimpots incorrectly, the initial adjustment instruction that we give in the set-up procedure will be wrong.

During assembly, look closely at the photos, Figs.1 & 2 and the parts list to avoid making mistakes.

Manual Gearboxes?

QuickBrake may not be suitable for use in manual cars when driven aggressively because it may not be able to distinguish between throttle lifts for emergency stops and those used during rapid acceleration through the gears. On the other hand, if you normally drive your manual car in a leisurely manner, it should not have problems.

Fitting it to your car

As mentioned earlier, before you buy the components you need to check if your car has a throttle position sensor (not a throttle switch!). Now is the time to measure the output of the throttle position sensor. This should be done with the engine off (but the ignition on!) by probing the throttle position sensor.

With one multimeter probe earthed (connected to chassis), you should be able to find a wire coming from the connector that has a voltage on it that varies within the 0-5V range as you manually open and close the throttle. Yes, you can manually open and close the throttle by operating the mechanism on the side of the throttle body.

Once you have confirmed that the varying signal voltage is present, make a connection to this wire – either at the ECU itself or under the bonnet – and run it to the QuickBrake signal input. (Note that you simply tap into the throttle position output wire – you don't need to cut it.)

Next, connect ignition-switched +12V and 0V (chassis) to the QuickBrake. The other connections, to the brake switch, don't need to be made at this stage.

Rotate trimpot VR1 (Sensitivity) fully anti-clockwise and VR2 (timer period) fully clockwise – this increases the sensitivity of the QuickBrake to throttle changes and reduces the timer's 'on' time to a minimum (note: both these pots are multi-turn so they don't have a distinct end 'stop'). Place the link in the Link 1

Unwanted Flashing

If the QuickBrake is set correctly and a competent driver is at the wheel, the brake lights should trigger no more frequently than normal. This is because the project should be calibrated so that it detects only *very fast* throttle lifts – the sort that are usually immediately followed by an application of the brakes. However, poor drivers who use very jerky on/off throttle movements will cause the brake lights to come on more than usual. Keep in mind that any brake light illumination will still indicate deceleration.

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position to configure the QuickBrake to activate with quick throttle lifts. (Link 2 causes the device to activate with quick throttle pushes.)

Turn on the ignition but don't start the car. Wait five seconds (to allow for the ignition-on reset pause), press the throttle and then quickly lift off, checking that the relay pulls-in and the LED lights. The relay should click out (and the LED go off) fairly quickly, so then adjust VR2 anticlockwise and again push down and then quickly lift the throttle. This time the 'on' time should be longer. Adjust VR1 clockwise until the QuickBrake responds only when the throttle is being lifted with 'real life' quick movements.

Note that if you find the relay clicks off after 10 seconds or so, then it is likely that trimpot VR2 is installed the wrong way around. Don't pull it out – just wind the adjustment fully in the other direction.

Once the QuickBrake module is working correctly, make the brake switch connections. These are straightforward – connect wires to both sides of the brake pedal switch and check that when you join the wires, the brakelights come on. Then run these wires to the adjoining 'Normally Open' and 'Common' connections on the QuickBrake relay screw terminal connector.

Set-up

Setting up the QuickBrake is also easy. Normally, you'll find that driving on the road actually involves slightly different speeds of throttle movement than you thought during the static set-up, so the sensitivity control (trimpot VR1) will need to be adjusted accordingly. The length of time that you set the timer (VR2) to operate for will depend on how quickly you typically move your foot from the throttle to the brake pedal. It's best to set the time so that it just covers this period.

The PC board fits straight into a 130 x 68 x 42mm box, so when the system is working correctly, the board can be inserted into the box and tucked out of sight.

Conclusion

If you're often worried about how closely others follow you at highway speeds, this project is for you. We know we've already said it, but it's uncanny how quickly the brake lights come on when a car equipped with QuickBrake is slowing! ***EPE***

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PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

EXPERIENCED constructors probably give the matter little thought when soldering the components onto a printed circuit board (PCB). For them it is a fairly routine matter. It is something that they have done many times before, and they know from past experience how to deal with any problems that may occur. They also know how to avoid most problems in the first place. There may be the occasional awkward component to deal with, or a board might represent a major challenge due to its sheer size, but 'old hands' probably build most circuit boards without too much conscious effort.

Complete beginners are in a very different situation, and will probably approach the task with a certain amount of trepidation. Self-doubt is then likely to result in hesitant progress and endless rechecking as the job progresses. Advising newcomers that 'there is nothing to it' would certainly be very misleading. On the other hand, problems should be few and far between if you set about the task in the right way. There is every chance that your first few circuit boards will work perfectly first time, provided you go about the job in a meticulous fashion.

Error Checking

It is probably no bad thing if progress is a bit slow when building your first few circuits boards. Initially, a slight lack of confidence tends to lead to much checking and rechecking. Being realistic about things, a few errors are likely to creep in when you first undertake any new task. Large amounts of checking and rechecking increase your chances of success, whereas proceeding in a rush practically guarantees failure when undertaking any task. It is certainly not the right way to go about electronic project construction. It is probably best to forget the old ethos of 'he who hesitates is lost'.

Experienced project constructors have a huge advantage over beginners in that they know what is likely to go wrong when working on a circuit board. It is a case of 'forewarned is forearmed'. Many errors are detected and corrected while board population is being built up. Beginners are more likely to make errors, but are less well equipped to spot them. Whether you are an experienced constructor or a complete beginner, you have to be on a constant lookout for problems.

What errors should you look for while constructing circuit boards? Designers of electronic equipment have been preoccupied with miniaturisation since the early days of semiconductors. Hence printed circuit boards tend to be small and have masses of tightly packed copper tracks and pads. In the case of stripboard, all the tracks run very close to at least one other track for their full lengths.

When soldering components onto a circuit board you must try to orient the iron to avoid short circuits caused by excess solder flowing between the copper tracks and pads. Being careful not to feed an obviously excessive amount of solder into a joint will help in this respect. It is important to use an iron having a suitably narrow bit. One having a diameter of about 2.5mm is suitable.

No matter how skilfully and carefully you proceed, it is probably best to regard the occasional short circuit as inevitable. This is not to say that it is inevitable that the finished printed circuit board will have errors and will not work. Most solder blobs and trails will be spotted immediately provided you look carefully at what you are doing, and inspect each joint once it is completed.

When a short circuit does occur, the excess solder can be removed with the aid of even the simplest of desoldering equipment. In most cases it can be wiped away using the bit of the soldering iron. The tip of the bit should then be cleaned using a moist sponge or bit cleaning block.

Brush-Up and Clean

The copper side of the completed circuit board will probably be contaminated with half–burned flux. This can hide small solder trails so it is a good idea to clean the underside of the board by brushing it vigorously with an old toothbrush. Using some form of magnifier greatly increases your chances of locating any short circuits.

At one time it was quite normal for there to be problems with so-called 'dry' joints. These are produced when the solder fails to flow over the lead and pad correctly. This can be due to dirt or corrosion on one of the surfaces, or inadequate flux in the solder. With improvements in components and solders this type of thing is relatively rare these days. If there is an obvious problem with contamination on one of the surfaces, scrape it away with the small blade of a penknife before trying to make the joint.

A 'dry' joint is usually easy to spot because it tends to be something other than the usual mountain shape, and the solder generally has a dull finish instead of the usual shiny type. When a joint appears to be at all iffy, remove all the solder, clean the two surfaces, and try again. Always check that you have not made the alternative form of 'dry' joint. This is the type where you use too little solder to produce a proper joint, or you simply forget to do one of the connections!

Gaping Error

A common mistake made by beginners is to leave a gap between the body of the component and the circuit board. It is very important to ensure that the components are fitted right up against the board, as in Fig.1(a). If they are spaced off the board or fitted at an angle, as in Figs.1(b) and (c) respectively, any pressure on the component tends to tear the copper pads away from the underside of the board.

Due to the very small pads used on most modern circuit boards, they are very vulnerable to this kind of damage. Leaving a gap is likely to give poor reliability in the long term, but that might be irrelevant. Handling the board during construction could easily result in damage occurring before you even get it finished.

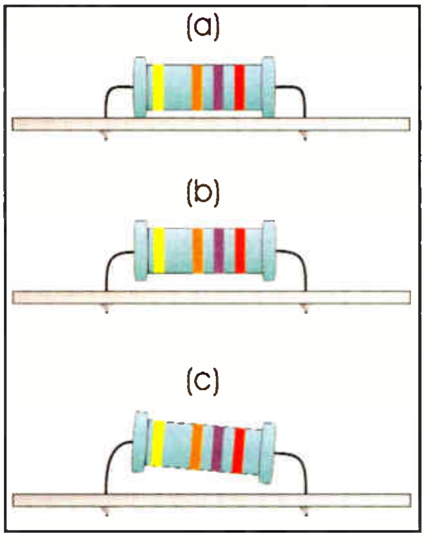

Fig.1. Components should be mounted right against the board, as in (a), and not with a gap as in (b) and (c). Leaving a gap risks damage to the copper pads and tracks on the underside of the board. The only time you would intentionally mount a resistor slightly proud of the board is if you are using a high power/wattage type. As the resistor is likely to run 'warm', a small air-gap below it will help cooling.

A gap is most likely to give problems with radial electrolytic capacitors and inductors. Vertical mounting components tend to get knocked slightly before too long. The result is that they end up keeled over sideways unless they are mounted flush with the board. This merely looks a bit untidy when looking at the component side of the board, but inspecting the copper side of the board is likely to reveal some damage to the pads and tracks.

Fall-Out

Another potential cause of problems is where components are flush with the board when the leadout wires are trimmed, but they are allowed to fall slightly out of place before being soldered into place. This leaves the components vulnerable to the trouble mentioned previously, but there is another potential problem. It is possible that the leadout wires will fail to reach the soldered joints properly. Everything might appear to be fine, but the joints will be

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physically weak. There is a likelihood of a few leadout wires becoming detached from the board before too long.

This problem is fairly easy to spot. Apart from the fact that the affected components will not be flush with the board, things will not look right on the copper side of the board either. The soldered joints will be noticeably flatter than normal, with no hint of any leadout wires. This can be seen in the middle joint of Fig.2. The fact that the joint is offset to one side also suggests that all is not well.

Another cause of this problem is the leadout wires simply being cut too short. Leaving about three millimetres or so of wire protruding through the board is sufficient to provide strong soldered joints. Anything less tends to give poor joints, while much longer lengths run the risk of wires getting bent sideways and producing short circuits.

A similar problem can occur with some integrated circuit holders when they are used with thick circuit boards. The relatively short pins of some holders barely protrude on the underside of thick circuit boards, making it difficult to produce good soldered joints. The only solution to this problem is to not use this type of holder on thick circuit boards.

There can also be problems with integrated circuit holders that have long and rather flimsy pins. It is necessary to take due care when fitting these onto the board, because it is easy to get a pin buckled under the holder rather than fitted into its hole in the board. This problem is not obvious from the component side of the board, since the pin is hidden away out of sight under the holder. Provided you are paying proper attention, the missing pin should be pretty obvious when making the connections on the copper side of the board.

In The Frame

Soldering components onto a circuit board is one of those tasks that is no problem at all provided you have three hands! One hand is needed to hold the soldering iron, the other hand to feed in the solder, and an extra hand to hold the board and components in position. Most constructors soon develop their own ways around this problem.

A popular solution is to use something like a large chunk of 'Plasticine' or Bostik 'Blu Tack' to hold a few components in place, and to temporarily stick the board to the workbench with the copper side uppermost. This keeps the board and components firmly in place, and leaves both hands free to deal with the solder and the iron.

There is a more up-market method, which is to use a printed circuit construction frame. These frames differ in points of detail, but they all have a large piece of soft foam material in the base section. There is an adjustable frame into which the board is clipped or clamped. The components are fitted on the board, which is then mounted with the copper side facing upwards. This results in the component side being pressed down into the piece of foam, which presses them firmly against the board.

Fig.2. The middle joint in the front row is typical of one where the leadout wire has been cut too short, or is otherwise not protruding far enough through the board. The joint in the background on the left looks suspiciously like a 'dry' joint.

In theory it is possible to fit all the components and then solder them into place. In practice this is only possible if all the components are quite small. When there is a mixture of small and large components there is a tendency for the large components to hold the foam away from the smaller ones. This results in some of the smaller components falling out of place. The way around this is to deal with the small components first, and then progress to the larger ones that protrude further above the board.

One slight problem with a printed circuit frame is the fairly high cost. It is probably not something that you are going to buy in order to make your first project. On the other hand, if you build projects on a regular basis one of the lower cost printed circuit frames is something you are probably going to need.

Although the slow and hesitant approach is not a problem with most aspects of construction, it is not one that should be used when making the soldered connections. It is important to learn the art of making quick and effective soldered joints. There is an excellent soldering tutorial on the *EPE* web site.

It is a good idea to practice with a piece of stripboard and some cheap components such as resistors before starting on your first project. You are completing the joints too slowly if the components become at all discoloured or show any signs of damage.

Right Component

Identifying the components and getting everything in the right place tends to be problematic for beginners. It is not possible to cover this subject in the space available here, but it is something that has been dealt with in many previous articles in this series. Do not be tempted to resort to guesswork, and do not fit anything on to a circuit board until you are sure of its correct position. With components that have to be fitted the 'right way round', such as electrolytic capacitors and diodes, do not fit them unless you definitely know the right orientation.

The printed circuit overlay usually provides a good physical representation of each component, and the accompanying photographs can also be very helpful. The Internet contains a mine of information on electronic components in general, and semiconductors in particular. It is possible to obtain the data sheet for practically any semiconductor component by entering its type number and 'data sheet' into a good search engine. Remember that the convention is for transistor leadout diagrams to be base views, while the pinout diagrams for integrated circuits are top views.

Finally

When building circuit boards, always work to the highest standards you can achieve. Produce finished boards that look as neat and tidy as possible. This is not just a matter of trying to impress your friends by making boards that 'look pretty'. In general, if a board has been built carefully and looks immaculate it will work well. Furthermore, it will probably go on functioning efficiently for many years.

A circuit board that looks a complete mess is likely to contain errors, and it will probably be difficult to get the board working at all. Even if the board is made to work, it could well be problematic thereafter.

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C for PICs

A four part beginners guide to using the C programming language for PIC microcontrollers

Part 1 – Introduction, overview and getting started

By Mike Hibbett

WHEN Microchip first introduced the PIC range of microcontrollers in the early 1990s, they came with limited code and data space, which meant assembly language programming was the only option for producing programs. The devices were simple and targeted at engineers implementing peripheral interface controllers – hence the name, PIC – and so this limitation was not a problem. Engineers became adept at assembly language programming, so as the devices and the roles they were used in became more complex, engineers quickly adapted and stayed with assembly.

As PICs became more widely available to the hobbyist market, the need for easier to use higher level languages arose. That need was initially met by third party vendors who supplied devices preprogrammed with BASIC interpreters. BASIC, although a lot simpler to learn and use, is significantly slower than assembly due to the way in which user code is interpreted rather than executed directly. BASIC filled one market segment but a more powerful solution was still required. With time, as PICs grew in code and data space, high level language compilers for several languages started to become available.

High Level Languages

High level languages that can be used on microcontrollers require a compiler program to convert the language written by the user into the low level assembly code used by the device itself. Compilers are available for many languages including BASIC; in this tutorial series we will explore the C programming language in the context of PICs.

So why not BASIC? It is after all a very popular easy to use language and a BASIC compiler would remove concerns over how fast a BASIC program executes. There are many reasons; but most importantly it is difficult to write large programs in BASIC, and the compilation process is not very efficient when translating down into assembly.

There is also an enormous collection of high quality C software freely available on the Internet that can be used with only minimal changes in a microcontroller application. Microchip themselves provide a large library of C source code, which can be used 'out of the box'. The library includes some very complex code such as USB driver and TCP/IP stacks – software that would be incredibly difficult to write in assembly.

Free C Compilers

Free C compilers are available from several vendors, such as PICC-Lite from HiTech and C18 from Microchip. There is also the completely free SDCC compiler which can be downloaded from the Internet. SDCC's support for the PIC is still 'work in progress' however. The free versions of commercial compilers typically run in a restricted mode; placing a limit on code size is the norm. Microchip simply disable some of the more advanced optimisations that are performed during the translation to assembly, resulting in slightly larger code sizes.

We will be covering the free compiler from Microchip, C18. It integrates very well into the MPLAB IDE program to provide an excellent development environment: editor, compiler and debugger. Microchip's C software library is, of course, written with their own compiler in mind which will make using their code straight forward, as we will see later in the series.

What is C?

So what is 'C' exactly? The C programming language was devised in 1969 by a team of engineers at Bell Labs in the USA, led by an engineer named Ken Thompson. Derived from an earlier language BCPL, it was intended to be the systems programming language for the newly created Unix operating system.

It was formally described in the book *The C Programming Language* first published in 1973, and over thirty years later that book still serves as the definitive reference to the language. The language was updated to reflect formal standardisation by ANSI during the mid 1980's, and a second edition of the book released to reflect that. The second edition of the book remains the current version today. It makes for a rather terse read but is a 'must have' if you intended to program in C.

The C programming language is itself quite simple and there are only a few concepts that need to be mastered to understand it. Some people (the author included) consider C not to be a high level language at all, but instead view it as an 'improved' assembler, and thus if you are familiar with assembly you will pick up C relatively easily.

Understanding C

Understanding how to use C in an embedded environment, however, can be very difficult to grasp, so we shall concentrate on setting up and using C in an embedded environment during these tutorials. If you are new to C itself then get a copy of *The C Programming Language* book, and find another book that teaches the C language, such as *C*

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for Dummies Volumes I and II. There are many other books on learning to program in C, though, so visit a good bookshop before deciding.

Looking ahead, this tutorial will be split into four consecutive articles. This one presents an overview of embedded programming in C, installation of the compiler software and a quick test program to check that everything is working. Next month we discuss how C programs are structured, what goes on during a 'build' and what files are created.

Following that we go into the problems that are unique to embedded programming, covering the normal 'gotchas' that trip up even the seasoned programmer. In the final installment we will develop a simple but useful PIC application to demonstrate why it is worth all the effort. Distanced from the complexities of assembly language nuances we hope you will discover how programming in C can be fun and highly productive.

Assembly Program Writing

Before we dive into the C programming environment, let's review how software is written in assembly.

Programs are entered into a text file using any text editor, often into a single file for small programs. For larger programs you might place code in additional text files that are *included* into the main file by an **#include filename** line (called a *directive*). Assembly language files are typically given the file extension of .ASM (upper or lower case), although that is not mandatory. These files are called *source files*.

Usually a single program is responsible for converting the source files into a format suitable for loading into the chip. They effectively perform two steps in one: convert your text into the actual binary data required by the processor, then translate that into a standard format recognised by the programming software that we use to actually move the program into the processor. This final format, typically a text file itself, is normally given a file extension of .HEX.

After each step a new file is generated, and these files will remain in your project directory once the process has completed.

Other Files

Most assembler programs will create other files too. These can include the raw binary representation of your program, called the *object code*, and a *listing* output that contains your original source code annotated with the actual processor instructions created.

Assembly language programs are almost always created in 'Absolute' format. This means that the assembler knows where in the processor memory space you want the program to be loaded, as indicated by an **ORG 0** directive that appears at the beginning of the source file.

Integrated development environments (IDEs) such as TK3 or MPLAB are programs that help you automate some of these steps by providing an editor, assembler, simulator, debugger and programmer in one program. They essentially perform exactly the same steps that you would do manually.

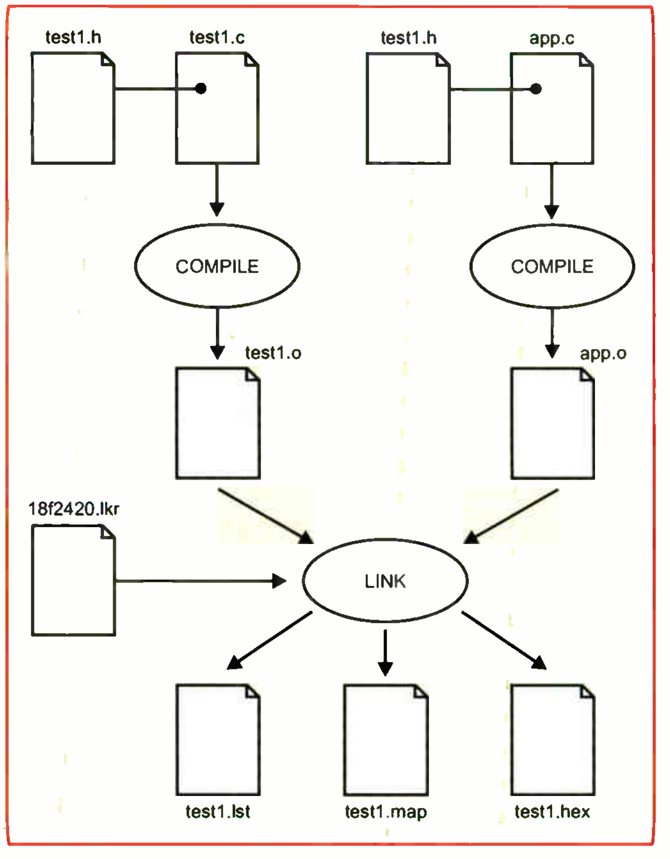

Fig.1. The steps in producing a C program

Assembly language programming is a straightforward process and relatively easy to pick up, enabling you to concentrate on the content of your program and not be concerned about the development process that surrounds it.

C Program Writing

Programming in C is a little more complicated, and programming in C for an embedded system, more so. Once you understand the principles, however, you can ignore them and let the development tools do the work for you. You will quickly find yourself once again concentrating on writing the program and letting the tools do the rest. Fig.1 shows the steps involved in a typical build, or compile, converting C source files into a .HEX file.

During a compile, the compiler reads and translates (compiles) each C source file individually. The compiler has no implicit knowledge of information held in other C files. If there is a call to a function, say **getData();** in file **main.c**, if that function was not defined in **main.c** then the compiler will display an error message and stop.

To use that function you must add an **extern** declaration in **main.c**. This is an instruction to the compiler to say 'the code for that function is somewhere else; just put a placeholder in the object file, the linker will sort it out'. These **extern** declarations are normally held in a header file (with a **.h** extension) and included in the C source file with an **#include** statement. **#include <stdio.h>** is an example of this.

Once all of the files have been compiled, the linker gets called to fix up all those missing **extern** references and to decide where to put the code, then spit out a single .HEX file.

Definitions

Now we have described the process, let's define some of the terms we have just used. These terms appear frequently so it is important to know what each one means.

Source file: A text file that contains high level or assembly language

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instructions. Typically, the file that you edit.

Header file: When you want to use the functions defined in one file in another, you must declare those functions before their use using an **extern** statement. This is typically done by placing all the **extern** statements in a header file, which has a **.h** extension to its name.

Makefile, workspace: A file that contains a list of commands required to be executed to translate your source files into a program. It typically contains a list of those files, and the options to give the compiler and linker when they are run. There is normally one **makefile** per project.

Compiler: A program that translates a higher level language (in our case C) into assembly code.

Assembler: A program that translates assembly code into object code, the raw binary instructions used by the microcontroller. It may also create a text format file that can be read by programming hardware.

Linker: A program that collects several object code files and adds the 'links' so that calls to routines in different files match up. It also generates the text format output file that can be read by programming hardware.

Librarian: A program that can collate many object code files into a single file, called a **.lib** file. This can be useful if you want to create re-usable utility modules and store them in a single file. The use of the **librarian** is optional and we will not cover it in this tutorial series.

Compile: The act of running the compiler on a source file.

Build, Make: Generic terms which refer to the act of running the compiler, assembler and linker on a collection of one or more source files to create a program file.

Using a good IDE will hide all of these steps from you, but remember they are still happening in the background when you compile your code.

Installation

Before installing the software, we must download it. The IDE and C compiler come as two separate downloads; the IDE is 37MB and the compiler 23MB. If you don't have a high speed internet connection then we suggest you find a friend who has, and ask them to download the two files for you.

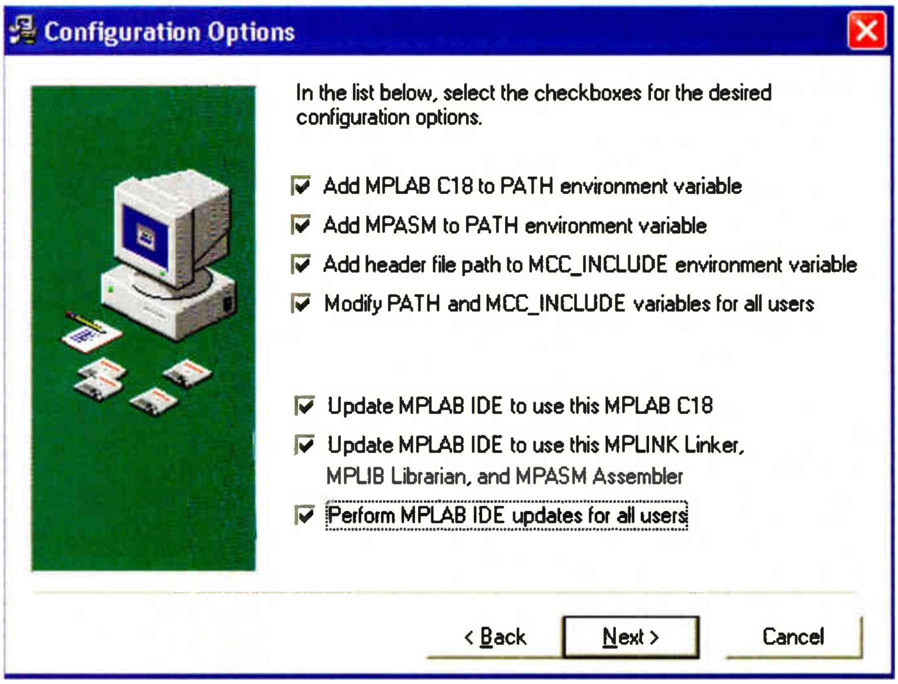

Fig.2. Configuration options for the Microchip C Compiler

Go to the Microchip website, and on the main site under the heading 'Design' click on the 'MPLAB IDE' link. Download MPLAB IDE – 'MPLAB IDE v7.41 Full Zipped Installation' from the bottom of the page under 'Software Downloads'. Save it to your hard drive.

Back on the main page go to 'Development Tools' and then MPLAB C18 compiler. At the bottom click on 'MPLAB C18 v3.02 Student Edition with docs'. If you haven't done so already, you will be asked to register with the website before being allowed to download the file. This is a free registration process requiring you to enter your name and address.

Once you have done this, you will be returned to the download page. Click on the link 'MPLAB C18 v3.02 Student Edition with docs' again and save this file to your harddrive.

Once both have downloaded, double-click on the file **MP741.zip** and extract the files into a temporary folder on your desktop. In that directory, double-click on **MP741_setup.exe** to start the installation. Accept the defaults, answer 'I agree' to the usual license statement and the installation will start. When the **MPLAB IDE Document Select** dialog appears, close it. Once the installation completes, you can then start installation of the C compiler.

Double-click on the **MPLAB-C18-Student-Edition.exe** file that you downloaded earlier. Agree to the license, and accept all other defaults except at the **Installation** options screen (see Fig.2). Enable all the options as shown. Click **Next** and continue accepting the defaults to complete the installation. When it finishes, you can delete the temporary directory you created earlier. We recommend keeping the original downloaded installation files in case you need to reinstall them at a later date.

Well done! You now have an integrated editor, debugger, simulator and C compiler system installed. That was the easy bit; now, how do we use it?

Getting Started

As part of the installation, a desktop icon will have been created which can be used to start the IDE. Before you do, it's worth taking a look at some of the documentation for the IDE and compiler.

Documentation for the IDE can be found on the Microchip website at the bottom of the page where you downloaded the install file. The Users Guide and Quick Start Guide should be downloaded, and read at your leisure. Documentation for the C compiler will have been installed on your computer in the default documentation directory, **C:\MCC18\Doc**. The Getting-Started, Libraries and Users Guide are all invaluable and you will certainly be referring to at least the last two while you become more proficient with the compiler.

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Let's wrap up this introduction with our first simple C program. It's a very simple example that just toggles the PORTB outputs on and off. It looks like that in Listing 1.

The first line, **#include <p18f2420.h>**, instructs the compiler to load a file from the C compiler's standard header file directory **C:\MCC18\h**. This file contains some useful variable names for the standard features of the chip we will be using. In this example, we are using the variables TRISB and PORTB. The second line, **#pragma config WDT = OFF**, ensures that the watchdog option will be disabled in the configuration bits. The rest of the code simply sets Port B as an output, then enters an infinite loop turning the port outputs off, delaying for a short time, then back on.

Listing 1

```
#include <p18f2420.h>
#pragma config WDT = OFF
void main(void)
{
    int lp;
    TRISB = 0x00;
    while ( 1 ) {
        PORTB = 0x00;
        for (lp=0; lp < 10000; lp++) {
        }
        PORTB = 0xFF;
        for (lp=0; lp < 10000; lp++) {
        }
    }
}
```

Unlike assembly language programs, there is no need to specify a start address. All C programs start automatically at the **main()** function. We will explain more about how this occurs later in the tutorial.

Start the MPLAB IDE by double-clicking on the desktop icon. From the menu bar select **Project**, then **Project Wizard**. In the dialog box that appears click **Next**. You are now prompted to enter a processor for this project. Choose **PIC18F2420**, then click **Next**. You are now prompted to select the language toolset; this should default to Microchip C18 Toolsuite, so just click **Next**.

Now enter a name for this project enter 'test1' and select a directory where you would like the project files to go. Let's put it on the desktop, so click on **Browse**, then click once on **Desktop**. Click on the **Make New Folder** icon and then type 'test1' and click on **OK**. Now click on **Next**. You are now prompted to select any existing files that you want to add to the project. We haven't created any yet, so just click **Next**, then **Finish**.

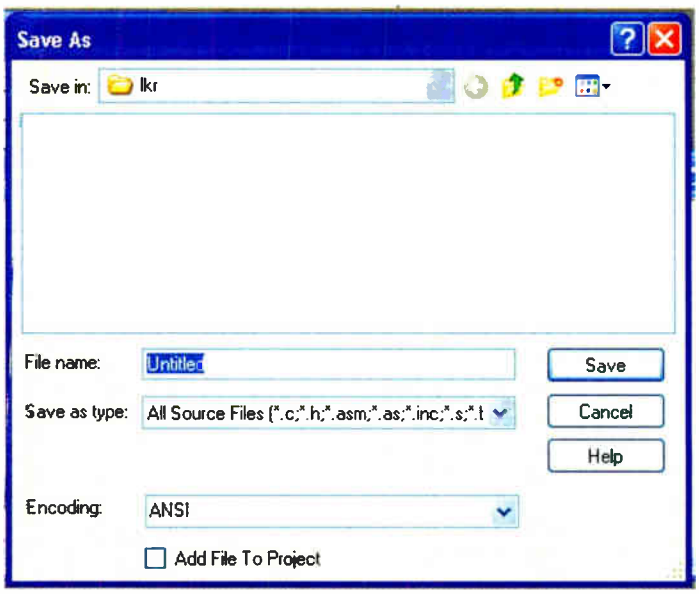

Fig.4. File saving panel

Source Creation

We have just created an empty project, and the IDE should display something like Fig.3. The dialog labelled **test1.mcw** is a 'control panel' that lists all your files that make up the project. We can use this dialog to add new files to the project. Let's start by creating our source file.

From the main menu bar click on **File** and then **New**. A new, empty text editor window appears, labelled 'Untitled'. Type program Listing 1 into this window. When you have finished, select **File** from the main menu bar and then **Save**. A dialog similar to Fig.4 will appear. Type in the file name as 'test1.c'. We need to save it in our project directory, so click the **Save in:** drop down list box and navigate to the **test1** directory you created earlier. Click on the **Add File To Project** check box, then click on **Save**. You will see the filename appear in the **test1.mcw** window, confirming it has been added to the project.

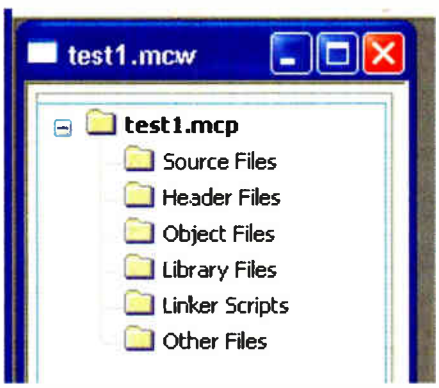

Fig.3. IDE File source panel section

There is one final step now, before we can build the project. We must add a 'linker file' to the project. This file will tell the linker program where the various memory sections should reside inside the microcontroller.

Since each PIC has different code and memory sizes, there is naturally a different configuration per processor. Fortunately, Microchip have defined default linker files for each processor so we just have to select the appropriate one and add it to our project.

In the MPLAB IDE main window, select the **test1.mcw** window, position the mouse over the 'Linker Scripts' icon and right-click. From the pop-up window select **Add Files...**. In the **Add files to Project** dialog that appears, browse to the directory **C:\MCC18\lkr** and double-click on the file **18f2420.lkr**. The filename should now appear in the **test1.mcw** window under 'Linker Scripts'.

Compilation

That's it! You are now ready to compile your first program. From the main menu bar of the IDE select **Project** and then **Build All**. A new window labelled **Output** appears, which displays the progress of the various programs involved in creating your program. The final line of text written to this window should say **BUILD SUCCEEDED**.

If all went well, you can close the Output window – it is only a temporary

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message display. If the build failed, for example if you made a typing mistake, you can scroll back through the window to locate the source of the error message. Doubling-clicking on the line with the error message will take you straight to the offending line in your source file.

The program **.hex** file will appear in the **test1** directory, along with a number of other useful files. You can program this **.hex** file into a chip and try it out, but we can also run it immediately in the IDE's built-in simulator. Let's give that a go now. You are only a few mouse clicks away.

From the IDE main menu bar, click on Debugger, then **Select Tool**. Click on **MPLAB SIM**. From the main menu bar click on **Debugger** again, then **Run**.

A new source file will open up, **c018i.c**, on the line

_asm goto _startup _endasm

This is the true start point of your program; it runs before your **main()** routine to set up the C language environment (more on that later). Click **Run** again from the Debugger menu. At the bottom of the IDE window you will see the word '**Running..**'. Select **Halt** from the Debugger menu and the program will stop running, with the cursor positioned at the next C language instruction to run. You can single step (run one line of code at a time), animate it (watch the code running, at a slow speed) or select **Run** to return to high speed execution.

If you are curious about the translation of your code from C to assembly, look in the file **test1.lst**. This contains the C code annotated with the assembly language generated. You can see all the code that runs before your **main()** function, and also see how each line of code is translated. You may be surprised by how much code is actually generated. Again, we will explain this later, and how you can optimise your programs.

Onwards

This has been a short whistle-stop tour through the build process; we will expand on the details in later tutorial articles. If you would like to experiment more before next month, then feel free to run through some of the examples in the 'Getting started' guide in the **C:\MCC18\doc** directory.

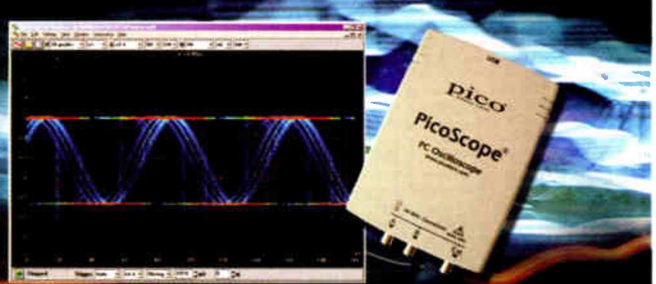
Next month we look in more detail at how the project files are organised, and what goes on during the build process. Until then, have fun!

Resources

www.microchip.com – Microchip website

PicoScope 3000 Series PC Oscilloscopes

The PicoScope 3000 series oscilloscopes are the latest offerings from the market leader in PC oscilloscopes combining high bandwidths with large buffer memories. Using the latest advances in electronics, the oscilloscopes connect to the USB port of any modern PC, making full use of the PCs' processing capabilities, large screens and familiar graphical user interfaces.



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- High speed USB 2.0 interface
- Advanced display & trigger modes
- Compact & portable
- Supplied with PicoScope & PicoLog software

PicoScope	3204	3205	3206
Bandwidth	50MHz	100MHz	200MHz
Sampling rate (repetitive)	2.5GS/s	5GS/s	10GS/s
Sampling rate (single shot)	50MS/s	100MS/s	200MS/s
Channels	2+Ext trigger	2+Ext trigger/Sig gen	2+Ext trigger/Sig gen
Oscilloscope timebases	5ns/div to 50s/div	2ns/div to 50s/div	1ns/div to 50s/div
Timebase accuracy	50ppm	50ppm	50ppm
Spectrum ranges	0 to 25MHz	0 to 50MHz	0 to 100MHz
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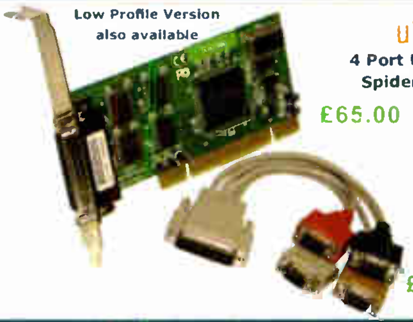

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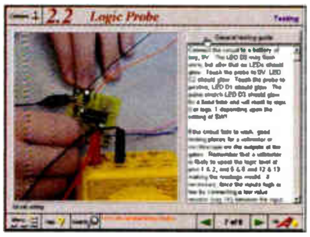
ELECTRONICS CD-ROMS

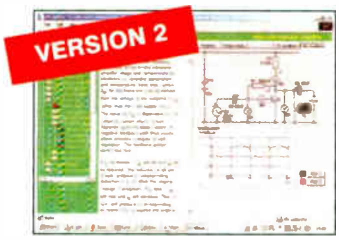
ELECTRONICS PROJECTS



Logic Probe testing

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

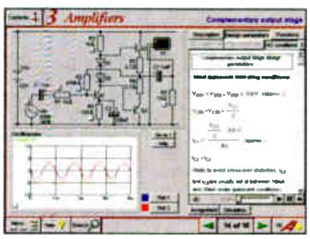
ELECTRONIC CIRCUITS & COMPONENTS V2.0



Circuit simulation screen

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

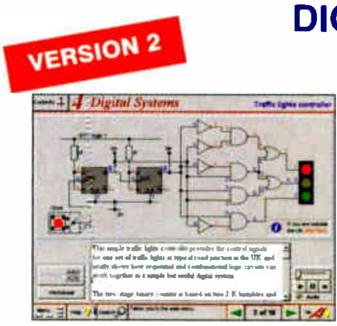
ANALOGUE ELECTRONICS



Complimentary output stage

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

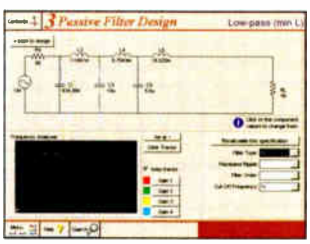
DIGITAL ELECTRONICS V2.0



Virtual laboratory – Traffic Lights

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

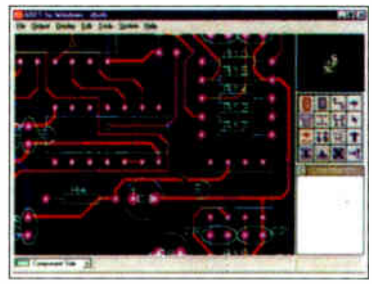
ANALOGUE FILTERS



Filter synthesis

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

ELECTRONICS CAD PACK



PCB Layout

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

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

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

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

PRICES

Prices for each of the CD-ROMs above are:

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Hobbyist/Student	**£45 inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99 *plus* VAT**
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PICmicro TUTORIALS AND PROGRAMMING

HARDWARE

VERSION 3 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

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

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

£158 including VAT and postage

supplied with USB cable and programming software

SOFTWARE

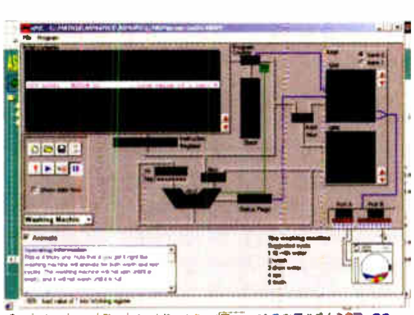
Suitable for use with the Development Board shown above.

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.

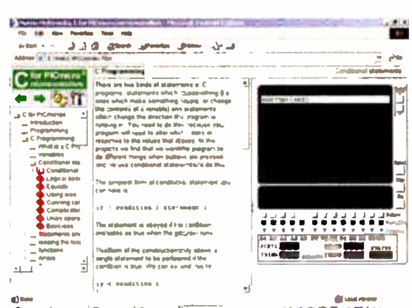


'C' FOR PICmicro VERSION 2

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

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

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



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

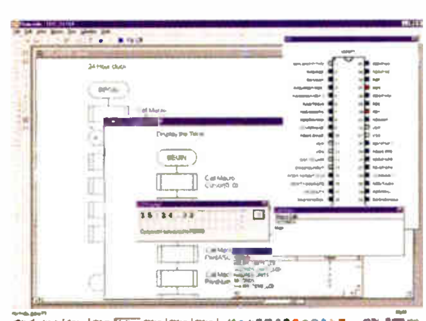
FLOWCODE FOR PICmicro V2

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

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

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

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



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

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

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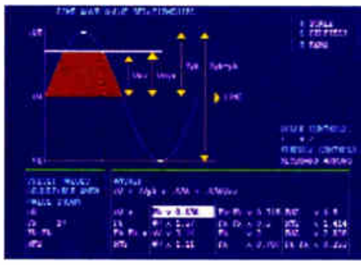
TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In 2000* series by John Becker in PDF form plus the *Teach-In* interactive software (Win 95, 98, ME and above) covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering*. The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue.



Sine wave relationship values

FREE TWO BOOKLETS PLUS CD-ROM WITH TEACH-IN 2000

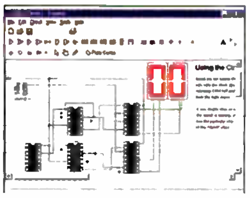
Each part has an associated practical section and the series includes a simple PC interface (Win 95, 98, ME **ONLY**) so you can use your PC as a basic oscilloscope with the various circuits.

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

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

FREE WITH EACH TEACH-IN CD-ROM – *Understanding Active Components* booklet, *Indentifying Electronic Components* booklet and *The Best Of Circuit Surgery* CDROM.

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.

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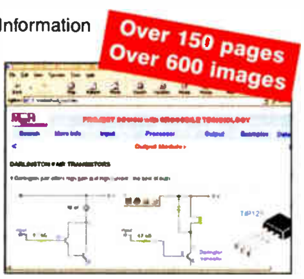

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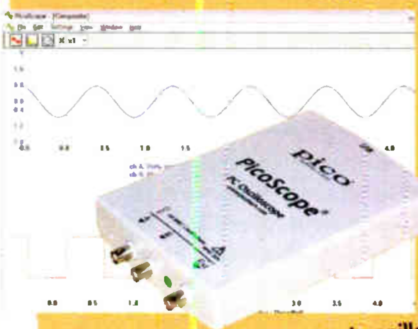

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Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas.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

Disco Light – *Illumination for a few coppers*

THE circuit of Fig.1 might be described as a 'Poor Man's Disco Light'. Arguably it is the simplest such circuit that could be conceived. It conveniently attaches directly to the loudspeaker cables of one's power amplifier – provided that the output is above about two watts RMS, which is required for it to 'fire up' (if desired, the sensitivity of the circuit may be greatly increased with a simple preamplifier stage with a gain of about five, as covered in the *Teach-In 2006* series).

Circuit Details

IC1 is a voltage controlled oscillator (VCO), which is controlled by the voltage at its CTRL pin 9, tapped from a loudspeaker of one's power amplifier (points A and B in the circuit diagram). Alternatively, the input may be tapped from the two positive leads of stereo loudspeakers for a more interesting effect. IC1 is surely the simplest and most versatile VCO available. Strictly speaking, it is a phase-locked loop, of which only the oscillator section is put to use.

The frequency of switching is determined by the value of resistor R1. If desired, a high value resistor may be wired from IC1 pin 12 to 0V, to raise the minimum speed of switching (as shown, bulb LP1 does not switch at all when the circuit is quiescent).

As the voltage at CTRL pin 9 rises, so O/P (output) pin 4 begins to switch on and off. Resistor R2 is not strictly necessary, but serves to protect the circuit (and perhaps the amplifier) should TR1 fail. The greater the overall amplitude and 'density' of the music, the faster the O/P will switch, thus potentiometer VR1 is provided to adjust the input amplitude to provide an agreeable result.

Almost any *n*-channel power MOSFET may be used for TR1. The power MOSFET shown (an IRF610) can handle up to 36W. A heatsink would be required if it should be pushed past about 15W.

The result is a unique disco effect that is a function of the amplitude of the music and the beat combined. Perhaps the best way to describe it is that it captures the 'ambience' of the music.

Thomas Scarborough, Cape Town, South Africa

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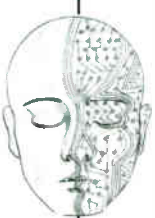

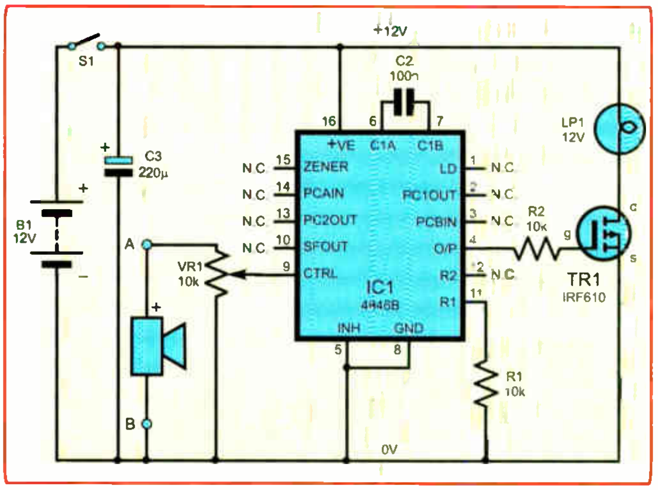

Fig.1 Complete circuit diagram for the 'poor man's' Disco Light

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Improved Model!

Requires 9VDC wall adaptor (Maplin #GS74R £9.99)

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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 new 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, all electronic components and clear English instructions. Suitable for 6, 12 and 24V batteries
- Powered by the battery itself

Improved Model!

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Theremin Synthesiser MKII

KC-5426 £43.50 + post & packing

By moving your hand between the metal antennae, create unusual sound effects! The Theremin MkII improves on its predecessor by allowing adjustments to the tonal quality by providing a better waveform. With a multitude of controls, this instrument's musical potential is only limited by the skill and imagination of its player. Kit includes stand, PCB with overlay, machined case with silkscreen printed lid, loudspeaker, pitch antennae, all specified electronic components and clear English instructions.

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Improved Model!

As used in the Beach Boys classic hit 'Good Vibrations'

NEW FOR '06

Galactic Voice Kit

NEW FOR '06

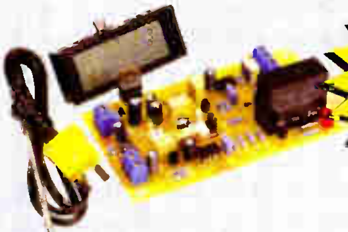
KC-5431 £13.25 + post & packing

Be the envy of everyone at the next Interplanetary Conference for Evil Beings with this galactic voice simulator kit. Effect and depth controls allow you to vary the effect to simulate everything from the metallically-challenged C-3PO, to the hysterical ranting of Daleks hell-bent on exterminating anything not nailed down. The kit includes PCB with overlay, enclosure, speaker and all components. For those who really need to get out of the house a lot more. Take me to your leader.
- Requires 9V battery

High Range Adjustable Switch with LCD

KC-5376 £22.75 + post & packing

This temperature switch can be set anywhere up to 1200°C, so it's extremely versatile. The relay can be used to trigger an extra thermo fan on an intercooler, mount a sensor near your turbo manifold and trigger water spray cooling, or a simple alarm to warn you of overheating. The LCD, which can easily be dash mounted, displays the temperature constantly. Kit supplied with solder masked PCB with overlay, LCD panel, temperature probe and all electronic components.



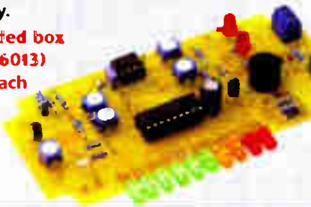
We stock an extensive range of quality automotive kits

Smart Fuel Mixture Display Kit

KC-5374 £8.95 + post & packing

This kit features auto dimming for night driving, emergency lean-out alarm, better circuit protection, and a 'dancing' display which functions when the ECU is operating in closed loop. Kit supplied with PCB and all electronic components.
- Car must be fitted with air flow and EGO sensors (standard on all EFI systems) for full functionality.

Recommended box UB3 (HB-6013) £1.40 each



Magnetic Cartridge Pre-amp

KC-5433 £11.75 + post & packing

This kit is used to amplify the 3-4mV signals from a phono cartridge to line level, so you can use your turntable with the CD or tuner inputs on your Hi-Fi amplifier - most modern amps don't include a phono input any more. Dust off the old LP collection or use it to record your LPs on to CD. The design is suitable for 12" LPs, and also allows for RIAA equalisation of all the really old 78s. Please note that the input sensitivity of this design means it's only suitable for moving-magnet, not moving-coil cartridges. Kit includes PCB with overlay and all electronic components.

NEW FOR '06

Requires 12VAC wall adaptor (Maplin #GU10L £9.99)

Universal High Energy Ignition Kit

KC-5419 £27.75 + post & packing

A high energy 0.9ms spark burns fuel faster and more efficiently to give you more power! This versatile kit can be connected to conventional points, twin points or reluctor ignition systems. Kit supplied with diecast case, PCB and all electronic components.

NEW FOR '06

Intelligent Turbo Timer Kit

KC-5383 £14.75 + post & packing

This great module uses input from an airflow, oxygen, or MAP sensor to determine how hard the car has been driven. It then uses this information to calculate how long the car needs to idle, reducing unnecessary idle time. The sensitivity and maximum idle time are both adjustable, so you can be sure your turbo will cool properly. Kit supplied with PCB, and all electronic components.

Recommended box UB3 (HB-6013) £1.40 each

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EPE had been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are brilliantly designed, '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.

Delta Throttle Timer

KC-5373 £7.95 + post & packing

It will trigger a relay when the throttle is depressed or lifted quickly. There is a long list of uses for this kit, such as automatic transmission switching of economy to power modes, triggering electronic blow-off valves on quick throttle lifts and much more. It is completely adjustable, and uses the output of a standard throttle position sensor. Kit supplied with PCB and all electronic components.

As published in this month's Everyday Practical Electronics Magazine

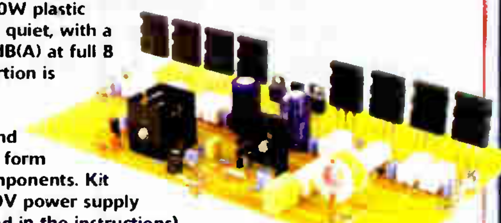
Recommended box UB3 H3-6013 £1.05

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 Everyday Practical Electronics October 2006



Smart Card Reader and Programmer Kit

KC-5361 £15.95 + post & packing

Program both the microcontroller and EEPROM in the popular gold, silver and emerald wafer cards. Card used needs to conform to ISO-7816 standards, which includes ones sold by Jaycar. Powered by 9-12 VDC wall adaptor or a 9V battery. Instructions outline software requirements that are freely available on the internet. Kit supplied with PCB, wafer card socket and all electronic components. PCB measures: 141 x 101mm.

- As published in Everyday Practical Electronics May 2006

Requires 9-12VDC wall adaptor (Maplin #JC91Y £14.99)

Jaycar cannot accept responsibility for the operation of this device, its related software, or its potential to be used in relation to illegal copying of smart cards in cable TV set top boxes.

2 Amp DC-DC Converter Kit

KC-5358 £13.75 + post & packing

This kit will step-up 12V to between 13.8 and 24VDC. Use it to charge 12V sealed lead acid batteries (6.5Ah or larger), run your laptop and many other devices from a 12V supply. It uses an efficient switchmode design, features fuse and reverse polarity protection, and an LED power indicator. Kit includes PCB, all electronic components, and silkscreened front panel.

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50MHz Frequency Meter Kit

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This meter is autoranging and displays the frequency in either hertz, kilohertz or megahertz. Features compact size (130 x 67 x 44mm), 8 digit LCD, high and low resolution modes, 0.1Hz resolution up to 150Hz, 1Hz resolution maximum up to 150Hz and 10Hz resolution above 16MHz. Kit includes PCB, case with machined and silkscreened lid, pre-programmed PIC and all electronic components with clear English instructions.

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Requires 9VDC wall adaptor (Maplin #GS74R £9.99).

AC/DC Current Clamp Meter Kit for DMMs

KC-5368 £8.75 + post & packing

A great low cost alternative. It uses a simple hall effect sensor, an iron ring core and connects to your digital multimeter. It will measure AC and DC current and has a calibration dial to allow for any magnetising of the core. Kit supplied with PCB, clamp, case with silkscreened front panel and all electronic components.

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Audio Video Booster Kit

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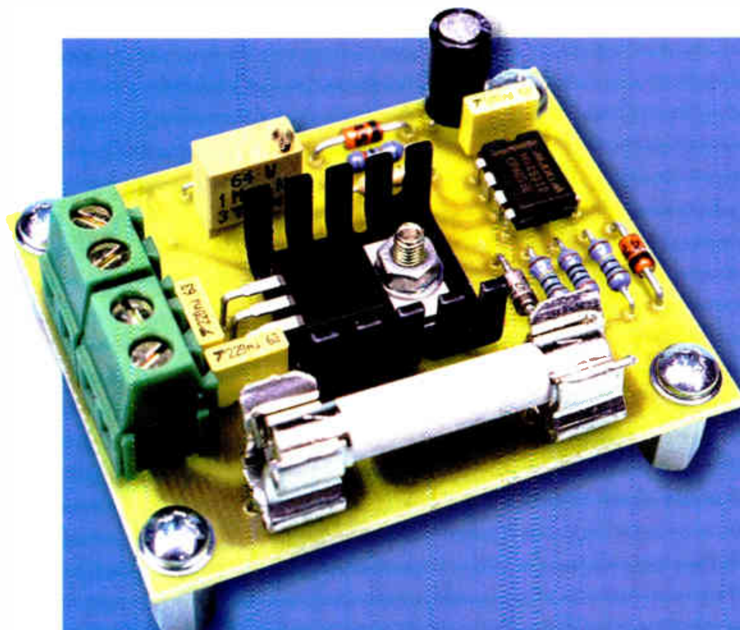

Protect your expensive batteries with this mini-sized, micro-powered electronic cut-out switch. It uses virtually no power and can be built to suit a wide range of battery voltages.

By PETER SMITH

MICROPOWER BATTERY PROTECTOR

MOST BATTERY-POWERED equipment provides no mechanism for disconnecting the batteries when they're exhausted. Even when the voltage drops too low for normal operation, battery drain usually continues until all available energy is expended. This is particularly true of equipment designed to be powered from alkaline or carbon cells but retro-fitted with rechargeables.

Another example is emergency lighting and security equipment designed to be float-charged from the mains. In an extended blackout period, the batteries can be completely drained and may not recover when the mains power is finally restored.

Death by discharge

Over-discharge is undoubtedly one of the main causes of early battery failure. How well a particular battery can cope varies according to type and application. Some "gel" electrolyte lead-acid batteries will not fully recover after a discharge right down to 0V. On the other hand, batteries designed for deep-cycle use can usually withstand such treatment, albeit with a reduction in maximum cycle life.

The latest generation of NiCd and NiMH cells can be completely discharged without damage. However, when connected in series to form a battery pack, unequal cell conditions mean that some cells will reach 0V before others. These "weaker" cells are then reverse-charged until all of the energy in the pack is expended. This results in heat damage and electrolyte loss, or worse.

In most cases, the battery will be functional again after a recharge but the reverse-charged cells will have been weakened. And that makes the problem even worse the next time around.

Obviously, the solution to this problem is to disconnect the batteries at some minimum terminal voltage, allowing enough headroom for cell imbalances. For NiCd and NiMH batteries, this is typically 0.9V per cell. For lead-acid batteries, the minimum voltage is dependent on discharge current.

Fig.1 shows the relationship between discharge current and the minimum recommended terminal voltage

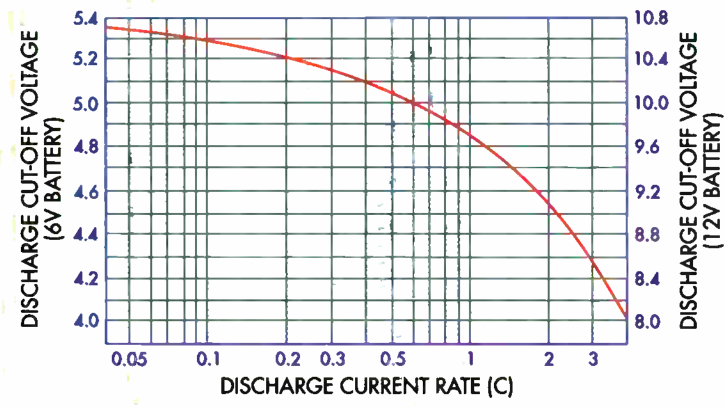

Fig.1: the cut-off voltage for lead-acid batteries is dependent on the rate of discharge. This graph enables you to determine the correct voltage for your application. Although representative of "Panasonic" brand 1.3Ah - 33Ah VRLA batteries, all good quality sealed lead-acid batteries will exhibit similar characteristics.

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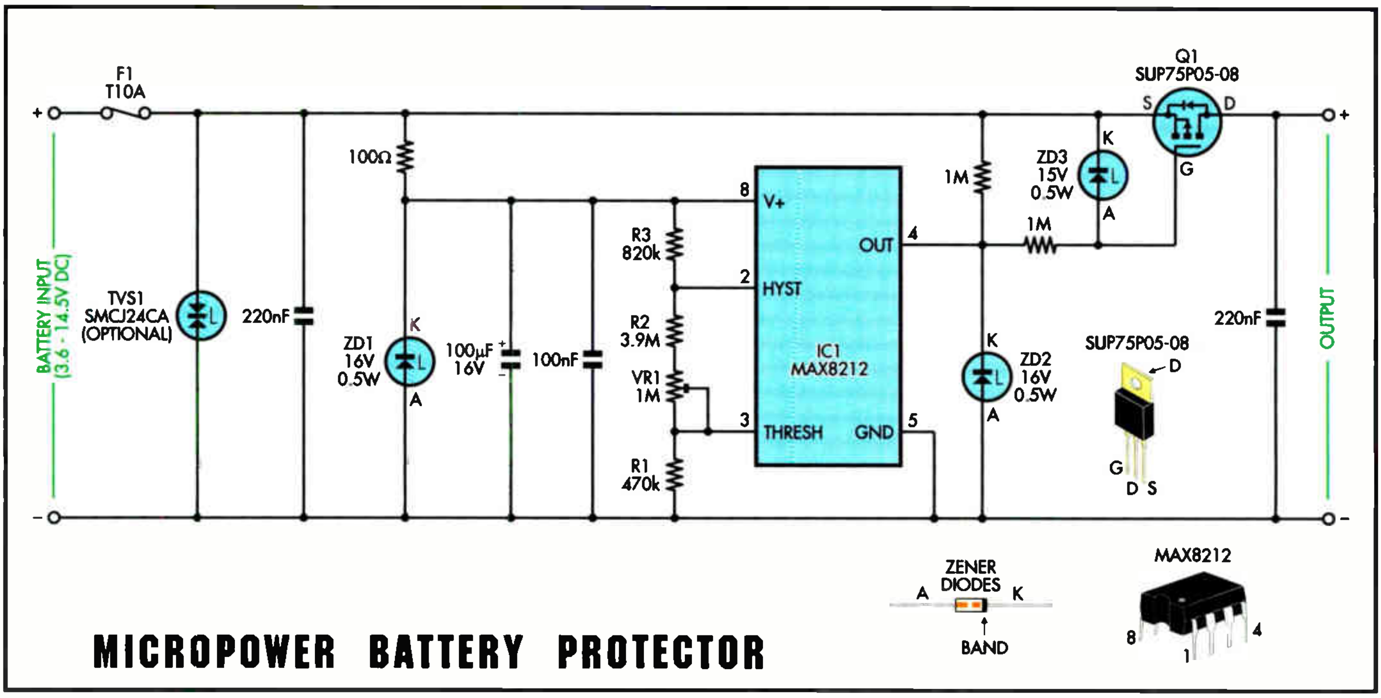

Fig.2: the circuit is based on a MAX8212CPA voltage monitor IC (IC1), which controls MOSFET Q1 to switch the power to the load. Resistor R2 selects the cut-off voltage (see Table 2), with fine adjustment provided by VR1.

for both 6V and 12V VRLA batteries – also commonly referred to as "SLA" (sealed lead-acid) batteries.

The discharge capacity of SLA batteries is measured over a 20-hour period and normalised to an amp-hour (Ah) rating. In theory, a 7.2Ah battery can deliver 7.2A for one hour. This is referred to as the "C" or "1C" discharge rate. In practice though, the battery will be exhausted before the hour's end, due to inefficiencies in the electrochemical process.

The horizontal axis represents the discharge current, expressed as a fraction of the "C" rate. For example, a 6V 7.2Ah battery discharged at 3.6A corresponds to a 0.5C rate, with a recommended cut-off voltage of 5.05V.

Note that high-capacity lead-acid car batteries have different characteristics to SLA batteries. Where possible, refer to the manufacturer's datasheets for the recommended cut-off voltage. We've listed a cut-off of 11.4V in Table 2 simply because at this voltage, there should still be enough energy in the battery to start the engine!

Circuit description

The circuit diagram for the module appears in Fig.2. Battery voltage is applied to the input (lefthand) side of the circuit and switched through to the load on the output (righthand) side via P-channel MOSFET Q1. The gate of this MOSFET is controlled by IC1, a MAX8212 micropower voltage monitor.

Power for the MAX8212 is derived from the battery input, which is filtered using a 100Ω resistor and 100μF & 100nF capacitors before being applied to the V+ input. A 16V Zener diode (ZD1) ensures that the supply rail cannot exceed the maximum input voltage of the IC (16.5V).

Fig.3 shows the basic internals of the MAX8212. The voltage on the threshold (THRESH) input is connected to

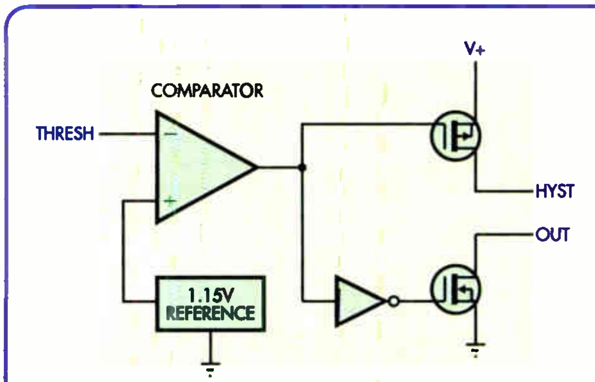

Fig.3: block diagram of the MAX8212CPA voltage monitor IC. It contains a 1.15V reference and a comparator which drives complementary FET output stages.

Main Features

- Disconnects load at preset battery voltage
- Automatically reconnects load when battery recharged
- Ultra-low power consumption (<20μA)
- Miniature size
- 10A maximum rating
- Suitable for use with 4.8-12.5V batteries
- Transient voltage protection (optional)

Suitable for use in . . .

- Cars, boats & caravans
- Security systems
- Emergency lighting
- Small solar installations
- Camera battery packs
- Many other low-power applications

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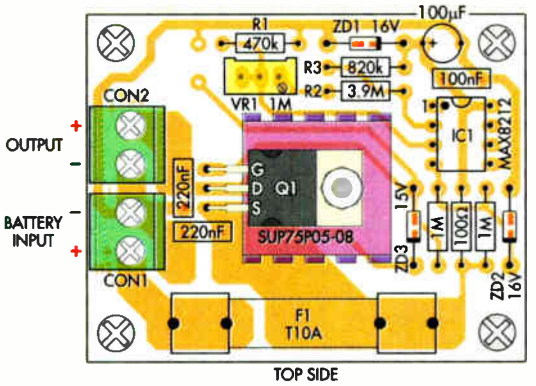


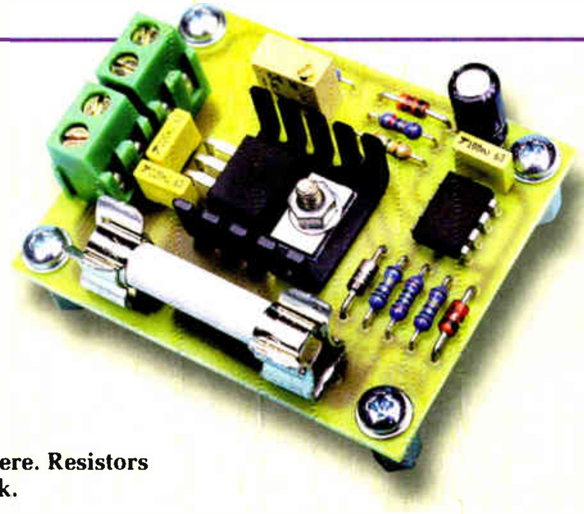
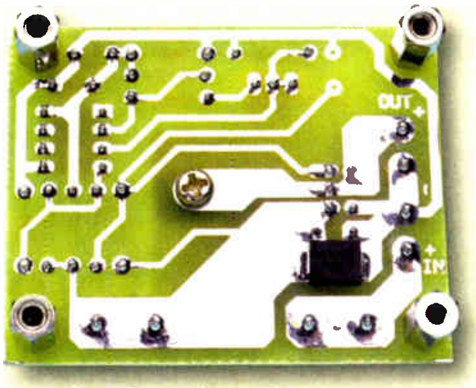


Fig.4: install the parts on the top of the PC board as shown here. Resistors R2 & R3 must be chosen from Table 2, to suit the battery pack.



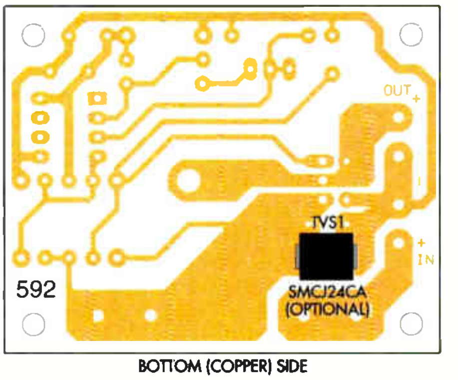


Fig.5: the optional transient voltage suppressor (TVS1) is soldered directly to the copper side of the PC board. It's non-polarised and can be mounted either way around.

the inverting input of a comparator, while a 1.15V reference is connected to the non-inverting input. When the threshold voltage is below 1.15V, the comparator's output is driven towards the V+ rail and the two FETs are off. Conversely, when the threshold voltage is above 1.15V, the comparator's output is near zero volts, switching the FETs on.

Now back to the circuit – a string of resistors (R1, R2 & VR1) divide down the positive rail such that 1.15V will be present on the "THRESH" input at the desired lower threshold voltage. We've also called this the "cut-off" voltage because this is the point at which Q1 is switched off, disconnecting the battery from the load.

The lower threshold voltage (V_L) can be determined from the formula V_L = 1.15 x ((R2+VR1)/R1 + 1). Using the values shown and with VR1 in its mid position, the load will be disconnected at approximately: 1.15 x ((3.9MΩ + 500kΩ)/470kΩ + 1) = 11.9V.

You will recall that when the threshold voltage is above the trip point, both FETs in the MAX8212 are switched on. This means that the "HYST" output

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	3.9MΩ 5%	orange white green gold	not applicable
❑	1	3.3MΩ 5%	orange orange green gold	not applicable
❑	1	2.7MΩ 5%	red violet green gold	not applicable
❑	1	1.8MΩ 5%	brown grey green gold	not applicable
❑	1	1.5MΩ 5%	brown green green gold	not applicable
❑	1	1.2MΩ 5%	brown red green gold	not applicable
❑	3	1MΩ	brown black green brown	brown black black yellow brown
❑	1	820kΩ	grey red yellow brown	grey red black orange brown
❑	1	620kΩ	blue red yellow brown	blue red black orange brown
❑	2	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	1	100Ω	brown black brown brown	brown black black black brown

World Radio History

Table 2: Selecting Resistors R2 & R3				
Number of Cells	Recommended Cut-Off Voltage	Reconnect Voltage (nominal)	R2	R3
4	3.6V	5.1V	820kΩ	620kΩ
5	4.5V	6.5V	1MΩ	820kΩ
6	5.4V	7.8V	1.2MΩ	1MΩ
7	6.3V	9.2V	1.8MΩ	1.2MΩ
8	7.2V	10.8V	1.8MΩ	1.5MΩ
9	8.1V	11.7V	2.7MΩ	1.5MΩ
10	9V	13.4V	2.7MΩ	1.8MΩ
6V SLA	5.4V	6.8V	1.2MΩ	470kΩ
12V SLA	10.8V	13.4V	3.3MΩ	820kΩ
12V Car Battery	11.4V	13.4V	3.9MΩ	820kΩ

Table.2: select R2 & R3 according to battery type and number of cells. The cut-off voltages shown for SLA batteries are for low-drain applications only. Refer to Fig.1 for more realistic cut-off voltages in higher power applications. Fine adjustment of the cut-off voltage is achieved with the 1MΩ trimpot (VR1), as shown in more detail in Table 3.

is connected to the positive (V+) rail, shorting out the top resistor in the string (R3), so it is disregarded in the above calculation.

However, when the threshold voltage falls below the trip point, the "HYST" output goes open-circuit, adding R3 into the equation. The rail voltage must now rise higher to generate 1.15V on the "THRESH" input than it did before R3 was in-circuit. This is called the upper threshold or "reconnect" voltage, and it ensures a clean, positive switching action at the output.

The upper threshold (V_U) voltage can be determined from the formula $V_U = V_L + ((R3/R1) \times 1.15V)$. Using the values shown, the reconnect voltage will be approximately 11.9V + (820kΩ/470kΩ) x 1.15) = 13.9V. We've used quite a large hysteresis value (2V) because the battery voltage will "rebound" somewhat when the load is disconnected. Ideally, the load should only be reconnected once the battery is recharged or the input power is cycled.

The "OUT" pin of the MAX8212 drives the gate of the P-channel MOSFET (Q1). When the internal FET driving this pin switches on, Q1's gate is pulled towards ground via a 1MΩ resistor, switching it on. Conversely, when the internal FET switches off, Q1's gate is pulled up to the positive rail via a second 1MΩ resistor, switching it off. Two

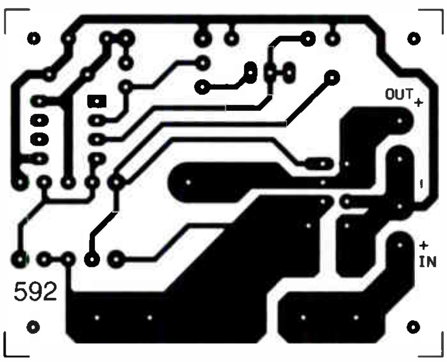


Fig.6: this is the full-size etching pattern for the PC board.

Zener diodes protect the gate-source junction of Q1 (ZD3) and the drain-source junction of the internal FET of IC1 (ZD2) from potential over-voltage conditions.

Circuit protection

Output overload protection is afforded by a slow-blow fuse (F1) at the input. For light load switching, the size of the fuse can be reduced accordingly, to provide increased protection for the MOSFET.

No reverse polarity protection has been provided. Due to the 10A current rating of this circuit, a series protection diode would reduce the output voltage by as much as 1V and generate considerable heat. Momentary reversal of the battery leads will probably not damage either IC1 or Q1. However, the intrinsic drain-source diode in the MOSFET will conduct, allowing reverse current flow through the load.

For use in a car or other noisy electrical environments, an optional bidirectional transient voltage suppressor (TVS1) can be installed. These devices behave like back-to-back Zener diodes but are faster acting and can absorb much more energy. The specified device will clamp the input rail to ±39V peak, protecting the MOSFET and load from all but the most severe high-voltage transients.

Parts List

1 PC board, 592 available from the *EPE PCB Service, 58 x 46mm*
2 2-way 5/5.08mm 10A terminal blocks (CON1, CON2)
1 Micro-U TO-220 heatsink
2 3AG PC-mount fuse clips
1 3AG 10A slow-blow fuse
4 M3 x 10mm tapped spacers
5 M3 x 6mm pan head screws
1 M3 nut & flat washer

Semiconductors
1 MAX8212CPA voltage monitor (IC1)
1 SUP75P05-08 75A 55V P-channel MOSFET (Q1)
2 16V 0.5W (or 1W) Zener diodes (ZD1, ZD2)
1 15V 0.5W (or 1W) Zener diode (ZD3)
1 SMCJ24CA transient voltage suppressor (TVS1) (optional)

Capacitors
1 100µF 16V PC electrolytic
2 220nF 63V MKT polyester
1 100nF 63V MKT polyester

Resistors (0.25W)
1 3.9MΩ 5%
1 3.3MΩ 5%
1 2.7MΩ 5%
1 1.8MΩ 5%
1 1.5MΩ 5%
1 1.2MΩ 5%
3 1MΩ 1%
1 820kΩ 1%
1 620kΩ 1%
2 470kΩ 1%
1 100Ω 1%
1 1MΩ 25-turn trimpot

Note: the above list includes all values for R2 & R3 shown in Table 2, so you'll have some resistors left over after assembly.

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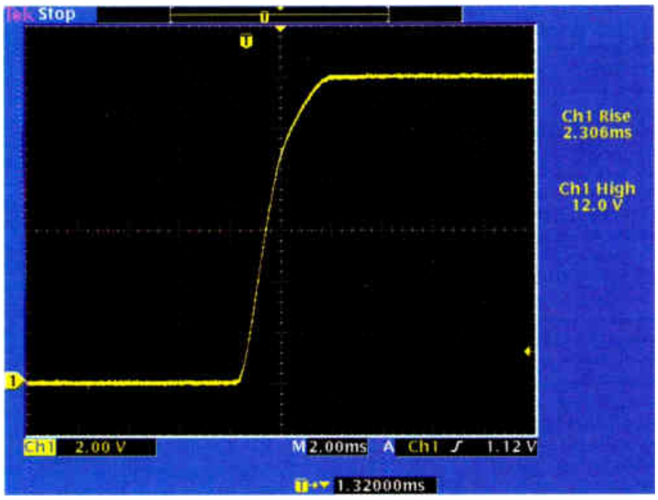

Fig.7: this scope shot shows the rise time of the voltage at the output terminals when a 12V battery is connected to the input. The rounded edge at the top of the waveform is probably due to the battery's response as full load is applied.

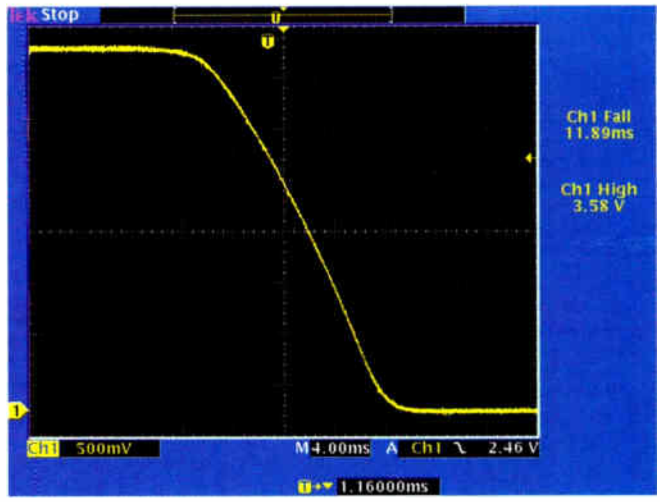

Fig.8: again captured at the output terminals, this waveform shows the voltage fall time when a 4-cell battery pack drops below the preset 3.6V level. Note that it's much longer than the rise time because the MOSFET's gate must be discharged through two 1MΩ resistors.

Assembly

The assembly is quite straightforward, with all parts mounting on a small PC board coded 592 and measuring 58 x 46mm. Install the low-profile components first, using the overlay diagram (Fig.4) as a guide. Take care to align the banded (cathode) ends of all the Zener diodes (ZD1-ZD3) as shown.

The values shown for R2 & R3 are suitable for use with a 12V car battery. For other applications, select the appropriate values from Table 2.

Note that the MAX8212 (IC1) should be installed without a socket. Make sure that the "notched" (pin 1) end of the IC goes in as indicated on the overlay diagram.

A small "micro-U" style heatsink is needed to keep MOSFET Q1 cool. It is sandwiched between the MOSFET and the PC board, with both items held in place with a M3 x 10mm screw, nut and flat washer.

Bend the MOSFETs leads at 90° about 5mm from the body and trial fit it in position. If the lead bend is correct, the hole in the metal tab will line up with the hole in the PC board without stressing the leads. Apply a thin smear of heatsink compound to the mating surfaces before assembly. Be sure to tighten up the mounting screw before soldering the MOSFET's leads.

The optional transient voltage suppressor (TVS1) can be left until last. It mounts on the copper side of the board and must be positioned precisely as shown in Fig.5 before soldering.

Finally, for operation in high-humidity environments, we recommend that the board be cleaned, thoroughly dried and then coated with a circuit board lacquer. This will prevent problems associated with leakage currents that could affect the accuracy of the threshold voltage setting over time.

Setup and testing

In order to set the cut-off voltage accurately, you'll need an adjustable DC bench supply, a multimeter and a small load for the output. A 680Ω 0.25W resistor in series with a LED makes an ideal load (see Fig.9).

Hook up the bench supply to the battery input terminals and the load (resistor & LED) to the output terminals, observing correct polarity. Initially, set the input voltage a couple of volts higher than the desired cut-off level.

Now wind VR1 fully anti-clockwise and then power up. The LED should illuminate, indicating that the MOSFET has switched power through to the output.

Next, monitor the input voltage while you carefully adjust your bench supply to the desired cut-off level. That done, wind VR1 slowly clockwise

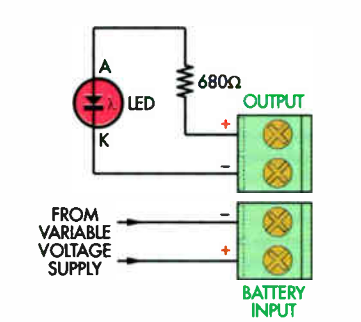

Fig.9: a 680Ω 0.25W resistor in series with a LED makes an ideal load when setting the cut-off voltage – see text.

Table 3: Max. & Min. Cutoff Voltages

R2	Max. Cut-Off	Min. Cut-Off
3.9MΩ	13.1V	10.6V
3.3MΩ	11.6V	9.2V
2.7MΩ	10.2V	7.7V
1.8MΩ	8.0V	5.5V
1.2MΩ	6.5V	4.0V
1MΩ	6.0V	3.5V
820kΩ	5.6V	3.1V

Table 3: by selecting an appropriate value for R2 and adjusting VR1, cut-off voltages from 13.1V to 3.6V are achievable. Note that with a value of 820kΩ for R2, it is possible to achieve a cut-off of 3.1V. However, you should not adjust VR1 for less than 3.6V to avoid overheating Q1.

World Radio History

Switching Capacitive Loads & Incandescent Lamps

Capacitive loads can cause huge instantaneous currents to flow at switch-on. One way of reducing this in-rush current is to reduce the switching speed of the MOSFET. To this end, we've used a 1MΩ resistor in series with the gate, which acts with gate capacitance to slow MOSFET turn-on. The result (see Figs.7 & 8) should be sufficient for most general-purpose applications.

In-rush current is an even bigger problem for lamp loads and cannot be solved by simply slowing gate turn-on. Tungsten-filament incandescent lamps, for example, exhibit a very low cold-filament resistance – as much as 10-12% of the hot resistance. This means that when an incandescent lamp is switched on, at least 10 times the normal current flows through the filament. After about 5ms, this reduces to about twice the normal level, decreasing slowly until full brilliance at over 100ms later.

We therefore recommend a maximum lamp load of 3.5A (3.4W @ 12V) for use with the Micropower Battery Protector, as higher power lamps may well damage the MOSFET switch.

Note that it is possible to increase lamp load handling by connecting a positive temperature coefficient (PTC) resistor in series with the lamps(s). For example, to switch a 10A lamp load, a 30A PTC with a cold resistance of 0.5Ω and a hot resistance of 0.01Ω would be suitable. This will protect the MOSFET switch and your lamps will last much longer to boot!

until the LED goes out, indicating that the MOSFET has disconnected the load.

To check the "reconnect" voltage level, slowly increase the input voltage. The MOSFET should switch on again at the expected level, illuminating the LED. Note that there will be some deviation from the listed voltage due to resistor tolerances.

In use, the battery cut-out level will also vary slightly from that set above due to the resistance of the fuse, battery connections, cabling and any other in-line connectors.

Housing and wiring

The small size of this module means that, in many cases, it can be built right in to the equipment it protects. Alternatively, it can be installed in a small plastic box.

All wiring to and from the terminal blocks on the PC (B) must be rated to suit the intended application. When operated at or near the maximum rating, be sure to use extra-heavy duty automotive-type cable.

For use in a car, the unit can simply be wired in-line with the cigarette lighter plug that's connected to the appliance. Alternatively, power should be sourced from a fused terminal in the fuse box. Do not connect the Micropower Battery Protector directly across the vehicle battery! ***EPE***

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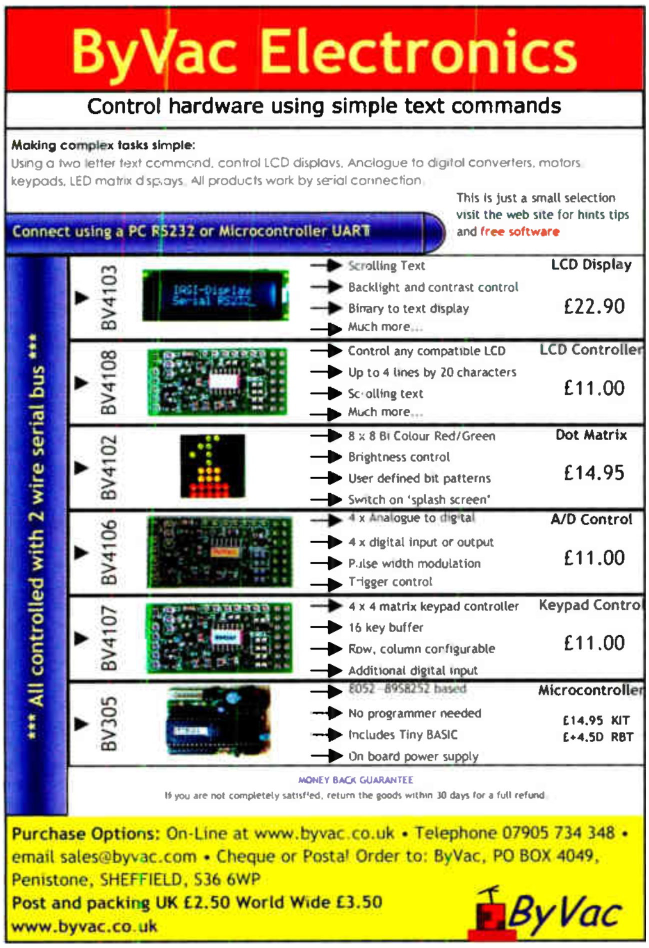

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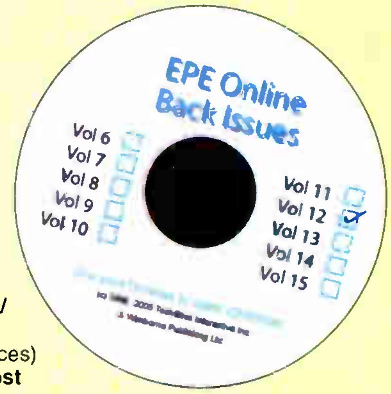

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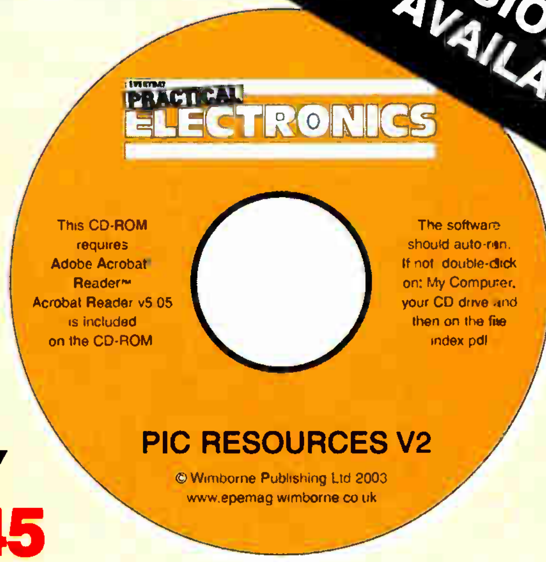

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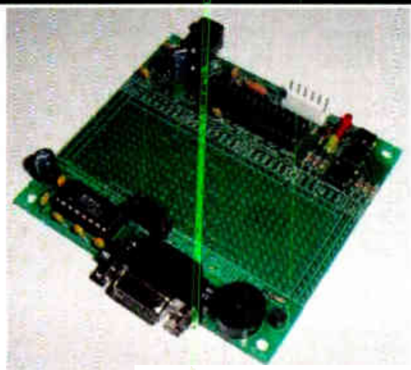

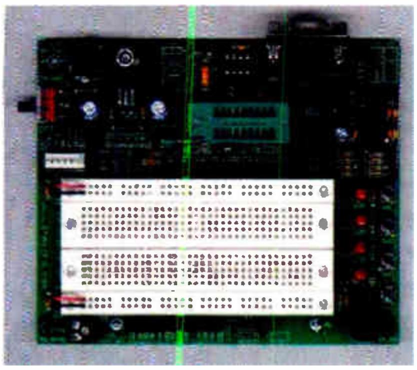

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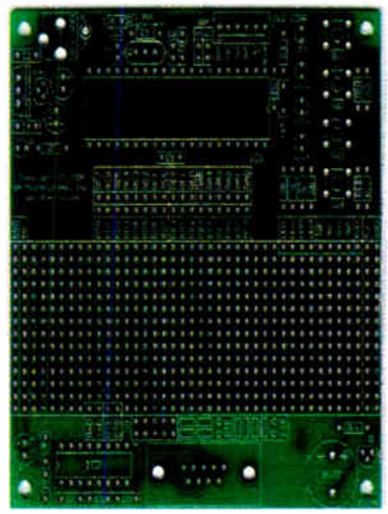

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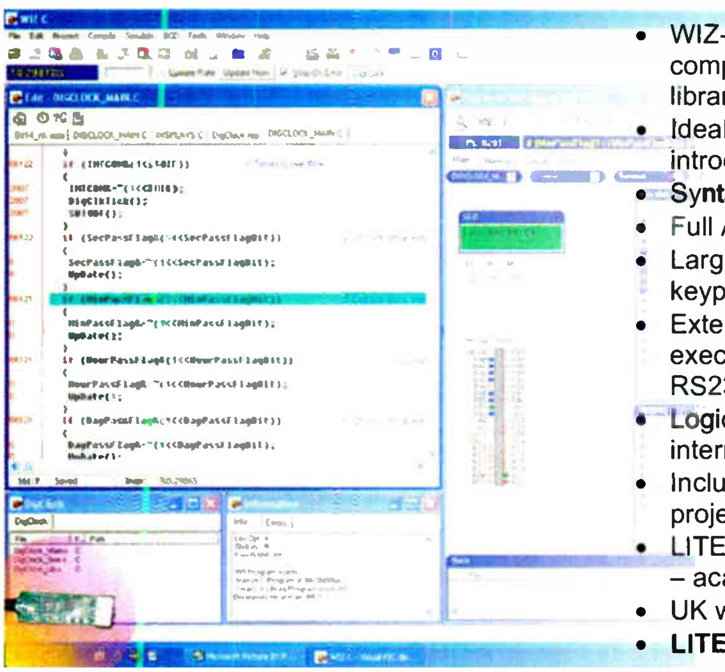

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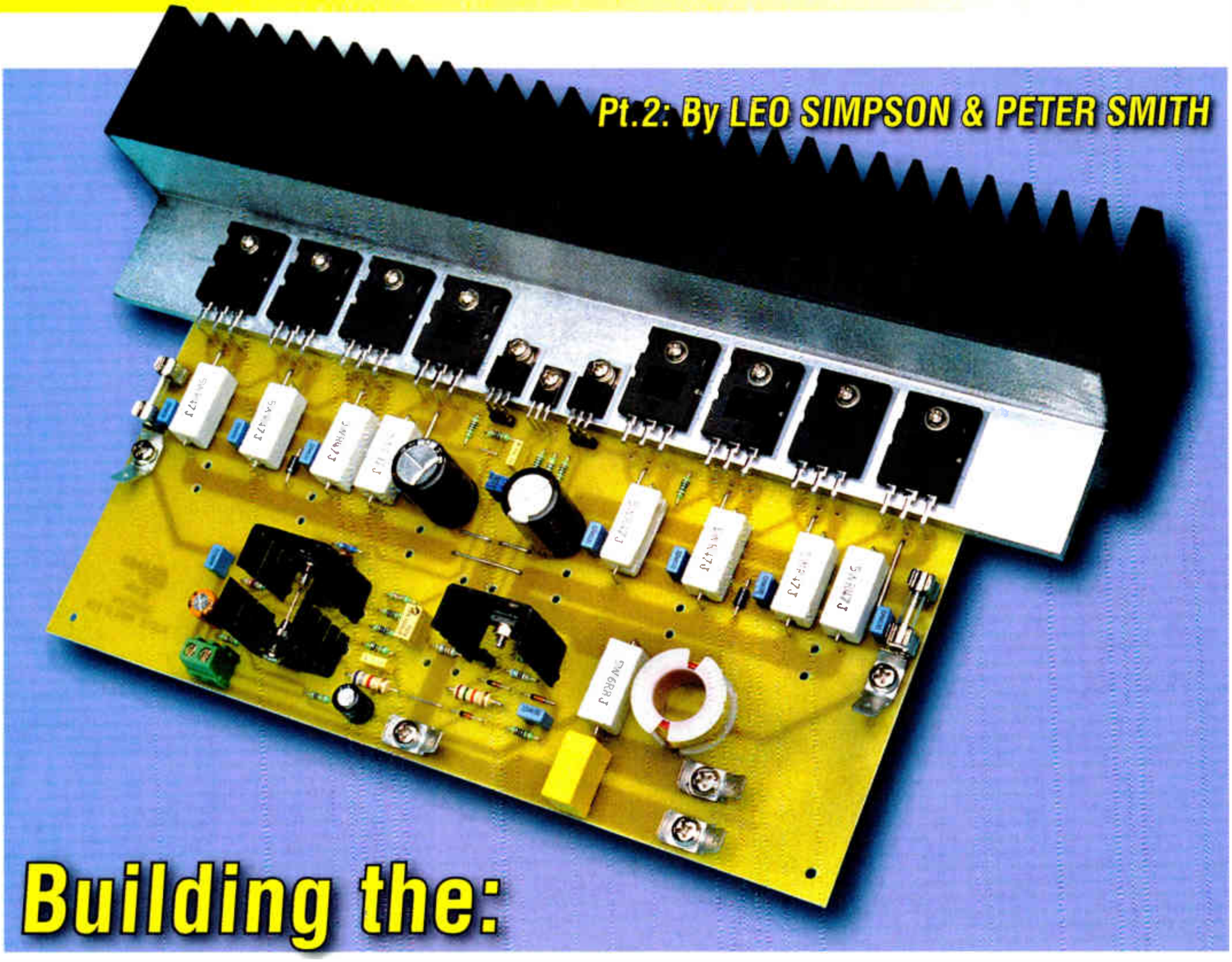
Constructional Project



Pt.2: By LEO SIMPSON & PETER SMITH

Building the: Studio 350 Power Amplifier Module

Last month, we introduced our rugged 350W power amplifier module and gave the circuit details. This month, we show you how to build it and describe a matching power supply.

TO HELP ENSURE that everything goes together without a hitch, it's a good idea to read the following information in its entirety before reaching for your soldering iron!

Referring to the overlay diagram in Fig.1, begin by installing all the wire links. There are 15 links in total. 11 of which must be formed from 1mm tinned copper wire. Use 0.7mm wire for the remaining four links. The overlay diagram shows the larger (1mm) links in red.

Set aside all of the heatsink-mounted transistors (Q4-Q17), the two 470µF electrolytic capacitors, choke (L1) and 6.3mm spade lugs for the moment. We'll deal with these in more detail shortly. All other components can now be installed, progressing from smallest to largest.

The 1W and 5W resistors should be mounted about 1mm proud of the PC board to aid heat dissipation. Also, be sure to orient the cathode (banded) ends of diodes D1-D5 as shown.

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When installing the fuse clips, note that the small retaining lug on each clip must be positioned to the outer (fuse end) side, otherwise fuse installation will be impossible.

If you intend mounting the output transistors horizontally, then it's also necessary to install 3-pin header strips in the mounting positions for Q8 & Q9. As we'll see shortly, these are required because the transistor leads are too short to extend all the way through the PC board holes.

TO-220 heatsinks

Transistors Q4, Q5 & Q6 must be attached to TO-220 heatsinks before fitting them to the PC board. First, smear a thin film of heatsink compound to both the rear (metal) area of each transistor as well as the mating areas of the heatsinks. That done, fasten them to the heatsinks using M3 screws, nuts and washers (see Fig.2) but don't fully tighten the screws just yet. Note that insulating pads are not required here.

Now slip each assembly into place in its PC board holes, taking care not to mix up the BF469 and BF470 types. The tabs of the heatsinks should fully engage the holes in the PC board, such that all of the heatsink edge contacts the PC board surface.

Finally, push the transistors all the way down the slots in the heatsinks and then tighten up the screws. The transistor leads can now be soldered, taking care that the assemblies remain in place when the board is turned over.

Winding the choke

The 6.8μH choke may be supplied pre-wound. If so, all you'll need to do is scrape the enamel insulation off the wire ends, tin them and solder the part in place.

Alternatively, it's a relatively simple matter to wind the choke yourself. You'll need a 13mm, inside diameter, plastic former (bobbin) and about three metres of 1mm enamelled copper wire.

Begin by bending the wire at right angles, about 10mm from one end. This will be the starting end. Slip it into the bobbin and position the end in one of the slots.

Now wind on 23.5 turns as evenly and tightly as possible, then pass the remaining wire length out through the opposite slot and cut off any excess, leaving about 10mm protruding. Finally, wind on a couple of turns of insulation tape to hold everything in place.

You can now test-fit the assembly in position, bending the leads as necessary to get the bobbin to sit down on the PC board surface. That done,

Parts List – Studio 350 Power Amplifier Module

1 PC board coded 591, available from the *EPE PCB Service*, 136mm x 241mm
1 6.8μH air-wound choke (L1) (see text)
1 2-way 2.54mm terminal block (CON1)
2 3-way 2.54mm pitch SIL headers (for Q8 & Q9)
3 TO-220 heatsinks, 25mm x 12.5mm with PC board tabs
1 diecast heatsink, 300 x 75mm, 35mm shelf (0.4°C/W or better)
8 TO-3P or TO-264 silicone-based insulating pads
2 TO-220 silicone-based insulating pads & washers
1 TO-126 silicone-based insulating pad
350mm (approx.) 1.0mm tinned copper wire for links
70mm (approx.) 0.7mm tinned copper wire for links
4 M205 PC-mount fuse clips (F1, F2)
2 M205 5A slow-blow fuses
5 6.3mm chassis-mount spade lugs

Semiconductors
1 BC556 PNP transistor (Q1)
2 2SA1084 PNP low-noise transistors (Q2,Q3)
2 BF469 NPN transistors (Q4, Q5)
1 BF470 PNP transistor (Q6)
1 MJE340 NPN transistor (Q7)
1 MJE15030 NPN transistor (Q8)
1 MJE15031 PNP transistor (Q9)
4 MJL21194 NPN transistors (Q10, Q12, Q14, Q16)
4 MJL21193 PNP transistors (Q11, Q13, Q15, Q17)
3 1N4148 small-signal diodes (D1-D3)
2 1N4936 fast-recovery diodes (D4, D5)

Capacitors
2 470μF 100V PC electrolytic
1 47μF 16V non-polarised PC electrolytic
1 1μF 16V non-polarised PC electrolytic
10 220nF 100V MKT polyester
1 150nF 250V MKT polyester
1 100nF 63V MKT polyester
1 12nF 100V MKT polyester
1 330pF ceramic disc
1 68pF 250V ceramic disc (or mica)
1 10pF ceramic disc

Resistors (0.25W 1%)

2 22kΩ	1 1kΩ
1 18kΩ	1 680Ω
1 15kΩ 1W	1 470Ω
1 6.8kΩ 1W	10 100Ω
2 4.7kΩ	1 10Ω
1 2.2kΩ	

Wirewound resistors
2 470Ω 10W wirewound (for setup)
1 6.8Ω 5W wirewound
8 0.47Ω 5W wirewound

Trimpots
1 200Ω 25-turn miniature horizontal trimpot (VR2)
1 100Ω 25-turn miniature horizontal trimpot (VR1)

Screws & nuts
8 M3 x 20mm pan-head screws
3 M3 x 15mm pan-head screws
3 M3 x 10mm pan-head screws
14 M3 nuts
28 M3 flat washers
5 M4 or 3BA x 10mm pan-head brass screws
5 M4 or 3BA brass nuts
10 M4 or 3BA internal star washers (brass or stainless steel)

Power supply
1 50V+50V 500VA toroidal mains transformer
1 35A 400V chassis-mount bridge rectifier
6 8000μF 75V chassis-mount electrolytic capacitors
2 470nF 100V MKT polyester capacitors
4 15kΩ 1W resistors

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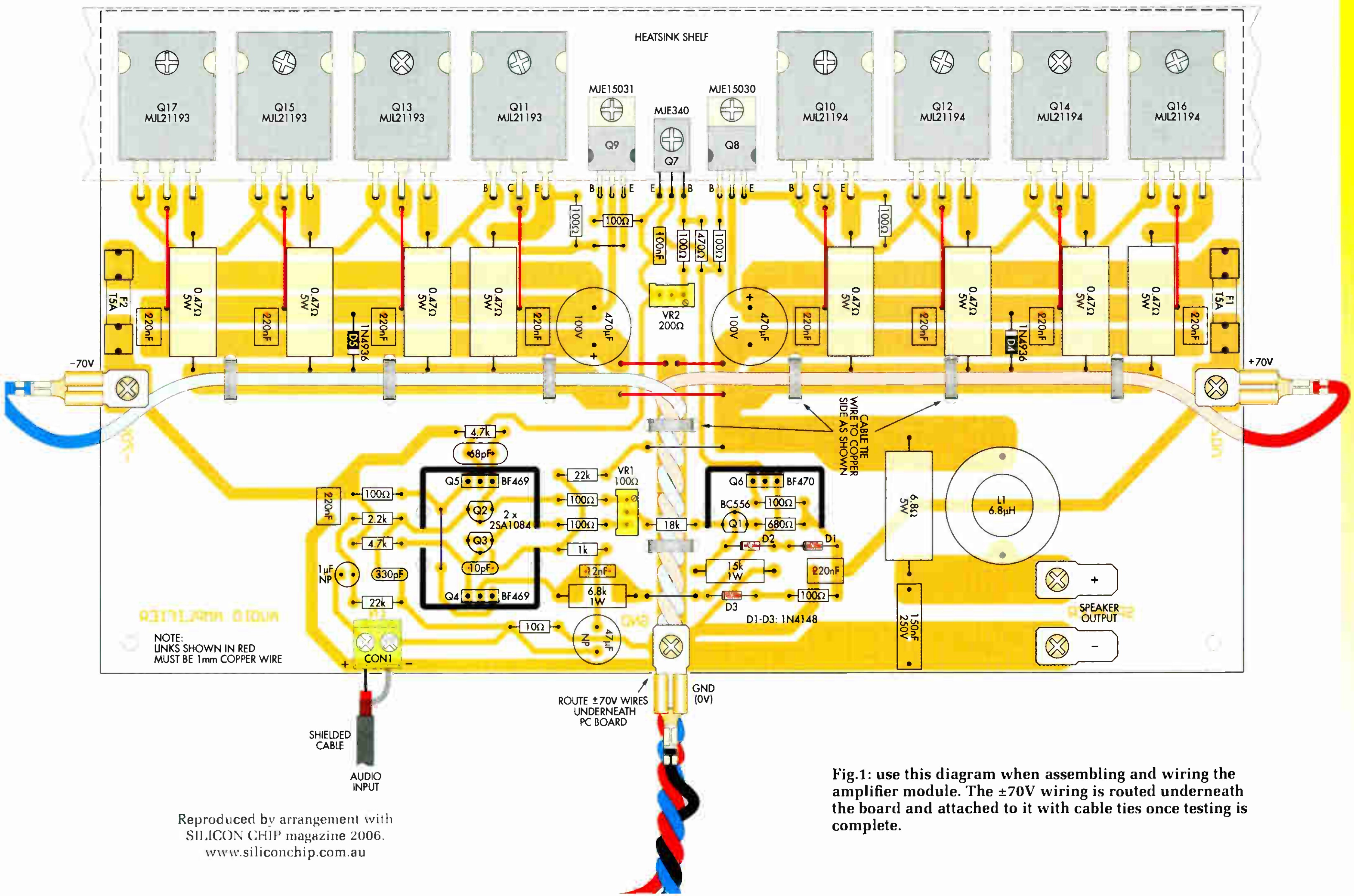

Fig.1: use this diagram when assembling and wiring the amplifier module. The ±70V wiring is routed underneath the board and attached to it with cable ties once testing is complete.

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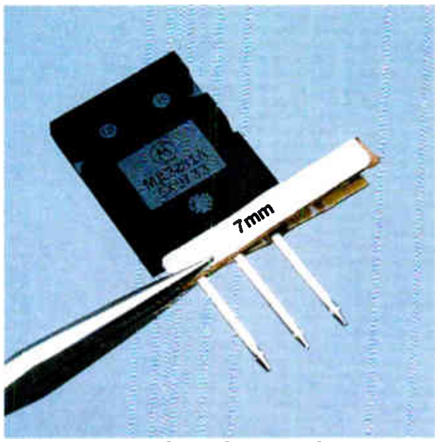

A strip of cardboard cut to the correct width (7mm) makes a handy bending guide for the leads of the heatsink-mounted transistors.

scrape the enamel insulation off the wire ends with a scalpel blade or similar and tin them before soldering the choke permanently in position.

Lug terminations

Except for the audio line input, all connections to the PC board are made via 6.3mm spade lugs. If the lugs are double-ended, then cut off one end using electrician's sidecutters. Position each lug as shown on the overlay diagram and fasten it securely to the PC board using the method depicted in Fig.3.

We recommended raw brass (rather than nickel-plated) screws and nuts for securing the lugs. These return a slightly lower distortion figure at the high-power end of the spectrum.

Apart from the main heatsink-mounted transistors, the only parts yet to be installed are the two 470µF electrolytic capacitors. These can go in now, with an eye to correct orientation. Take particular care here, as they're oriented differently to one another. If you get one the wrong way around, it will be damaged at power up and may even explode!

Horizontal heatsink mounting

The amplifier module was designed for mounting to the horizontal shelf of a diecast heatsink. However, a vertical-mounting configuration is also possible – see the panel entitled "Using Different Heatsinks" for a discussion of this alternative method.

We recommend a 300mm diecast heatsink with 35mm shelf, as used on the prototype. So let's look at how the PC board and transistors are attached to this heatsink.

The only guaranteed way of getting all the heatsink holes in the right places is to use the PC board as a drilling template. First, find the smoothest side of the heatsink shelf and place it upwards. That done, position the PC board on the top of the shelf and butt it right up against the main body of the heatsink, centred left to right within the available space.

Next, making sure that nothing moves (clamp the board to the shelf if necessary), use a sharp pencil to mark through all 11 transistor mounting holes. Be sure to mark a clean circle around the circumference of each hole, so that you'll easily be able to find the centre. Remove the PC board and gently centre-punch your marks before drilling.

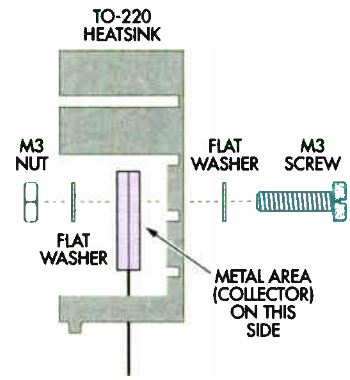

Fig.2: transistors Q4-Q6 must be attached to TO-220 heatsinks as shown here. Insulating pads are not necessary, but you should apply heatsink compound to the mating surfaces.

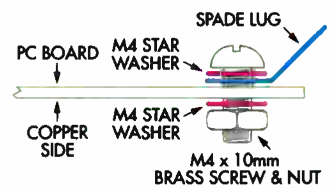

Fig.3: here's how to bolt up the spade lugs. If you have double-sided lugs, cut off one side with heavy-duty sidecutters first. Tighten them up enough so that they don't move around when the receptacles are pushed on.

Initially, drill a pilot hole at each mark, using a 1mm bit. Finish with a 3.3mm bit, then deburr the holes by hand using a much larger drill size. Both sides of the shelf must be completely free of swarf and sharp edges.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	22kΩ	red red orange brown	red red black red brown
❑	1	18kΩ	brown grey orange brown	brown grey black red brown
❑	1	15kΩ	brown green orange brown	brown green black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	10	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown
❑	2	470Ω 10W	not applicable	not applicable
❑	1	6.8Ω 5W	not applicable	not applicable
❑	8	0.47Ω 5W	not applicable	not applicable

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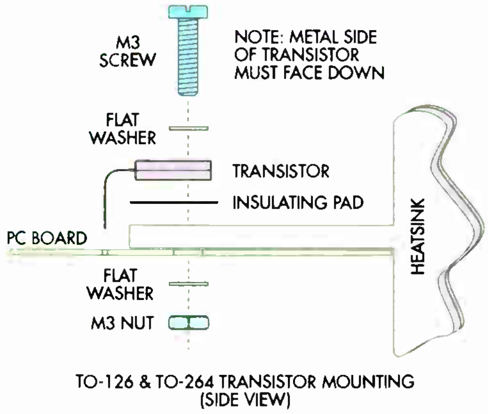

Fig.4: the mounting details for the TO-126 (Q7) and TO-264 (Q10-Q17) transistors. Don't solder the leads until the screws have been tightened to their final torque.

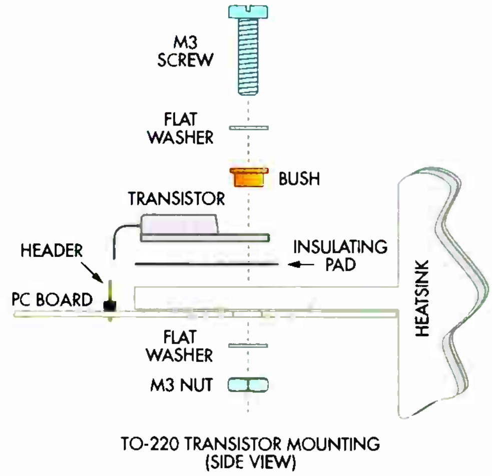

Fig.5: the leads of the TO-220 (Q8 & Q9) packages are too short to reach all the way through the PC board. Simply bend the leads so that they touch the header pins instead. Again, don't solder the leads until the mounting screws have been tightened.

Insulated TO126 Packages

Transistor Q7 (an MJE340) is supplied in a "plastic" TO-126 package. These packages usually include a small rectangular metal area on the rear. This area is electrically connected to the collector and therefore must be isolated from the heatsink with an insulating washer (see Fig.4).

However, some TO-126 packages do not have this metal area – they're "plastic" on both sides. This isolated type package should be mounted without an insulating washer. Simply smear its mating surface with a small amount of heatsink compound and bolt it directly to the heatsink.

By the way, a drill press is mandatory for this job, as drilling accurate holes in thick aluminium with a hand drill is extremely difficult.

Attaching the transistors

Now position the PC board beneath the heatsink shelf and insert two M3 x 20mm screws in the extreme left and righthand holes. Fit M3 washers and nuts (on the PC board side) and wind them up barely finger tight. The idea here is not to clamp the board against the heatsink shelf too tightly; it must be allowed to move at this stage. These screws are temporary placeholders and can be removed when necessary.

All transistors must be insulated from the heatsink with silicone-based pads. The TO-220 devices (Q8 & Q9) also require insulating bushes for the screws. Figs.4 & 5 shows how to mount each transistor type.

As you can see, the leads of each transistor must be bent at right angles before installation. The position of the bend should be placed so that the leads slip easily into the PC board holes while the mounting holes line up with the holes in the heatsink and the PC board underneath.

A strip of cardboard cut to the appropriate width makes a handy bending guide (see photo). Mount the TO-126 package (Q7) first, then progress outwards in left and right pairs (Q8 & Q9, Q10 & Q11, etc).

The two TO-220 transistors (Q8 & Q9) present a special case. Their leads are not long enough to reach all the way through the PC board holes, so instead must be soldered to the 3-pin headers installed earlier. However, do not solder to the header pins just yet. Simply bend the device leads so that they just make contact with the rear of the header pins.

You'll probably find that you need to trim a little off the leads so that they don't interfere with the plastic base of the header strips.

Wind up the nuts only finger tight during installation. Once they're all in place, go back and tighten each one to the final torque, starting in the middle and working towards the sides. Don't overtighten – about one click of the elbow is more than enough!

That done, set your meter to read Ohms and measure between the heatsink and the centre lead (collector) of each device. You should get an open

Although featuring a different amplifier module, this picture shows the vertical mounting method for the output and driver transistors.

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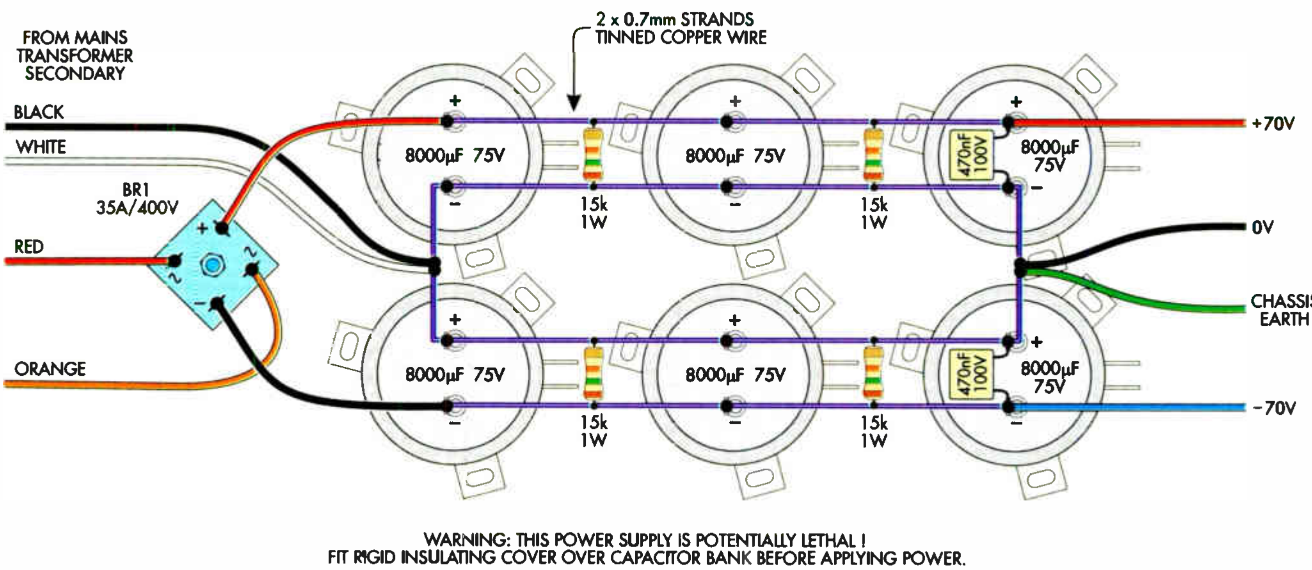

Fig.6: the power supply wiring is quite straightforward. Take particular care that you have the positive (+) and negative (-) terminals of the capacitors connected as shown. The same goes for the bridge rectifier, also noting that it must be bolted firmly to a metal surface for heatsinking. Note the safety warning.

circuit reading in all cases. If everything checks out, then solder all transistor leads to complete the assembly.

Note that the mounting screws must be tightened up before soldering the leads. If this is done in reverse order, then stress will eventually crack the solder joints and perhaps even delaminate the PC board copper.

DANGER: HIGH VOLTAGE!

The 140V DC supply across the filter capacitor bank and the amplifier supply rails is potentially lethal! After the power supply wiring is complete and before you apply power, mount a clear Perspex sheet over the capacitor bank to protect against inadvertent contact – now or in the future! Note that the capacitors take some time to discharge after the power is switched off.

Vertical heatsink mounting

Details for vertical mounting will vary according to the style of heatsink. However, we've included a rough guide to get you started. Of course, you must have already modified the PC board as described in the "Using Different Heatsinks" panel!

To begin, use what ever you have on hand to raise the PC board to the required mounting height. A pair of 3mm holes is provided at the rear of the board for tapped spacers but you'll also need to place something under the front of the board to bring it back to the horizontal position.

Next, fit the 11 transistors (Q7-Q17) into their respective mounting holes but don't solder or cut any of their leads just yet! That done, butt the assembly up against your chosen heatsink and centre it roughly within the available space. Note that the transistors should be mounted as close to the centre of the heatsink as practical, although this will be affected by the available transistor lead length.

If possible, line up the transistors so that the mounting holes will fall between the heatsink's cooling fins. This way, you can avoid the additional task of thread tapping.

Once you're happy with the positioning, mark through each transistor mounting hole with a sharp pencil. Now centre-punch each mark and drill 1mm pilot holes. Redrill to 3.3mm if you'll be using screws with nuts, or use a smaller, 2.5mm bit size in preparation for M3 thread tapping.

After drilling, deburr the holes by hand using a much larger drill size so that the mating surface is entirely smooth.

Attaching the transistors

Loosely attach the transistors to the heatsink using insulating pads and bushes where necessary. The requirements here are similar to those shown for horizontal mounting as shown in Figs.4 & 5. Be sure to check that the PC board is sitting horizontal and at right angles to the heatsink before tightening up the screws. It's then just a matter of turning the assembly over and soldering all transistors in place.

Finally, it's a good idea to make sure that all transistor collectors are indeed isolated from the heatsink. To do this, set your meter to read Ohms and measure between the heatsink and the centre lead (collector) of each device. You should get an open circuit reading in all cases.

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
220nF	0.22µF	224	220n
150nF	0.15µF	154	150n
100nF	0.1µF	104	100n
12nF	0.012µF	123	12n
330pF	–	331	330p
68pF	–	68	68p
10pF	–	10	10p

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Using Different Heatsinks

As shown in the various photos, the transistors on our prototype are mounted horizontally, on the shelf of a large diecast heatsink. This method of mounting is mechanically robust and relatively easy to assemble but obviously unsuitable for heatsinks without a shelf.

Suppose, for example, that you've decided to build a stereo unit, utilising a pair of Jaycar's fan-cooled tunnel heatsinks (Cat HH-8532). In this case, the transistors must be mounted vertically along the edge of the PC board, allowing them to be bolted directly to the heatsink faces. With just one modification, the PC board can accommodate this alternative, vertical mounting style.

This modification involves cutting off a portion of the PC board so that the transistors are just a few millimetres from the PC board edge. This must be done before any components are mounted on the PC board!

A thin broken track has been included on the PC board as a cutting guide. Note that there should be about 0.5mm of space between the pads/tracks and the board edge. This ensures that once the unit is assembled, the bare copper tracks can not short out on the face of the heatsink. For this reason, we suggest cutting along the outside of the line, to allow for the width of the cut and any subsequent filing (see Fig.8).

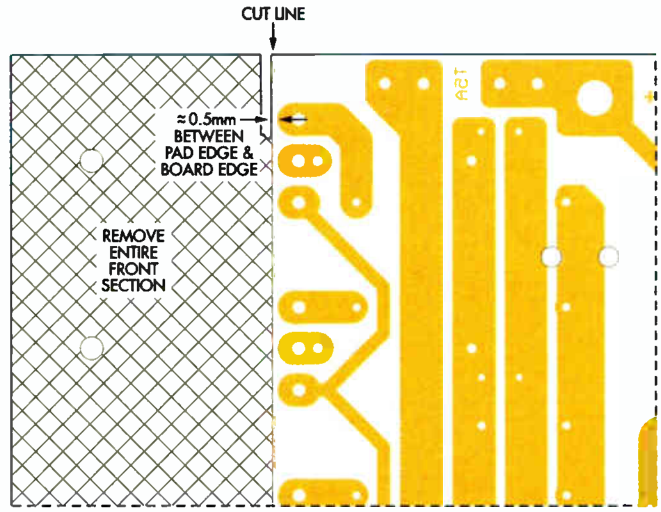

Fig.8: to enable vertical transistor mounting, cut off the entire front section of the PC board as shown here. You do not need to do this for the horizontal mounting style shown in the various photographs!

Power supply assembly

Due to the weight of the mains transformer, the power supply components must be mounted on a substantial metal baseplate. Typically, this will be the base of a rack-mount case or similar. If deemed necessary, the base can be strengthened with an additional plate to achieve sufficient rigidity.

The suggested wiring for the bridge rectifier (BR1) and capacitor bank is shown in Fig.6. The bridge rectifier must be attached directly to a flat area of the metal chassis for heatsinking. Smear the face of the rectifier and the contact area with a thin film of heatsink compound before assembly.

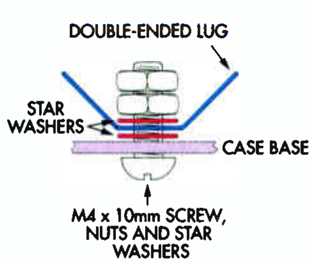

Fig.7: the mains earth should be securely attached to the base of the metal chassis as shown here. Tighten the first nut very firmly before winding on the second "locknut". The earth wire from the capacitor bank also connects to this point.

The 8000µF capacitors are attached to the baseplate using circular clamps. They should be positioned as close together as practical, with their terminals in line to allow hookup with lengths of solid-core wire. Use two strands of 0.7mm tinned copper wire or similar for a total wire diameter of at least 1.4mm for each connection.

If you only ever intend driving 8Ω speakers, the filter capacitor count can be reduced by two for a worthwhile saving. For 4Ω speakers, the full complement of six capacitors is required to achieve the listed power and distortion figures.

Connections to and from the capacitor bank should be made with extra-heavy duty (10A) multi-strand cable. The +70V, -70V and 0V wires leading away from the bank should be twisted tightly together to minimise radiated noise and improve appearance.

Safety precautions

Before applying mains power, the capacitor bank must be covered with a rigid, non-conductive shield. A section of clear perspex is ideal for the job. This step is very important, as simultaneous contact with the +70V & -70V rails could easily kill you (or someone else)!

As shown on the wiring diagram, four 15kΩ 1W resistors must be installed across the ±70V rails. These will gradually discharge the capacitors after power is switched off. However, before working on any part of the circuit, always measure the supply rails with a multimeter first to make sure that it is safe to do so.

Wiring

Housing and wiring of the amplifier modules is totally up to you. However, we've outlined a few points below that will help you to get the most from your amplifier.

First, never take shortcuts with mains wiring. Always use mains-rated cable and be sure to insulate all exposed connections. This includes the use of rubber boots (or equivalent) on the rear of IEC sockets, switches and fuseholders.

The mains earth must be connected to the metal chassis using the arrangement shown in Fig.7. Return all earth wires to this point to eliminate potential earth loops.

Use extra heavy-duty (10A) multi-strand cable (or larger) for all power

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and speaker connections. The wire ends need to be terminated with 6.3mm push-on receptacles to suit the board-mounted lugs. These are available in insulated and non-insulated varieties.

For the insulated type receptacles, you'll need a ratchet-driven crimping tool. Don't be tempted to use a cheaper (non-ratchet style) crimper, as they're just not up to the job.

If you don't want the expense of a new crimper, then you can use the non-insulated style receptacles and solder them on instead.

Supply wiring

The +70V, -70V and 0V connections to the amplifier module should be twisted tightly together and positioned as shown on the overlay diagram. Note how the 0V wire connects to the centre lug, whereas the ±70V wires continue beneath the PC board. Small cable ties are then used to secure the wires in place underneath the PC board.

Positioning the wires as shown helps to cancel the fields resulting from currents flowing in the PC board tracks. This produces the lowest possible signal distortion.

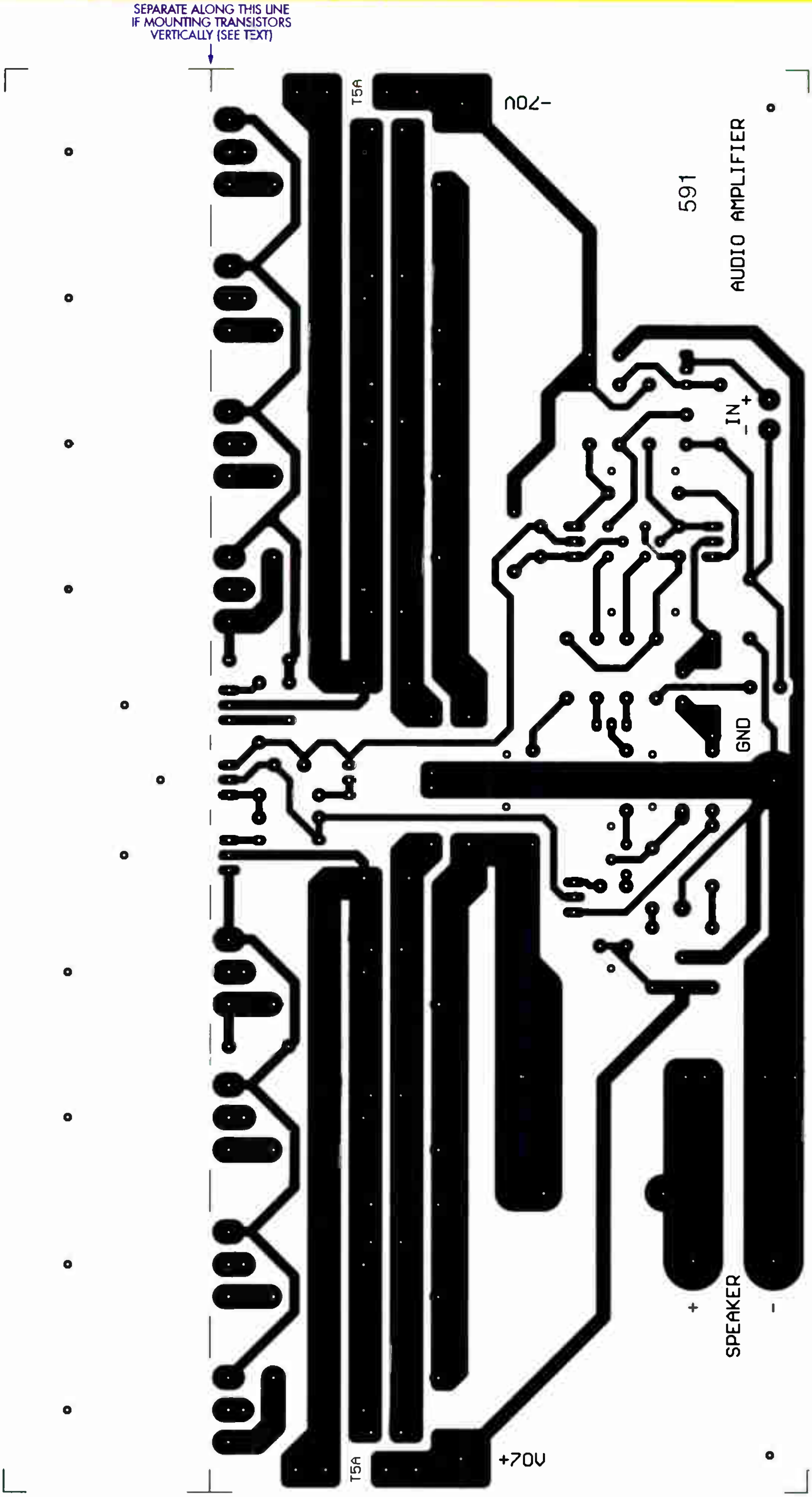
Setup & testing

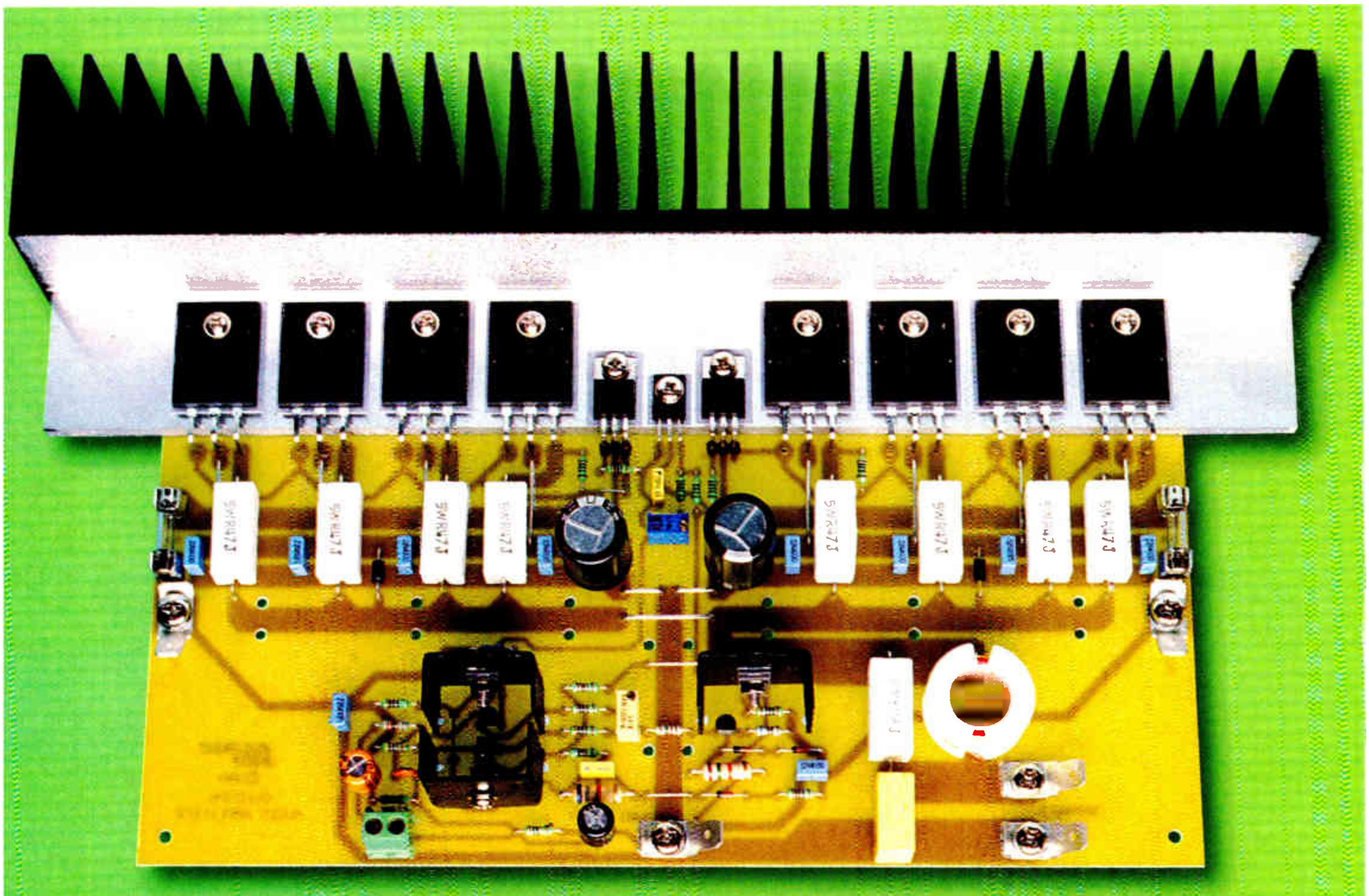
With nothing connected to the power supply output, apply mains power and measure the positive and negative rails. Both readings should be close to the 70V mark, depending on mains fluctuations.

The next task is to zero the amplifier's input offset voltage and set the quiescent current in the output transistors. To protect the amplifier in case of faults and to simplify adjustment, remove both fuses from the board and solder a 470Ω 10W resistor across each fuseclip pair. Alternatively, you may find it easier to tack solder the resistors on the rear (copper) side of the PC board.

Note that nothing should be connected to the input or output terminals until these checks are complete.

Set VR2 fully anticlockwise and then apply power. With your multimeter set to read millivolts, measure the voltage across the





This is what the completed amplifier module looks like. Be sure to mount the 5W wirewound resistors about 1mm proud of the PC board, to allow the air to circulate beneath them for cooling. The spare holes in the PC board allow the supply power wiring to be secured in position using cable ties.

output (speaker) terminals. Adjust VR1 for a reading of 0V ±2mV.

That done, set your meter to read 70V or more and measure the voltage across one of the 470Ω 10W resistors. It's not important which one you choose. Rotate VR2 clockwise until you get a reading of 47V. This gives a total quiescent current of 100mA.

Now give the amplifier about 10 minutes to warm up, then readjust VR2 if necessary. It's normal for this reading to vary by a few volts as circuit temperature varies.

To check that each output transistor is doing its job, you can measure the voltages across the 0.47Ω emitter resistors. With about 25mA flowing in the emitter legs, you should get a reading near 11mV across each of these resistors. Note that the innermost pair of resistors also carry the driver transistor (Q8 & Q9) emitter current, so these two will read a few millivolts higher.

Problems?

If you're unable to adjust VR1 or VR2 for the specified readings, then there is a fault somewhere on the board. We've provided voltage readings for various points on the circuit that may help you to track down the problem (see Fig.7, Pt.1). Your readings should fall within ±10% of our listed values.

If everything checks out OK, switch off the power, remove the 470Ω resistors and install the fuses. That's it – your amplifier is now ready for use! ***EPE***

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Circuit Surgery

Ian Bell

More on timing formulae for 555 timers

LAST month we started to answer CherryTree's question from the *EPE Chatzone* (via **www.epemag.co.uk**) about where the formula used in 555 (and similar) RC-based timer circuits come from. We started with a simple RC circuit, in which a capacitor charges through a resistor, as shown in Fig.1. Although this circuit looks very simple – it only has two components, a power supply and a switch – the mathematics required to fully describe it is quite advanced.

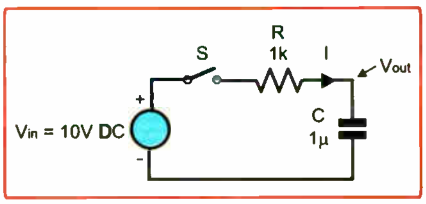

Fig.1. RC circuit. C charges through R when S is closed (from last month)

In fact, you need calculus, specifically a differential equation, to work out what exactly the voltage will be a specific time after the switch is closed. Of course, it is possible to use the result of solving the differential equation – formulae relating voltage and time in the RC circuit – without performing the calculus yourself, and this is what we shall be doing here, but last month we tried to give an informal view hinting at how the calculus works. The resulting formulae are also mathematically interesting (or difficult depending on your perspective!) because they involve the exponential function and Euler's number – more about this later.

Differential Equations

Last month we mentioned differential equations – note that the key word here is *difference*. We showed that with just some basic circuit theory and the defining formula for capacitance we could obtain a simple equation telling us how much time a certain amount of change in V_{out} would take, if we knew the current value of V_{out} (and V_{in} of course). This time depends on the value of RC (the resistance and capacitance values multiplied together), which is known as the time constant.

By actually working out some real values we demonstrated that this approach was only accurate if the changes we looked at were very small. Unfortunately, this means that using the 'difference formula' to work out the voltage at a given time takes a lot of effort if we do it manually. This numerical approach is far from worthless though, and sophisticated versions of it are used in software such as circuit simulators. The massive number of 'small step change' calculations required can easily be performed at great speed by modern computers.

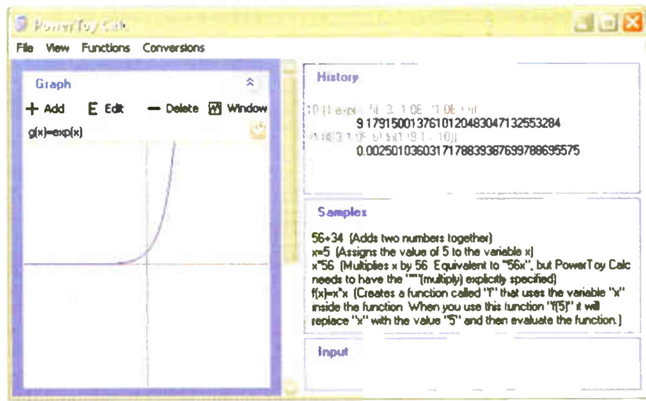

Fig.2. Screenshot of Microsoft PowerToys scientific calculator in use

Finally, we quoted the solution to the circuit's differential equation. This is the formula which gives us the value of V_{out} at time *t* after the switch is closed (we are assuming V_{out} = 0V before S is closed). The equation is:

$$V_{out} = V_{in}\left[1 - \exp\left(\frac{-t}{RC}\right)\right]$$

which possibly does not look very friendly, particularly if you are not already familiar with *exp()* – the exponential function. Last month we noted that you will find it on scientific calculators written either as *exp* or e^x, but you have to be careful as some calculators use *exp* for *enter exponent*, which is denoted *EE* on other calculators.

If you do not have a scientific calculator and want to play with the *exp()* function and capacitor calculations you can get a free PC Windows-XP based scientific calculator from Microsoft PowerToys, see **www.microsoft.com/windowsxp/downloads/powertoys/xppowertoys.mspx** for the download. Fig.2 shows a screenshot of the PowerToys calculator in use.

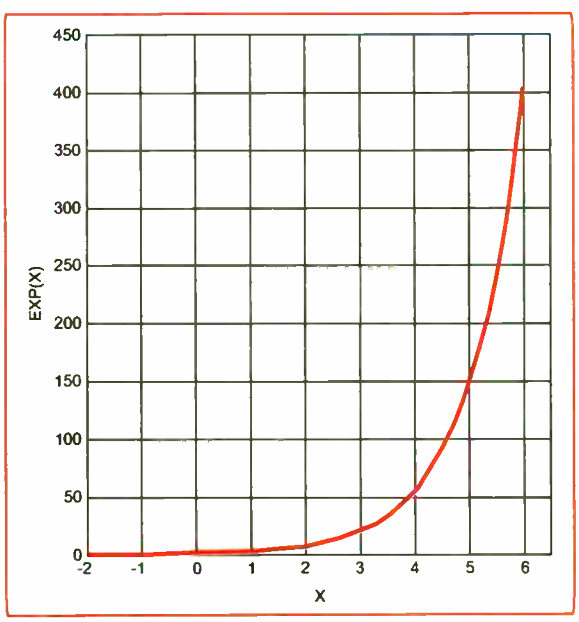

Fig.3. Plot of the exponential function e^x or exp(x) which is fundamental to RC charging. The value varies so dramatically it is impossible to read all the figures from the graph so we have included a table of values. Note that for negative values of x, exp(x) is a small positive value

-2	0.135335
-1.5	0.22313
-1	0.367879
-0.5	0.606531
0	1
0.5	1.648721
1	2.718282
1.5	4.481689
2	7.389056
2.5	12.18249
3	20.08554
3.5	33.11545
4	54.59815
4.5	90.01713
5	148.4132
5.5	244.6919
6	403.4288

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Exponential Function

Having finished recapping and commenting on last month, we will continue this month by trying to get a feel for what the *exp()* function is about. The symbol or e^x is a clue to the nature of the *exp(x)* function, in fact *exp(x)* simply means the number *e* raised to power *x*. Now *e* is a very interesting number, like the better known *pi* (Π) it is one of the most important numbers in the universe because the function *exp(x)* occurs very many times throughout a wide range of engineering, science and mathematics calculations.

The number *e* is approximately 2.718281828459... (this is e^1 or *exp(1)*). Like pi, *e* has been calculated to millions of digits and these digits go on forever in a random (non-repeating) manner.

The number *e* is known as *Euler's number* because the Swiss mathematician Leonhard Euler was the first to use the symbol *e* to represent it in 1727. However, *e* was known before then, with the earliest reference to it being in 1618 by the Scottish mathematician John Napier, who pioneered work on logarithms. So *e* is sometimes also called *Napier's constant*. It is worth noting that *e* has been known about for far less of human history than pi.

Yet another name for *e* is the *magic number of growth* because the exponential function occurs in many formulae relating to growing (and diminishing) quantities, including biological population sizes, interest on loans and, of course, the voltage on a charging capacitor. The plot of *exp(x)* against *x* in Fig.3 shows basic exponential growth, but capacitor charging does not follow this particular curve.

The capacitor charging formula is of the general form (1-*exp*(-x)), rather than simply *exp(x)*. Here, as the magnitude of *x* gets larger (longer time spent charging), the value of *exp(-x)* gets smaller and so (1-*exp*(-x)) gets closer to 1 (the 'final' voltage). The capacitor charging curve is shown in Fig.4

Logarithms

We mentioned that John Napier came across *e* when investigating logarithms and indeed the *exp(x)* function is closely related to logarithms. 'Normal' logarithms use base 10 – the numbers we usually count in. Many readers will also be familiar with base 2 or binary and base 16 or hexadecimal, as these are used extensively in computing. As well as base 10 logarithms, there are *natural logarithms* which use *e* as their number base. It might seem strange using something other than an integer as a number base, but it works in this context.

If we take the log of a number *x* in base 10 logarithms and get a value, say *y*, we write $y = log(x)$. If we know *y* is the log of *x*, we can find *x* from *y* using $x = 10^y$ (ten to the power (*y*). So 'to the power of' reverses the action of taking the log of something. You will find *log* and 10^x keys on calculators. The function *exp(x)* or e^x is the inverse of taking a logarithm in base *e*. The base *e* logarithm function itself is given the name *ln* (*l* for log and *n* for natural). So if $y = ln(x)$ then $x = e^y$. Again you will find an *ln* key on scientific calculators. We will see that *ln* also turns up in formulae relating to capacitor charging and discharging.

An Example Formula

As an example of using the charging formula, we will find the voltage on the capacitor in Fig.1 at 2.5ms after S closes. Using the values from Fig.1 (V_{in} = 10V, R =1kΩ and C = 1μF), we get:

$$RC = 1.0 \times 10^3 \times 1.0 \times 10^{-6} = 1.0 \times 10^{-3} = 1ms$$

So to find the voltage at 2.5ms after S in closed, we calculate:

$$10 \times (1\text{-}exp(-2.5 \times 10^{-3} / 1.0 \times 10^{-3}))$$

or writing both *t* and RC in milliseconds,

$$10 \times (1\text{-}exp(-2.5 / 1)).$$

Using a calculator, we find *exp*(-2.5), which is 0.0821. Subtracting this from 1 and multiplying by 10 gives 9.18V. The voltage against time curve for Fig.1 is shown in Fig.4 and we can see that this value corresponds correctly with the curve.

The exact way in which you best do this on a calculator depends on the model you are using. With the Microsoft PowerToys calculator you can simple type in the whole formula, with the individual R and C values, on the input line as follows:

```
10*(1-exp(-2.5E-3/(1.0E3*1.0E-6)))
```

and the 'virtual' calculator will return 9.1791500... Note that we have entered 2.5ms as 2.5E-3 (for 2.5×10^{-3}) and similarly for the resistor and capacitor values. Also note that the '*' character is used to represent multiply.

But How Long?

So far we have a formula to find the voltage at a given time, but how do we find how long it takes the capacitor to charge to a particular voltage? Obviously we can read it off the curve if we have one, but it would be useful to have a formula for this too. What we have to do is rearrange our voltage formula to make *t* the subject of the equation. We do this as follows:

$$V_{out} = V_{in}\left[1 - \exp\left(\frac{-t}{RC}\right)\right]$$

Dividing both sides of the equals sign by V_{in}, this cancels the V_{in} on the right and gives:

$$\frac{V_{out}}{V_{in}} = 1 - \exp\left(\frac{-t}{RC}\right)$$

Now we subtract 1 from both sides and multiply by -1. This removes the 1 from the right side and the minus sign in front of the *exp*:

$$1 - \frac{V_{out}}{V_{in}} = \exp\left(\frac{-t}{RC}\right)$$

We need to get rid of the *exp* to get *t* on its own. We apply to both sides the inverse function of *exp()*, which, as we saw earlier is *ln()*:

$$\ln\left(1 - \frac{V_{out}}{V_{in}}\right) = \ln\left(\exp\left(\frac{-t}{RC}\right)\right) = \frac{-t}{RC}$$

Now we multiply both sides by *-RC* and swap the left and right hand sides to get our result:

$$t = -RC \bullet \ln\left(1 - \frac{V_{out}}{V_{in}}\right)$$

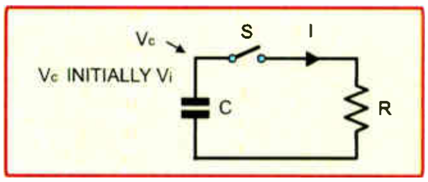

Fig.5. Basic circuit for looking at a capacitor discharging through a resistor

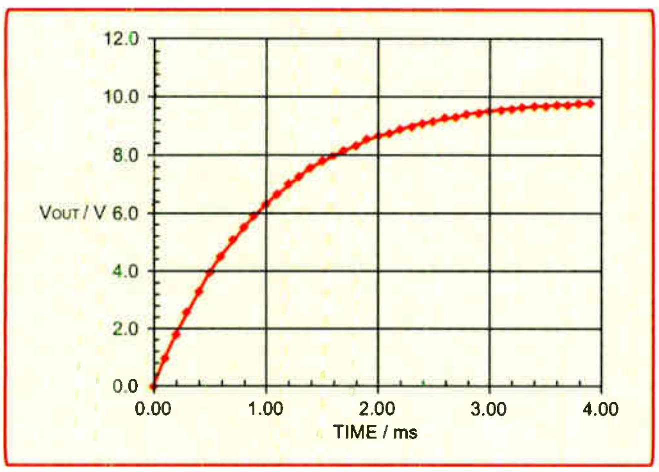

Fig.4. RC charging curve for Fig.1

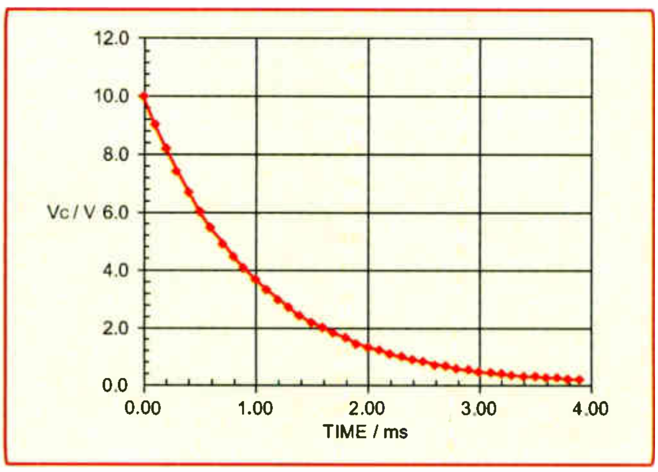

Fig.6. RC discharge curve for Fig.1

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We can check this by reversing our previous example, that is, finding the time taken to get to 9.12V. We first find 9.18/10, which is 0.918. Then we subtract this from 1 to get 0.082. Using a calculator we then find *ln*(0.082), which is -2.5. We multiply this by *-RC*, which is -1.0ms × -2.5, or 2.5ms, as expected. On the PowerToys calculator we can enter the whole formula in one go:

-(1.0E3*1.0E-6)*ln(1-(9.18/10))

which returns 0.00250... as expected.

Capacitor Discharging

Capacitors can discharge as well as charge and any RC-based oscillator circuit, such as the 555, will have to repetitively charge and discharge its timing capacitor. The simple 'theoretical' circuit for a capacitor discharging through a resistor is shown in Fig.5. Here we assume that the capacitor has somehow already been charged to an initial voltage $V_C = V_i$. When we close S, C will discharge through R and V_C will decrease towards zero.

We approach the capacitor discharge problem in the same way as charging, we need a differential equation, but can it approximate with a difference calculation as we did for charging last month? The formula we get by solving the differential equation for Fig.5 is:

$$V_c = V_i \exp\left(\frac{-t}{RC}\right)$$

The time taken to discharge from Vi to Vc is given by:

$$t = RC \bullet \ln\left(\frac{V_i}{V_c}\right)$$

Note that these equations are very similar to, but not exactly the same as, the charging equations. The discharge curve for the circuit in Fig.5, with V_i = 10V and R = 1kΩ and C = 1μF as before is shown in Fig.6.

Now we have our capacitor charging and discharging equations, we can start to apply them to more practical circuits. One of the simplest applications of an RC charging circuit for timing is the power-on reset (POR) circuit, an example of which is shown in Fig.7. This is typically used in digital circuits to hold the master reset active during and just after power-up to ensure that the circuit starts in the correct state.

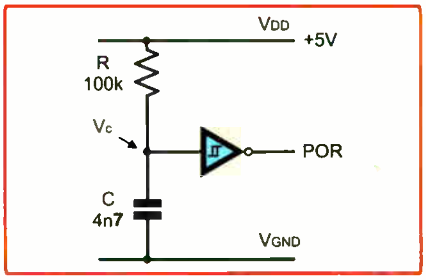

Fig.7. Power-on reset (POR) circuit

The output in Fig.6 stays at logic 1 (5V) until the capacitor charges past the logic switching threshold, at which point it changes to logic 0 (0V). A Schmitt trigger logic gate is used to ensure clean switching with the slowly changing input. The capacitor only charges once – when power is applied – and stays charged throughout circuit operation. When power is removed it will discharge through leakage via the circuit and internally.

If we assume that the logic switching voltage for a change of input logic level from 0 to 1 for the Schmitt trigger in Fig.7 is 2.2V (this is just an example, it is not based on a real device), then using the R and C values from Fig.7 and the charging time equation we can find the length of the reset pulse. Note that V_{in} from Fig.1 is now the supply voltage, V_{DD} (5V in this case) and we have written V_c rather than V_{out} for the capacitor voltage:

$$t = RC \bullet \ln\left(1 - \frac{V_c}{V_{DD}}\right)$$

$$t = -100 \times 10^3 \times 4.7 \times 10^{-9} \times \ln\left(1 - \frac{2.2}{5}\right)$$

$$t = -4.7 \times 10^{-4} \times \ln(0.56) = 270\mu s$$

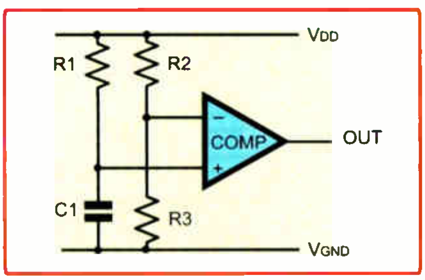

Fig.8. Simple comparator based timer triggered at power-up

Timing Control

The circuit in Fig.7 does not give us very precise control over the timing because it depends on the logic threshold. Furthermore, if we change the supply voltage the time may change, which does not matter too much for the POR circuit, but may not be ideal for other timer applications. The circuit in Fig.8 is better in this respect and, although it may not seem obvious at first, takes us on a big step towards the 555 timer.

Like the POR circuit, the circuit in Fig.8 switches on once at power up, however, it uses a comparator to determine when switching occurs. The switching point is set by the two potential divider resistors R2 and R3. Specifically it is R3V_{DD} / (R2 + R3). By suitable choice of R2 and R3 we can set this voltage to any fraction of the power supply. For example, we could choose to switch when the capacitor voltage reaches two thirds of V_{DD}.

Let's try this situation in the charging time formula. We have $V_{in} = V_{DD}$ as with the POR circuit, but now we can use $V_c = 2V_{DD} / 3$. The charging time formula becomes:

$$t = -R_1C_1 \bullet \ln\left(1 - \frac{2V_{DD}}{3V_{DD}}\right)$$

$$= -R_1C_1 \bullet \ln\left(1 - \frac{2}{3}\right)$$

$$= -R_1C_1 \bullet \ln\left(\frac{1}{3}\right)$$

The natural logarithm of 1/3 is approximately -1.1, so for this circuit we can simply change the timing formula to:

$$t = 1.1R_1C_1$$

The equation no longer has a logarithm in it – so it is 'user friendly' – and the time value does not depend on the supply voltage – very useful for creating a general purpose timer that can operate on a wide range of supplies and is insensitive to supply fluctuations. Next month, starting with this comparator circuit we will work towards the actual 555 timer circuit and its timing formulae.

Sources of information on *e*

http://www.austms.org.au/Modules/Exp/exp.pdf

http://en.wikipedia.org/wiki/Euler%27s_number

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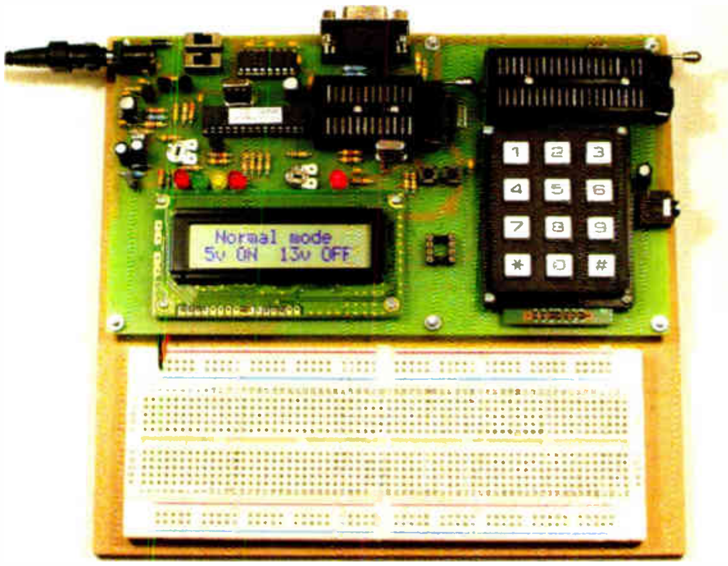

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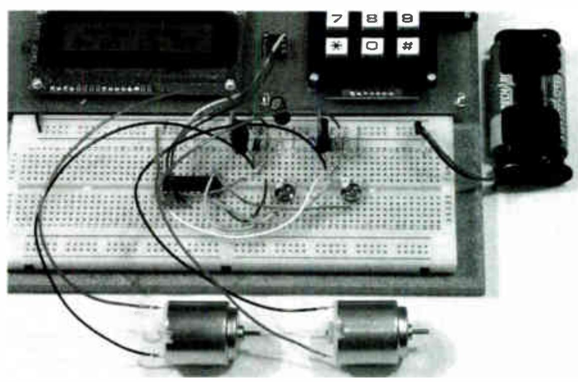

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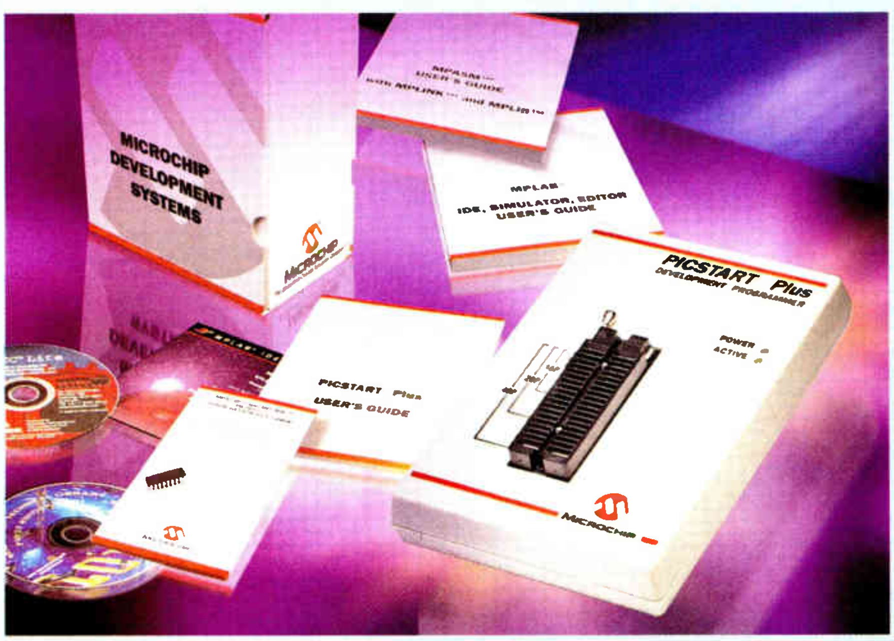

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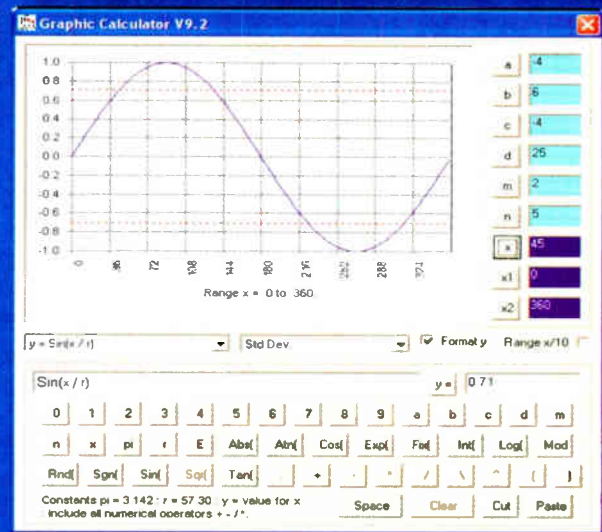

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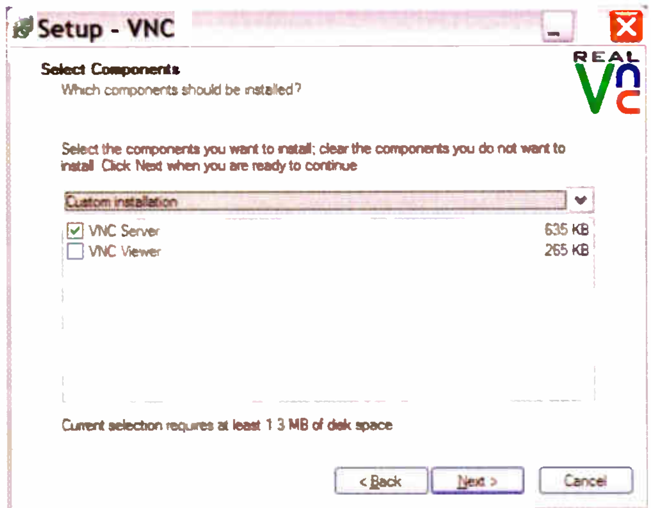
World Radio History

Net Work

Alan Winstanley

Route to your network

With the growth in broadband services, coupled with the stellar drop in hardware prices, it is now easier than ever to install a sophisticated home network that connects multiple PCs or Macs together around the house. A *switch* is used to wire computers together to share data, e.g. over a local area network (LAN). Join multiple LANs together, and you have a wide area network (WAN). A hub is a less efficient version of a switch but does the same job. The purpose of a router is to connect one type of network to another, in our case connecting our home computer(s) to the Internet. A wireless access point (WAP) provides cordless connections to the network – ideal for connecting a wireless laptop or PC to the Internet.



Install RealVNC (virtual network computer) and choose Server and/or viewer mode

Mouse over VNC icon to reveal the computer's IP address

With prices falling, the author recently ditched his separate Linksys switch, ADSL router and WAP boxes in favour of a combined and compact Belkin unit that works more efficiently. The built-in hardware firewall of a router acts as a barrier against intrusion from outside, and some routers offer a built-in wireless access point to share the broadband wirelessly.

The use of network address translation (NAT) means that although a router is connected to the Internet as a node with its own unique IP address, the individual machines on the network behind the router/firewall can use their own local IP addresses. The very fact that a router has a hardware firewall is the best reason why cheap, free USB broadband modems should be thrown away: modems provide zero protection and they merely hook your machine nakedly to the Internet, exposing it to all the anarchy that forms the lifeblood of the Internet's undesirables. Therefore, it is wise to use a router instead of a simple ADSL modem, even if you only have one machine connected to the Internet and only use one port on the router.

Nevertheless, it is possible to breach these defences by launching Trojan horses and viruses that sneak in via emails or other files or malicious web pages: vigilance and strong software protection are required at all times, and the author stands by his recommendation of Avast! antivirus from **www.avast.com**, or AVG from **www.grisoft.com**. Avast! is free for home users and is constantly updated, leaving no excuse to leave home machines unprotected.

As a word of warning, the writer once rebuilt his network from scratch, including rebuilding a new machine from the ground up. During testing of the Internet connection, the system fetched mail from a long-forgotten mailbox – success first time! Unfortunately, the antivirus system had not been enabled (let alone updated for the latest signatures), and the very first virus that arrived immediately spread itself over the LAN and corrupted all the other machines. This was a very painful lesson to learn.

As easy as VNC

At the moment, I am typing on a wireless laptop downstairs in the lounge, half-watching the TV whilst writing Net Work at the same time. The remarkable thing is that, actually, although I am using a laptop downstairs, I am operating a network PC that is situated upstairs. In fact, I am able to use the desktops of any of the machines connected to the same network. This saves a tremendous amount of legwork and – at last – enables multiple resources to be managed in the comfort of a place of one's choosing. You can run software, move files, access other machines and print documents over the network. This flexible way of working can justify the cost of a new wireless laptop to manage everything and work more flexibly.

This system is implemented using a VNC, or virtual network computer. By installing some simple and readily available VNC software onto each machine, users can log into them over the network and operate them as if sat in front of them, using their keyboard and mouse (rather like the principles of Telnet). Based on digital data transmitted over the network, the video image is pixel perfect and interference-free, though it may not handle video or animations very well, depending on bandwidth, and monitor resolutions might need adjustment.

An excellent VNC software package is RealVNC downloadable from **www.realvnc.com**. The software is unintimidating and is easily installed by any reasonably experienced computer user. For each machine that you wish to operate, ensure that the VNC *Server* software is installed and running (e.g. start it automatically when a PC boots up). On each machine that will be utilised to operate other machines, simply install the VNC viewer. A VNC icon appears in the Windows system tray: mouse over it to see the machine's IP address. Operating the VNC is as simple as logging into another machine, using either its local IP address or – easier still – its network name.

This system is also proving beneficial in commercial applications, enabling an IT specialist to log into client machines in order to debug and troubleshoot them. It can even help to train computer users, because the mouse pointer and keyboard of the client machine can be worked in front of their eyes, as if by magic, by the IT technician working remotely. Thus, computer users can be walked through procedures and problems can be fixed remotely. RealVNC understands a number of operating systems, see **http://www.realvnc.com/what.html**. Also check their commercial KVM over IP (KVM is keyboard, video, mouse), it enables you to operate machines anywhere in the world using the same principles.

Windows XP users might also search the Help files for 'Remote Desktop', a similar feature that arrived as part of Windows XP. End-users never seemed terribly confident about utilising it, presumably due to a perceived loss of privacy or security. You can E-mail the writer at **alan@epemag.demon.co.uk**

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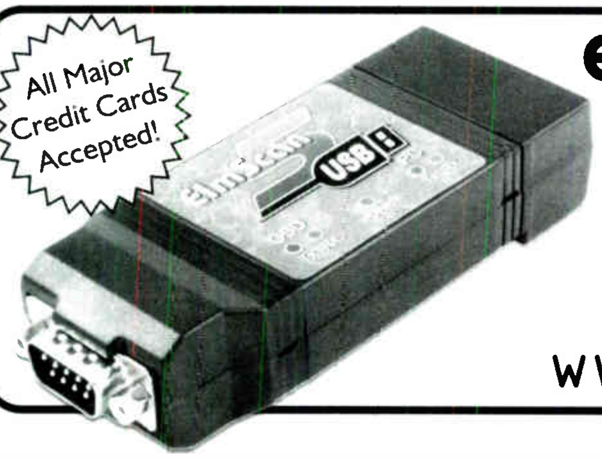

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READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

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★ LETTER OF THE MONTH ★

High Intensity Torch

Dear EPE,

I've recently downloaded my copy of August '06 *EPE*, and noticed with interest the LED torch design. I think that there are some issues that should be looked at with regards to improving the brightness and possible LED lifetime problems.

First, it appears that the LED is simply being provided with battery power via the transistor, while varying the duty cycle of the LED current to provide a constant brightness throughout the voltage cycle of the battery.

Although a reasonable approach with an incandescent lamp, one has to take into account the junction temperature of the LED. Basically the brightness goes down as the junction temperature increases. So running an LED at a high current doesn't necessarily mean highest brightness (disregarding the magic smoke issue for now). The peak current should be determined not by duty cycle, but by refresh rate. With the LED on for a shorter time, the junction temperature will not rise as high. The design might be improved by increasing the frequency of the PWM signal, when the battery voltage is higher. Osram have a discussion on this effect in their application note: **http://catalog.osram-os.com/media/_en/Graphics/00017058_0.pdf** (page 15 onwards).

The internal resistance of the battery will also be a factor in the LED current. Different battery types will give higher/lower brightnesses. The torch mod types over at **candlepowerforums** have many threads on this issue.

Additionally, if the junction temperature exceeds the maximum rating, the life of the LED will be reduced due to the internal stresses of the resin on the die connections. Zapping an LED with high currents will reduce the lifetime of the LED, by how much is no doubt hard to determine, but should be considered. Use of high frequency PWM and good thermal design are important factors to reduce the amount of time the LED spends heating up the resin.

Odds are for most people, the battery voltage V_{ce} of the transistor will be enough not to stress the LED except when the battery is newly charged, but it might be interesting for anyone constructing the device to measure their peak currents rather than average currents and doing the maths on their LEDs to see if the junction temperature is being exceeded, and for how long.

Philip Pulle, RGB Sunset Productions, www.rgbsunset.com, via email

Thanks Philip, you've highlighted an issue that most people will not have considered.

Rushing Nostalgia

Dear EPE,

I was having a nostalgia rush the other day! I bought a CD from Old Colony Labs in the USA where I now live, which has the early issues of the American magazine *Audio Amateur* from 1970-1979. In there was an advert for Electrovalue America, which made me think of the '70s when I was buying parts in the UK from Electrovalue, and was buying the odd *Everyday Electronics* magazine.

I came across your online forum, and was saddened at the discussion of the demise of Electrovalue, and then saw the links to *PE* and *EE* history. I was fascinated to see the picture of *EE* December '74 – I believe I bought that copy and think I still have the data check card somewhere, and probably some of the fold out component information sheets (e.g. resistor colour codes). Not sure if I have any complete magazines left from those times – I used to tear out interesting articles, so probably still have some of these.

EE taught me a lot about electronics, a career I have had for the last 26 years since leaving Lanchester Polytechnic (now Coventry University). I now work for the Bose Corporation in Massachussetts, designing audio amplifiers for automotive applications.

Ah, fond memories!

Paul Joyce, Milford, NH USA, via email

Paul had sent his comments direct to Alan Winstanley, who replied:

Paul, many thanks for your mail. It is always terrific to receive appreciative mail from readers – we know that very many hobbyists and enthusiasts pass through our hands on their way to better things in their career, and we're really proud of the part we play in helping our readers to develop their interest in electronics.

You would find that the magazine has changed a lot (as has the technology we routinely deal with). A downloadable PDF version is available from **www.epemag.com** and back issues can be bought online from **www.epemag.wimborne.co.uk**.

Best wishes from everyone here at *EPE*!

Alan Winstanley, On-Line Editor, alan@epemag.demon.co.uk, via email

Sorting Strings

Dear EPE,

Regarding Craig Patterson's query about strings (July '06). In VB6 I use a list box with the properties set to *sort*. Add each letter to the list box and it is automaticaly sorted ascending. Just read out the list. I am using this to make my own crossword solver for anagrams.

Ken Smith, Capetown, South Africa, via email

Thanks Ken. Yes, all you need to do is write a subroutine to take each letter of the string(s) and enter it into the box, and then recompile it to just one long string after sorting has been done by the automatic process. It could be easy enough I guess.

Strings Sorted

Dear EPE,

I'd like to thank Richard Graham for his reply (*Readout* Sept '06). The function as shown couldn't be more suited to my application if he'd had a list of criteria. So thanks again and also to John Becker.

Craig Patterson, via email

Thanks for telling us Craig.

World Radio History

Power Factor Correction

Dear EPE,

The other day I was building an AC lamp control circuit using a PIC and I found that it is very easy to create a zero crossing detector using the op amp input. It then occurred to me that if I could detect the current waveform within the AC and determine the current zero crossing point, then I could use the time difference between the two to work out the power factor.

Some quick sums indicated that the correction capacitors would be in the region of a few microfarads. I see Maplin do a range of motor start capacitors from 2μF to 30μF. But how to measure the current in the incoming supply? The usual way would be a current transformer but that involves breaking the supply to fit it and there is the added problem of high voltages if the circuit's secondary winding gets disconnected.

But I wonder if a Hall effect transducer taped to the outside of one of the cables would give an AC output in phase with the current. The leads from the incoming cable to the consumer unit are often two individual single cores and so it would be easy to get close to the incoming line and there is no tricky disconnection required.

Using a PIC to determine the power factor lag, which almost always is because of the inductive loads in household machines, it would be possible to switch in the appropriate capacitors to correct the lag. If we use thyristors to do the switching through opto-couplers then the whole thing is solid state and with some judicious time lags to stop oscillation it could save some cash. The connection to mains would simply be a three-pin plug somewhere close to the incoming supply, but this is not critical.

This is as far as I have got. I don't know if the Hall Effect sensor will work and I haven't a scope to check it (or the time to work it all out yet.) So is this an idea for you to run with?

Just a thought.

Bruce Beattie, via email

Bruce, I'm not too familiar with designs based around AC mains, preferring to stick with low voltage DC that is no potential hazard to our readers.

In principle, a Hall effect device will be sensitive to local magnetic fields around it, but only minutely and the signal needs amplifying in some way before it becomes useful. Conventionally, a transformer of some sort is used to amplify mains current magnetic fields to make it easier for the Hall device to sense them.

As shown by commercial mains current detector clamps, it is not necessary to break into the mains cable, the transfomer windings being wrapped around the cable to be monitored. The wrapping does not need to be a tight fit and can consist of coils in a sort of horseshoe formation through the centre of which passes the cable. The two sides of the horseshoe are often hinged to allow the clamp to be opened to allow the cable to pass through – see our Current Clamp Adaptor for Multimeters *in the Jan '06 issue.*

I'm not clear how you would intend to use the capacitors, but you're not going to be able to pass large currents.

I regret I've no wish to design something to meet your needs, even though it would be PIC-based! But by quoting your letter here, let's see if readers have any suggestions to make. You could also ask your question on our Chat Zone *(via **www.epemag.co.uk**) where many readers chat with each other and get help.*

Camels and VB6

Dear EPE,

Readers interested in trying out VB.NET 2005 as a vehicle for interfacing via the parallel and serial ports have an alternative to getting it from Microsoft in the form of a massive download.

At least two relatively inexpensive books have been published accompanied by a CD holding the NET framework and Visual Basic 2005 Express edition. *Build a Program NOW! Microsoft Visual Basic 2005 Express Edition* by Patrice Pelland, explains how to do just that. *Mastering Visual Basic 2005 Express Edition* by Evangelos Petrousos and Acey J. Bunch is more in the nature of a reference book.

Once the NET framework is installed on a machine it is worth downloading the 4.2MB SharpDevelop 2.0. This is a free, OpenSource, IDE for developing NET programs. At present it comes with compilers for Visual Basic, C#, and a language called Boo. A couple of nice features are the facility to instantly convert a useful bit of C# code to VB.NET code for incorporation into a program and the provision of a serial port component. I find SharpDevelop 2.0 to be a more congenial environment in which to program than Visual Studio.

I never felt happy using VB6, which always reminded me of the old saying about a camel being a horse designed by a committee, and quickly moved to Delphi. I originally ignored VB.NET, wrongly assuming it would have all the faults of VB6. It was a pleasant surprise to find it gave me the things I like in Delphi; strong typing and the ability to detect many errors at compile time. It is definitely worth a look at.

Dr Les May, Rochdale, Lancs, via email

Thanks Les. Personally, I get on very well with VB6 and seldom have trouble.

13.5V PSU

Dear EPE,

I refer to your *Dirt Cheap High Current Bench Supply* in the July '06 issue. Some years back I suggested to a competitor mag of yours an article on using a PC PSU for this sort of project. They declined to do it, so congratulations on publishing one.

One thing that's missing I think in the article is that, without a dummy load connected, the PSU may not start up. I wasted a lot of time wondering why my PSU had no volts at all at the output, and no oscillations in the switching chip. The article does mention testing it with a load, but does not say it *has* to be connected. Mine needs to draw more than 0.5A on +5V and +12V outputs before it starts up. My PSU is a Seventeam 220, whereas the one featured was a 230.

Edward Chase, via email

Thanks Edward, that looks useful.

Positive Feedback

Dear EPE,

Just a few words on the 'new look magazine', now that it's had a few issues to mature. I was initially quite concerned that another revision to the format was going to happen. For many other magazines, a format revision was often the last thing that happened before their collapse. I held my breath for a while, I can tell you. Glossy, colour pages seem to have heralded death for others.

On the UK newsagents' shelves, there are precious few mags for electronics and radio enthusiasts these days. The list of survivors is short and the list of the dead, long. Over the years, I've regularly bought numerous, now defunct, titles.

The common thread amongst them? A mix of information, instruction and construction articles. That's what I like. Sadly, the number of 'us' that enjoy the achievement and technical challenge of building something seems to have radically dwindled, judging by the loss of titles over the years, and I suppose it is, in some part, due to the instant gratification of the iPod and mobile phone era. To me, there's no magic in them – not like that through having built your own hi-fi or superhet.

I see your association with *Silicon Chip* magazine and I hope this is the way to go to preserve the publication. Certainly amalgamation, in a way, of readerships in similar English-speaking countries is probably a way to keep reader numbers up and to ensure a flow of good-quality articles and projects from contributors. Jaycar kits seem very good from my experience of them.

That matter could ramble on into questions about the way components suppliers have also withered away or gone over to selling kids toys and gizmos.

So, well done. Please, please, keep it up or I'll have to resort to buying woodworking tools!

Bill Jones CEng MIET,
Senior Component Engineer,
Ford PD Europe, via email

Thanks for that Bill. I too have seen many changes in the hobby during the forty-odd years I've been connected with it in many ways. What we have now is a hard-core of interested readers, yet new people are coming in to participate on a regular basis, which is good for the hobby. Despite misgivings in the past, I look at the future with confidence.

World Radio History

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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 to your door. Full ordering details are given on the last book

For a further selection of books see the next two issues of *EPE*.

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Robotics

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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. Then 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.

Details building and programming instructions provided, including numerous step-by-step photographs.

288 pages – large format **Order code BP901** **£14.99**

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 'waiter 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**

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224 pages **Order code MGH1** **£16.99**

Radio

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£18.99**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£4.45**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£5.49**

Computers and Computing

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages **Order code BP600** **£8.99**

HOW TO BUILD YOUR OWN PC – Third Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format **Order code MGH2** **£20.99**

PIC YOUR PERSONAL INTRODUCTORY COURSE SECOND 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 PIC's 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 second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

270 pages **Order code NE36** **£16.99**

eBAY FOR BEGINNERS
Cherry Nixon

There are two kinds of people, those who are trading on eBay and the rest who are missing out. Though eBay has been embraced by entrepreneurs all over the world, it remains the peoples' site and offers the largest market for the smallest fee.

eBay presents an opportunity for everyone, the trick is to master it. This book shows you how to start trading on eBay UK. It also offers advice on getting organised and tips to put you ahead.

The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaining eBay and how to trade on it there are sections on Paypal, producing pictures of your sale items, fees and accounts, safety and security including what to do when things go wrong and what protection is provided.

178 pages **Order code BP551** **£8.99**

NEWNES PC TROUBLESHOOTING POCKET BOOK – THIRD EDITION
Howard Anderson, Mike Tooley

All the essential data for PC fault-finding and upgrading. This book provides a concise and compact reference that describes, in a clear and straightforward manner, the principles and practice of fault-finding and upgrading PCs and peripherals. The book is aimed at anyone who is involved with the installation, configuration, maintenance, upgrading, repair or support of PC systems. It also provides non-technical users with sufficient background information, charts and checklists to enable the diagnosis of faults and help to carry out simple modifications and repairs. In order to reflect rapid changes in computer technology (both hardware and software) this new edition has been completely revised and rewritten.

256 pages **Order code NE41** **£19.99**

World Radio History

Theory and Reference

ELECTRONIC CIRCUITS – FUNDAMENTALS & APPLICATIONS
Third Edition
Mike Tooley

A comprehensive reference text and practical electronics handbook in one volume – at an affordable price!
New chapter on PIC microcontrollers – the most popular chip family for use in project work by hobbyists and in colleges and universities.
New companion website: spreadsheet design tools to simplify circuit calculations; circuit models and templates to enable virtual simulation; a bank of on-line questions for lecturers to set as assignments, and on-line self-test multiple choice questions for each chapter with automatic marking, to enable students to continually monitor their progress and understanding.
The book's content is matched to the latest pre-degree level courses, making this an invaluable reference for all study levels, and its broad coverage is combined with practical case studies, based in real-world engineering contexts throughout the text.
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400 pages **Order code NE43** **£21.99**

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (Max) Maxfield

BOOK PLUS CD-ROM

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

500 pages **Order code BEB1** **£27.50**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

CD-ROM

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!
Over 800 pages in Adobe Acrobat format

CD-ROM **Order code BEB2 CD-ROM** **£21.95**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

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

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

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.

Breadboard 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 equiped lab.

288 pages **Order code NE42** **£10.99**

THE AMATEUR SCIENTIST CD-ROM – VERSION 2

CD-ROM

The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards. Plus over 1,000 pages of helpful science techniques that never appeared in *Scientific American*.
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MAKING MUSIC WITH YOUR COMPUTER
Stephen Bennett

Nearly everyone with musical aspirations also has a computer. This same computer can double as a high quality recording studio capable of producing professional recordings. This book tells you what software and hardware you will need to get the best results.

You'll learn about recording techniques, software and effects, mixing, mastering and CD production.

Suitable for PC and Mac users, the book is full of tips, "how to do" topics and illustrations. It's the perfect answer to the question "How do I use my computer to produce my own CD?"

92 pages **Order code PC120** **£10.95**

QUICK GUIDE TO ANALOGUE SYNTHESIS
Ian Waugh

Even though music production has moved into the digital domain, modern synthesisers invariably use analogue synthesis techniques. The reason is simple – analogue synthesis is flexible and versatile, and it's relatively easy for us to understand. The basics are the same for all analogue synths, and you'll quickly be able to adapt the principles to any instrument, to edit existing sounds and create exciting new ones. This book describes: How analogue synthesis works, The essential modules every synthesiser has; The three steps to synthesis; How to create phat bass sounds; How to generate filter sweeps; Advanced synth modules; How to create simple and complex synth patches; Where to find soft synths on the Web.

If you want to take your synthesiser – of the hardware or software variety – past the presets, and program your own sounds and effects, this practical and well-illustrated book tells you what you need to know.

60 pages **Order code PC118** **£7.45**

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages **Order code PC119** **£7.45**

THE INVENTOR OF STEREO – THE LIFE AND WORKS OF ALAN DOWER BLUMLEIN
Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

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

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

420 pages **Order code NE32** **£17.99**

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.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

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** ~~£10.95~~ **£5.45**

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Data and Design

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 rythm 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.

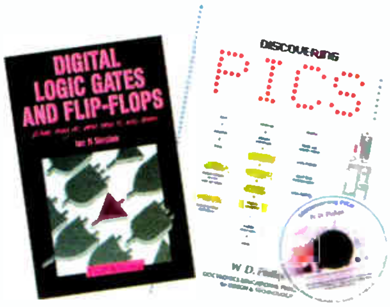
88 pages **Order code BP299** **£5.49**

DIGITAL LOGIC GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explaination of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**



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**

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** **£23.99**

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones*. These books include the *Comprehensive Radio Valve Guides*. Also Jonathan Hill's excellent *Radio Radio*, a comprehensive book with hundreds of photos depicting the development of the British wireless set up to the late 1960s.

The four volumes of our own *Wireless For the Warrior* by Louis Meulstee are also available. These are a technical history of radio communication equipment in the British Army and clandestine equipment from pre-war through to the 1960s.

For details see the shop on our UK web site at **www.epemag.co.uk** or contact us for a list of *Radio Bygones* books.

Project Building & Testing

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**

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. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

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**

DISCOVERING PICS
W.D.Phillips

BOOK PLUS CDROM PLUS HARDWARE

A good introduction to PIC programming, covering everything you need to know to get you started. No previous knowledge of microcontrollers is required, but some previous experience with electronic circuits is assumed. Covers the basic concept of a microcontroller, fundamentals of a PIC-based circuit and using the MPLAB program. Further chapters introduce binary, PIC architecture, the instruction set, the PIC memory map and special registers plus real world programming. Four simple projects are also fully described; a Wavy Wand, an Electronic Dice, a Games Timer and a Pulse Monitor.

The associated CDROM contains the book in PDF format, MPLAB (plus instruction manuals in PDF format) and all the programs covered in the book as assembler (ASM) files.

In addition a p.c.b. based hardware kit is also available that makes up into the Wavy Wand which will spell out a short message via a line of l.e.d.s when waved through the air.

190 pages, A4 spiral bound

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EPE PIC PROJECTS VOLUME 1 MINI CD-ROM

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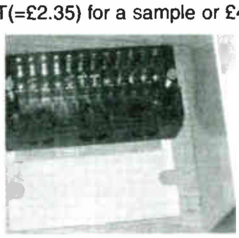


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