THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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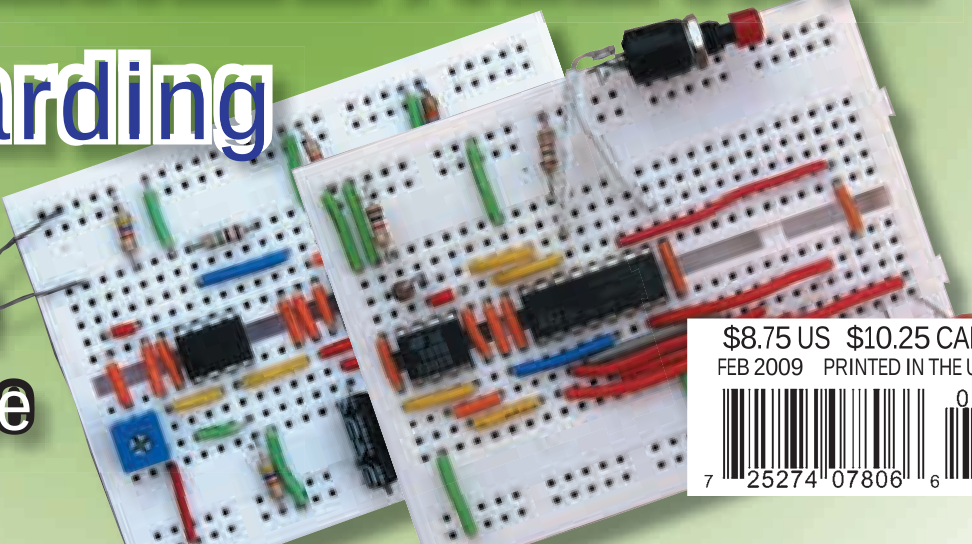

$8.75 US $10.25 CAN
FEB 2009 PRINTED IN THE UK
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ISSN 0262 3617
• PROJECTS • THEORY •
• NEWS • COMMENT •
• POPULAR FEATURES •
VOL. 38. No 2 February 2009

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INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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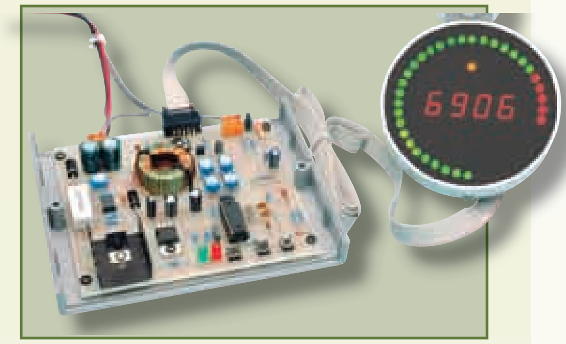

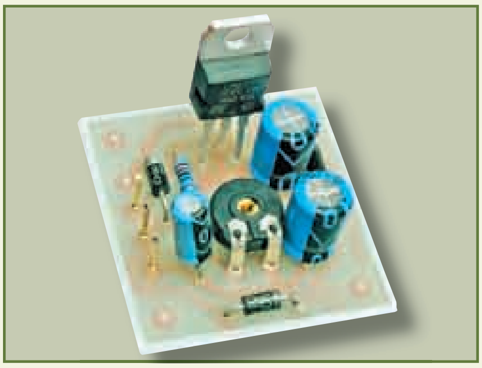

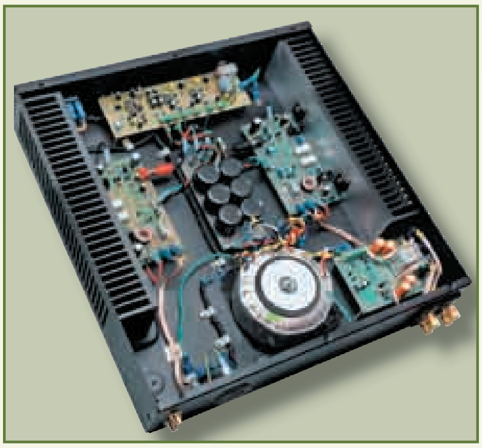

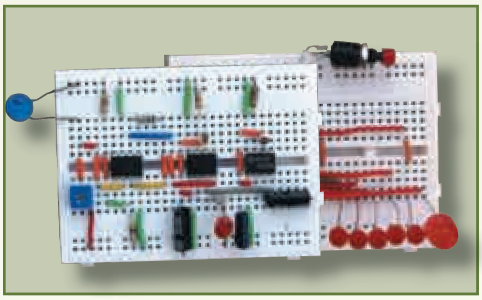

Projects and Circuits

Series and Features

Regulars and Services

Our March 2009 issue will be published on Thursday 12 February 2009, see page 72 for details.

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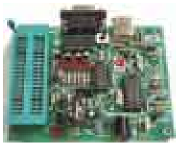
PIC & ATMEL Programmers

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

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

NEW! USB & Serial Port PIC Programmer



USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149KT - **£39.95**
Assembled Order Code: AS3149 - **£49.95**

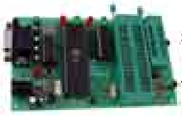
NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.
Assembled Order Code: AS3128 - **£44.95**
Assembled with ZIF socket Order Code: AS3128ZIF - **£59.95**

'PICALL' ISP PIC Programmer

Will program virtually all 8 to 40 pin *serial-mode* AND *parallel-mode* (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.
Assembled Order Code: AS3117 - **£24.95**
Assembled with ZIF socket Order Code: AS3117ZIF - **£39.95**

ATMEL 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**

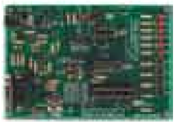
Introduction to PIC Programming

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**

PIC Programmer Board

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

PIC Programmer & Experimenter Board



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

Controllers & Loggers

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

USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: VK8055KT - **£20.95**
Assembled Order Code: VVM110 - **£39.95**

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two *& Ten Channel versions also available.*
Kit Order Code: 3180KT - **£44.95**
Assembled Order Code: AS3180 - **£54.95**

Computer Temperature Data Logger

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

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

4-Ch DTMF Telephone Relay Switcher

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

8-Ch Serial Port Isolated I/O Relay Module

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

Infrared RC 12–Channel Relay Board

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

Audio DTMF Decoder and Display

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

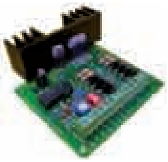
Telephone Call Logger

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

Hot New Products!

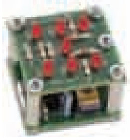
Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

Bipolar Stepper Motor Chopper Driver



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

Shaking Dice

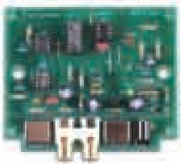


This electronic construction kit is great fun to build and play with. Simply shake and watch it slowly roll to stop on a random number.
Kit Order Code: VMK150KT - **£9.95**

Running MicroBug

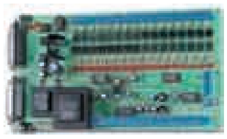
This electronic construction kit is an attractive bright coloured bug-shaped miniature robot. The microbug is always hungry for light and travels toward it!
Kit Order Code: VMK127KT - **£9.95**

Video Signal Cleaner



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

PC Interface Board



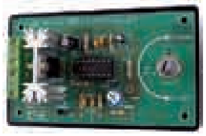
This interface card excels in its simplicity of use and installation. The card is connected in a very simple way to the printer port (there is no need to open up the computer). Likewise there is no need to install an extra printer port, even if a printer is to be used. This can be connected to the card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

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

Motor Speed Controllers

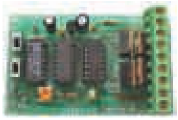
Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)



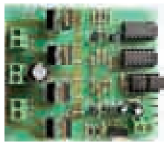
Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£21.95**

PC / Standalone Unipolar Stepper Motor Driver



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

Bi-Polar Stepper Motor Driver



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

Bidirectional DC Motor Controller

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

AC Motor Speed Controller (700W)

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

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Electronic Project Labs

Great introduction to the world of electronics. Ideal gift for budding electronics expert!

500-in-1 Electronic Project Lab

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

Tools & Test Equipment

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

Two-Channel USB Pc Oscilloscope

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

Personal Scope 10MS/s

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

See website for more super deals!

No.1 FOR KITS

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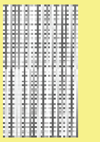
Secure Online Ordering Facilities • Full Product Listing, Descriptions & Photos • Kit Documentation & Software Downloads

PCB Production - Development

0.1" Copper Stripboard

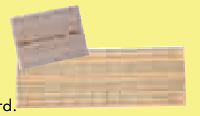
Size	Tracks/Holes	
25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
95 × 127mm	36T / 50H	£1.41
95 × 432mm	36T / 170H	£4.39
100 × 100mm	39T / 38H	£1.40
100 × 500mm	39T / 199H	£7.50
119 × 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99



Solderless Breadboard

Tie Points & Size		Power Rails	
390	81 x 60mm	2	£2.75
840	175 x 67mm	2	£4.86
740	175 x 55mm	1	£3.32
640	175 x 42mm	0	£3.08

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



PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)

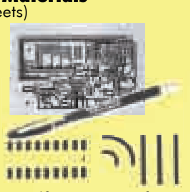
Clear Manual Film	£1.20
Clear Laser Film	£1.75
White HQ Laser Film	£4.62

Etch Resist Pens

"Dalo" Pen	£3.36
"Staedtler" Fine Pen	£1.20

Etch Resist Transfers

Seno mixed DIL pads	£2.24
Seno mixed Rnd pads	£2.24
Alfac mixed pads	£1.84
Transfer Spatular	£1.25



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

Soldering Irons

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

25W 240V Ceramic	£6.00
30W 240V Basic	£4.68

Desolder Pumps

Basic 165 x 18mmØ	£2.85
Antistatic 195mm	£4.12
Antex Mini 198mm	£6.52
Antex Pro 210mm	£11.11

Soldering Station

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

Model 167-540 £49.00

Soldering Station

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

Model 167-570 £52.23

Digital Multimeter

Model: 121-120
Price: £11.47

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

Technical Specifications

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

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PCB Production - Processing Equipment

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

UV Exposure units

2 x 8W Tubes, 6 min timer
229 x 159mm working area
Model 332-002 £95.00
4 x 15W Tubes, 7½ min timer
330 x 260mm working area
Model 332-004 £207.99

Chemical Processing

Low cost plastic tray £2.90
Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable.
ET20 Low cost Etching Tank with heater &pump. £42.84
Universal Tank with heater
Model 333-007 £160.00
Bubble etch Tank with heater & bubble pump.
Model 333-004 £196.00
Any of these items, carriage £5.50

PCB Production - Tools

Drill Bits

HSS parallel shank bits available in sizes from 0.3mm to 2.0mm

0.3-0.95mm in 0.05mm steps	£0.60ea	£4.00/10
1.0-2.0mm in 0.1mm steps	£0.40ea	£3.60/10

HSS Reduced shank (2.35mm) bit available in sizes from 0.6mm to 1.7mm in 0.1mm steps £0.84ea £7.60/10

Reground Tungsten carbide reduced shank available in sizes from 0.6 to 1.6mm in 0.1mm steps £1.90

Drilling Machines

Expo Zircon 12V drill, 3.8mm capacity, 11900rpm £14.20

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

SPECIAL PRICE £31.02

Servisol Products

Aerosols

200ml	Switch Cleaner	£2.61
200ml	Freezer	£4.75
400ml	Foam Cleanser	£2.60
400ml	Cleaner / lubricant	£2.99
75ml	Vide Head Cleaner	£1.94
200ml	Aero Klene	£3.90
200ml	Aero Duster	£5.89
400ml	Isopropyl alcohol	£3.58

Tubes

10g	Heatsink Compound	£1.66
25g	Heatsink Compound	£2.60
50g	Silicone grease	£3.16

Bench Power Supplies

A range of single output regulated bench power supplies with variable voltage & current limiting. Features: Short circuit and "Foldback" overload protection, Metal case with on/off switch, outputs via Red, Black & Green (Earth) 4mm shrouded sockets.

Model 461-540	**0-20V 2A**	**£19.95**
Model: 461-550	**0-30V0-3A**	**£67.95**
Model: 461-552	**0-50V 0-3A**	**£69.50**
Model: 461-554	**0-30V 0-10A**	**£145.00**

Panel Meters

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

All meters £5.89 each

Range	Int Ω
0-50uA	6k5
0-100uA	1k0
0-1mA	200Ω
0-10mA	2Ω6
0-50mA	1Ω2
0-100mA	0Ω65
0-500mA	0Ω12
0-1A	60mΩ
0-3A	20mΩ
0-5A	12mΩ
0-15A	4mΩ
0-10V	10k
0-15V	15k
0-30V	30k
±50uA	1k9

Magnifying Desk Lamp

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

Model: 028-205 £28.80

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PCB Production - Laminates

Copper clad - paper

Single sided low cost paper composite board

100 × 160mm Board	£0.58
100 × 220mm Board	£0.62
160 x 233mm Board	£1.34
220 x 233mm Board	£1.86
8" x 12" Board	£2.22

Copper clad - glass fibre

Single & Double 1.6mm 305g/m²

100 × 160mm Single	£1.06
100 × 220mm Single	£1.49
160 x 233mm Single	£2.29
220 x 233mm Single	£3.50
8" x 12" Single	£3.98
100 × 160mm Double	£1.09
100 × 220mm Double	£1.23
160 x 233mm Double	£2.30
220 x 233mm Double	£2.90
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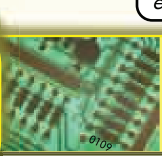

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EPE EVERYDAY PRACTICAL ELECTRONICS

THE UK'S NO.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
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Email: enquiries@epemag.wimborne.co.uk
Web Site: www.epemag.com
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VOL. 38 No. 2 FEBRUARY 2009

Happy New Year

It's hard to believe, but it's now a year since I became editor of EPE. I have thoroughly enjoyed my first 12 months working with the team at Wimborne Publishing, helping to produce a first-rate magazine, backed up by an active and well-designed website. We particularly appreciate the input from you, the readers, whether it is informal on-line discussions in the 'Chat Zone', letters to the editor or the fascinating designs you dream up for Ingenuity Unlimited. Please do carry on, your contributions are an important part of EPE's success.

I hope that like me you are enjoying our new series on recycling components. It is a dreadful waste to just throw out obsolete machines when half the contents (power supplies, displays, switches) are still perfectly useable. This is one of the great pleasures of electronics – applying ingenuity and inventiveness to get something of value for next to nothing.

One small word of caution though, especially for our younger readers: do be very careful when recycling mains-powered or mains-related components. If in doubt, always get advice from someone with experience about the suitability of a component for a new project, and remember that heat dissipation can be as important as electrical insulation or grounding. Devices that get warm under normal use can get dangerously hot if they are not given adequate ventilation through natural or forced air flow.

Where I live in Brighton the recycling bug certainly seems to be alive and well. I have hung on to a fair amount of IT equipment, hoping that I could find a use for it, but in the end I decided that I was too busy to make much of it. Rather than 'skip it', I tried leaving it next to our communal council bin – two PCs, three Macs, two printers and a huge CRT monitor. Well, the silicon vultures descended, and within 12 hours it had all gone, hopefully being recycled by resourceful EPE readers as I write!

Matt

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years' old. Letters requiring a personal reply must be accompanied by a stamped self-addressed envelope or a self-addressed envelope and international reply coupons. We are not able to answer technical queries on the phone.

PROJECTS AND CIRCUITS

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

COMPONENT SUPPLIES

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

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NEWS

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

Freesat and Apricot

Barry Fox reports on two product introductions – one new and the other a revival

First Freesat+ recorder

The first Freesat+ recorder, the FOXSAT-HDR from Humax, is now on sale for £300, and Freesat is finally offering consumers advice – albeit none too clear – on what kind of dish they need to let a dual tuner recorder record one channel while watching another, or record two channels.

Humax told Freesat soon after the May '08 service launch that it was essential to warn consumers of the need to install a dual LNB for future use of a recorder, because Humax feared future calls from confused customers.

Freesat acknowledged in July '08 'that there needs to be further information on installation, etc, so this is definitely something that is in development and will be improved upon over the next few weeks.'

In early Oct '08 there was still no sign of advice. Now there is advice in the Freesat website FAQ, but it is still not clear.

Instead of posing the simple questions 'What kind of dish should I have installed if I want to use a Freesat recorder?', Freesat's web site FAQ asks the question: 'How many cables will I need from my satellite dish to connect to Freesat+?'.

This is likely to confuse because Sky dishes with quad LNBs use what looks like a single cable, made from four bonded strands.

Freesat says "we try and provide clear information to consumers on our website without confusing them with lots of technical detail".

MD Emma Scott puts the price for a dual LNB installation at £120 instead of the usual £80 and claims: "40% of customers are up-sold to a dual LNB."

Freesat is confident that no consumers have been disadvantaged because its "call centre staff were explicitly briefed to explain recorder installation".

Freesat asks if we have heard 'anything from consumers to the contrary'. As no dual tuner recorders have yet been sold, no viewers have yet had the chance to find out they cannot record one channel while viewing another.

Blast from the past

Twenty years ago, Sir Clive Sinclair's devices were fine for hobbyists, but Apricot was the Great British Hope for home office computing. Apricots were designed to compete with pre-Mac Apples and the IBM PC. The first models had two 3.5-inch floppy drives and were beautifully styled. But they were infuriatingly not fully IBM compatible. The disc formatting was slightly different and the screens incompatible. Quality control at the factory was poor. The power supplies overheated and solder joints opened up. The venture collapsed and in 1990 Mitsubishi bought the brand name – and then closed the factories.

Now Apricot is back, in a highly competitive market, with small laptops that look much like other laptops and are similarly priced; Linux versions cost £279, and Windows XP costs £49 extra. Says CEO Shahid Sutan: "My partner, Julien Clairet and I have been negotiating for years to buy the trademark. We are now bringing the brand back. The components of course come from the Far East but the laptops are assembled in the UK."

GROUND-BREAKING

Microchip has announced that work has started on building its new European headquarters located in the Winnersh Triangle, near Reading. The ground-breaking ceremony took place on 18 September 2008 and completion of the new building is scheduled for September 2009.

Part of a £100 million development scheme for the Winnersh Triangle, Microchip's new headquarters will be purpose-built to house their European sales and support teams, as well as a state-of-the-art regional training centre with extensive training rooms, conference suites and laboratories.

Gary Marsh, Microchip's European VP Sales, explains; "Building the new European headquarters to our own specifications gives Microchip the opportunity to create one of the industry's most advanced training centres. Easy access to customers throughout the UK and Europe, and a comprehensive programme of workshops and seminars, will allow customers to enhance their skills in embedded solutions, RF and analogue design. The training centre will also enhance our opportunity to engage in a two-way dialogue with our customers, which will help to shape the development of future Microchip products."

The new building will integrate innovative features designed to reduce carbon emissions to levels which are around 50% lower than conventional buildings. These features include a heat-recovery system to recycle warm air, peripheral infra-red lighting and access to a bore-hole to provide a sustainable source of water for heating and cooling.

Navigation with a rear view

The Travel Liberty 7 is Sevic's brand-new GPS navigation device, with a 4.3-inch TFT touch screen as well as a rear view camera. The device features: GPS-navigation; 4.3-inch TFT touchscreen; 2D/3D map depiction; day and night mode; voice guidance; points of interest (POIs); intelligent destination search; warning signal if you exceed the speed limit; zoom function (zoom-in/zoom-out); favourites; prepared for TMC (optional accessory, not available for all countries); European maps (Teleatlas); Bluetooth; camera. The Teleatlas European map, including POIs, is pre-installed onto the provided 2GB SD card. An intelligent destination search makes using the pilot incredibly simple. It costs: 349.00 Euro.

For more information, contact Sevic Systems Luxembourg SA, Zone Industrielle Bommelscheuer, L-4901 Bascharage, Luxembourg. Tel: + 352 (0) 26 65 65. Email: info@sevic.com. Web: **www.sevic.com**.

PEAK EXPANSION

Peak Electronic Design has recently expanded their distributor network with the appointment of five new distribution partners. Now the famous Peak Atlas range of automatic component identification and measurement tools are easier to get hold of in Australia, Holland, Germany, USA and the UK. This is in addition to a worldwide network of established distributors, so buying Peak products is faster and easier.

To assist with the UK Hobbyist market, a new UK distribution partner has joined Peak. JPR Electronics in Dunstable offer the full range of Peak products as well as many other products aimed at hobbyists, education and industry.

To find your nearest distributor, simply visit **www.peakelec.co.uk** and click on the distributors tab. If you can't find a distributor near you then you can, of course, order from Peak directly: West Road House, West Road, Buxton, Derbys SK17 6HF. Tel: 01298 70012. Fax: 01298 70046. Email: **sales@peakelec.co.uk** and **technical@peak elec.co.uk**

PICO'S NEW SCOPE PROBES

Pico Technology, renowned leaders in PC oscilloscopes, has released a new range of oscilloscope accessories, including three high-voltage differential probes, a passive 500MHz scope probe, a set of 50Ω coaxial attenuators and a 50Ω coaxial terminator.

The new high-voltage differential probes give a choice of bandwidths from 70 to 100MHz and have differential measuring ranges from 700V to 7kV. They are suitable for measurements on mains circuits, motors and switch mode power supplies, especially in applications where voltages are not referenced to ground.

The new 500MHz passive scope probe is perfect for general-purpose use, with 10:1 attenuation and an input impedance of 1MΩ. It has adjustable low-frequency and high-frequency compensation, and is compatible with all major brands of oscilloscope. The cable length is 1.5 metres. The new BNC attenuator set allows you to increase the input range of your scope, or reduce the output level of a fixed-amplitude signal source. The BNC feed-through terminator is useful for connecting signals from a low-impedance source.

Alan Tong, MD of Pico Technology, commented, "With our 16 years of experience in PC oscilloscopes, we know how difficult it can be to find good-quality probes and accessories for your scope. Now we can save you time and money by supplying all the scope accessories that you need."

The prices are: TA042 100MHz 1400V CAT III differential probe £330; TA043 100MHz 700V CAT III differential probe £450; TA044 70MHz 7kV CAT I differential probe £480; TA049 500MHz passive 10:1 probe £45; TA050 3/6/10/20 dB 50Ω 1GHz attenuator set £39; TA051 50Ω 1GHz feedthrough terminator £9.50.

The new accessories are available from local distributors, or direct from Pico Technology at **http://accessories.picotech.com**.

ENHANCED 8-BIT PIC CORE

Microchip has announced its enhanced mid-range 8-bit PIC microcontroller core (MCU) architecture supporting PIC12 and PIC16 MCUs, with feature and peripheral improvements including more program and data memory; a deeper/enhanced hardware stack; additional reset methods; 14 additional programming instructions, including C efficiency optimisations resulting in code size reductions; increased peripheral support; reduced interrupt latency.

The enhancements provide users with a performance boost of up to 50% and code-size reductions of up to 40%. Peripheral support includes Microchip's mTouch module for touch-sensing user interfaces; LCD displays; multiple analogue-to-digital converters (ADCs) and pulse width modulation (PWM) modules; additional timers and analogue comparators.

Additional feature enhancements include increased memory support with program flash addressability up to 56KB and data RAM up to 4KB. With 14 additional instructions giving a total now of 49, the enhanced core optimises program code and data handling, which reduces code space and increases efficiency with fewer clock cycles. It also provides the ability to migrate with minimal effort among existing mid-range PIC MCUs; as well as up or down with PIC12, PIC16 and PIC18 MCUs.

The first devices based upon the enhanced 8-bit mid-range PIC MCU core are expected to roll out in the spring of 2009. Third-party compiler support for devices utilising the enhanced core will be provided by HI-TECH Software, CCS, microEngineering Labs and Byte Craft Limited. For further information, visit Microchip's Web site at **www.microchip.com/enhanced**.

Passport to World Band Radio

The 2009 edition of *Passport to World Band Radio* explodes with hundreds of programmes you cannot find elsewhere. From the matchless reporting of the BBC to the musical heights of the Andes, it is a broadcast menu that is one part *Newsweek*, another *National Geographic*. Every station stands out; comedy from England, science from Russia, waltzes from Austria. It is the depth and variety that is missing from ordinary radio and TV.

This book 'covers it all' – what's on, what to buy, how to get started. It is the world's best-selling short-wave guide, trusted by over a million readers since 1985. 560 pages, 175 × 235mm, colour and B/W photos. £17.50, IBS. Gazelle Book Services Ltd, tel: +44 (0) 1524 68765. Email: sales@gazellebooks.co.uk.

Conned

It's a safe bet that every EPE *reader will have received emails, or faxes, or even letters, which tell of a trapped fortune in a far off land that can be released for sharing by handing over a handling fee. It's known as the* 419 scam, *because many of the missives come from Nigeria where Section 419 of the Penal Codes makes them illegal.*

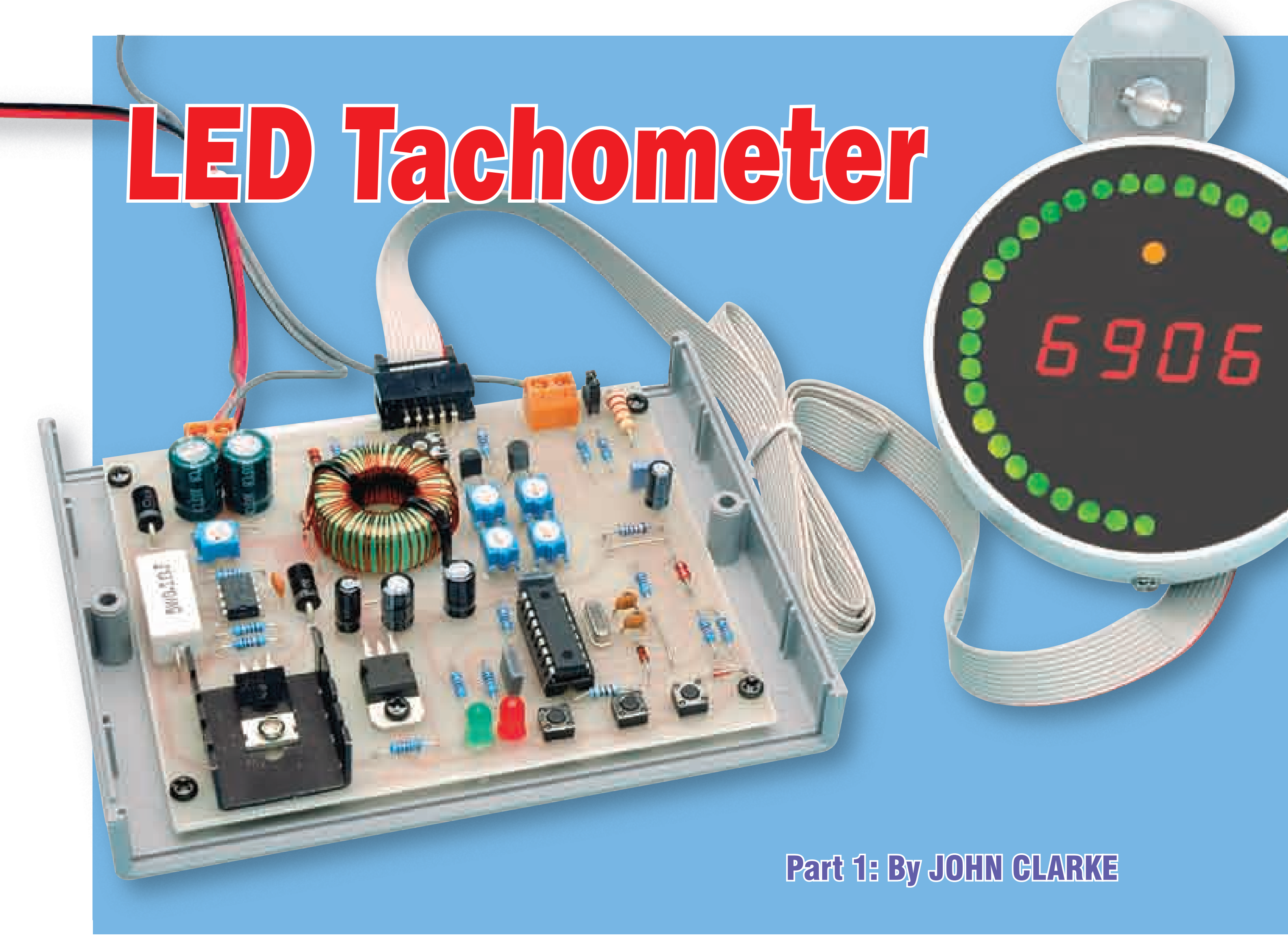
A new book, Conned, *by James Morton and Hilary Bateson, reveals that greedy gullibles have been falling for the same trick for over a hundred years. In 1905 a prisoner in a Spanish jail was mailing letters asking for cash to retrieve impounded luggage which contained details of a secret bank account in Britain.*

In China 419 scammers can expect the death penalty; in the US there is a little known provision for claiming tax relief on money lost to scammers.

The book also tells how a Brit gets his revenge by asking any scammers who contact him to prove their identity by emailing back a photo of themselves holding a fish, while balancing a loaf of bread on their head and with a sign round their neck saying 'plonker'.

Barry Fox

LED Tachometer



Part 1: By JOHN CLARKE

A responsive and accurate tachometer is essential for motoring enthusiasts. This unit features a bright 4-digit display, plus a 32-LED circular bargraph. The LED bargraph responds rapidly to changes in RPM, while the digital display shows accurate RPM readings with a steady throttle.

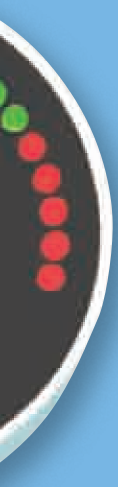
DIGITAL tachometers might be accurate, but they don't respond like an analogue instrument. This tachometer combines the best features of analogue and digital instruments: blip the throttle and the LED bargraph rapidly responds to the change in engine revs, while the true RPM will be shown on the 4-digit display, with up to one RPM resolution.

A gear shift light and a rev limiter output are standard features and it can operate with virtually any car or motorcycle (except magneto ignition). Its vast array of optional setting adjustments makes this tachometer a truly versatile instrument. For performance cars and motorcycles, this versatility includes the ability to display engine speed above 10,000 RPM.

On display

The circular display section of the tachometer has been made as small as is practical and it can be installed within the instrument cluster of your car if there is sufficient space available. Alternatively, it can be housed in a cylindrical case and mounted using a suitable holder on the dashboard, windscreen or instrument cluster. The main electronics part of the tachometer needs to be mounted under the dashboard (or within a side cover in a motorcycle).

The LED bargraph is arranged in a 76mm diameter circle that covers a 286° span. The 32 LEDs are green except for the extreme clockwise end, which uses five red LEDs to indicate the 'red line' RPM. You can increase the 'red line' indication to as many as 10 LEDs.



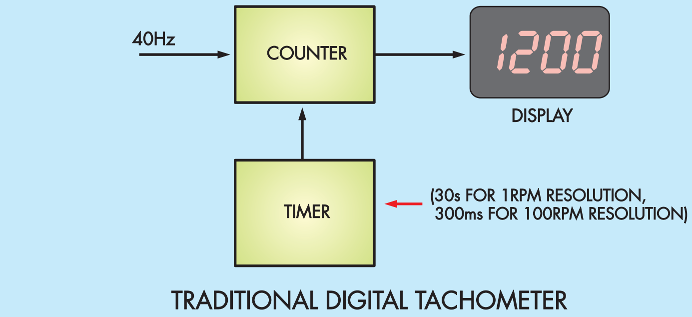


Fig.1: the basic arrangement for a digital tachometer. It comprises a counter, a timer and a digital display.

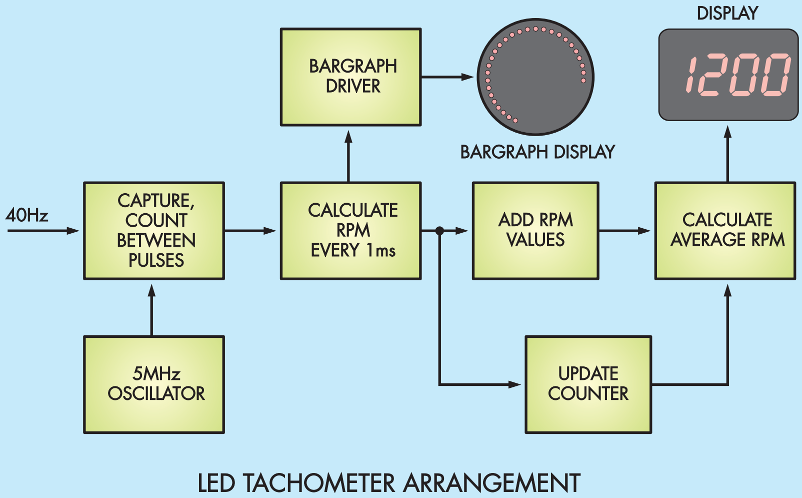


Fig.2: the block diagram for the LED Tachometer is more complicated than the basic unit and includes both digital and bargraph LED displays.

During calibration, the red line RPM can be selected, as well as the number of red line LEDs. The tachometer then automatically calculates the RPM increments required to light each LED.

The shift light RPM can also be entered into the tachometer during the setting up procedure. If you do not want the shift light LED to operate, you can enter an RPM setting higher than the engine will reach.

The rev limiter output from the tachometer can be used to prevent the engine from over-revving if say, you miss a gear. However, the limiter action is very abrupt and is not suitable for normal speed or RPM restriction. The limiter output controls an external cutout circuit that works by 'killing' the ignition or interrupting fuel to the injectors. We will discuss these options in Part 2, next month.

Setting up the tachometer is easy because we use the digital display to show the options and the current settings, while you set the number of cylinders and other settings using pushbutton switches.

Basic digital tachometer

The basic arrangement for a typical digital tachometer is shown in block diagram Fig.1. It comprises a counter, a timer and a digital display. For a 4-cylinder 4-stroke engine, there are two sparks or firing pulses per engine revolution. A 40Hz pulse signal from the engine therefore corresponds to 1200 RPM (40 x 60 x 1/2).

If we want the display to show 1200, we can do this in several ways. First, we can wait 30 seconds so that the counter reaches a count of 1200, but this is far too long to be practical.

A better method is to count the incoming signal over a 300ms period. This would allow the counter to reach 12 after 300ms. The display would then show a 12, and two more zeros could be added after the 12 to make it display 1200. These last two digits will always be set at zero and so the resolution is only 100 RPM. The resulting 300ms update time (ie, three times a second) is probably fine for a digital display because we would not be able to read it if it changed at a much faster rate.

However, if we add a multi-LED bargraph to the tachometer, then the 300ms update period would prevent the bargraph from rapidly responding to changes in engine revs; a quick blip of the throttle would probably not even be registered. The other problem with the 300ms update period is that it only has 100-RPM resolution and so the increments on the circular display would not be very precise.

Problem solved

Clearly, a tachometer with a bargraph that has many steps will need a much faster and more accurate means of measuring RPM. Fig.2 is the solution.

Essentially, we have a high-speed oscillator running at 5MHz and this frequency is counted and then captured for the period between firing pulses. For a 40Hz input we would have 40 firing pulses every second and the counter would count up to 125,000 (5,000,000/40) between pulses. The value of 125,000 may not appear to be of much use, but if we divide this number into 150 million we get the correct 1200 RPM reading for a 4-cylinder 4-stroke engine. The resolution is now one RPM.

We can use a different numerator for the division calculation for each type of engine. For example, for a twin cylinder 4-stroke engine we use a value of 300 million for the numerator. In this case, a 40Hz signal would give a reading of 2400 RPM.

The RPM calculations are repeated every 1ms and a new RPM reading will be obtained if the captured count value is different from the previous count. The actual rate at which the RPM is updated is dependent on the time period between the firing pulses.

For the 40Hz signal, we have an RPM update 40 times per second, or once every 25ms. This is 12-times faster than the RPM measurement described in Fig.1. At higher RPM, the update time is even quicker. With a 100Hz signal (equivalent to 3000 RPM for a 4-cylinder 4-stroke engine), the

Main Features

- Fast 32-LED circular bargraph
- Dot or bargraph option
- 4-digit display
- Gear shift indicator LED
- Limiter signal output
- Display from 0-9999 RPM or above 10,000 RPM (optional)
- Two display options for RPM above 9999 RPM
- Options for 1 RPM, 10 RPM or 100 RPM display resolution
- Automatic display dimming in low ambient light
- Set-up for 1, 2, 3, 4, 5, 6, 8, 10 and 12-cylinder, 4-stroke engines, and 1, 2, 3, 4, 5 and 6-cylinder, 2-stroke engines
- Selectable red line RPM
- Selectable shift light RPM
- Selectable limiter RPM
- Selectable number of red line LEDs
- Selectable display update period
- Selectable RPM hysteresis for LED bargraph
- Selectable limiter minimum on time

RPM reading is updated every 10ms or 100 times per second.

Note that because the calculation of RPM is made every 1ms, the new RPM value is available almost as soon as the counter value has been captured. The resulting RPM value is sent to the bargraph driver to display the latest reading.

Twin-cylinder motorbikes

One small problem with this method of RPM measurement is that it does not work with engines that have uneven firing between cylinders. It would measure two different RPM readings because of the uneven spacing between successive firing pulses. This is mainly a concern with twin-cylinder 4-stroke engines with cylinder separations of less than 180°, such as from Harley Davidson, Ducati and Moto Guzzi.

To prevent this reading problem, we have included setting selections for these engines that count between four successive firing pulses. Because the spacing is constant (in engine rotational degrees) between an even number of firings, it prevents erratic RPM measurements.

We also set the tachometer to count between four successive firing pulses for engines with six cylinders and over. This is to provide a sufficient count value, especially at high RPM, to ensure a high-resolution calculation.

For the 4-digit display, the fast updates are not required and so the update is slowed down to a more readable rate, as set by the update counter. Between display updates, each RPM calculation is added together and the total is averaged before being displayed. The display update period is one of the tachometer settings that can be adjusted. Typically, a 200ms update (five times a second) is satisfactory, however update times from 0-510ms can be set, in 2ms steps.

Circuit description

The circuit can be divided into two sections (Figs 3 and 4) which correspond to the control board and the display board. The control section includes microcontroller IC3 and the LED display power supply involving IC4, inductor L1 and transistor Q1. The display section incorporates the 32-LED bargraph, the four 7-segment displays, the shift LED, the LDR and the display drivers (IC1 and IC2).

The control section of the circuit is shown in Fig.3. IC3 is the microcontroller that drives the data and clock lines for the display driver ICs. It also accepts the tachometer signal from the engine and performs the calculations required to display the RPM. Calibration and option settings are set using switches S1 to S3, while LED34 and LED35 show the display status. IC3 operates at 20MHz, as set by the crystal X1.

The ignition signal from the engine can be obtained from the car's Engine Control Unit (ECU), from a reluctor, Hall effect trigger or points, or via an ignition coil connection for cars that have a distributor. Two separate inputs are provided, a high level input for connecting to high-voltage signals, such as from an ignition coil and reluctor, and a low-level input for a low-voltage source such as the ECU.

The high-level signal is fed via an attenuation network consisting of a 22kΩ resistor, two 47nF capacitors and the 10kΩ resistor to ground. The resulting signal is coupled via a 2.2µF capacitor (to remove any low-frequency or DC voltages that may be present) and limited by 10V Zener diode ZD2. The signal is then applied to the pin 6 input of IC3 via a 10kΩ limiting resistor.

By contrast, the low-level input is applied to pin 6 via a 2.2kΩ resistor and 100Ω resistor. Diodes D3 and D4 limit the signal swing to between –0.7V and +5.7V. IC3's pin 6 input also incorporates its own protection diodes and these are protected from excessive current by the 100Ω resistor.

Display section

The display section shown in Fig.4 mainly involves IC1 and IC2, which might just have been designed for our very purpose. Each M5451 IC can drive up to 35 LEDs and a dimming control is included. Serial data is fed in at pin 22 of each IC and the clock signal is fed into pin 21. The serial data comes from the microcontroller (IC3) on the control board and this selects which LEDs are to be lit and which are not.

IC1 and IC2 are run at 5V (at pins 1 and 20), while the LEDs have their own adjustable high-current supply. Pin 19 (BRC) is the brightness control input. It requires 750µA to fully drive the LEDs; lower current reduces the LED brightness. A 1nF capacitor at each pin prevents oscillations.

We have provided separate dimming control for each IC so that they can be adjusted to provide the same apparent brightness. The light dependent resistor (LDR1) controls the brightness.

Power

There are two power supply circuits, one to provide 5V for the ICs and the above mentioned LED supply, which operates in switch mode to minimise heat dissipation. It comprises IC4, transistor Q1 and inductor L1 – see the circuit diagram in Fig.3.

IC4 is an MC34063 DC-DC converter, which runs at around 40kHz to switch transistor Q1 on and off. Each time Q1 switches on, current builds through L1 until it reaches a peak of about 3A, as detected by the voltage drop across the 0.1Ω 5W resistor between pin 6 and 7. When the current reaches 3A, Q1 switches off and the charge within L1 is allowed to continue to flow via diode D2. The resulting supply is filtered with a 470µF low ESR capacitor.

Voltage feedback is provided via the 3.3kΩ resistor to pin 5 and the 1.2kΩ

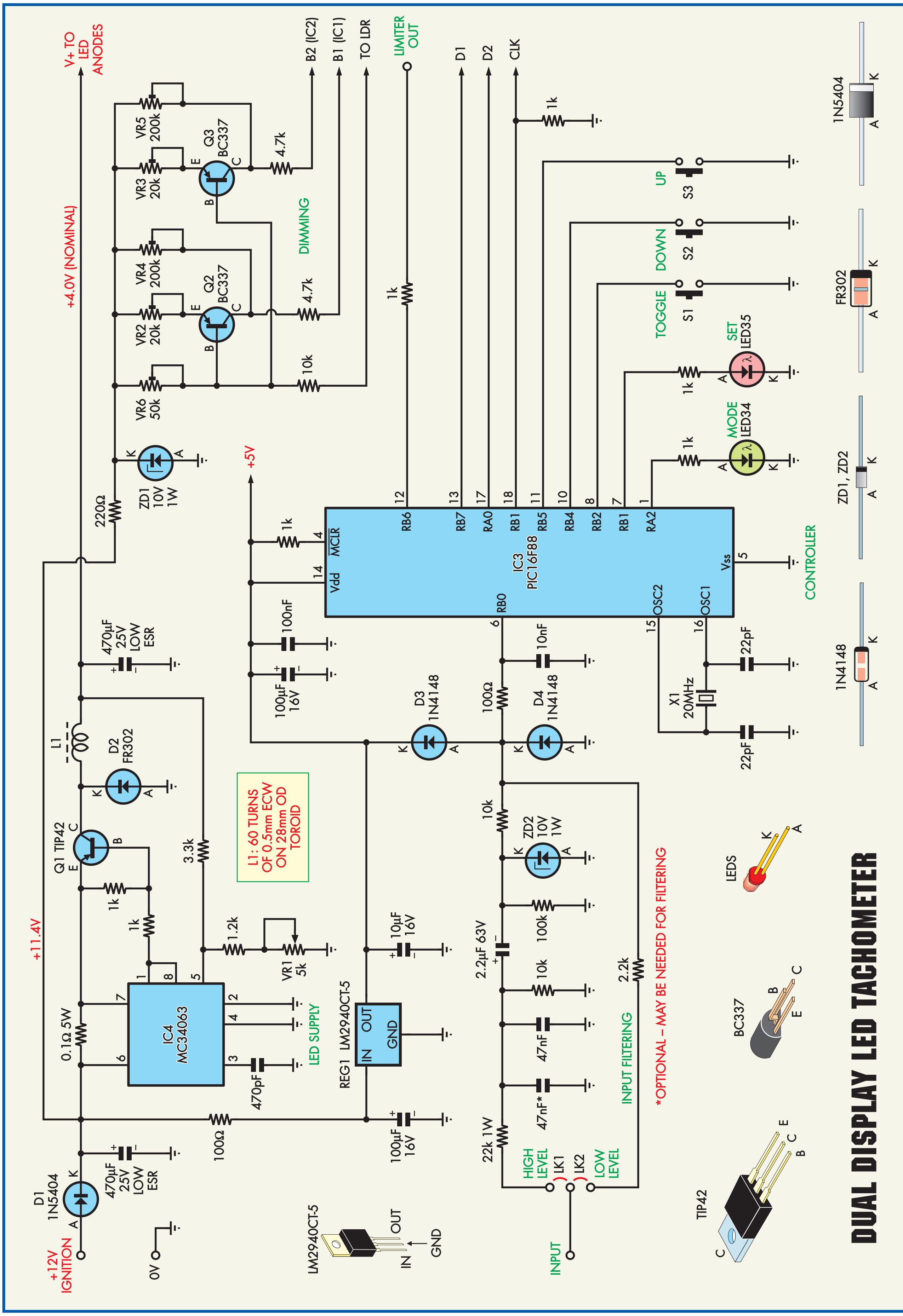


Fig.3: the control circuit is based on IC3, which is a PIC16F88 microcontroller. This processes the input signals and drives the display circuit of Fig.4.

Parts List – LED Tachometer

1 PC board, code 699, size 117 × 101mm
1 PC board, code 700, 89mm diameter
Both circiut boards available from the *EPE PCB Service*
1 small instrument case, size 140 × 110 × 35mm
1 ORP12 type light-dependent resistor (LDR1)
1 20MHz parallel resonant crystal (X1)
1 right-angle 10-pin IDC header
1 10-way IDC line socket
1 10-way IDC PC board transition connector
1 3-way pin header
1 jumper shunt for 3-way header
2 2-way PC board mount screw terminals (5.08mm pin spacing)
1 powdered iron core 28mm OD × 14mm ID × 11mm (Jaycar LO-1244) (L1)
1 TO220 heatsink 25 × 29.5 × 12.6mm
3 SPST micro tactile switches vertical mount 0.7mm actuator (S1 to S3)
2 50mm cable ties
1 18-pin DIL IC socket
1 500mm length of 0.7mm tinned copper wire
1 1m length of 10-way IDC cable
1 3.5m length of 0.5mm enamelled copper wire
2 M3 × 10mm screws
4 M3 × 6mm screws
2 M3 nuts
2 PC stakes

Extra hardware for Display
3 M3 brass nuts
6 M3 × 12mm Nylon screws
6 M3 Nylon nuts
3 M3 × 12mm countersink screws
1 90mm female stormwater fitting (90mm ID × 21mm)
1 40mm suction cap (with 5mm diameter × 15mm locking pin)
1 90mm diameter neutral-tint 1.5mm display filter with display masking (cut for a tight fit inside the 90mm PVC pipe)
1 90mm diameter piece of 0.5mm galvanised steel
1 piece of 25 × 42mm × 1mm aluminium
4 M3 tapped 6mm long Nylon spacers

Semiconductors
2 M5451B7 (PDIP40 package) (IC1,IC2)
1 PIC16F88-I/P microcontroller programmed with ledtacho.hex (IC3)
1 MC34063 DC-DC converter (IC4)
1 LM2940CT-5 low dropout TO-220 3-terminal 5V regulator (REG1)
1 TIP42C *PNP* transistor (Q1)
2 BC557 *PNP* transistors (Q2,Q3)
4 common anode 12.5mm red 7-segment displays (LTS542R or equivalent) (DISP1-DISP4). Note: for sunlight readable displays use the Agilent 16mcd @ 20mA HDSP-H151 from Farnell, Cat. 100-3141 or 264-313 (www.farnellinone.com.au).
28 green 5mm LEDs (LED1-LED27, LED34). Note use >400mcd @ 20° angle and @10mA for sunlight readability.
6 red 5mm LEDs (LED28-LED32, LED35). Note use >400mcd @ 20° angle and @10mA for sunlight readability.
1 high intensity 5mm orange LED (LED33)
1 10V 1W Zener diode (ZD1)
1 1N5404 diode (D1)
1 FR302 100V 3A fast recovery diode (D2)
2 1N4148 switching diodes (D3,D4)

Capacitors
2 470mF 25V low ESR PC electrolytic
1 220mF 10V PC electrolytic
2 100mF 16V PC electrolytic
2 10mF 16V PC electrolytic
1 2.2mF 63V PC electrolytic
1 100nF MKT polyester
2 47nF MKT polyester
1 10nF MKT polyester
2 1nF MKT polyester
1 470pF ceramic
2 22pF ceramic

Resistors (0.25W 1%, except where stated)

1 100kΩ	1 1.2kΩ
1 22kΩ 1W 5%	7 1kΩ
3 10kΩ	1 220Ω
2 4.7kΩ	2 100Ω
1 3.3kΩ	1 0.1Ω 5W
1 2.2kΩ	

Potentiometers
1 50kW horizontal mount trimpot (VR1)
2 20kW horizontal mount trimpots (VR2,VR3)
2 200kW horizontal mount trimpots (VR4,VR5)
1 5kW horizontal mount trimpot (VR6)

resistor in series with trimpot VR1. The feedback voltage at pin 5 is maintained at 1.25V for regulation of the output. It means that with the addition of the resistive divider, the output voltage can be higher than 1.25V. VR1 allows adjustment of the output from 1.8V up to 4V.

The incoming 12V supply from the car's battery is fed via diode D1, which provides protection against reversed polarity, and the supply is filtered with the 470µF capacitor. The cathode (K) side of the diode also supplies the 5V regulator REG1, an LM2940CT-5. This is a low dropout regulator intended for automotive use, with input protection against supply transients. The 100Ω series resistor supplying REG1 limits peak currents into the transient protection circuitry.

Dimming

As mentioned, display drivers IC1 and IC2 include dimming inputs. The dimming control circuitry comprises LDR1 and transistors Q2 and Q3, along with the associated trimpots (VR2 to VR6). This circuit is operated from a 10V supply derived from the 220Ω dropping resistor and Zener diode ZD1. Transistors Q2 and Q3 act as voltage followers, where the emitter voltages are 0.7V above the base voltage. The emitter voltages therefore 'follow' the voltage across the LDR.

With high ambient light, the LDR is a low resistance and the voltage across the LDR is about 1V. The emitters of Q2 and Q3 are at 1.7V. This fixes the

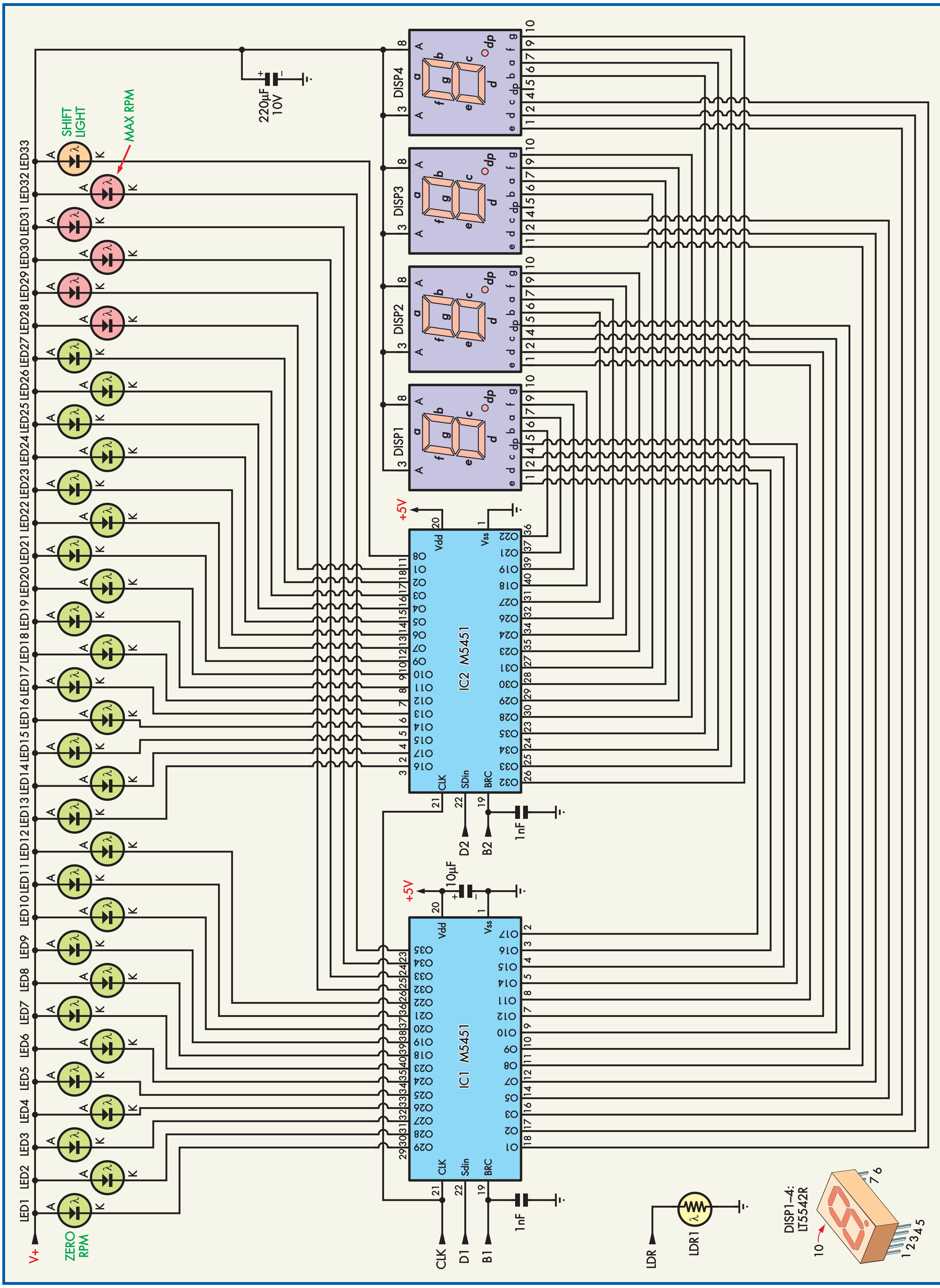


Fig.4: the display section is based on display drivers IC1 and IC2 which have individual brightness control at pin 19.

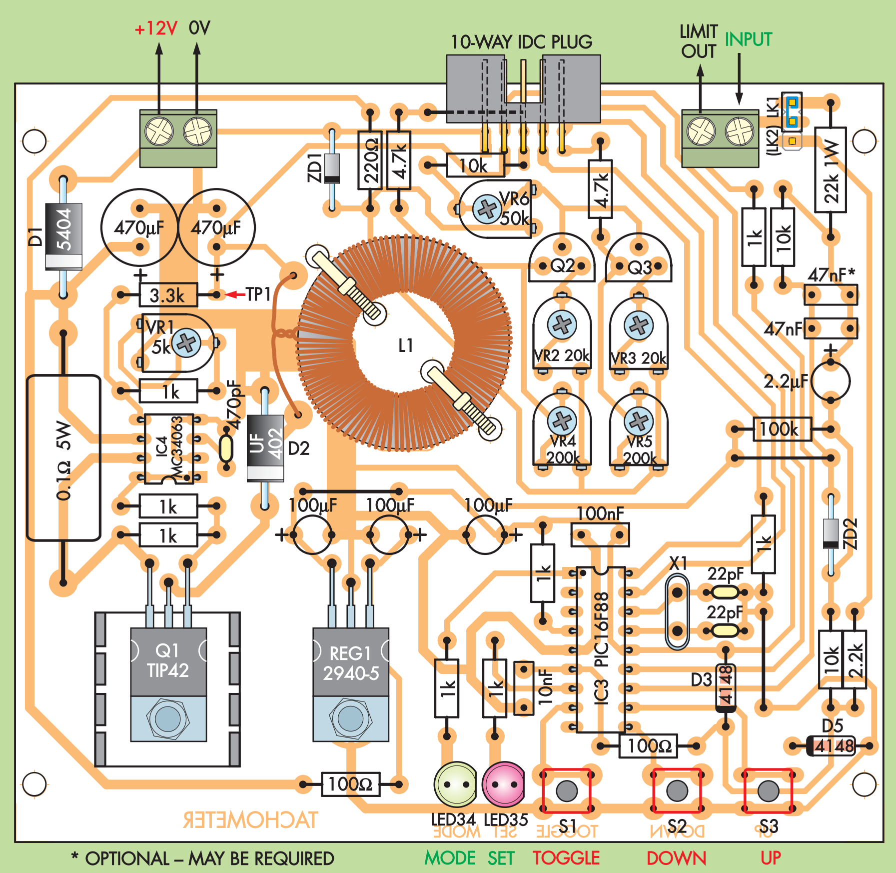


Fig.5: follow this parts layout diagram to build the control PC board. Take care with component orientation and note that IC3 goes in a socket.

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0.1µF	104	100n
47nF	0.047µF	473	47n
10nF	0.01µF	103	10n
1nF	0.001µF	102	1n0
470pF	NA	471	470p
22pF	NA	22	22p

voltage across trimpots VR2 and VR3 at 10V – 1.7V, or 8.3V. The resistances of VR2 and VR3 therefore set the current through the collectors and emitters of Q2 and Q3. This in turn sets the brightness for display drivers IC1 and IC2 respectively.

In low ambient light, the LDR resistance rises and so the emitter voltage rises. Current sources Q2 and Q3 therefore drop their collector current because there is less voltage across VR2 and VR3, and so the displays dim. Trimpots VR4 and VR5 shunt Q2 and Q3 to set the minimum current flow into IC1 and IC2 when the LDR is in darkness, which results in Q2 and Q3 being fully switched off. Trimpot VR6 is included to adjust the threshold where the LDR starts dimming.

The individual adjustments of dimming current for IC1 and IC2 are included to allow balancing the display brightness for each driver. Balancing is required because there may be variations in the current drive between IC1 and IC2 with dimming current.

Software

The software files are available for download via the *EPE* Downloads site, access via **www.epemag.com**. Pre-programmed PICs are available from **Magenta Electronics** – see their advert in this issue for contact details.

Construction

The Digital Tachometer has two PC boards. The control PC board is coded 699 and measures 117 × 101mm. It is housed in a small instrument case measuring 140 × 110 × 35mm. The display PC board is coded 700 and is 89mm in diameter. Both boards are available from the *EPE PCB Service*.

Fig.5 shows the component overlay for the control board, while Fig.6 shows the components on both sides of the display board. While it is a single-sided board (ie, copper pattern on one side only), it does have components on both sides.

Begin construction by checking the PC boards for any shorts between tracks, for breaks in the tracks and for correct sized holes. Some components such as the screw terminals and the 3A diodes will require hole sizes that are larger than the standard 0.9mm required for most other components.

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	100kW	brown black yellow brown	brown black black orange brown
❏	1	22kW	red red orange brown	red red black red brown
❏	3	10kW	brown black orange brown	brown black black red brown
❏	2	4.7kW	yellow violet red brown	yellow violet black brown brown
❏	1	3.3kW	orange orange red brown	orange orange black brown brown
❏	1	2.2kW	red red red brown	red red black brown brown
❏	7	1kW	brown black red brown	brown black black brown brown
❏	1	1.2kW	brown red red brown	brown red black brown brown
❏	1	220W	red red brown brown	red red black black brown
❏	2	100W	brown black brown brown	brown black black black brown

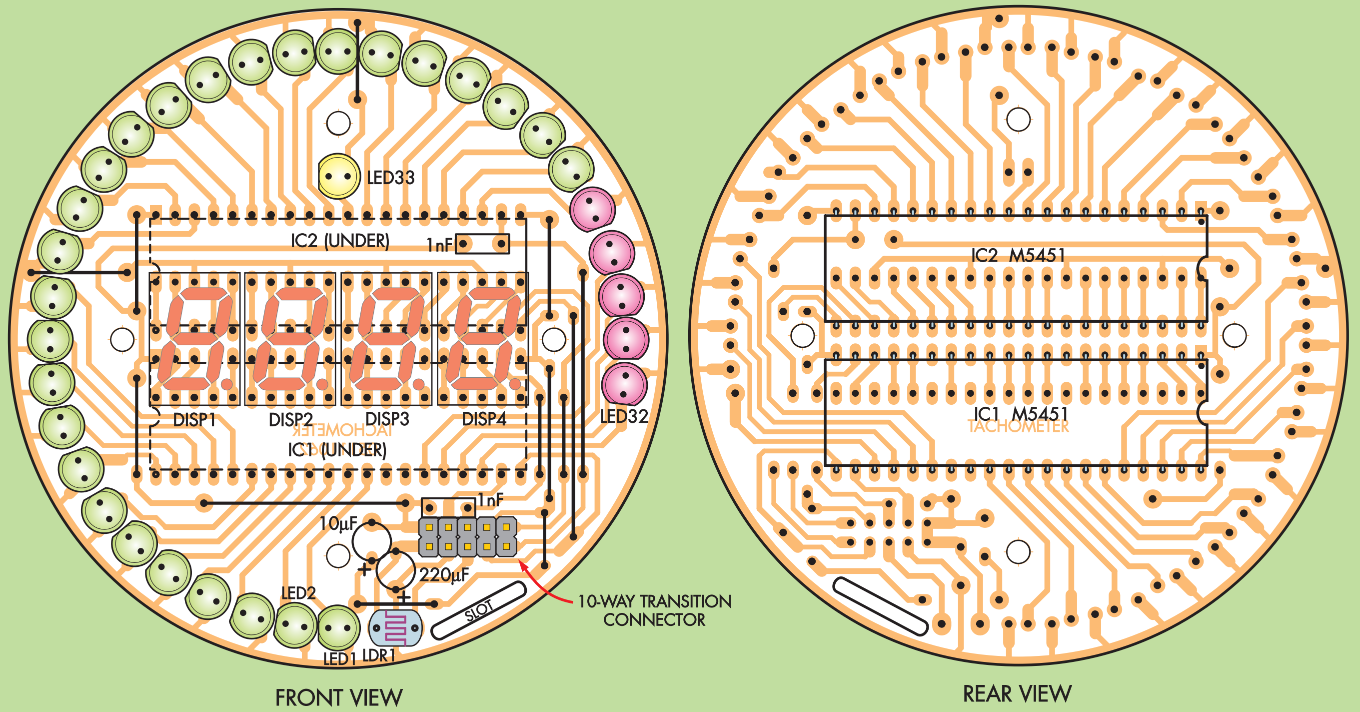
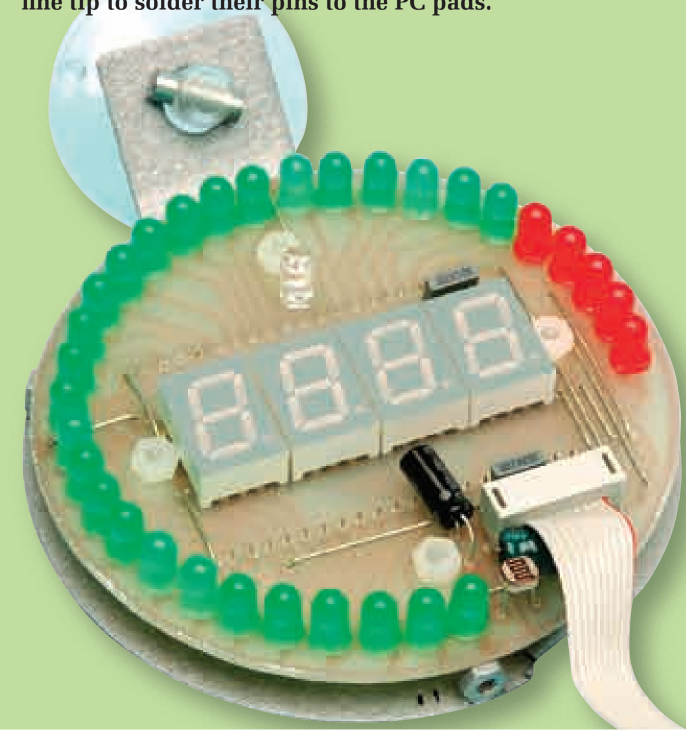
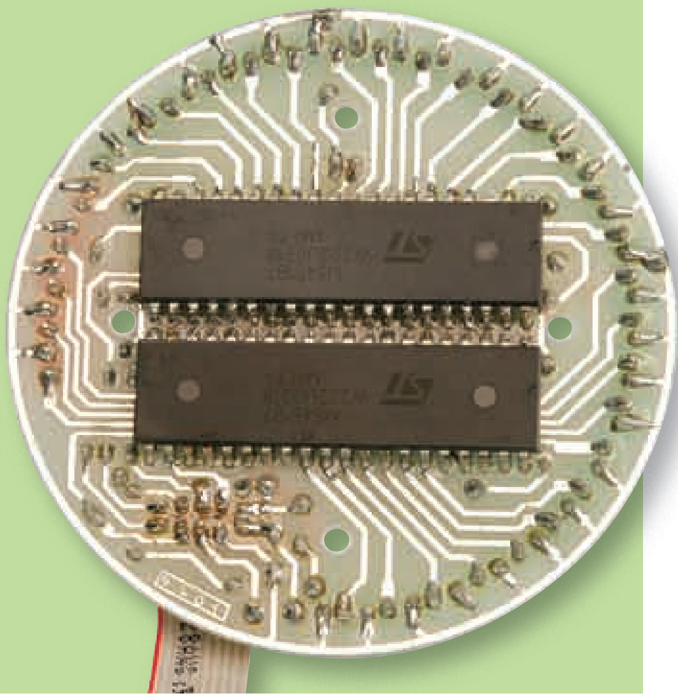


Fig.6: here's how to assemble the display PC board. The 7-segment displays and the LEDs all sit flush against the board, while the LDR should be mounted so that its face is level with the tops of the LEDs. The two display driver ICs (IC1 and IC2) are mounted on the rear of the display board as shown on the right. Use a soldering iron with a fine tip to solder their pins to the PC pads.





Also, the mounting holes for both PC boards, the REG1 and Q1 mounting holes and the cable tie holes (for securing L1) need to be 3mm in diameter.

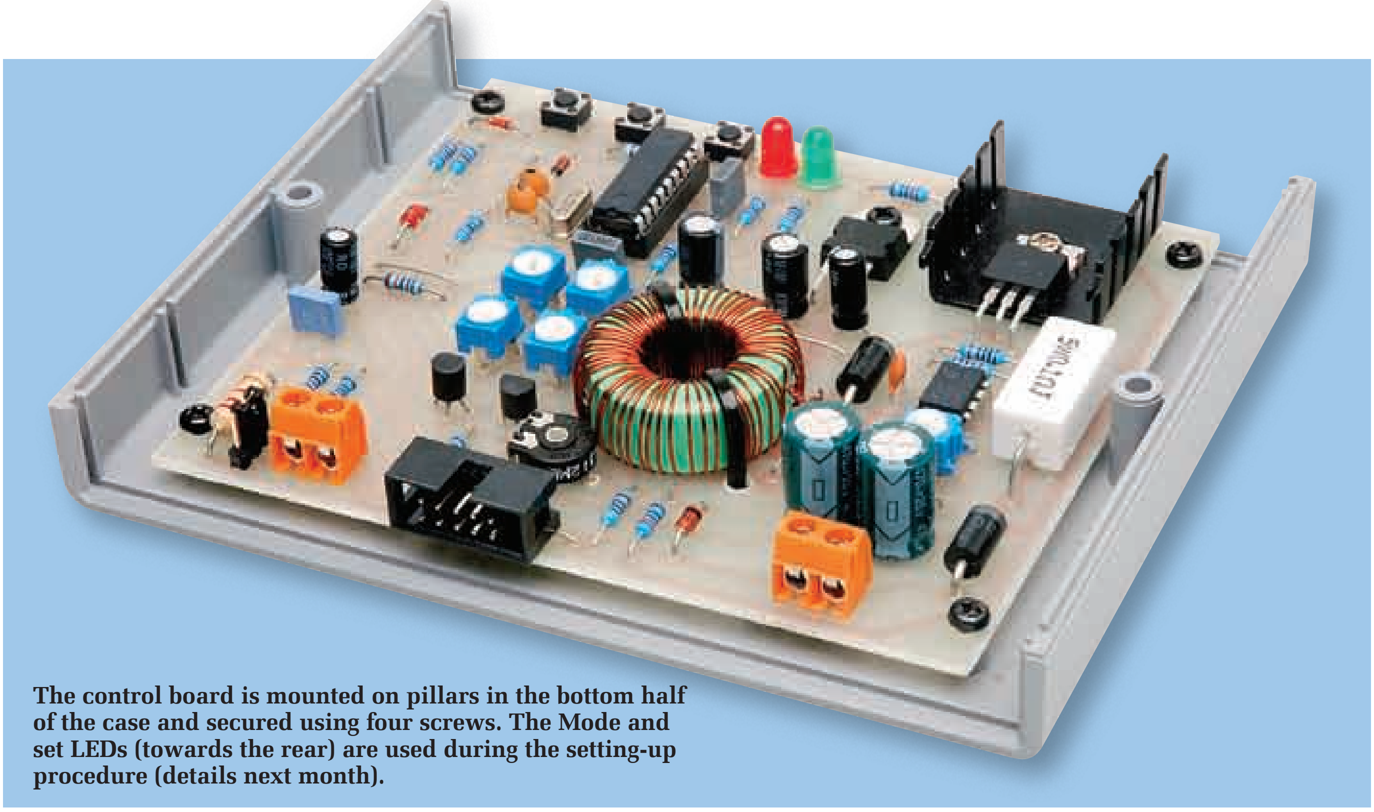
Control board

Start with the control PC board, you can install the low-profile components such as the resistors, links and ICs. Use Table 1 to select the resistors and check each value with a digital multimeter. IC3 is installed in a socket – make sure it goes in with the correct orientation.

The diodes go in next, making sure that the orientation of each is correct. That done, install transistors Q2 and Q3, the trimpots and the switches. The 10-way IDC plug can then be installed, as well as the two 2-way screw terminal connectors.

Next, install the capacitors but note that the 47nF capacitor (top right) marked with the asterisk should be left out of the circuit for the moment.

Both transistor Q1 and the regulator REG1 are mounted horizontally and secured with an M3 screw and nut to



The control board is mounted on pillars in the bottom half of the case and secured using four screws. The Mode and set LEDs (towards the rear) are used during the setting-up procedure (details next month).

the PC board. Q1 is also mounted on a small heatsink. The leads can be bent using pliers before each component is inserted into the PC board holes.

Next, install the 3-way pin header, the crystal and the two LEDs (take care to orient these correctly). We used a red LED for LED35 and a green LED for LED34.

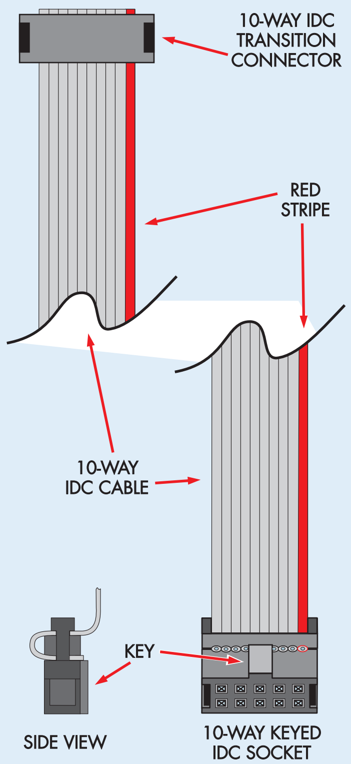


Fig.7: here's how to assemble the IDC lead.

Winding inductor L1

Inductor L1 is wound on a 28mm powdered iron core using 0.5mm enamelled copper wire. Neatly wind on the 60 turns and twist the wires together to prevent the windings loosening, then secure it in position on the board using two cable ties. That done, strip the insulation from the ends of the wires using a utility knife and solder them to the PC board.

The board can now be mounted in the small instrument case and secured with four M3 × 6mm screws. You will need to cut holes in the rear panel for the IDC socket and for the cable entry for the screw terminal points.

Display board

The commonly-available display LEDs used for the tachometer are suitable for inside a car providing the sun does not shine directly on the display. However, they are not bright enough when operating in direct sunlight. For this, you will need sunlight-readable 7-segment displays and high-intensity LEDs. The parts list has the details.

Begin the assembly by installing all the wire links. Keep these straight and tight so that they will not short against each other. That done, install the 7-segment LED displays with the decimal points at the lower right-hand side of each display.

Next, install the two 1nF capacitors and the two electrolytic capacitors. The latter both lie on their sides (see photo) and must be oriented as shown (the 220µF capacitor lies adjacent to the 10-way IDC connector).

Now install all the LEDs, taking care to orient these correctly. These all sit flush against the PC board. We used green LEDs for all except the red line LEDs and the shift light LED. Note that you can use any number of red LEDs for the red line from 0-10 – it's your choice. The LDR should be installed at the same height as the LEDs.

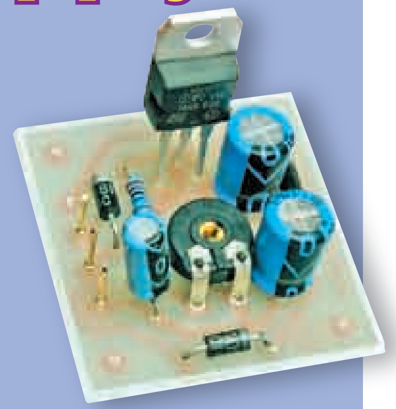
IC1 and IC2 are installed on the rear of the PC board. Before installing them, make sure that the displays have been soldered in correctly and that there are no shorts between pads. Now place the ICs in position and solder each pin using a fine-tipped soldering iron.

The next job is to make up an IDC lead using a 10-way IDC (insulation displacement connector) and the keyed IDC socket – see Fig.7. The cable is inserted into the IDC, which is then squeezed together using a vice or clamp. Install the transition connector on the display PC board.

That's all for this month. In Part 2, we'll finish the construction, describe the test and set-up procedures and give some hints on installation. ***EPE***

Adjustable 1.3V to 22V Regulated Power Supply

Want a regulated voltage that can be adjusted to suit your application? This Adjustable Power Supply is small, easy-to-build and can be adapted to produce a fully regulated voltage ranging from 1.3V to 22V, at currents up to 1A.



By JOHN CLARKE

THERE are many fixed-voltage IC regulators available, and these can be had with 5V, 6V 8V, 9V, 12V and 15V outputs. But what if you want a voltage output that does not fit into one of the standard ranges, or if you want to be able to easily adjust this output voltage? An adjustable regulator is the answer – one that can be set to provide the exact voltage you require.

This Adjustable Power Supply comprises a small PC board that utilises a 3-terminal voltage regulator. It does not have too many other components – in fact, there are just three diodes, three capacitors, a resistor and a trimpot to set the output voltage from the regulator.

Circuit details

The full circuit diagram for the Adjustable Regulated Power Supply is shown in Fig.1. REG1 is an LM317T 1.5A adjustable voltage regulator that provides a nominal 1.25V between its OUT and ADJ (adjust) terminals.

We say it is a 'nominal 1.25V' because, depending on the device, it can be anywhere between 1.2V and 1.3V. This doesn't really matter though, because we can adjust the output voltage to the required level using the trimpot.

Note: if you do want a regulator that provides a better tolerance for the 1.25V reference, then you could use an LD1117V instead. This has a 1.238-1.262V range. However, do not apply more than 15V to the input of this regulator.

Output voltage

The output voltage from REG1 is set by the 110Ω resistor (R1) between the OUT and ADJ terminals and by the resistance between the ADJ terminal and ground (0V). This works as follows.

By using a 110Ω resistor and assuming an exact 1.25V reference, the current flow is set at 11.36mA. This is calculated by dividing the voltage between the OUT and ADJ terminals (1.25V) by the 110Ω resistor. This current also flows through trimpot VR1.

Parts List

- 1 PC board, code 698, available from the *EPE PCB Service*, size 35 × 38mm
- 1 LM317T adjustable 3-terminal voltage regulator (REG1)
- 3 1N4004 1A diodes (D1-D3)
- 2 100mF 25V PC electrolytic capacitors (C1,C3)
- 1 10mF 25V PC electrolytic capacitor (C2)
- 1 110W 0.25W 1% resistor (R1)
- 1 2kW horizontal trimpot (VR1)
- 4 PC stakes
- 1 T0-220 semiconductor insulating kit

This means that if VR1 is set at say 1kΩ, then the voltage across this resistor will be 1kΩ x 11.36mA, or 11.36V. This voltage is then added to the 1.25V reference to derive the output voltage – in this case 12.61V.

In practice, however, the current flow out of the ADJ terminal also contributes slightly to the final output voltage. This current is of the order of 100µA. So, if VR1 is set to 1kΩ, this can add 0.1V to the output – ie, we get 12.71V.

If you are interested in the output voltage equation, then it is:

$$V_{OUT} = V_{REF}(1 + R1/R2) + (I_{ADJ} \times R2)$$

where V_{OUT} is the output voltage, V_{REF} is the voltage between the OUT and ADJ terminals, and I_{ADJ} is the current out of the ADJ terminal (typically 50µA, but can be as high as 100µA). R1 is the resistance between the OUT and ADJ terminals, while R2 is the resistance between the ADJ terminal and ground (0V).

Protection

Diode D1, in series with the input, provides reverse polarity protection. This means that if you connect the supply voltage around the wrong way, you cannot do any damage.

Diode D2 protects the regulator should the input become shorted to ground. If that happens, D2 becomes forward biased and conducts, effectively preventing any reverse current

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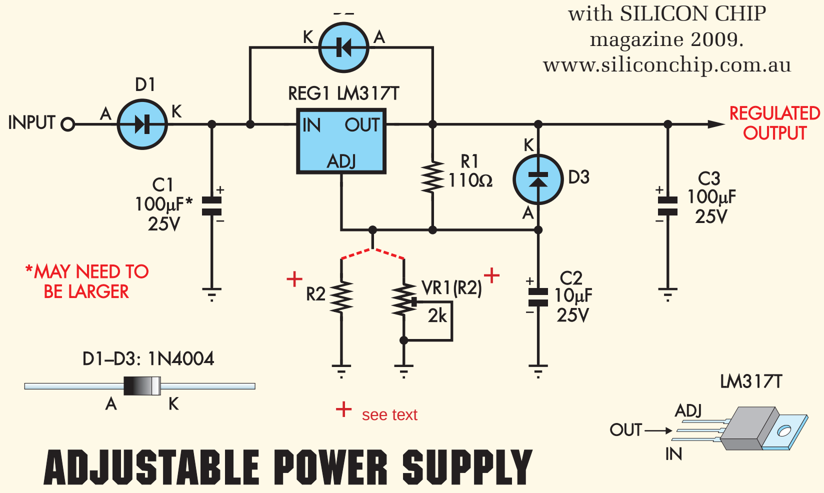


Fig.1: the circuit is based on an LM317T adjustable voltage regulator. D1 provides reverse polarity protection, while VR1 sets the output voltage.

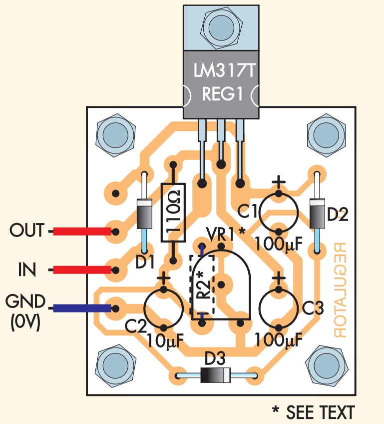


Fig.2: here's how to install the parts on the PC board.

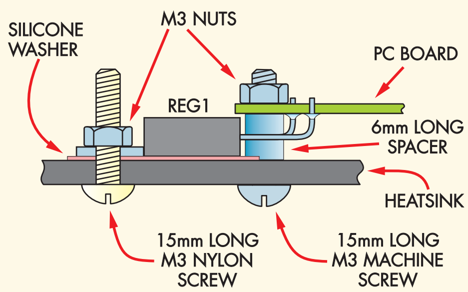


Fig.3: regulator REG1 can be mounted underneath the PC board and attached to a heatsink, as shown here. Note that its metal tab must be isolated from the heatsink using a TO-220 silicone washer and a nylon screw.

flow through REG1, which could cause damage.

Diode D3 is also included to protect REG1. It does this by clamping the voltage between the ADJ terminal and the OUT and IN terminals in the event that one of the latter is shorted to ground (0V).

Finally, capacitors C1 and C2 reduce ripple by bypassing the IN (input) and ADJ terminals respectively. Capacitor C3 prevents regulator oscillation by swamping any low-value capacitance that may be connected to this output.

Construction

All parts for the Adjustable Power Supply are mounted on a PC board, code 698, measuring just 35×38mm. This board is available from the *EPE PCB Service*. The circuit board component layout is shown in Fig.2 and the PCB copper foil master in Fig.4. As usual, begin construction by checking the PC board for any shorts between copper tracks or open circuits and make any necessary repairs.

You can now begin the assembly by installing the 110Ω resistor (R1) and the three diodes, making sure the latter are all oriented correctly (the banded ends are the cathodes (K)). That done, capacitors C1 to C3 can be installed, again taking care with their orientation since they are all electrolytic types.

Next, install PC stakes for the IN, OUT and GND terminals, then install trimpot VR1. Regulator REG1 can also be mounted. It can either be mounted on the top of the PC board (as shown in the photo) or underneath, as shown in Fig.3, so that it can be fastened to a heatsink.

Heatsinking

Whether or not you need a heatsink for REG1 depends on the output current and the voltage between the IN and OUT terminals of the regulator. That's because these two values together determine the power dissipation within the regulator. It's determined simply by multiplying the two values together to get the power dissipation in watts – ie, *P = VI*.

Generally, if the dissipation is less than 0.25W, no heatsink will be required. For example, if the current drawn from the regulator is 50mA and the voltage between the IN and OUT terminals is 5V, then the dissipation will be 0.25W and no heatsink will be necessary.

However, if the dissipation is more than this, you will need to fasten the regulator to a heatsink to keep it cool. For example, let's say that the current drawn from regulator REG1 is 250mA and that the voltage across it is 5V. In this case, the dissipation will be 1.25W (ie, 5 × 0.25) and a heatsink will be necessary.

Heatsink temperature

The type of heatsink required depends on the amount of power dissipated by the regulator and the temperature rise that can be tolerated. Typically, a 20°C rise in heatsink temperature is acceptable because this means that at a typical room temperature of say 25°C, the heatsink will run at 45°C which is quite tolerable.

Most heatsinks are specified by their temperature rise in °C per watt (°C/W). This means that a 10°C/W heatsink will rise 20°C above ambient when dissipating 2W. Note that the LM317T TO-220 package is rated at 15W maximum power dissipation.

Isolation

Usually, it will be necessary to electrically isolate the tab of the regulator from the heatsink – see Fig.3. The reason for this is that the heatsink may be connected to ground (0V), while the regulator metal tab sits at the output voltage.

To isolate the tab, use a TO-220 silicone insulating washer and secure the assembly to the heatsink using an M3 *nylon* screw and nut. Alternatively, you can use a metal screw provided you fit an insulating bush into the regulator tab fixing hole.

Note that capacitor C1 may need to be increased in value if the input voltage has a lot of ripple. In addition, you should make sure that the input

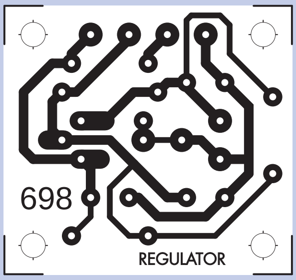


Fig.4: this is the full-size etching pattern for the PC board. Check your board for defects before mounting any of the parts.

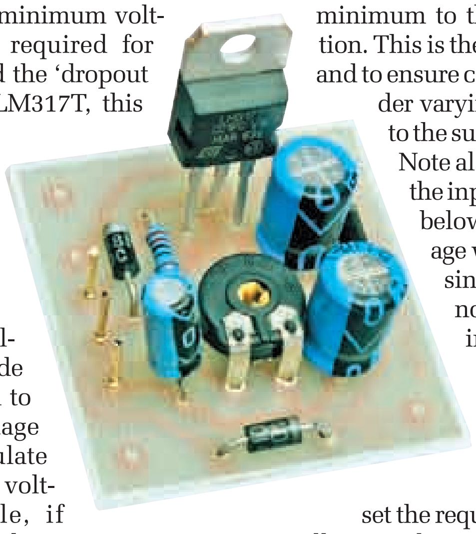
voltage does not go above C1's 25V rating. Increase C1's 'working' voltage rating to 35V if it does.

In fact, you can apply up to 35V to the input if C1 is a 35V type.

Adjusting the output

Note that the voltage applied to the supply must be several volts higher than the required output voltage. This is necessary in order for the regulator to provide regulation.

In practice, the minimum voltage across REG1 required for regulation is called the 'dropout voltage'. For the LM317T, this voltage varies with the current and is typically 1.5V for currents below 200mA, rising to 1.7V at 500mA and 2V at 1A.



Note that the voltage drop across diode D1 must be added to the dropout voltage in order to calculate the required input voltage. For example, if our power supply draws 200mA and the required output voltage is 6V, then the input voltage must be 6V plus 0.7V (to compensate for the voltage across D1) plus 1.5V (for the dropout voltage) – ie, the input voltage must be 2.2V higher than the output voltage.

Therefore, we need to apply 8.2V minimum to the input for regulation. This is the absolute minimum and to ensure correct regulation under varying loads, a 9V input to the supply would be ideal.

Note also that any ripple on the input supply that drops below the required voltage will cause problems, since the supply will not be regulated during these low-going excursions. Once you've connected the supply, it's just a matter of adjusting trimpot VR1 to set the required output voltage.

Finally, note that in some applications, you might want to replace VR1 with a fixed resistor (eg, if VR1's setting is close to a standard fixed value). This has been catered for on the PC board – just replace VR1 with resistor R2 (shown dotted).

Unforgettable Memories

Mark Nelson

An experiment using a camera chip to replace a damaged eyeball may have far more applications than the designer intended, and the future looks bright for analogue semiconductors. Mark Nelson casts an eye over the facts.

Scientists involved with optics must have stronger stomachs than me, as I have never felt comfortable with the notion of playing with human eyes. So you had better 'Look away now if you are squeamish', although I promise there is no gratuitous gore in this article.

I must confess I still get the shivers when I read about Logie Baird's 1928 television experiment using an eyeball removed by a surgeon from a young man's head. To quote the man himself...

"As soon as I was given the eye, I hurried in a taxicab to the laboratory. Within a few minutes I had the eye in the machine. Then I turned on the current and the waves carrying television were broadcast from the aerial. The essential image for television passed through the eye within half an hour after the operation. On the following day the sensitiveness of the eye's visual nerve was gone. ... The most sensitive optical substance known is the nerve of the human eye ... I had to wait a long time to get the eye because unimpaired ones are not often removed by surgeons ... Nothing was gained from the experiment. It was gruesome and a waste of time."

Eye on the future ...

Eighty-one years later the idea is reborn in reverse, well nearly. A one-eyed San Francisco artist is trying to replace her missing eye with a webcam, and technical experts say it's possible. To be fair, they are not proposing to connect the artificial eye to her brain but to computers.

Tanya Vlach is a 35 year-old artist who lost her eye in a 2005 car accident. She wears a realistic replica eye made of acrylic, but feels she could do far more than this. She wants scientists to build an 'eyecam' for her prosthesis that can dilate with changes of light and allow her to blink to control its zoom, focus, and on/off switch. She explains: "There have been all sorts of cyborgs in science fiction for a long time, and I'm sort of a sci-fi geek. With the advancement of technology, I thought – Why not?"

Her surgeon, R William Danz, told the *New York Daily News*, "I'd always given thought to using cameras to restore sight to the blind. This is a little different, more like James Bond stuff."

But Vlach has no desire to intrude on other people's privacy with her eyecam. There are amazing other possibilities, she asserts, one being to record her entire life from now on or even shoot a reality TV show from her eye's perspective. She says she will let inspiration strike once she has the device.

... and on the past

Roy Want, a senior principal engineer at Intel is assured that it's entirely possible to build a wireless camera to fit inside Vlach's prosthetic and link it to a smart phone that could transfer the video to another phone, a TV studio, or a computer. In a world where eyecams were common, they might serve as a kind of computerised backup to people's memories, he said. 'You'd never need to forget anything again, you'd never lose anything. You could ask it, for instance – Where was the last time I saw my car keys?'.

The *Test & Measurement World* website notes that if the project is a success, it could not only lead to medical advancements for the blind, but also to creating a widespread innovation to digitise people's memories by recording everything for them to refer back to. If so, one hopes the manufacturers can agree a single common format. The video-to-brain interface may take some development too.

Moore's Law queried

Back in 1965, Gordon Moore, a co-founder of semiconductor manufacturer Intel made a prediction now known as Moore's Law. It states that the number of transistors on a chip will double about every two years, thus increasing the power and reducing the cost of products made with semiconductor devices. Brian Halla, chief executive officer of National Semiconductor, argues it is not universally applicable, however.

Speaking last November at the international *Electronica* trade show he declared, "Analogue does not follow Moore's Law. Moore's Law is not about power efficiency, it is only about more transistors. There are smarter things for us to do now."

And analogue is what he predicted would create the next great growth cycle for the semiconductor industry. "Semiconductors implement everything," he argued and new markets in renewable energy, electric vehicles, distributed healthcare and better battery management would all demand analogue semiconductors. He summed up, "The semiconductor industry is essential for everything and this spells a rebirth for the semiconductor industry."

Funny by gaslight

Have you ever tried to read a newspaper or magazine by gaslight? Probably not, although firms like Camping Gaz still sell gas lighting systems using gas canisters and proper incandescent mantles. There are also parts of London and Malvern (and other towns I'm sure) where street lighting still uses gas.

The point I'm making is that gas lighting has a strange green cast, making colours look slightly 'odd' (mind you, so do sodium and mercury vapour street lights). It was only recently that I discovered the green tinge had nothing to do with gas as a substance. In fact, today's natural gas light has the same green glow as the old town gas (coal gas) did and the greenish blue colour comes from the emission spectrum of thorium. The mantles are made by soaking cotton bags in thorium and cerium nitrates, and then drying them out.

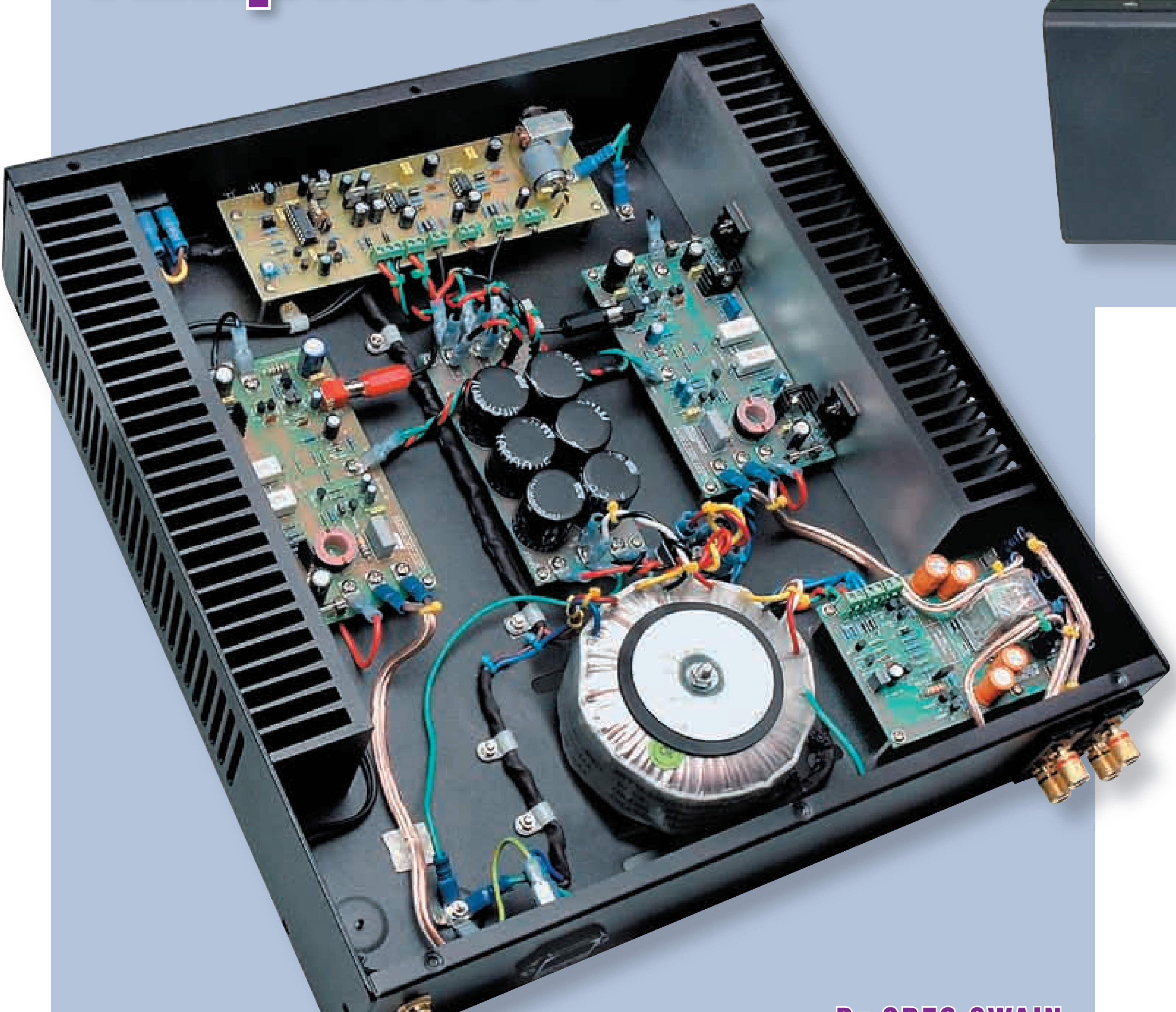
In a world rightly obsessed with finding greener methods of lighting our homes, offices, factories and public buildings, thorium may represent the answer. Not because of its unnatural light spectrum, but because thorium is mildly radioactive and a potential energy source. In fact, thorium may be a solution to our energy needs in the coming decades, particularly because the energy stored in known reserves of thorium exceeds the total of all fossil fuels.

According to the World Nuclear Association, a commercial organisation committed to sustainable development, thorium is three times more abundant in nature than uranium and can be used as a nuclear fuel through breeding to uranium-233 (U-233). When this thorium fuel cycle is used, much less plutonium and other transuranic elements are produced, compared with uranium fuel cycles. Several reactor concepts based on thorium fuel cycles are under consideration, notably by Russia, which has had a programme to develop a thorium-uranium fuel since the early 1990s.

Thorium is a naturally-occurring, slightly radioactive metal found in small amounts in most rocks and soils. Up to now it has been used in light bulb elements, lantern mantles, arc-light lamps, welding electrodes and heat-resistant ceramics. Glass containing thorium oxide has a high refractive index and dispersion and is used in high-quality lenses for cameras and scientific instruments.

Thorium certainly has potential, although any gains will be hard won. The World Nuclear Association concedes, "Much development work is still required before the thorium fuel cycle can be commercialised, and the effort required seems unlikely while (or where) abundant uranium is available." Shame!

Stereo Class-A Amplifier Pt.5



By GREG SWAIN

Chassis assembly, wiring and adjustment details

In this final article, we show you how to build a high-performance 20W Class-A Stereo Amplifier using the modules described over the last few months.

IN the Oct '08 and Nov '08 issues, we published the circuit and assembly details for our new high-performance *20W Class-A Stereo Power Amplifier* modules, along with a suitable *Power Supply* module. Then, in the Dec '08 issue, we described a *Speaker Protection & Muting* module and followed that up in Jan '09 with a *Low-Noise Preamplifier & Remote Volume Control*.

This month, we show you how to assemble everything into a custom-made steel chassis that's been designed by Altronics (**www.altronics.com.au**). This precision laser-cut chassis is supplied with all the holes drilled and with pre-punched front and rear panels with screened lettering.

This case is similar to their '2U' deluxe rack cases (but is much deeper) and features a bevelled front panel. The completed amplifier looks very professional, although at 420 × 425 × 88mm (W × D × H) it's really quite a large unit. This size is necessary to accommodate the large finned heatsinks used for the power amplifiers and to allow the various modules to be logically placed (and separated) inside the chassis.

The large chassis size is also important to aid ventilation, as the main heatsinks run quite hot in operation (about 30° above ambient). In addition, the bottom of the chassis and the lid have large ventilation slots, which line up with the heatsink fins, to allow the air to circulate through them.

That's one of the drawbacks of a class-A amplifier – they generate lots of heat that has to be dissipated.

Now, let's assume that you've completed all the modules and that you're ready to mount them in the chassis and install the wiring. Here's how to go about it.

Preparing the case

The supplied case has a tough powder-coating that's also a good insulator. **However, you *must* ensure that all sections of the case, including the side panels and the front and rear panels, are correctly earthed and that means ensuring they make good electrical contact with each other. There are two reasons for this:**

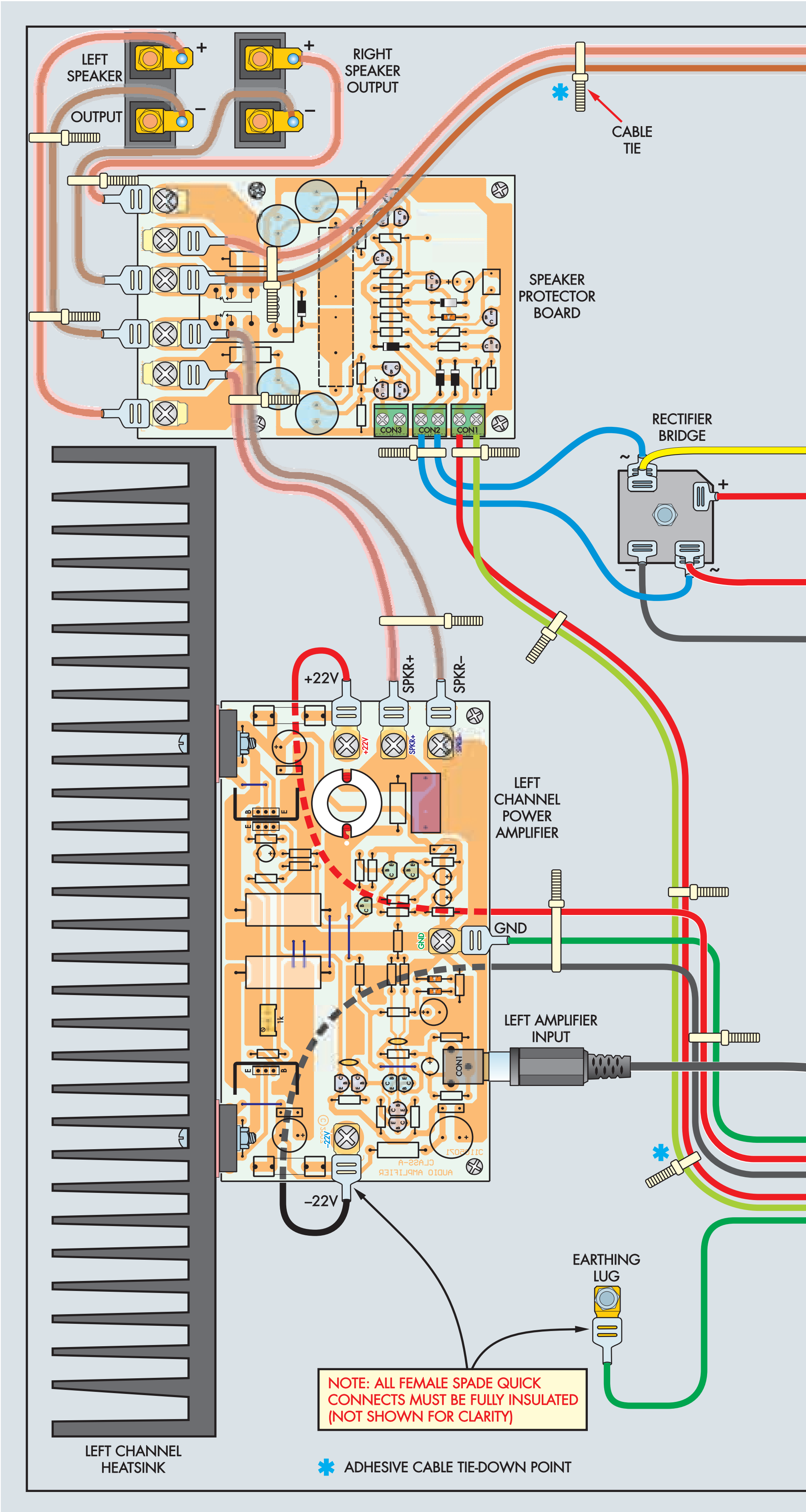
1) **All sections of the case must be connected to the mains earth to ensure safety**
2) **Correct earthing is essential to keep RF interference out of the audio circuitry.**

The first job is to ensure that the two side panels, the front and rear panels and the lid are all earthed to the bottom section of the chassis. This is done by using an oversize drill to remove the powder coating from the countersunk screw holes. Use a drill that's slightly smaller in diameter than the screw heads and be sure to remove the powder coating right back to the bare metal.

Don't just do this for one or two holes – do it for *all* the holes in each panel. Provided you use a drill that's not too big, the bare metal will later be covered by the screw heads.

Next, scrape away the powder coating around the screw holes inside the panels, the underside of the lid and from the matching contact areas around the screw holes in the chassis. This includes the contact areas around the screw holes on the inside folded sections of the front panel. That way, when the case is assembled, earthing takes place via the

Fig.1: follow this diagram and the photos to install the parts in the chassis and complete the wiring. Note that the supply leads to the modules, transformer and mains switch are twisted together – see photos and text.



screws themselves and also via direct metal-to-metal contact between the various sections.

The transformer mounting bolt must also be earthed. This means that you have to remove some of the powder coating from around the mounting hole on the outside of the chassis (ie, from under the bolt head). The same goes for all other mounting screws that go through the bottom of the chassis. In particular, make sure that you clear away the powder coating from around the six heatsink mounting holes.

Once you've done all this, remove the front panel, wrap it up and put it to one side, so that it doesn't get scratched or damaged. It doesn't take much of an accident to spoil the panel's appearance while you are installing the parts in the chassis and completing the interwiring.

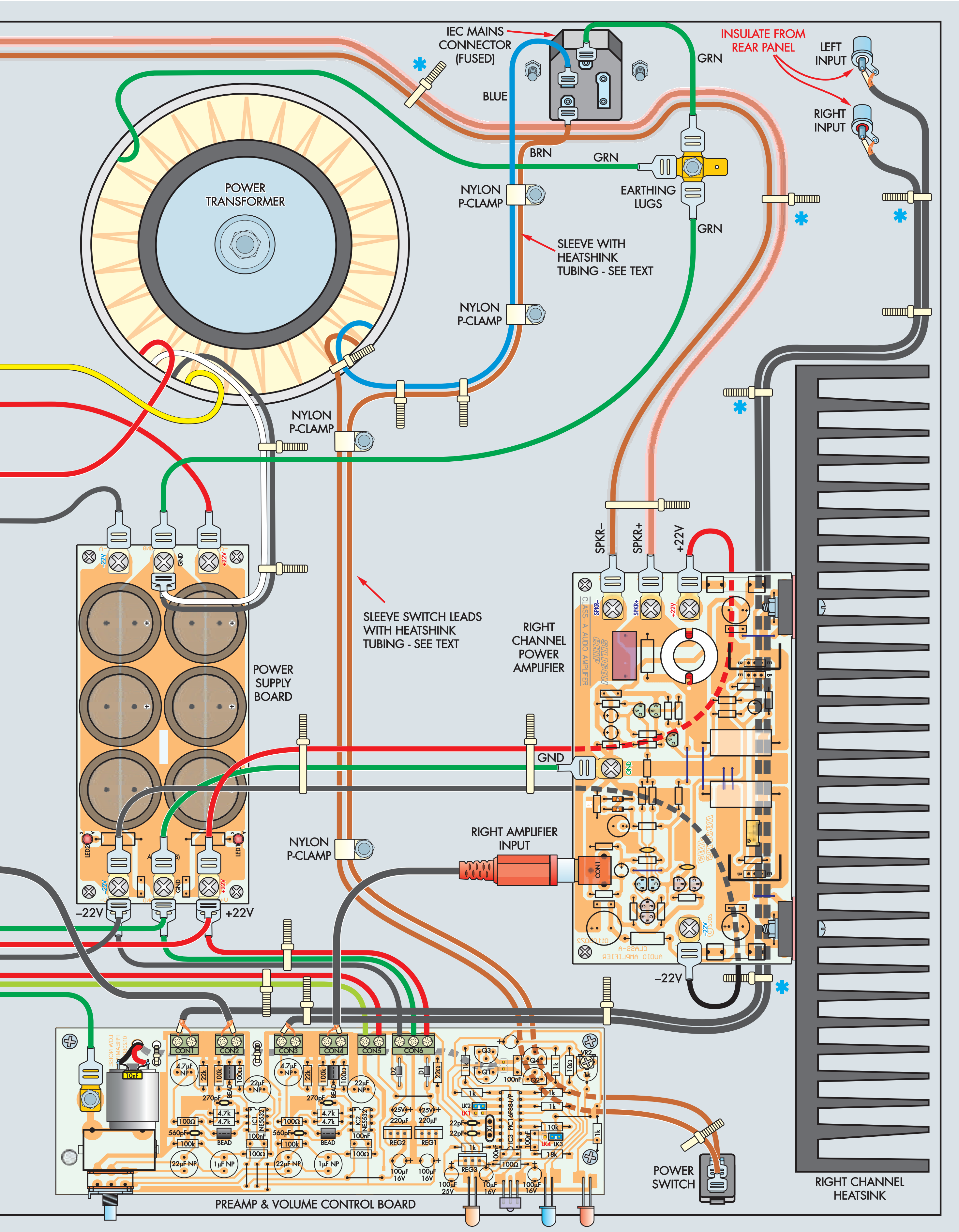
Installing the hardware

You can now start installing the hardware in the case – see Fig.1. Begin by securing the IEC (fused) power socket to the rear panel using two 6g × 12mm countersink self-tappers. That done, mount the two insulated RCA phono input sockets and the two loudspeaker terminal panels.

Note that the white (left) colour-coded RCA phono socket goes to the top, while the red (right) socket goes to the bottom. The loudspeaker terminal pairs go in with their red (positive) terminals towards the top and are again secured using 6g × 12mm countersink self-tappers.

The 35A bridge rectifier can go in next. Because it uses the chassis for heatsinking, it's important to ensure good metal-to-metal contact. It's mounting area should be completely free of powder coating – if it isn't, mark out the area and remove the powder coating using a small grinding tool.

Now smear the underside of the 35A bridge rectifier (BR1) with heatsink compound and bolt it to the chassis using an M4 screw, star washer and nut. Fig.1 and the photos show BR1's


IEC MAINS
CONNECTOR
(FUSED)
BLUE
BRN
GRN
INSULATE FROM
REAR PANEL
LEFT
INPUT
RIGHT
INPUT
POWER
TRANSFORMER
NYLON
P-CLAMP
EARTHING
LUGS
SLEEVE WITH
HEATSHINK
TUBING - SEE TEXT
SPKR–
SPKR+
+22V
SLEEVE SWITCH LEADS
WITH HEATSHINK
TUBING - SEE TEXT
RIGHT
CHANNEL
POWER
AMPLIFIER
POWER
SUPPLY
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PREAMP & VOLUME CONTROL BOARD

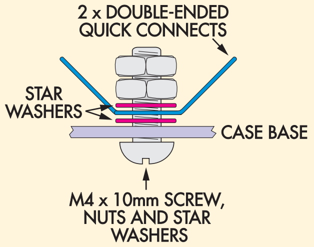


Fig.2: the Altronics case will come with the main earth lugs mounted in place. However, if you're using a different enclosure, here's how to install the chassis earth point. Two nuts are used to permanently lock the assembly in place. Make sure that it forms a sound electrical contact with the chassis.

mounting location and orientation. It's mounted with its positive DC output at top right.

Chassis earth lugs

Fig.2 shows the mounting details for the main chassis earth lugs. This assembly consists of two double-ended quick-connect spade terminals, which are bolted to the chassis using an M4 × 10mm machine screw, two star washers and two nuts. The second nut on top locks the first nut in place, so that there's no possibility of the earth terminals coming loose.

The chassis supplied with the kit will come with the earth lugs mounted in position. However, if you are using a different case, then you will have to remove the powder coating yourself. To do this, temporarily bolt one of the double-ended quick connects to the chassis and use a pencil to outline the contact area. The connector can then be unbolted and the powder coating removed using a sharp implement or a small grinding tool.

The two double-ended earth lugs can then be bolted in position. Be sure to do the nuts up nice and tight, to ensure a reliable earth.

A second earth lug is mounted at the front of the chassis, to the left of the preamp board. This is a single-ended lug and is used to ensure a reliable earth connection for the body of the volume potentiometer.

Installing the modules

The five PC-board modules can now be installed in the chassis. Note that these modules are all mounted on 10mm tapped stand-offs, except for the preamplifier module, which mounts on three 25mm tapped stand-offs.

Begin by mounting the left and right channel power amplifier modules. These should already be attached to their heatsinks and it's just a matter of lining these up with their mounting holes in the chassis and bolting them into position using M4 × 10mm machine screws and star washers. The star washers go under the heads of the screws and bite into the chassis to ensure that the heatsinks are securely earthed.

Note: do not over-tighten these screws. The heatsinks are made of aluminium and it's all too easy to strip the threads if you are ham-fisted.

Once the heatsink screws are in, the spacers fitted to the power amplifier boards can be secured to the chassis using M3 × 6mm screws and flat washers. If necessary, loosen off the heatsink screws under the chassis to get everything to line up, then do the screws up nice and tight.

Preamplifier module

The preamplifier module can now be mounted. As previously mentioned, the preamplifier is secured using only three of its four mounting holes – the hole adjacent to the volume control pot is not used. This avoids placing strain on the pot's soldered joints and in any case is unnecessary, since the pot's ferrule is also secured to the front-sub-panel.

Before mounting the preamp, fit a flat washer over the pot's threaded ferrule. That done, fit the three 25mm tapped spacers, then slip the preamp board into position and secure it to the front sub-panel by fitting the nut and a shakeproof washer to the pot. Do this nut up firmly but don't over-tighten it, to avoid stripping the thread.

Finally, the three spacers can be secured to the chassis using M3 × 6mm machine screws and washers.

The three indicator LEDs and the IR LED on the preamp board all go through a cutout in the front sub-panel. Provided you've installed them correctly, as shown in Part 4 last month, they should all line up neatly with their respective holes when the front panel is later installed.

Note that the photos show these parts going through separate holes in the front sub-panel. The chassis supplied for kits will feature a large cut-out in the sub-panel instead.

Note also that if the infrared receiver module (IRD1) has a metal shield, then it must be insulated from the front panel (see p36, Jan '09).

Power supply module

The power supply board is next on the list, but first you have to add some extra spade connectors. First, you need to install three extra single-ended connectors at the DC output end of the board, to go with the existing double-ended connectors. That done, install an extra double-ended connector at the GND terminal (to go with the existing single-ended connector) at the input end of the board – see Fig.1.

Make sure that the screws that hold these connectors in place are done up nice and tight. You will need a screwdriver to hold the head of each screw in place and a ratchet-driven socket to tighten up the nuts.

Having added the extra connectors, the power-supply board can now be mounted in position. Secure it using M3 × 10mm screws and flat washers.

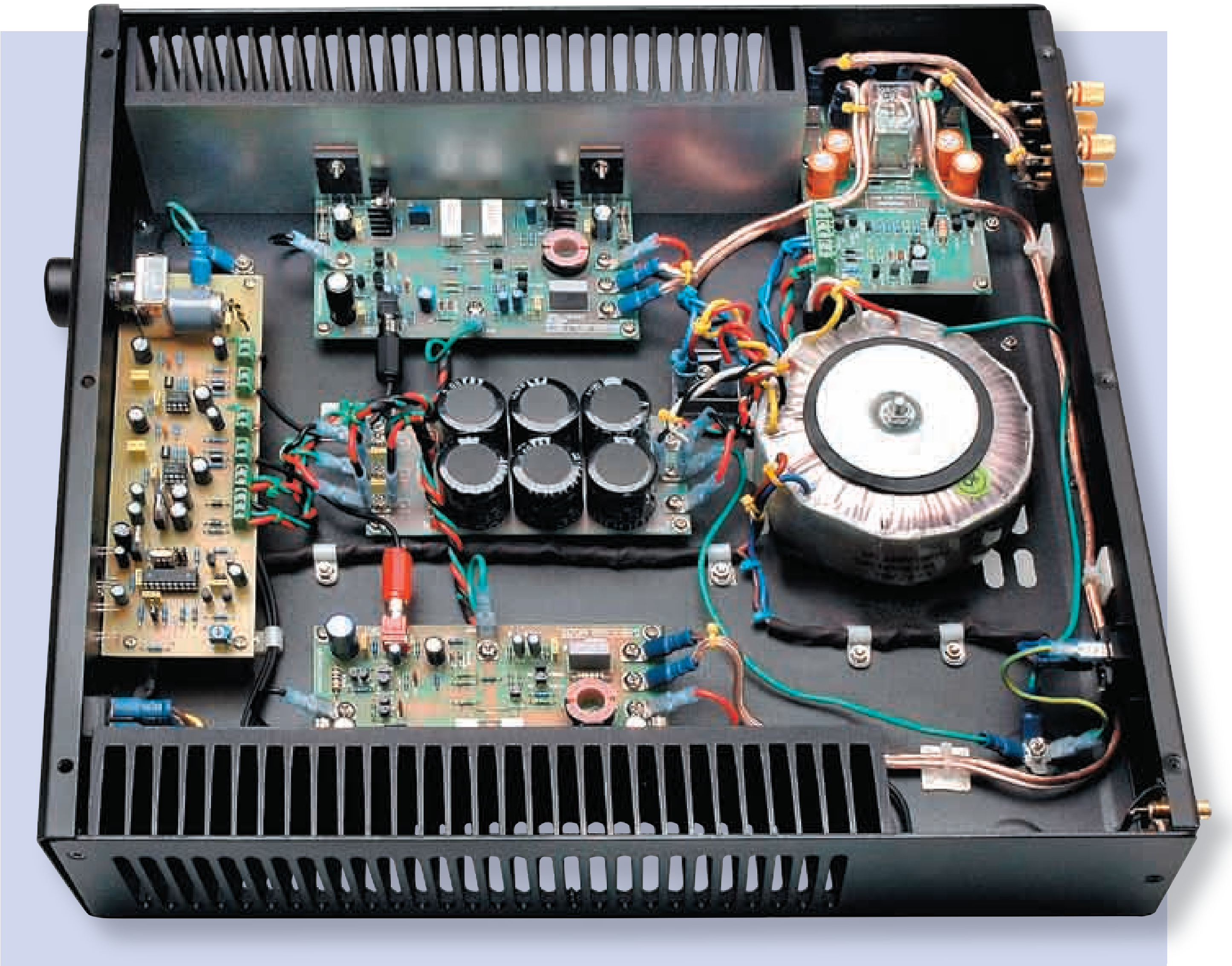
Leave the power toroid transformer out for the time being – that step comes a little later, after you've installed the low-voltage DC wiring.

Wiring up

Fig.1 shows the wiring routes. It's not nearly as intimidating as it appears at first sight, as most of it simply consists of DC supply wiring to the various modules. In addition, there's a small amount of audio signal cabling, plus the loudspeaker cabling and the mains wiring.

As can be seen, most of the supply wiring is terminated using insulated female spade connectors. These simply plug into the quick connect spade terminals on the various modules. Screw terminal blocks handle most of the other terminations, the exceptions being the RCA phono input sockets on the two audio power amplifier boards.

By the way, a ratchet-driven crimping tool (see photo) is an absolute necessity when it comes to installing the crimp connectors. Low-cost automotive type crimpers are definitely not suitable here, as their use would result in unreliable and unsafe connections – particularly where the mains wiring is concerned.



This chassis view clearly shows the routing of the loudspeaker cable from the right channel power amplifier. It runs along the bottom of the rear panel and is secured using adhesive cable tie mounts and cable ties.

As shown in the photos, all the supply leads are tightly twisted together. This not only keeps the wiring neat but also minimises hum pick-up, since the hum fields are effectively cancelled out.

There's an easy way to twist the leads together, and that's by using a hand drill. All you have to do is secure one end of the leads in a vice and the other end in the drill chuck. You then rotate the drill handle until you get a nice even lead twist along the full length of the cable.

Tight squeeze

Make the twists reasonably tight but don't overdo it – the wire will break through the insulation if you do. Once it's done, trim the ends to remove any damaged insulation and fit spade connectors to the leads at one end of the cable only. The spade connectors are fitted as follows:

1) Trim 6mm of insulation from the end of a lead and twist the wire strands together
2) push the lead into the connector until the insulation hits the internal collar
3) Crimp the connection using the crimping tool
4) Check that the connection is secure and properly insulated, with no wire strands outside the connector (this is particularly important for the 230V AC wiring).

The leads at the other end of each cable are also later fitted with spade connectors, after they have been run to their destinations and cut to the correct length.

It's best to install the low-voltage DC wiring first. This can go in as follows:

1) Install the supply wiring to the two power amplifiers. These cables should be run using extra heavy-duty red, green and black leads. Twist the leads together and initially fit spade connectors to the power supply ends only. That done, plug each cable into the power supply board and route it to its respective power amplifier board. When it reaches the amplifier board, cut the green lead to length, fit it with a spade connector and plug it in. The red and black leads then continue under the amplifier to the centre of the board. They then diverge at right

You need a ratchet-type crimping tool

One essential item that's required to build this amplifier is a ratchet-driven crimping tool, necessary for crimping the insulated quick-connect terminals to the leads.

Don't even think of using one of the cheap (non-ratchet) crimpers that are typically supplied in automotive crimp kits. They are not up to the job for a project like this, as the amount of pressure that's applied to the crimp connectors will vary all over the place. This will result in unreliable and unsafe connections, especially at the mains switch and IEC socket terminals.

By contrast, a ratchet-driven crimping tool applies a preset amount of pressure to ensure consistent, reliable connections.

angles and are routed to the +22V and –22V terminals.

2) Install the +22V, 0V and –22V supply wiring between the power supply board and the preamplifier.

3) Install the +22V and 0V wiring between the preamplifier and the loudspeaker protector module. Note that this wiring actually runs behind the bridge rectifier (Fig.1 shows it in front for clarity) and is tied down to one of the transformer ventilation slots. An adhesive cable tie mount at the front left corner of the power supply board provides a second anchorage point.

4) Install the ±22V wiring between the bridge rectifier (BR1) and the power supply board.

5) Install earth leads from the power supply board to the main chassis earth point and from the preamplifier board (near the volume pot) to its adjacent chassis earth.

AC-Sense leads

The two 'AC-Sense' leads that run from the bridge rectifier to the loudspeaker protector are next on the list. These are the blue leads that run to BR1's AC terminals in Fig.1.

First, twist the two leads together and fit one end of each lead with a piggyback crimp connector (see photo opposite page). That done, plug these into the AC (~) terminals of the bridge rectifier, then route the leads to the loudspeaker protector and trim them to length. Finally, strip about 5mm of insulation from the ends of the leads and tin them before connecting them to the screw terminal block (CON2).

If you route these leads as shown in the photos, they can be secured to the chassis using a cable tie that passes through one of the transformer ventilation slots. A second cable tie adjacent to CON2 is also a good idea.

Audio input wiring

The audio input signal leads can now be run from the rear panel to the preamplifier. These leads should be run using figure-8 (stereo) screened audio cable (ie, with the inner conductor individually shielded).

Route these leads exactly as shown and secure them using cable ties and adhesive cable tie mounts. The locations of the latter are indicated on Fig.1.

Note that the shield leads are separately connected to their respective solder lugs on the insulated RCA input sockets. Do *not* connect these shield leads together or to chassis, otherwise you'll get an earth loop.

At the preamplifier end, trim each cable to length, then strip about 14mm of the outer insulation away from each conductor in turn and carefully separate and twist the screening braid wire strands together. That done, strip about 10mm of insulation from each inner conductor, then double each bared end back on itself, twist it together and lightly tin with solder. The shield wires can also be 'doubled up', twisted and tinned.

Now secure the audio input leads to the screw terminal blocks. **Note that it's important to do these screw connections up nice and tight, otherwise the signal-to-noise ratio will be compromised.**

Some of the left over figure-8 audio cable can now be used to make the two audio leads that run from the preamplifier to the power amplifier modules. Separate the cable into two separate leads and fit an RCA phono plug to one end of each lead (red for the right channel, black for the left).

Make sure that each shield wire connects to the 'earthy' side of its phono plug (ie, to the terminal that connects to the outer collar).

The other ends of these cables can then be trimmed to length and connected to screw terminal blocks CON2 and CON4 on the preamplifier. Be sure to tin the leads as before, and again make sure the connector screws are done up tightly.

Loudspeaker cabling

The loudspeaker leads, both to and from the loudspeaker protector module, are run using heavy-duty 90/0.18 speaker cable. The cables are terminated at both ends using female spade connectors and must be routed exactly as shown in Fig.1 and the photos.

In particular, note the path for the loudspeaker cable from the right channel power amplifier. This must be kept as far away as practical from the mains wiring between the IEC socket and the power transformer.

As shown, it runs around the chassis earth terminal and then runs along the bottom section of the rear panel (behind the transformer) to the

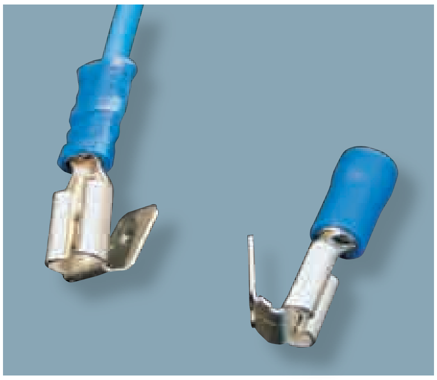
Where to buy complete and shortform kits

A kit of parts for the 20W Stereo Class-A Amplifier (Cat. K5125) is available from Altronics, 174 Roe St, Perth, WA 6000, Australia. The kit is complete and includes the five modules (unassembled) and a pre-punched steel chassis similar to that shown in the photographs.

Alternatively, you can purchase individual kit modules (but not the chassis) separately. Check the Altronics website at www.altronics.com.au for further details.

Note: the kit does not include an infrared remote control handpiece. This must be purchased separately. Almost any universal remote should be suitable – eg, Altronics Cat. A 1009 or Jaycar AR-1703.

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



The AC-Sense leads from the loudspeaker protector module are terminated in piggyback crimp connectors at the bridge rectifier end, as shown here.

Parts list for Class-A Stereo Amplifier

1 custom pre-punched steel case with screened front and rear panels (Altronics)
1 32mm black aluminium knob with grub screw
1 16V + 16V 160VA magnetically-shielded toroidal transformer (Altronics MA 5417)
1 SPST 10A 250V AC rocker switch
1 chassis-mount fused male IEC socket
1 4A 250V AC slow-blow fuse (M205)
1 230V AC 3-pin IEC mains power lead
3 6.3mm double-ended chassis-mount spade lugs
5 6.3mm single-ended chassis-mount spade lugs
40 6.3mm female spade fully-insulated connectors
2 piggyback crimp connectors
1 red RCA phono plug
1 black RCA phono plug
2 chassis-mount *insulated* RCA phono sockets (red and black)
2 2-way loudspeaker terminal panels
1 pot nut and washer
5 P-clamps
20 M3 × 6mm screws
20 M3 shakeproof washers
20 M3 flat washers
13 M4 × 10mm screws
1 M4 × 16mm screw (to secure bridge rectifier BR1)
22 M4 flat washers
1 M4 shakeproof washer (for bridge rectifier BR1)
Heatsink compound for BR1

Modules

1 right-channel class-A power amplifier module (Altronics K 5126)
1 left-channel class-A power amplifier module (Altronics K 5127)
1 power supply module (Altronics K 5128)
1 preamp and remote volume control module (Altronics K 5129)
1 loudspeaker protector module (Altronics K 5124)

Wire/cable, miscellaneous

1m brown 32/0.20 extra heavy-duty hook-up wire (mains rated)
2m red 32/0.20 extra heavy-duty hook-up wire
1m black 32/0.20 extra heavy-duty hook-up wire
2m green 32/0.20 extra heavy-duty hook-up wire (mains rated)
250mm 24/0.20 heavy-duty blue hook-up wire
1m figure-8 shielded audio cable
1m heavy-duty 90/0.18 speaker cable
40 small nylon cable ties
7 adhesive cable tie mounts
500mm of 10mm diameter heatshrink tubing

loudspeaker protector module. The cable is anchored in position using several adhesive cable tie mounts. Two of these are attached to the bottom of the rear panel, while the third sits in front of the chassis earth lugs.

Mounting the transformer

The toroidal mains transformer can now be bolted into position. This transformer is supplied with two neoprene rubber washers – one sits under the transformer (ie, between the transformer and chassis), while the other sits on top. A metal cup washer is then placed over the top rubber washer and the whole assembly secured using a large bolt that passes up through the centre of the transformer.

Before installing the mounting bolt, check that the powder coating has been cleared from around its hole at the bottom of the chassis (this is necessary to ensure the bolt is correctly earthed). Now, install the bolt and do the nut up finger tight, then rotate the transformer so that its yellow secondary lead is exactly in line with the GND (centre) connection on the adjacent power supply board.

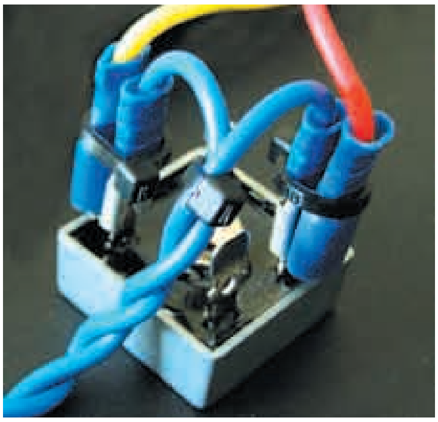
Finally, do the nut up firmly but don't over tighten it, otherwise you'll distort the metal chassis.

Note: Fig.1 shows both the transformer and the preamplifier module offset to the right, compared to their true locations in the chassis. This has been necessary to keep these parts clear of the magazine centre.

As previously mentioned, the transformer leads are all the correct length to reach their destinations and are pre-fitted with female spade quick connects. We'll deal with the secondary wiring first – all you have to do is twist the various lead pairs together and plug them into the relevant quick connect terminals on bridge rectifier BR1 and the power supply module.

First, twist the white and black leads together (to form the 0V centre-tap) and connect them to the adjacent GND point on the power supply module. That done, twist the red and

The RCA phono input sockets must be fully insulated from the chassis. The audio cable shield wires go to the individual solder lugs – do not join them or connect them to chassis at this point, as this would create an earth loop.



The transformer's red and yellow secondary leads plug into the piggyback connector at the bridge rectifier (BR1) as shown here. They should then be strapped using cable ties, so that the connectors cannot short against BR1's metal case.

yellow secondary leads together and plug them into the piggyback spade connectors on the AC terminals of BR1.

There's one important wrinkle you have to watch out for when plugging in the transformer secondary leads – it's all to easy to push the male lug of each piggyback connector down so that it shorts against the metal case of BR1. To avoid this, bend each male connector upright after plugging in the transformer lead and secure it in this position using a cable tie (see photo).

It's also a good idea to fit cable ties at both ends of the twisted pairs to keep the wiring tidy.

Mains wiring

It's now time to connect the transformer primary leads (brown and blue) and install the rest of the mains wiring. Take particular care with the mains wiring – your safety depends on it. In particular, be sure to use fully insulated spade connectors for all connections to the IEC socket and mains switch.

As shown in Fig.1, the transformer's blue primary lead connects to the Neutral terminal on the IEC socket, while its brown primary lead runs directly to the top terminal of the mains switch. In addition, you need to run a heavy-duty (32/0.20) mains-rated cable (brown) between the bottom terminal of the mains switch and the Live terminal of the IEC socket.

The best place to start this wiring is at the power transformer. Here's the procedure, step-by-step:

STEP 1: run the primary leads straight down the side of the transformer to the chassis and secure them together at top, bottom and centre using three cable ties.

STEP 2: cut a 600mm length of brown 32/0.20 heavy duty cable (this will be used to connect the IEC socket Live terminal to the mains switch).

STEP 3: twist this lead together with the brown primary lead. Start of the primary lead's quick connector and twist the leads together all the way back to the base of the transformer.

STEP 4: Slip a 320mm length of 10mm-diameter heatshrink tubing over this twisted pair and lightly shrink it into place using a hot-air gun. Be careful not to apply too much heat – you don't want the cable insulation to melt (gently does it)!

STEP 5: Secure this cable in position using the nylon P-clamps, as shown in Fig.1. Note the orientation of the P-clamps – the cable should run adjacent to the power supply board, so that it is well away from the righthand power amplifier. The switch end of the cable runs under the preamp and must be routed exactly as shown.

STEP 6: Trim the switch end of the added brown lead to the same length as the brown primary lead and crimp on a fully-insulated spade connector. Make sure that all the wire strands go inside the connector – a strand outside the connector will be dangerous.

STEP 7: Attach the front panel to the amplifier chassis and clip the mains switch into position. The two switch terminals go towards the top of the panel.

STEP 8: Connect the two spade connectors to the switch terminals. The transformer's primary lead goes to the top terminal. Use a cable tie to secure the leads at the switch terminal.

STEP 9: Twist the added brown lead with the blue primary lead all the way to the latter's spade connector.

STEP 10: Slip a 120mm length of 10mm-diameter heatshrink tubing over this twisted pair and lightly shrink it into place using a hot-air gun (gently does it).

STEP 11: Secure this section of the cable in position using another two nylon P-clamps. As before, these should be orientated exactly as shown in Fig.1.

STEP 12: Trim the brown cable to length and crimp on a female spade connector.

STEP 13: Plug the connectors into the IEC socket. The blue lead goes to the neutral terminal while the brown lead goes to Live.

STEP 14: Further secure the leads using cable ties – two between the transformer and the first P-clamp and one right at the IEC socket.

STEP 15: Prepare a 100mm-long earth lead with female spade connectors at either end and connect it between the earth terminal on the IEC socket and a spare chassis earth lug.

STEP 16: Fit a 4A slow-blow fuse to the IEC socket.

STEP 17: Secure all the wiring in the amplifier by fitting cable ties as shown in Fig.1. This not only improves the appearance by keeping everything tidy but ensures reliability as well.

In particular, make sure that the 230V mains wiring is properly secured by the P-clamps and by fitting cable ties immediately behind the spade connectors at the IEC socket and the mains switch.

Initial checks

That completes the wiring, but there are a few things to check before plugging in a mains cable and switching on. Just follow this step-by-step checklist:

1) Check the 230V wiring to the IEC socket, mains transformer and mains switch to ensure all is correct. In particular, the

Ditching the preamp and using a conventional volume pot instead

One of the options that you have in building this unit is to ditch the Preamplifier & Remote Volume Control module and use a dual 10kΩ log pot as the volume control instead.

This option would typically be used if you wanted to use a CD player to drive the power amplifier modules – the signal output from a CD player is usually (but not always) sufficient to drive the amplifier modules to full power output.

The advantage of this scheme is that you save money (ie, the cost of the preamplifier) and construction time. But there are a couple of disadvantages. First, as mentioned last month, using a simple volume control varies the input impedance to the power amplifiers, thereby slightly degrading the signal-to-noise ratio. And second, your CD player may not be able to drive the amplifiers to full output power on CDs that give below-average output signal levels.

Another disadvantage is that you no longer have the convenience of remote volume control.

If you do want to omit the preamplifier, Figs.3 and 4 show how it's done. As shown, the incoming left and right channel signals are fed to the top of the pot and the attenuated signals on the pot wipers are then fed directly to the power amplifier inputs. Fig.3 shows the circuit, while Fig.4 shows the wiring diagram.

External preamp

If you intend using an external preamplifier, you can omit the volume control altogether and simply run the audio input leads direct to the class-A power amplifiers.

What about all those blank holes on the front panel? Easy – just mount the necessary parts to fill in the holes but don't wire them up. The LEDs can be secured at the rear using epoxy resin.

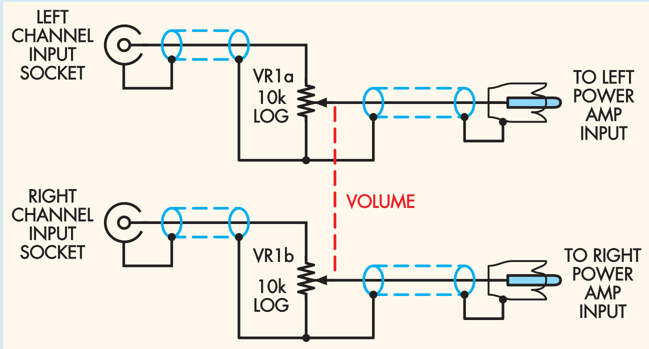


Fig.3: this circuit shows how to use a dual 10kΩ log pot as the volume control.

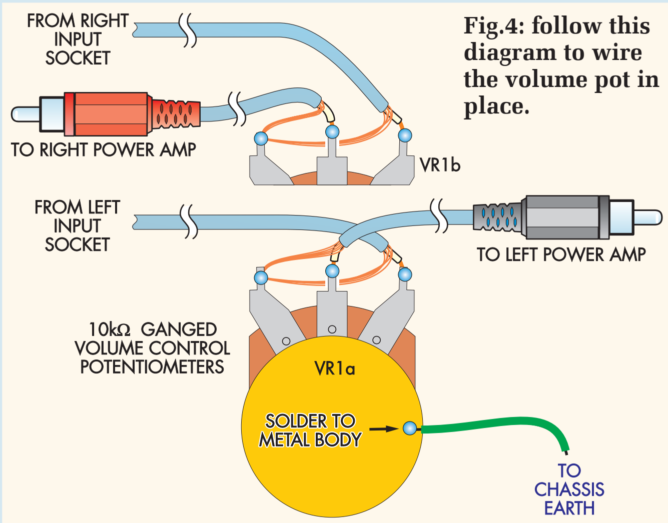


Fig.4: follow this diagram to wire the volume pot in place.

female spade connectors should all be tightly crimped, the connectors must be fully insulated and there must be no wire strands outside these connectors.

In addition, all spade connectors should be a tight fit onto their lugs, especially at the IEC socket, the mains switch and the bridge rectifier. Re-tension any connectors that slide on too easily.

2) Check that BR1's positive and negative terminals connect to the correct terminals on the power supply board.

3) Check that all the electrolytic capacitors on the power supply board are installed with the correct polarity. These things have a nasty habit of exploding if they're in the wrong way round. The same goes for other electrolytics across the supply rails on the other modules.

In fact, it's not a bad idea to wear safety glasses when switching on for the first time, just in case you do have a capacitor in the wrong way around or you accidentally reverse the supply polarity. Exploding capacitors and eyeballs generally don't mix too well!

4) Use a multimeter to confirm that all the chassis panels are correctly earthed. **Do that by checking for continuity between the earth terminal of the IEC socket and each of the panels in turn (remove some of the powder coating from an inside surface of each panel to make these checks, if necessary).**

Similarly, check that the heatsinks are earthed to the chassis and that all external screw heads are earthed.

5) Use a multimeter to confirm that the output transistors (Q12 and Q14) are correctly isolated from the heatsink of each power amplifier module.

Testing and adjustment

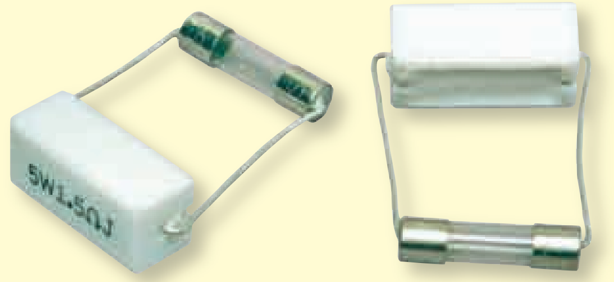
There are three basic procedures to go through here. First, you have to check that the power supply module is delivering the correct voltages. You then apply power to each power amplifier module in turn and adjust its quiescent current. Finally, you power up the preamplifier and loudspeaker protector modules and check their operation. Here's the procedure:

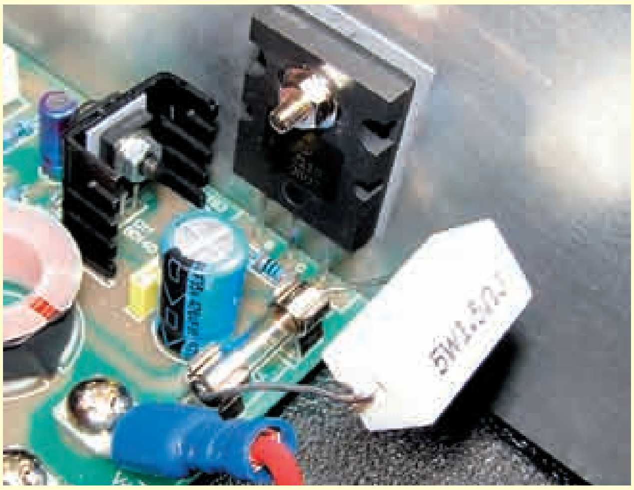
STEP 1: disconnect all nine spade connectors from the +22V, 0V, –22V terminals at the output end of the power supply module.

STEP 2: disconnect the loudspeaker leads from the power amplifier modules.

STEP 3: connect an IEC mains power cable to the amplifier and use a

Adjusting the quiescent current through the power amplifiers





The quiescent current flowing in the output stage of each power amplifier is initially adjusted by installing 1.5Ω 5W resistors in place of the fuses. The voltage across one resistor is then monitored and trimpot VR1 adjusted for a reading of 1.68V – equivalent to a quiescent current of 1.12A.

The easiest way to connect the resistors is to 'blow' the fuse wires in a couple of spare M205 fuses, then drill holes in the end caps and solder the resistors in place as shown. The original fuses can then be removed and the 'modified' fuses clipped into place – see photos.

multimeter to confirm continuity between the earth pin of the plug and the chassis earth. That done, plug the cord into a mains socket and switch on.

Warning: don't go poking around the rear of the IEC socket with power applied. The metal strap that runs from the Live terminal to one end of the fuse carries 230V AC.

STEP 4: check the unregulated ±22V rails at the output of the power supply module. These rails should both be measured with respect to the 0V terminal and should be a little high at around ±24V (since they are unloaded).

If the meter reads 0V, switch off immediately and recheck the connections to BR1.

STEP 5: switch off and connect the supply leads (+22V, 0V, –22V) for the righthand power amplifier to the power supply module.

STEP 6: remove the two fuses from the righthand power amplifier and install 1.5Ω 5W resistors in their place – ie, one in series with the +22V rail and one in series with the –22V rail.

The best way to do this is to solder these resistors across a couple of spare M205 fuses, after first destroying the internal fuse wires. First, drill a hole in each end cap, breaking the fuse wire in the process. The resistor leads can then be bent to shape, fed through the end caps and soldered (see photos).

The modified fuses with their resistors are now plugged into the fuseholders. These 1.5Ω resistors protect the output transistors by limiting the current through them if there is a fault, eg, if the V_{BE} multiplier circuitry (Q10) is not functioning correctly.

STEP 7: wind trimpot VR1 on the right channel power amplifier fully anticlockwise, switch on and check that the amplifier's output voltage (ie, between the loudspeaker terminals) is less than ±50mV. If not, check the base-emitter voltage of each transistor in the amplifier; they should all be 0.6V to 0.7V. Check also that the correct transistor is installed at each location and that they are all the right way round.

STEP 8: assuming the output voltage is correct, monitor the voltage across one of the 1.5Ω 5W resistors and wind trimpot VR1 slowly clockwise until the meter reads 1.68V. This is equivalent to a quiescent current of 1.12A.

That done, let the amplifier run for about five minutes or so and then check the voltage again. During this time the amplifier heatsink will become quite warm and the quiescent current will drift slightly. Readjust VR1 to obtain 1.68V again.

STEP 9: switch off, remove the 1.5Ω 5W resistors and install the 3A fuses.

STEP 10: repeat steps 5 to 8 for the left channel power amplifier module.

STEP 11: let the amplifiers run for about 30 minutes (so that the heatsinks get nice and hot), then check the voltage across one of the 0.1Ω 5W resistors in the right channel power amplifier. Adjust trimpot VR1 for a reading of 112mV. Now check the voltage across the other 0.1Ω resistor – these resistors have a tolerance of about 10%, so set VR1 so that the average voltage across them is 112mV.

STEP 12: repeat step 11 for the left channel power amplifier.

STEP 13: switch off and reconnect the preamplifier's +22V, 0V, –22V leads to the power supply module.

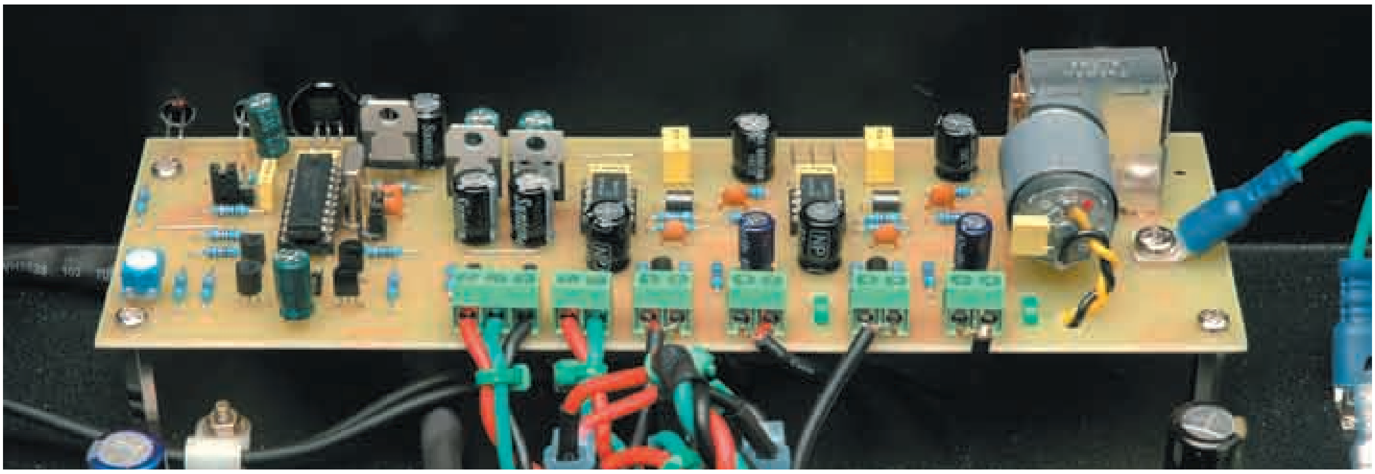
STEP 14: check the preamplifier and remote volume control for correct operation, as described in the Jan '09 issue (skip this step if you've already done this).

STEP 15: check the operation of the loudspeaker protector module if this hasn't already been done.

To do this, apply power and check that the relay turns on after about five to seven seconds. If it does, temporarily short the temperature switch input – the relay should immediately switch off. Similarly, the relay should immediately switch off if you disconnect one of the leads to the AC-Sense input.

Now check that the relay switches off if a DC voltage is applied to the loudspeaker terminals (this simulates an amplifier fault condition). This is done by connecting either a 3V, 6V or 9V battery (either way around) between the LSPKIN+ terminal and the ground terminal of CON1. The relay should immediately switch off.

Repeat this test for the RSPKIN+ terminal, then reverse the battery polarity and do these two test again. The relay should switch off each time the battery is connected (see also pages 26 and 27



This close-up view shows the mounting details for the preamplifier module. Note that it is mounted on three 25mm spacers only – two at the back and one at the front near the power LED. The other end of the board is supported at the front by securing the pot shaft to the front sub-panel (installing a spacer here would stress the pot connections).

Dec '08). Note: you need at least a 3V test battery to bias on the transistors in the DC detection circuit.

STEP 16: switch off and reconnect the loudspeaker leads to the power amplifier modules.

Watch the ventilation

That's it, your new 20W Class-A Stereo Amplifier is now ready for action.

Just one final thing – as previously mentioned, the heatsinks get quite hot and the air must be allowed to flow freely through the bottom and top ventilation slots. This means the amplifier must sit out in the open on a hard, level surface. Do not enclose it in a cabinet and do not stack anything on top of it. *EPE*

Recycle It!

BY JULIAN EDGAR

A voltmeter for almost nothing

Want a really cheap voltmeter? Here's how to adapt a VU meter that's been scrounged from an old audio cassette deck.

Here a, side-adjusted multiturn trimpot has been used as the series variable resistor. This makes calibrating the meter easy.

RECENTLY, in this column, we've covered both a very cheap lead-acid battery charger (made from a plugpack and a resistor) and a variable output switchmode 12V power supply (made from a phone charger).

Voltmeter

In both cases, it's useful to also have a meter displaying voltage. In the case of the battery charger, a voltmeter lets you monitor the battery's voltage as it charges, while in the power supply, it lets you monitor the output voltage.

There's a heap of other uses for a voltmeter as well – especially when you realise that this meter will cost you next to nothing. And it's easy to customise the scale and the voltage range over which the meter works.

Want some more possible uses? Well, in a model railway layout, you could use the meter to display the voltage being fed to the lighting – but instead of having 'volts' marked on the scale, you could have 'dusk', 'night' and 'day' ranges marked.

Another use is in battery-powered equipment. Because the meter draws very little power, it could be used in many applications to permanently display the battery voltage. That way, you'll always know if you've got a battery that's nearing the end of its charge (or its life).

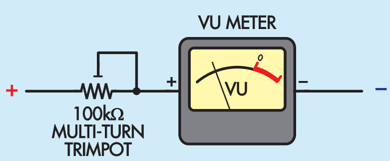


Fig.1: a VU meter is a very sensitive instrument. It can be adapted to measure a wide variety of voltages by installing a 100kΩ 'variable resistor' (potentiometer) in series with the supply voltage. This allows you to easily adjust the full scale deflection (FSD) to match the peak voltage you need to measure.

Components

You'll need only two components, as well as access to a computer, just about any image manipulation program, a scanner and a printer. You'll also temporarily need a plugpack, a 10kΩ pot and a multimeter to carry out the scale calibration.

The two electronic components required are: an analogue VU meter from a discarded audio cassette deck and a 100kΩ multiturn trimpot, used here as a variable resistor.

Old cassette decks with large illuminated VU meters turn up all the time in car 'boot' sales, and at the local tip. It is extremely rare for the VU meters to be dead, so you can be fairly safe in collecting any old cassette deck for this purpose. Try to obtain a deck that has two separate meters (one for each stereo channel), rather than one that has them combined into a single display.

VU meters are typically moving coil voltmeters that have a very high sensitivity. This means that it takes very little voltage to move the needle across the full scale – typically, just 0.3V to 0.4V. Their coil resistance is very high, at around 600Ω to 700Ω.

Plug these figures into Ohm's Law (ie, $I = V/R$) and you'll find that the meter current is only about 0.5mA for full-scale deflection (FSD)!

Building it

If you need to measure a voltage that rises only to about 0.4V, all you need do is connect the meter straight across the supply. However, it's much more likely that you'll want to measure a peak voltage of 5V, 12V or even 24V. Fortunately, it's very easy to decrease the sensitivity of the meter – just wire a variable resistor (preset) in series with the meter, as shown in Fig.1.

But how do you make the scale match the readings you want the meter to show? Most VU meters use a non-linear movement – that is, the needle moves less for a given voltage increment at the top end of the scale than it does towards the bottom. This means that you can either position the scale markings closer together as you move up the meter scale or you can space the markings evenly and jump further between numbers. We chose to do the latter.

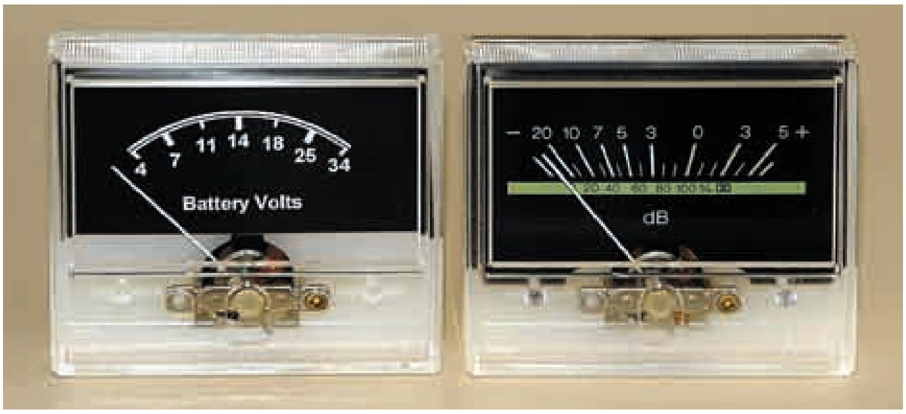
Meter scale

You can use your PC and printer to make the new scale. You could scan in the original scale and modify it, but in practice, it's best to start with the scale from another instrument. The meters shown here use a scale that was originally scanned in from an old speedo.

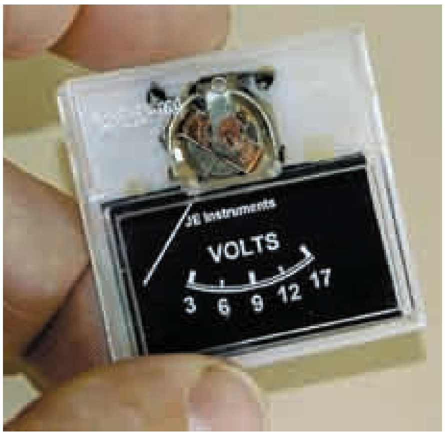
Once you have the arc and the increments, you can use the software to delete the numbers and any other markings you don't want. That done, measure the width of the scale on the meter and then size the on-screen version to match this and print it out – ie, without any numbers on it.

Next, carefully remove the original scale (most meters are held together with tape, with the scale glued in place) and temporarily place your 'un-numbered' scale behind the pointer.

To provide a variable calibration voltage, use the approach shown in Fig.2. This involves wiring a 10kΩ potentiometer across the output of a discarded plugpack. By adjusting the pot, you can vary the calibration voltage from 0V up to the maximum voltage provided by the plugpack. The multimeter is included so that you can measure the voltage being fed to the VU meter.



On the right is one of a pair of VU meters removed from an old cassette deck. At left is its modified brother, recalibrated and rescaled as a voltmeter reading up to 34V.



Hmm, 'JE instruments' . . . gee, that sounds like a good brand. When you make your own scales, you can put anything you like on them!

Calibration

So how do you perform the calibration? First, adjust the 100kΩ trimpot so that the most commonly read maximum voltage is towards the end of the scale. After you've set this, don't touch the trimpot again.

Next, alter the input voltage, measure it with the multimeter and work out what each of the other graduations on the modified meter scale should show. Be sure to round off the voltages to the nearest whole volt. For example, on one of the meters shown here, the scale goes: 4, 7, 11, 14, 18, 25, 34V.

Once you've figured it all out, use your graphics software to put the numbers on the scale, along with any other writing you want. Finally, print it out on gloss paper, cut it to shape and stick it in place.

Using it

Using the meter is as simple as connecting it (and its series 100kΩ trimpot) across the voltage source that you want to monitor. Note that if the meter needs to be used at night, it's easy to illuminate the scale. In fact, the cassette deck that you scrounged the meter from probably also had a suitable bulb in it. Make sure that it has the correct voltage rating for your application though. ***EPE***

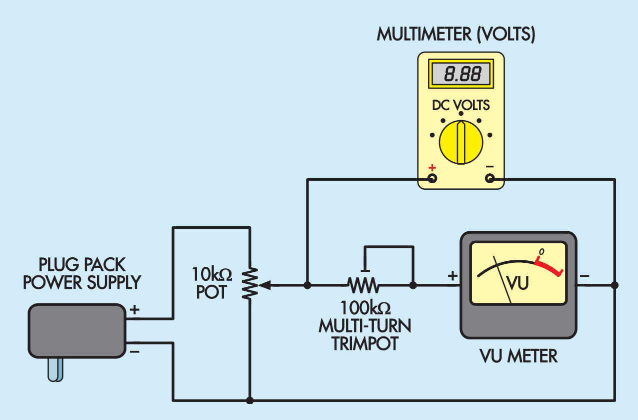


Fig.2: wiring a 10kΩ pot across a plugpack provides a variable voltage source, allowing you to calibrate the scale. The multimeter shows what the readings on the new meter scale should be.

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Recycle It!

BY JULIAN EDGAR

Salvaging and using common thermostats

Thermostats are attached to or buried in lots of consumer items and are easy to salvage. Here's a look at the common types and some hints on how they're used.

NEED to control a fan, heater or pump on the basis of temperature? It's a common requirement that can be achieved using an electronic circuit with a thermocouple or thermistor input.

However, it's much cheaper and easier to use a thermostat salvaged from a junked consumer item. Whether you need to switch at room temperature or 200°C, the thermostat doesn't have to cost you a cent.

How they work

A thermostat is basically an adjustable temperature switch. Nearly all thermostats that you can salvage work in a similar way.

A special piece of metal – called a bi-metallic strip – is the basis of the design. As its name suggests, this strip is actually two different metals joined together. These two metals have different expansion rates so as they are heated, one gets longer faster than the other. This causes the strip to bend.

When it has bent far enough (ie, it's hot enough!), it breaks the connection between two electrical contacts, turning off the circuit. The switching temperature is varied by using a threaded rod to vary the distance between the electrical contacts and the bimetallic strip.

As you can imagine, in this type of design the electrical contacts open and close very slowly. In certain applications, this could cause arcing, so many thermostat designs use a 'snap action' approach, where a small leaf spring causes the contacts to quickly snap open or snap closed once the trip point has been reached.

Another type of thermostat uses a remotely-mounted 'bulb'. This comprises a small copper cylinder (usually about as big as a short pencil) which is connected to the main switch mechanism by small-bore copper tube. The tube and the bulb are filled with a liquid or gas that expands as it gets warm and the resulting fluid pressure activates the switch.

Common consumer goods in which bimetallic strip thermostats are used include oil-filled electric space heaters, electric frying pans and clothes irons. Remote bulb thermostats are

You could pay lots for a professional looking thermostat like this… or instead, use a salvaged frying pan thermostat and a handful of other components to make your own for nearly nothing.

Electric frying pan thermostats use a stainless steel probe that can be inserted through the wall of a pipe or into liquids. They can be adjusted to trip at temperatures from about 40°C to 200°C.

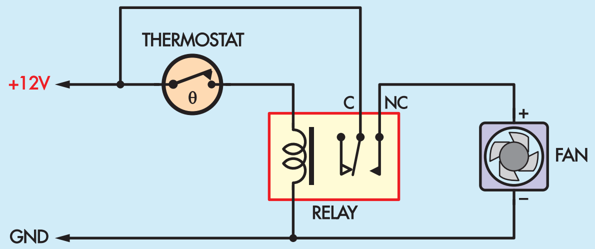

Fig.1: most thermostats are normally closed designs – ie, they open when the set-point temperature is reached. But by using a double-throw relay, it's possible to turn on something when the thermostat opens, as shown here. This circuit shows how to switch on a 12V DC fan at temperatures above the thermostat set-point.

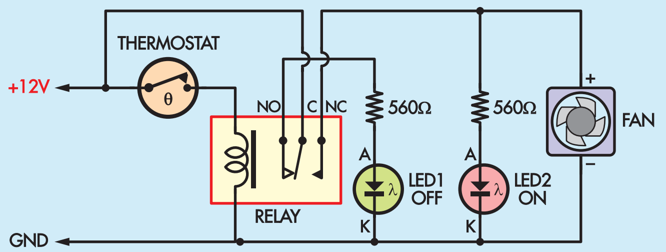

Fig.2: when a relay is used, adding LEDs to show the operating status of the thermostat is easy. In this case, LED1 lights when the fan is off, while LED2 lights when the fan is on.

Rat it before you chuck it!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month, we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you salvage the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up but you get the idea . . .)

If you have some practical ideas, write in and tell us!

used in old electric water-bed heaters. Table 1 shows the characteristics of each of these types.

Selecting a thermostat

Scrounge a few of the abovementioned consumer items (eg, during a trip to your local council tip) and in no time at all you'll have more thermostats than you know what to do with! So let's take a look at the characteristics of each design.

Frying pan thermostat: electric frying pans (and electric woks) use a thermostat that's integrated into the module that plugs into the handle. The module has a knob on it (for setting the temperature) and a stainless steel probe, about the length of your little finger (but a bit smaller in diameter).

These thermostats can be set to operate from about 40°C to 200°C. Their design makes them suitable for applications where the probe needs to remotely sense temperature; eg, by being pushed through a grommet and into a pipe. The hysteresis (ie, the difference between the switch-on and switch-off temperatures) is fairly small and they react quite quickly to temperature changes.

Both 'snap-action' and 'slow-moving' thermostats are used in frying pans, with later models more likely to be the 'snap-action' type. It's very easy to tell if you're salvaging a snap-action thermostat: hold the control box up to your ear as you slowly turn the knob. If you hear a satisfying 'click', you know you're got a snap-action type.

Clothes iron thermostats: clothes irons also use bi-metallic thermostats. Despite being controlled by a knob or lever placed on top of the iron, the thermostat is mounted deep inside the iron. In fact, one end of the bimetallic strip is actually bolted to the aluminium baseplate.

These thermostats are 'snap action' types and react more slowly than frypan thermostats (to ignore short-term temperature spikes). As a result, their hysteresis is also larger. Typically, they are suitable for sensing temperatures from about 60°C to 200°C.

Table 1: Characteristics Of Common Thermostats

	Electric Frypan Thermostat	Clothes Iron Thermostat	Oil-Filled Heater Thermostat	Water Bed Thermostat
Temperature Range	Wide (40-200°C)	Fairly wide (60-200°C)	Narrow (5-50°C)	Narrow (25-50°C)
Hysteresis	Small	Large	Small	Small
Sensitivity	Medium	Low	High	High
Action	Many not snap action	Most snap action	All snap action	All snap action
Sensing	Short stainless steel probe	Whole thermostat	Whole thermostat	Remote copper bulb

Every discarded electric iron has a thermostat mounted inside. These snap-action thermostats can be used to switch at temperatures from about 60°C to 200°C.

Take Care With Mains Voltages!

Although thermostats can be used to directly control mains voltages, we've covered only low-voltage DC switching in this article.

Make sure that you're up to speed with mains power wiring before attempting to use salvaged thermostats in high voltage applications. If in any doubt, you MUST consult a qualified electrician or someone who is experienced with mains circuits – otherwise the results could be fatal!

Because they don't use a remote probe, this type of thermostat is useful when the temperature of the general environment needs to be sensed.

Oil-filled heater thermostats: as with clothes iron thermostats, oil-filled heater thermostats are designed to sense the temperature of their environment and don't have a sensing probe. These thermostats are quite sensitive, have a small hysteresis and work at room temperatures, making them ideal for activating fans inside electrical equipment.

Water-bed heater thermostats: these thermostats use a remote bulb, allowing temperature sensing at a point remote from the thermostat itself. They can be set very precisely over the 25°C to 50°C range, are quite sensitive and have a small hysteresis.

However, the bulb may be too bulky for some applications and the sensing tube cannot be altered in length.

Using thermostats

Nearly all thermostats open when the trip-point is reached. This is because they were designed to control heating elements that need to be switched off when the temperature rises sufficiently. In other words, they're 'normally closed' (NC) designs.

Only one pair of contacts is provided, so what do we do when we want to turn something on (rather than off) when the trip-point is reached? This is easily achieved with a double-throw (or changeover) relay and Fig.1 shows how it's wired.

It's also easy to add a couple of LEDs to indicate the switching status of the thermostat. Fig.2 shows how to do this. In this case, LED1 lights when the fan is off (thermostat closed), while LED2 lights when the fan is running (thermostat open).

The two 560Ω resistors limit the current through each LED to about 18mA. ***EPE***

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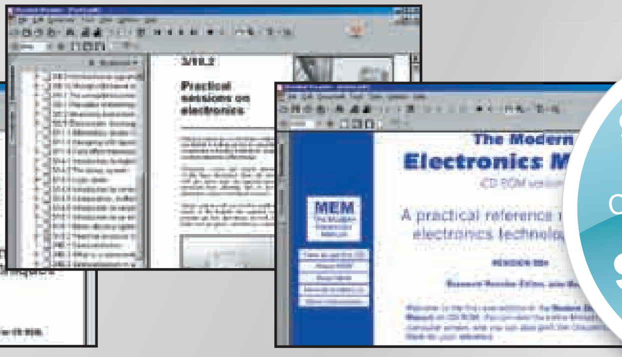

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By Robert Penfold

INTERFACE

MORE ON SERIAL PORT COMPATIBILITY

THE previous *Interface* article covered the use of the free programming language, Visual BASIC Express Edition 2008, to write data to a serial port. The latter could be a conventional PC RS232C port, but these days it would more probably be a virtual type added to a USB port or PCI expansion slot.

It does not really matter which type of serial port is used, since they are effectively the same once integrated into the operating system using the correct driver software. The method of writing to them using Visual BASIC is also exactly the same for conventional and virtual ports.

The obvious way of sending data to the outside world using a serial port is to write bytes of data to the port so that they are sent in standard asynchronous form, and then decoded by the receiving device in the normal way. However, this is not necessarily the best way of doing things for every application. Using an RS232C link tends to be more straightforward in theory than in practice, and it is not something you ever hear described as straightforward.

Level conversion

As explained in the previous *Interface* article, two of the handshake outputs of the port are under direct software control, and can therefore be used as general purpose outputs. The two handshake outputs are the DTR and RTS lines, which are respectively at pins 4 and 7 of the serial port (see Fig.1). One slight complication when using these is that they are at standard RS232C signal levels, which are approximately +12V (True) and –12V (False). It is, therefore, necessary to process these lines using RS232C line receivers in order to obtain signals at conventional logic levels.

For many purposes, a simple common emitter switching stage is all that is needed, such as the one shown in the circuit diagram of Fig.2. Transistor TR1 is switched on when the RS232C output is at +12V, sending its collector (c) to little more than the 0V supply voltage. Transistor TR1 is switched off when the driving output line goes to –12V, and R3 then pulls the output of the circuit high. Resistor R1 and diode D1 limit the input voltage to TR1 at about –0.7V, and protect it from an excessive reverse. There is an inversion through this circuit, so the software must be designed to take this into account.

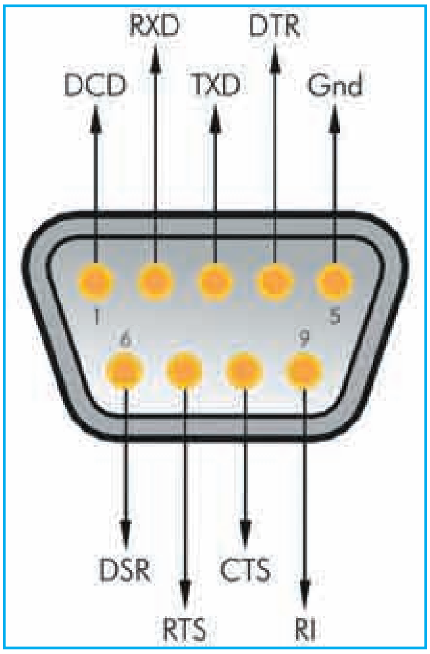

Fig.1. The DTR and RTS lines at pins 4 and 7 respectively can be directly controlled by a Visual BASIC program. This enables a basic synchronous link to be produced

Essentially, the same circuit can be used to control a relay, and a suitably modified version of the circuit is shown in Fig.3. As before, TR1 operates as a simple common emitter switch that is turned on when the RS232C output is at +12V, and turned off when it is at –12V. In this case though, the load for TR1 is the relay coil, and the relay is therefore switched on when the RS232C output is set at +12V.

Diode D2 protects the circuit from the high reverse voltage spike that occurs when the relay is switched off. The supply potential is given as +12V in Fig.3, which assumes that the relay has a 12V coil. The supply potential should be reduced to match the coil voltage if a 5V or 6V relay is used. The coil resistance should be about 180Ω or greater.

Easy does it

There are numerous integrated circuits designed to provide RS232C line drivers and (or) receivers, and the MAX202 is one of the easiest to use. It contains two line receivers plus a couple of line drivers, and the power supply circuitry to enable the drivers to operate at the correct output voltages, even though the MAX202 operates from a single +5V supply. Fig.4 shows the circuit for twin line drivers and receivers based on the MAX202.

In the present context it is only the line drivers that are of interest, but in many practical applications it is necessary for the peripheral device to send data or handshake signals back to the computer. The line drivers can then be used to provide the proper signal levels needed to drive RS232C inputs reliably.

An advantage of using the MAX202 is that it provides dual 12V supplies for the line drivers without the need for any

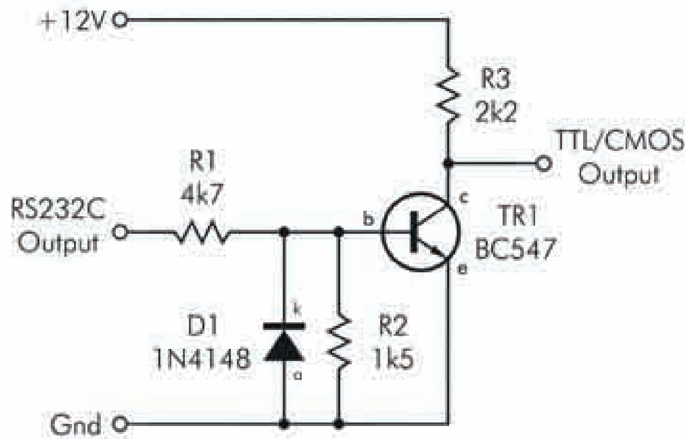

Fig.2. A simple line receiver circuit that is suitable for many applications. The outputs of an RS232C port are about ±12V, and should not be connected direct to ordinary logic inputs

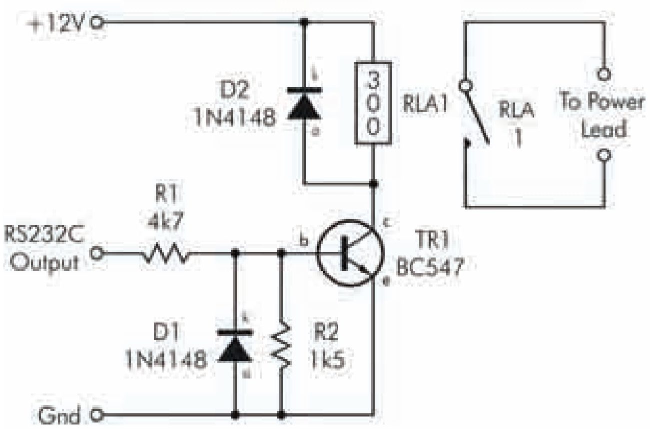

Fig.3. A simple relay driver circuit that can be controlled using an RS232C handshake output

expensive or awkward components such as high quality inductors for low frequency operation. Capacitors C2 to C4 are the only discrete components needed for the supply circuit, and these must be high quality types such as tantalum capacitors. Remember, it is the convention for line drivers and receivers to provide an inversion, and that the software must be designed to take this into account.

Synchronous link

An RS232C uses a form of asynchronous serial communication, which means that the link can be provided using just one signal line plus a ground connection, or two lines plus a ground connection if two-way communication is required. The two ends of the system are synchronised using additional signals on the data lines, and by using a standard rate when sending data. Provided the receiving system is set up to interpret the synchronising signals correctly, and it is also set to receive data at the correct rate, data will normally be transferred without any corruption of the data.

The alternative approach is to use a synchronous link, and the rate at which data is sent is not standardised with this method. There are no baud rates to contend with, or word formats either. A slight drawback of the synchronous approach is that each link requires two signal lines plus a ground connection for one-way operation, or four lines plus a ground connection for a two-way system. There are two handshake lines on each serial port that are under software control, which is sufficient for a basic synchronous output.

With a simple synchronous link the two signal lines are used to carry the data and a clock signal. The clock signal is not a regular series of pulses, and it is not a clock signal of the type used to control most digital circuits. It is used to indicate to the receiving equipment that a fresh bit of data is available on the data line and is ready for processing. There is more than one way of arranging things, but the waveform diagram of Fig.5 helps to explain a typical approach to synchronous communication.

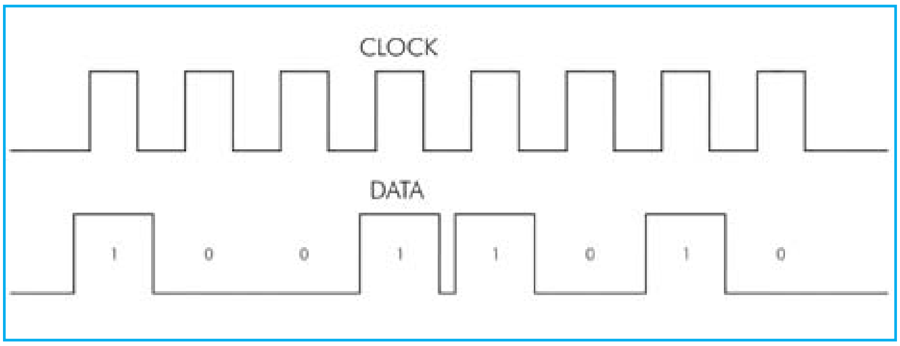

Fig.5. Timing diagram for a basic synchronous data link. In this example there are eight bits of data in the group, but within reason, any required number of bits can be used

With this scheme of things, the clock signal goes through a low-to-high transition each time a fresh bit of data is ready to be read. The receiving device must be designed to almost immediately detect each transition of this type, and then read the bit of data. In theory, it is possible for the data to be sent as fast or as slow as you like, but in practice there is obviously an upper limit.

It is important that data is not transmitted at a rate which is faster than the receiving device can handle properly. With a computer as the sending device this is unlikely to be a problem, because the transmission rate will usually be slow in relation to the speed at which the receiving device can process received data. It might be necessary to deliberately slow things down when the receiving device is a computer, or in any case where the receiving device is relatively slow.

Matter of timing

Returning to the waveform diagram of Fig.5, in this example there is a series of eight data bits. The receiving device is given an appropriate time to read the first bit, after which the clock line is set low, and then the data line is also set low. Next the data line is set to the appropriate state for the second bit, and then a low-to-high transition on the clock line is used to indicate to the receiving device that a fresh bit of data is available. This sequence of events is repeated for the remaining six bits.

In Fig.5 a low-to-high transition is used to latch each bit of data into the receiving device, but the system will work just as well if a transition in the opposite direction is used. The crucial elements are to always have the data line at the appropriate level when an active transition occurs, and to leave the data line at that level long enough for the data to be read properly. The system should function reliably provided those two criteria are met.

Of course, it is the convention for an asynchronous serial link to deal in bytes of data, or in certain applications five or seven bit groups of data are used. A normal RS232C interface is not used with groups of more than 8 bits of data. With a synchronous system things are less rigid, and the number of bits is tailored to match the requirements of the application. The data can be 4-bit nibbles, 32-bit long words, or anything else within reason. The system is not standardised and is designed specifically for a given application. In practice, this usually means designing the receiving device first, and then writing the software for the PC to match this design.

Missing link

Although a synchronous link can have as little as two connecting lines plus an earth connection, real-world links often have an additional line. The problem with a simple twin line system is that it can get out of synchronisation if there are any spurious pulses on the two lines, or it may never become properly synchronised if there are any such pulses initially, such as when the computer is booted. Each block of decoded data is then the end of one block and the beginning of the next one, giving totally scrambled and erroneous results. The hardware solution is to have a third output from the sending device that is used to reset the receiving equipment prior to a new set of data being sent.

This method is not a practical proposition using the handshake outputs of an RS232C port, since there are only two outputs that are under direct software control. However, it is still possible to have some form of error checking, but this has to rely on software routines at the receiving device instead of an extra wire in the link. For example, in a practical system there will often be a relatively long gap between each set of bits. This gap can be detected by a software routine at the receiving equipment and used as a reset signal.

Another ploy is to set one or both of the lines at a certain level before starting the transmission of data. In the example system of Fig.5 the two lines are normally low under standby conditions, so taking one or both of them high for a period of time could be used as a reset signal to the receiving device. The receiving equipment will usually be based on a microcontroller, so this type of checking will require a few lines of additional program code rather than any additional hardware.

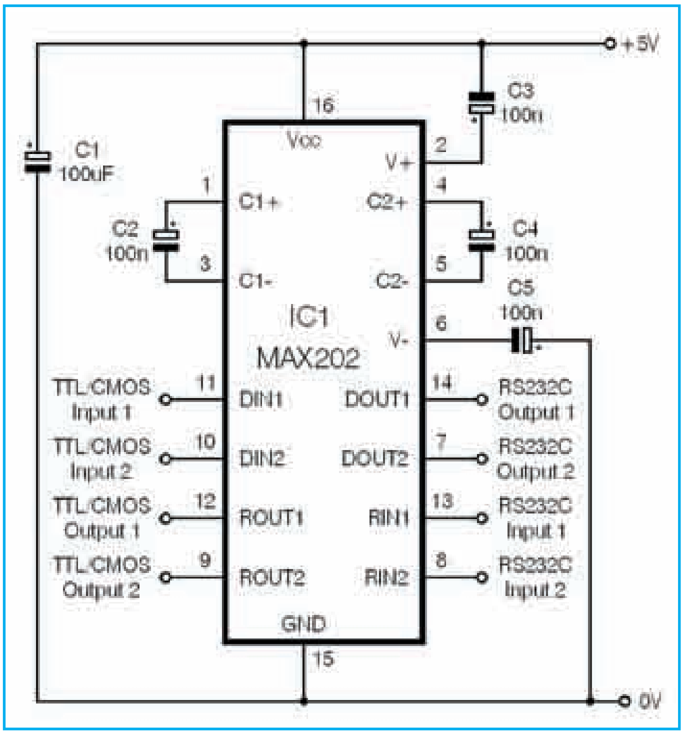

Fig.4. The MAX202 provides two line drivers plus two line receivers, but requires no awkward or expensive inductors, and operates from a single +5V supply

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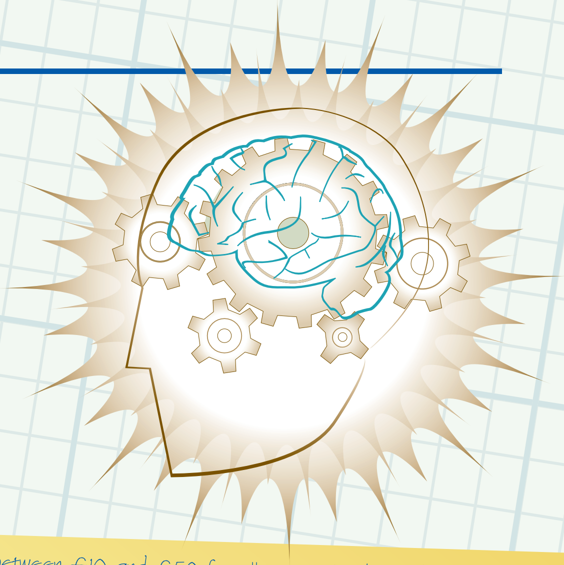

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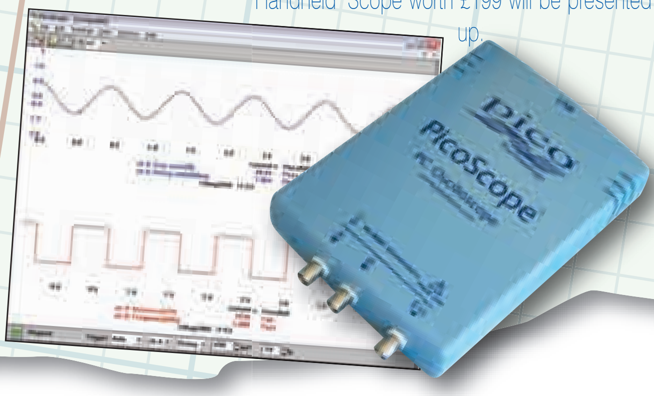

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Fuel Gauge Interface – *Rally round the tank!*

The Fuel Guage Interface circuit shown in Fig.1 was developed to assist in the display of fuel level on a rally car. A colleague presented the author with an 'ancient' Smiths analogue fuel meter, and asked if I could work out how to drive it.

The input is from a fuel sender – basically a float on a swinging arm in the fuel tank – offering a variable resistance output dependent on the height of the fuel in the tank. This is achieved by a shorting contact attached to the arm, moving across a resistive track.

Measurements of the two components suggested that the tank resistance was fairly linear over the fuel level range (30Ω empty to 300Ω full), and the gauge had a resistance of 60Ω, needing 2.5V to read 'Empty' and 7.5V to read 'Full'.

This confirmed that the obvious solution of putting the sender and gauge in series and running them off the vehicle supply wouldn't work – the sender resistance went in the wrong direction! Driving the sender with a constant current was also rejected and a PIC solution seemed too elegant. Using Excel 'modelling' on the computer it was found that a resistor in line driven from a regulated voltage would give an acceptably useful output, and one of 300Ω driven by 10V would be about right.

This voltage swing required some buffering to drive the gauge – over 100mA would be required at the upper end of the scale. A power audio op amp was considered, but with some voltages close to supply and ground it was decided to stick to a simple rail-to-rail CMOS 7621 wired in a voltage follower configuration, with the current amplification provided by the 'bomb-proof' Zetex ZTX653 transistor (2A continuous at 1W).

Although the output curve gave a good fit, especially in the all-important lower half of the fuel range, the voltage needed shifting 'up' by about a volt. This was accomplished by introducing a couple of diodes in the feedback loop – one silicon (1N4148) and one Schottky (BAT85). Added together, their forward voltage drops give about 0.95V, helped by some forward biasing current through resistor R2.

Setting up is quite simple – adjust preset VR2 to give 10V output from IC2, and tweak preset VRl to set zero on the gauge.

Some might raise the question – why no 'anti-slosh' conditioning,

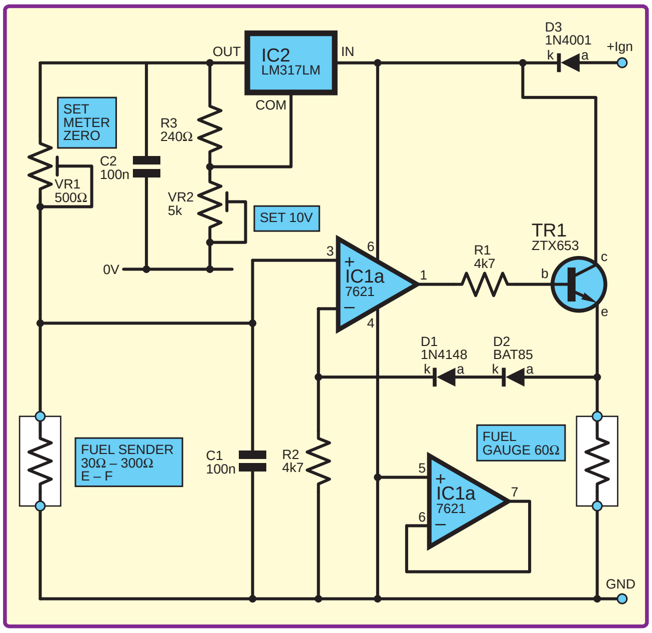


Fig.1. Circuit diagram for the Fuel Guage Interface

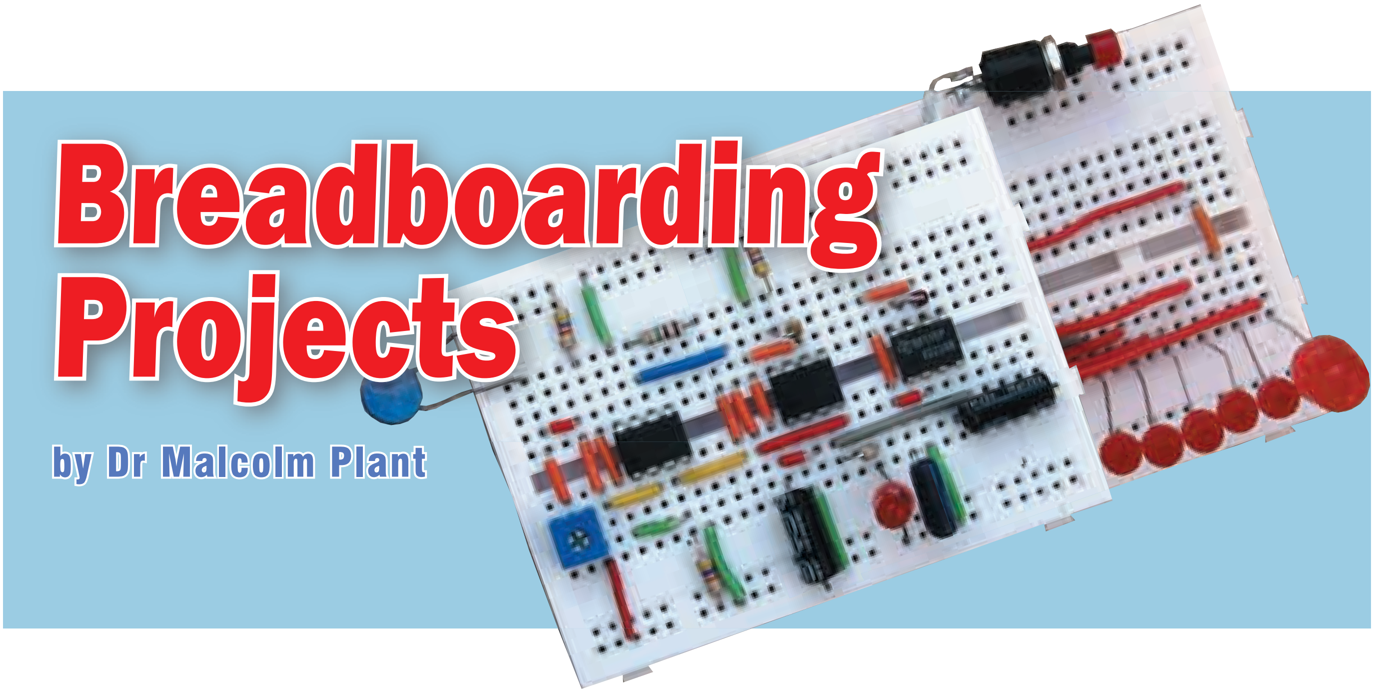
to prevent the needle swinging around as the car flies over the bumps and the fuel 'sloshes' around in the tank?

This is solved by the meter 'technology'. The fuel gauge needle is pivoted on a bimetallic arm. Wire coiled around the arm heats it according to the voltage applied to the gauge. Due to the differing expansion rates of the two metals, the arm bends in proportion to the temperature change caused by the current in the wires, and the needle moves across the scale. The thermal inertia of this system eliminates rapid changes in needle position – job done and no electronics required!

Steve Dellow, Warwick

Breadboarding Projects

by Dr Malcolm Plant



A beginner's guide to simple, solder-free circuit prototyping
Part 5: Frost Alert and Simple Dice

This month, in Part 5, we present a couple more interesting circuits for building on breadboard – a Frost Alert and a Simple Dice.

Project 9:
Frost Alert

THIS project produces an intermittent audio alarm when the air temperature reaches the freezing point of water, that is 0°C in normal conditions. The temperature sensing device is a thermistor, TH1, the resistance of which decreases with increasing temperature.

The circuit diagram shown in Fig.5.1 may be regarded as made up of two main building blocks. The first building block acts as a temperature-sensitive electronic switch based on operational amplifier (op amp) IC1, which is activated when the thermistor reaches 0°C. Once activated, it energises the second building block comprising two 555 timers, IC2 and IC3, that are interconnected as two coupled astables. Together, they produce a loud pulsing audio alarm from loudspeaker LS1 when the thermistor's temperature falls to 0°C .

How it works

In order to understand how the circuit works, focus first on IC1, which is connected as an electronic switch. Notice that the voltage divider action of resistors R1 and R2 provide a fixed voltage on the non-inverting pin 3 of IC1.

This voltage is compared with the variable voltage on its inverting pin 2, which is determined by the resistance of the thermistor, TH1, and of the setting of potentiometer VR1 (which is used as a variable resistor).

Once this variable voltage falls below the voltage on IC1 pin 3, the output of IC1 (pin 6) rises sharply to near the positive supply voltage and is sensed by pin 4 of IC2. IC2 is a timer IC wired as a low frequency astable, causing it to oscillate at a frequency set by the values

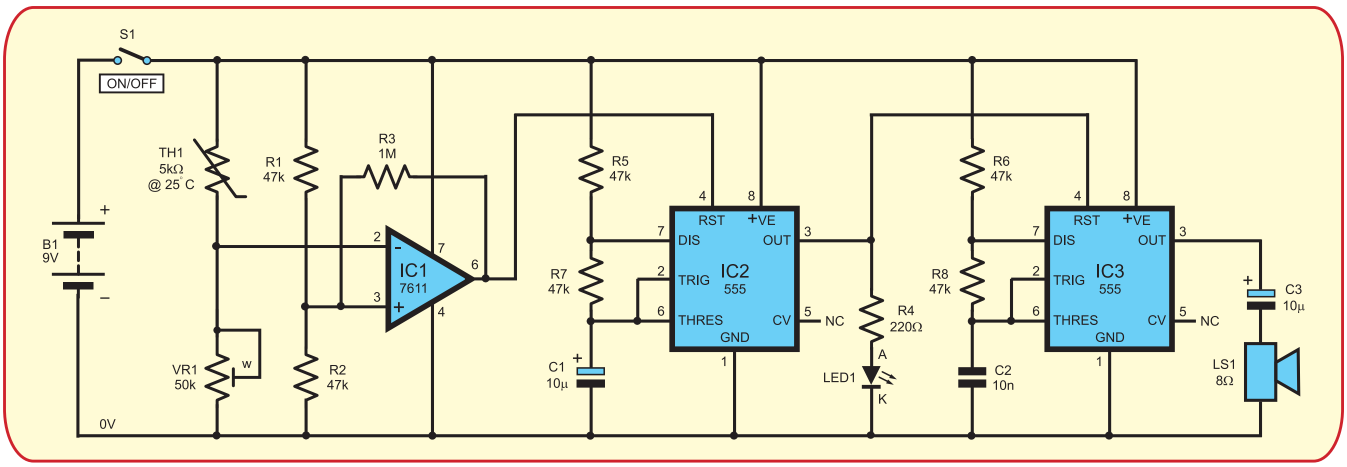


Fig.5.1: Frost Alert circuit diagram

Component Info

IC1, type 7611 CMOS op amp
IC2, IC3, type 555 timer IC

PIN 1

Viewed from the top, an indented dot and a 'half-moon' shape at one end indicates pin one. The pins are numbered anti-clockwise ending at pin 8 opposite pin 1.

TH1, disc thermistor (5kΩ resistance at 25°C). Example, type TTC502A
Has long leads and can be connected either way round in the circuit

LS1, loudspeaker

The two wires to the loudspeaker can be connected to the circuit either way round. The speaker will need two 0.6mm plastic covered wires attached to its terminals.

Components needed...

Integrated circuits, IC1, IC2 and IC3: type 7611 CMOS operational amplifier (op amp) (IC1); type 555 timer (IC2, IC3)
Thermistor, TH1: NTC (negative temperature coefficient) disc type with a resistance of 5kΩ at 25°C. For example, type TTC502A
Light emitting diode, LED1: suggest red
Loudspeaker, LS1: miniature 8Ω or 16Ω impendance
Capacitors, C1 to C3: values 10µF axial electrolytic 25V (C1, C3); 10nF polyester (C2)
Potentiometer, VR1: 50kΩ miniature preset type
Resistors, R1 to R8: values 47kΩ (R1, R2, R5 to R8); 1MΩ (R3); 220Ω (R4). All 0.25W carbon film.
Switch, S1 (On/Off): single-pole, single-throw (SPST)
Battery, B1: 9V and connecting leads
Protobloc and wire links

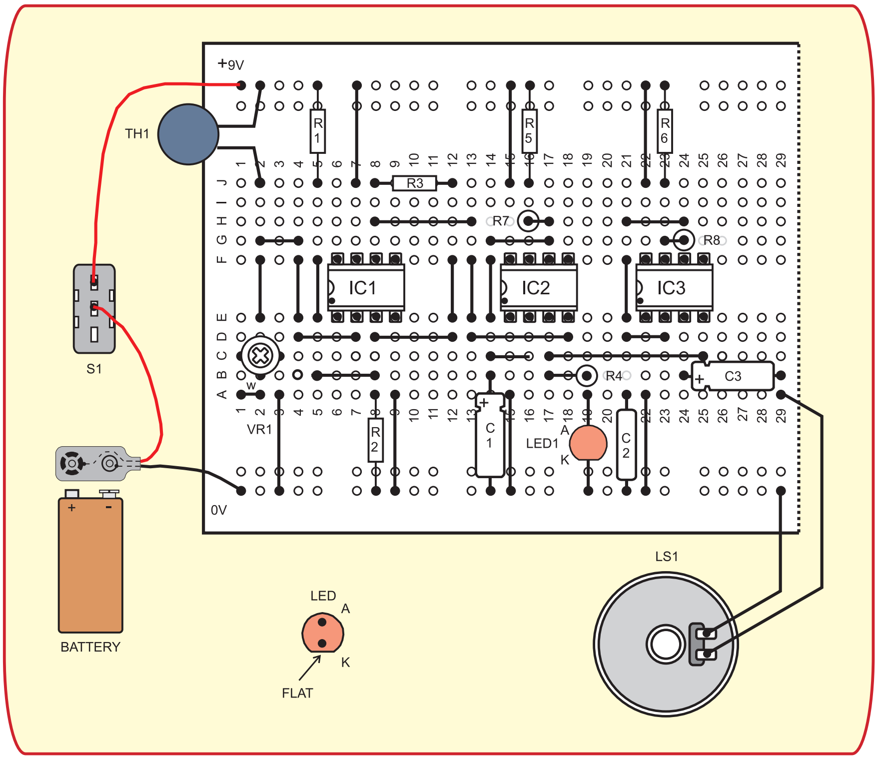


Fig.5.2: Assembly of the Frost Alert on Protobloc

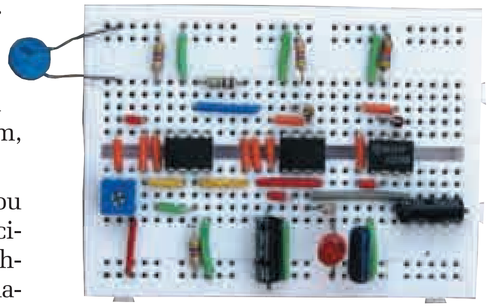
of capacitor C1 and resistors R5 and R7. This frequency is about 1Hz and is monitored by the flashing of LED1.

Each time IC2 output pin 3 goes high, so turning on LED1, it enables the second astable, based on IC3, via its pin 4. When IC2 pin 3 falls to 0V, it switches off IC3. The frequency of the astable that is centred on IC3 is 100 times higher than that based on IC2, so that the two astables provide a continuous 'beep, beep ...' sound from LS1.

The circuit is adjusted so that it responds to a temperature of 0°C by immersing the thermistor in melting ice (to make sure it is at 0°C) and adjusting preset VR1 so that the alarm is just triggered.

Notes

- Note that capacitors C1 and C3 are polarized as indicated by the '+' sign at one end
- If unsure, use the Circuit Tester described in Part 1 of this series to identify the anode lead for LED1.
- None of the component values are critical, except that it is advisable to use the values of TH1 and VR1 as listed.
- Use the recommended CMOS op amp for IC1, not a 741 op amp (the 741's output voltage does not fall to zero, as required to disable the alarm, when the temperature is above 0°C).
- If you want a simpler circuit, you could dispense with IC3 and its associated components, and then use the flashing LED as your alarm function. Alternatively, you could reduce the value of C1 to 100nF, to produce a continuous alarm tone (in which case LED1 would flash at too high a frequency to be of use!).
- The circuit could be set up to sound the alarm at a different temperature from 0°C, depending on the setting of VR1.



Protobloc component layout, minus speaker and battery

Project 10:

Simple Dice

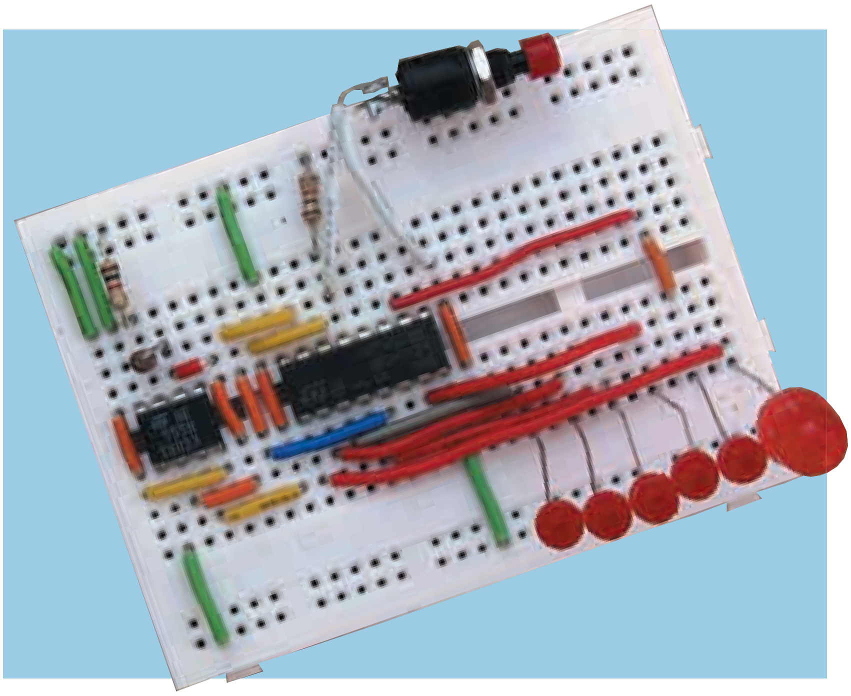
THE circuit diagram shown in Fig.5.3 makes an interesting electronic alternative to the traditional little cubic dice, with its collection of dots on its six faces. The circuit is based on a CMOS 4017 decade counter, IC2, which has ten outputs that go high (positive) in turn with each successive 'clock' pulse produced by a 555 timer, IC1, operating as an astable.

This is achieved by connecting output pin 3 of the 555 to the clock input pin 14 of the 4017. However, instead of allowing the 4017 to cycle through all of its ten states, the reset pin 15 is connected to the Q6 output (pin 5) so that the 4017 only cycles through states Q0 to Q5, resetting to Q0 as pin 5 goes high. When each of the six outputs Q0 to Q5 goes high, the associated LED lights.

On a roll

The 'roll' of the dice is accomplished by pressing push-to-make switch S2 to generate the clock pulses. These are generated at a rapid rate and all of the LEDs appear to be lit. Upon releasing S2, one of the six selected outputs stays high and the associated LED is lit.

To ensure that a player cannot anticipate when a particular LED remains lit, the astable operates at a high frequency, determined by the values of resistors R1 and R2 and capacitor C1. Thus, when S2 is pressed, all the



The prototype Simple Dice assembled on Protobloc (a score of '6' is represented by a jumbo LED!). Note C1 and LED ballast resistor R4 are missing in this photo.

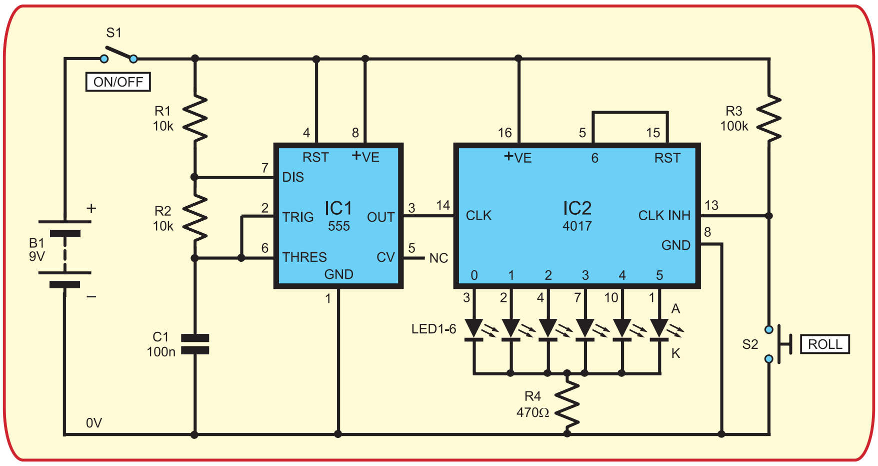


Fig.5.3: Simple Dice circuit diagram

Construction brief

To ensure trouble-free assembly, you should try and follow these basic guidelines

Always use single-core 0.6mm diameter plastic-sleeved wire for wire links, not thicker. The ends of the wire should be stripped of plastic for about 8mm. The use of thicker wire can permanently damage the springy sockets underneath each hole.

Never use stranded wire; it can fray and catch in the sockets, or a strand can break off and cause unwanted connections below the surface of the breadboard.

It is very important to make sure that the bared ends of link wires and component leads are straight before inserting them into the breadboard. Kinks in the wire will catch in the springy clip below the socket and damage it if you have to tug to release the wire from the holes.

Make sure that the arrangement of components and wire links is tidy, with components snugly fitting close to the surface of the Protobloc. This usually means providing more link wires than is perhaps necessary, so as to avoid having wires going every-which-way across the board.

Never connect the battery leads to the top and bottom rails of the breadboard until you have carefully checked that all the component connections correspond to those on the circuit diagram.

Some components, such as switches and relays, do not have appropriate wire leads for insertion into the Protobloc. If you have access to a soldering iron, solder short lengths of single-core 0.6mm diameter plastic-sleeved wire to the terminals of these components.

Component Info

IC1, type 555 timer IC

PIN 1

Viewed from the top, an indented dot and a 'half-moon' shape at one end indicates pin one. The pins are numbered anti-clockwise ending at pin 8 opposite pin 1.

IC2, type 4017 decade counter

PIN 1

Viewed from above, an indented dot and a 'half-moon' shape at one end indicates pin one. Once pin 1 has been identified, pins are numbered 1 to 16 going anticlockwise.

LED1 to LED 6, red light-emitting diode

The longer lead is the anode, the shorter lead is the cathode. The anode lead is connected to the the outputs of IC2, as shown in the circuit diagram.

C1, polyester capacitor

This capacitor is unpolarized, so it does not matter which way round it is connected

S1, single-pole changeover switch

Use the centre pole and either of the other two connections to make an on/off switch.

S2 , pushswitch

push-to-make, release-to-break

Components needed...

Integrated circuits, IC1, IC2: type 555 timer (IC1); type 4017 decade counter (IC2)
Light emitting diodes, LED1 to LED6: any colour. Suggest LED6 is a 'jumbo' type
Resistors, R1 to R3: values 10kΩ (R1, R2); 100kΩ (R3); 470Ω (R4). All 0.25W carbon film.
Capacitor, C1: value 100nF (0.1μF) polyester
Switch, S1 (On/Off): single-pole, single-throw (SPST)
Pushswitch, S2: push-to-make, release-to-break
Battery, B1: 9V and connecting leads
Protobloc and wire links

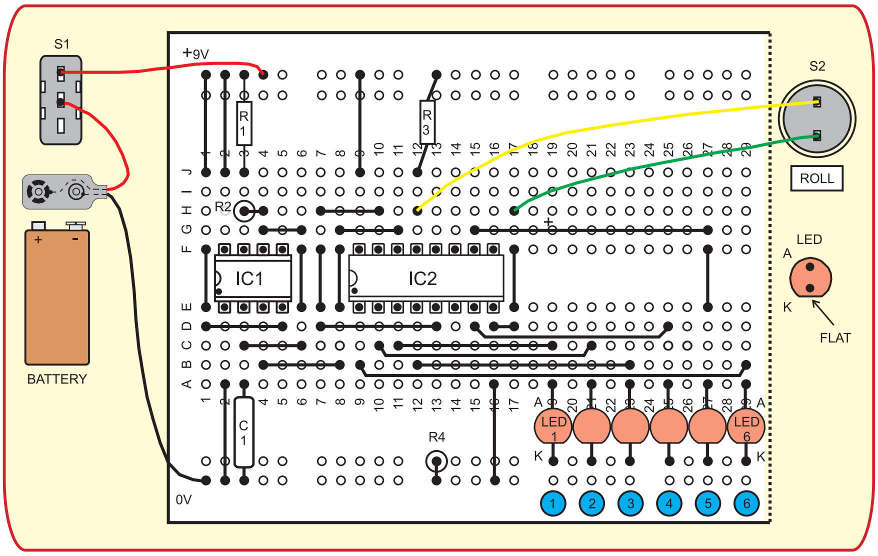


Fig.5.4: Assembly of the Simple Dice on Protobloc

LEDs light in rapid succession, too fast for the eye to see the lighting of individual LEDs.

While this arrangement does not mimic the dots on the six faces of a dice, it does provide an effective but simple electronic solution; it takes the effort (and some would say the fun!) out of rolling a traditional dice and picking it up off the floor!

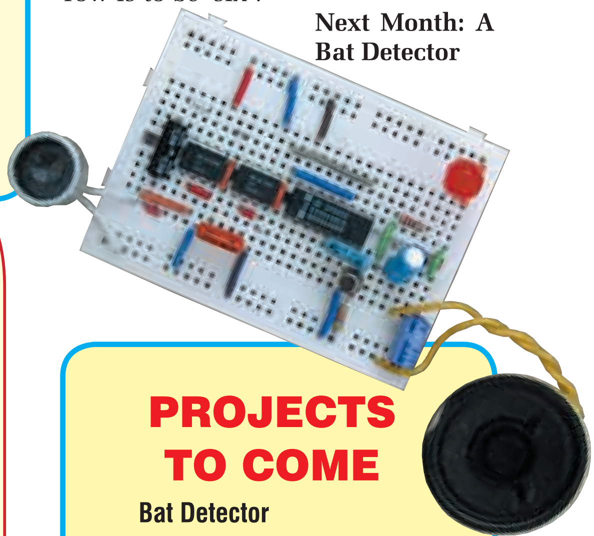
Notes

● Use the Circuit Tester to confirm or find the anode (a) lead of each of the six LEDs as described in Part 1 of this series.

● You can experiment with the values of R1, R2 and C1 as the values are not critical, provided the LEDs flash very fast when S2 is pressed. However, R1 should not be less than 1kΩ.

● Note that it does not matter which way you read the LEDs, left to right as on the diagram, or right to left, provided players agree which end of the row is to be 'six'!

Next Month: A Bat Detector



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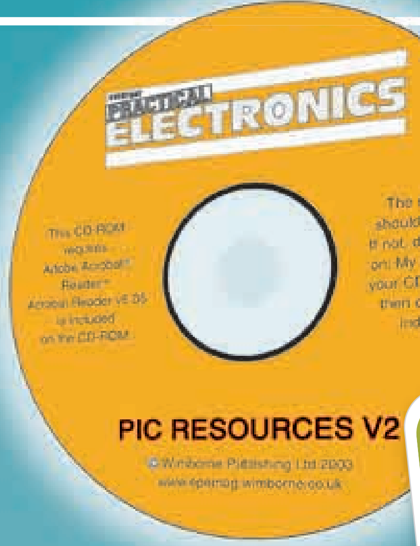

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MOSFET physics and parallel transistors

REGULAR *EPE Chat Zone* (**www.chatzones.co.uk**) contributor ***Gerry*** recently posted the following question about MOSFETs (Metal Oxide Semiconductor Field Effect Transistors):

It came up during discussion on another forum that the gate-source threshold of MOSFETs can vary with temperature. Lo-and-behold, page three of the datasheet for the BS170 shows a graph (datasheet Fig.6) demonstrating this (see **www.fairchildsemi.com/ds/BS/BS170.pdf***). None of us could think of an explanation. Anyone here like to hazard a guess?*

The graph in question is shown in Fig.1. The BS170 is an *N*-channel enhancement mode field effect transistor, which according to the datasheet is manufactured using DMOS technology. These devices have low on-state resistance and provide reliable and fast switching performance and can handle up to 500mA DC. They are suitable for low voltage, low current applications, such as small servo motor control, power MOSFET gate drivers, and other switching applications.

Discussion on the forum in response to this post raised issues such as parallel connection of devices and thermal runaway, including the differences between MOSFETs and BJTs (bipolar junction transistors) in this respect. Parallel connection of transistors seems like a great way to provide high power handling capability (see Fig.2).

However, this will only work if the transistors share the power handling equally and consistently – any imbalance may lead to destruction of the devices. So, this month, we will take a look at parallel transistors after discussing some of the physics of the MOSFET and the origin of its threshold voltage.

MOSFET operation

A full understanding of the operation of the MOSFET and other semiconductor devices (and the influence of temperature on their characteristics and operation) requires knowledge of atomic physics of solids and quantum statistical mechanics. This is beyond the scope of *Circuit Surgery* and most circuit designers do not need a really detailed knowledge of the physics; however, some idea of device physics is very useful for understanding circuit operation, datasheets and SPICE simulation.

A simplified cross-section diagram of a MOSFET is shown in Fig.3. Conduction between source and drain in a MOSFET takes place in a narrow channel region under the gate. The term *lateral MOSFET* is used to describe this structure, which is used for low power devices, as the current flows entirely through a horizontal plane.

The structure of power MOSFETs is different, but the fundamental principles of operation are the same. The basic operation of the *N*-channel MOSFET (as shown in Fig.3) is as follows:

If we apply zero, low or negative gate-source voltage, the device is off because the *N-P-N* regions act as two back-to-back diodes. Only a very small leakage current can therefore flow from drain to source (or vice versa). Appling a positive voltage to the gate creates a conducting channel under the gate due to the redistribution of charge within the device. This process is related to the operation of a diode.

MOSFET regions

The *N* and *P* regions in the MOSFET refer to the type of chemical used to dope pure silicon to create useful device behaviour. *N*-type silicon has more electrons free to take place in conduction than in pure silicon. These free-to-move electrons are referred to as *charge carriers* – it is the availability of free charge carriers which determines how well a material conducts electricity. *P*-type has fewer electrons, but these gaps can be regarded as mobile 'holes', which act like positive charge carriers. Thus both *P* and *N* type silicon conduct electricity reasonably well and increasing the dopant concentration increases conductivity.

Placing an *N* region next to a *P* region creates a *PN* junction, also known as a diode. With nothing connected to a diode free charge carriers (electrons in the *N* region and holes in the *P*) move by diffusion across the junction. The holes and electrons recombine, after which they are no longer available as charge carriers. This creates a depletion region around the *PN* junctions.

The movement of charge carriers to create the depletion region leaves behind fixed charges on the atoms in the depletion region. The build up of this charge tends

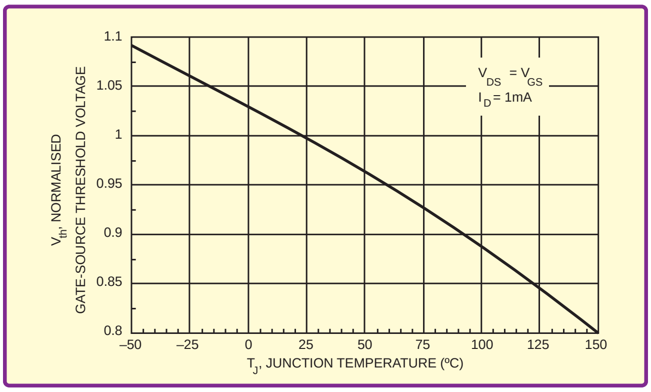

Fig.1. BS170 MOSFET gate threshold variation with temperature (from Fairchild Semiconductor datasheet, BS170 Rev. C, 1995)

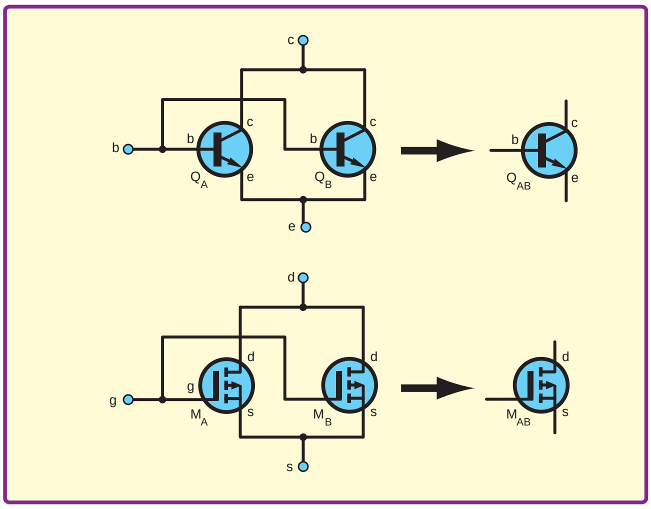

Fig.2. In a perfect world, transistors in parallel would behave like a larger (more powerful) transistor. In practice, this is easier with FETs than it is with BJTs

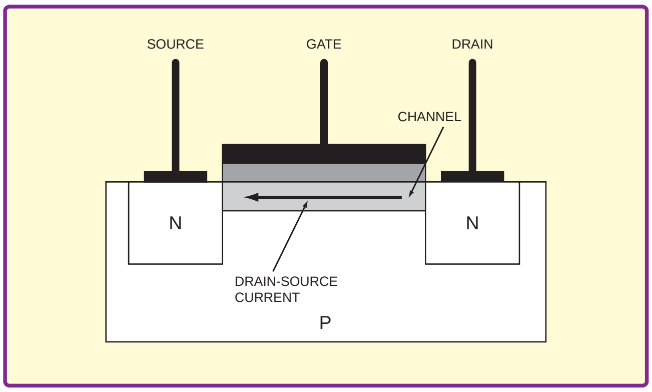

Fig.3. Simplified cross section of a lateral MOSFET used for low power applications

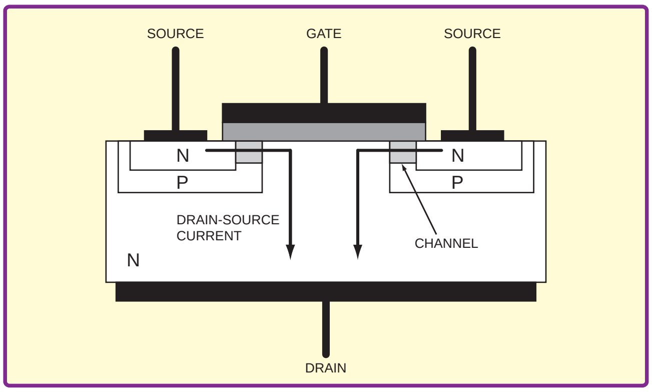

Fig.4. Simplified DMOS power MOSFET structure

to inhibit further movement of the charge carriers. Thus, the formation of the depletion region is a balance between the mechanisms of 'diffuse and recombine' and the opposing build-up of separated charges.

A reverse-biased diode enhances the formation of the non-conducting depletion region, so no current flows. When a diode is forward-biased a certain voltage has to be applied before the depletion region is reduced to the point at which the diode can conduct. The separated charges produce a potential barrier which must be overcome before conduction takes place – hence the typically 0.6V to 0.7V required to switch on a silicon diode.

MOSFET depletion regions

In an *N*-channel MOSFET with low, zero or negative voltage applied to the gate there, is a depletion region all around the source and drain and directly underneath the gate. So, like a reverse-biased diode, no current can flow.

If we apply a positive gate-source voltage, the electrostatic attraction of this gate voltage will pull (negatively charged) electrons from the nearby silicon (mainly the gate and drain) to the *P*-type region just under the gate. If sufficient electrons accumulate here there will eventually be an excess of electrons, so the area just under the gate will behave as if it is *N*-type silicon. This processes is known as *inversion,* because the type of semiconductor has been inverted (*P* to *N* or *N* to *P*) by the applied voltage.

Having created an *N*-type inversion region under the gate (Fig.3) we now have an *N-N-N* path from source to drain, rather than the *N-P-N* back-to-back diodes previously described. The conducting region under the gate is called the *channel*. Conduction can now take place from source to drain. The transistor is *on* and the gate-source voltage at which this occurs is called the *threshold voltage*.

Inversion does not occur instantly at one gate voltage, but actually takes place over a range of voltages, thus we can have weak inversion through to strong inversion at or above the threshold voltage. Traditional circuit design uses the MOSFET in strong inversion, but more recently very low power circuit design techniques using weak inversion have been developed.

The formation of depletion layers and channel inversion involves the availability of charge carriers and their distribution in the semiconductor. Distribution of charge produces potential – like the potential barrier in a diode. In the case of a MOSFET, a key quantity is the surface potential (particularly at strong inversion) at the silicon surface just below the gate. Surface potential is dependent on temperature and doping level, which is why we see a variation of V_T with temperature in Fig.1.

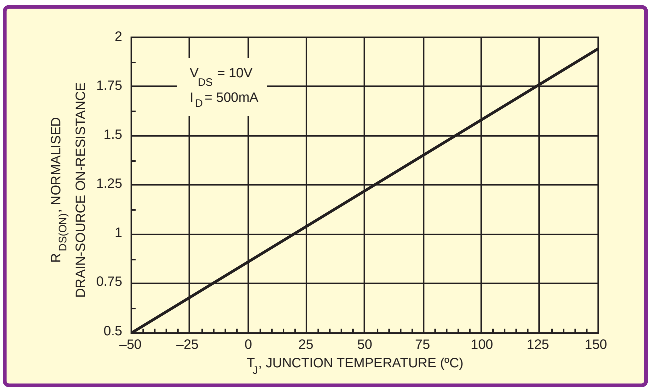

Fig.5. BS170 MOSFET $R_{DS(ON)}$ variation with temperature (from Fairchild Semiconductor datasheet, BS170 Rev. C, 1995)

BS170 MOSFET

The device Gerry referred to – the BS170 – is described as using DMOS technology, which uses a different physical structure from Fig.3 to create the MOSFET. The approach used in Fig.3 cannot readily be extended to produce high power devices – the cross sectional area of the conducting region simply cannot be made big enough (to make the on-resistance, $R_{DS(ON)}$, small) without using an unreasonably large area of silicon. Furthermore, the large gate area would make such a device very slow due to the high capacitance of a very large gate.

In Fig.4 is shown the structure of a basic power MOSFET. The channel is still horizontal under the gate, but it is much shorter than in the conventional MOSFET, and the current flow between channel and drain is vertical. The short channel means a low on-resistance, a property required by power devices. The actual structures of real power MOSFETS is more complex than that shown in Fig.4 and a variety of other structures, including 'trenches', are used.

The vertical nature of power MOSFETs means that the transistors can readily be repeated in parallel across a piece of silicon to increase current handling capacity. This is only feasible if they share the current equally, which brings us back to temperature coefficients in relation to parallel connection of transistors.

It is not just threshold voltage which varies with temperature and other parameters have a more obvious link to using MOSFETs in parallel. The drain-source resistance is of particular relevance here. Fig.5 shows the variation of $R_{DS(ON)}$ with temperature for the BS170. The temperature coefficient is clearly positive over the full operating range of the device.

The positive temperature coefficient of $R_{DS(ON)}$ means that if a MOSFET heats up due to power dissipation, its $R_{DS(ON)}$ increases. For two parallel MOSFETs of the same type this positive temperature coefficient reduces the current in the hottest device (as its resistance increases) and forces more current to flow in the cooler device. The warmer device will tend to cool and the cooler device tends to warm up, keeping the current and temperature balanced in the two devices. The same balancing effect occurs for any number of parallel devices.

This balancing is particularly effective when the MOSFETs are close together with a good thermal connection between devices – as they are in a single power transistor, formed from thousands of small MOSFETs connected in parallel (some power devices have over 20,000 parallel transistor cells). Thus, in general, MOSFETs can work in parallel both in discrete and integrated circuits.

Transfer characteristic

However, the situation is not quite as simple as it seems from just looking at $R_{DS(ON)}$, and the temperature coefficient of threshold voltage has a role, as we will see in a moment. The graph in Fig.6 shows the transfer characteristics (also known as *transconductance characteristics*) of the BS170 MOSFET. This graph shows the relationship between drain-source current (output) and gate-source voltage (input).

Fig.6 shows the characteristics for three different temperatures. Looking at the top

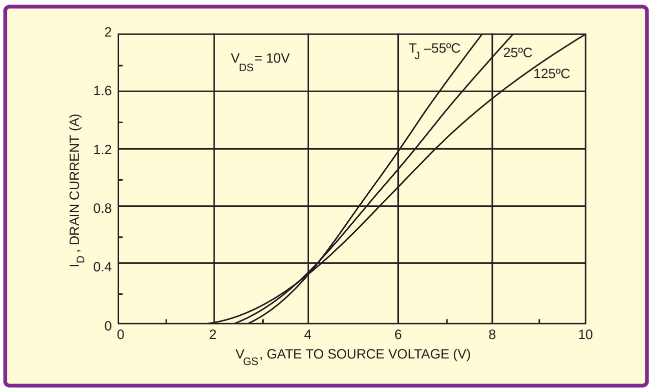

Fig.6. BS170 MOSFET transfer (transconductance) characteristics (from Fairchild Semiconductor datasheet, BS170 Rev. C, 1995)

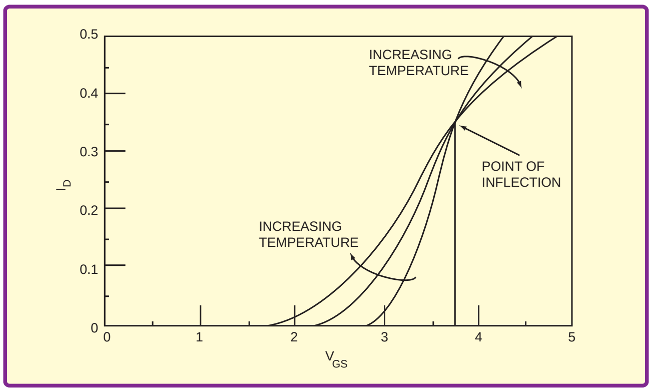

Fig.7. A closer look at the characteristics in Fig.6 for low gate – source voltages (approximate graph)

of the graph we can clearly see that for a given V_{GS} the drain current decreases as temperature increases (negative temperature coefficient). This is in line with our previous discussion and what we would expect from the positive temperature coefficient of R_{DS}. However, for low values of V_{GS} the temperature coefficient of drain current is positive. This is not very clear on Fig.6 so a portion of the graph is redrawn (approximately) in Fig.7.

For all three temperatures shown (and any we care to plot) the graph has an inflection point (where the curve changes from concave to convex). Here also the curves for the various temperatures cross over one another – the temperature coefficient is zero – changing the temperature does not change the drain current at this V_{GS} (about 3.8V on Fig.7). Below this value of V_{GS} the drain current has a positive temperature coefficient and above it, it is negative.

The basic formula for the drain current of a saturated MOSFET is:

$$I_D = k(V_{GS} - V_T)^2$$

In this formula, *k* is a gain parameter which depends on the size/shape of the transistor (width/length ratio and gate oxide thickness) and on the mobility of charge carriers in the channel. Mobility describes the ease with which electrons (or holes) move when under the influence of an electric field (applied voltage). For MOSFET channels, the mobility decreases with temperature causing *k* to have a negative temperature coefficient.

Simple explanation

Although there is more than one mechanism at work, a simple explanation for this is that at higher temperatures the increased vibration of the silicon crystal lattice means that electrons (or holes) cannot move so easily.

The formula also depends on the threshold voltage V_T. As we see from Fig.1, this has a negative temperature coefficient, but note that it is subtracted from V_{GS} in the formula. An increase in temperature will decrease V_T, increasing (V_{GS} – V_T) and hence increasing I_D.

Thus we have two opposing effects – mobility (via *k* in the formula) tending to decrease I_D as temperature increases and threshold voltage, tending to increase it. The threshold voltage variation has a stronger effect at lower values of V_{GS}, and mobility variation dominates at larger values of V_{GS}. Hence, we see the I_D curves move from positive to negative temperature coefficient as V_{GS} is increased.

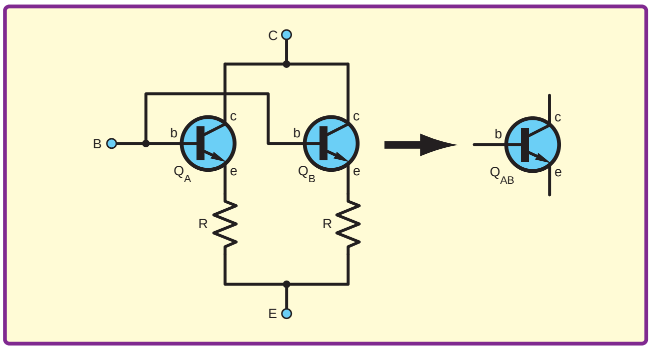

Fig.8. Parallel BJTs need emitter resistors to help reduce current hogging and thermal runaway problems. MOSFETs generally do not suffer from this problem

Thus, thermal instability in parallel MOSFETs is possible in situations where they are operated at low values of V_{GS} (above V_T). This is probably not a common problem, but could happen, for example, if an over-rated power MOSFET was used so that relatively low V_{GS} values were required for the currents in the circuit. A paper by Alfio Consoli *et al* in 2000 argued that trends in efficient power MOSFET design made this problem more likely. The issue is also discussed in a 2005 application note (AND8199) by Alan Bell from ON Semiconductor (**onsemi.com**).

BJTs have a positive temperature coefficient of the collector current for a given input – unlike the drain current for a MOSET, this occurs over the full operating range. For any set of parallel transistors they will all be slightly different, so one will inevitably take a little more current than the others. This one will get hotter, causing its current to increase, so it gets hotter still and so on – a process known as *thermal runaway*, which may lead to destruction of the transistor. The problem can be reduced by including a resistor in the emitter circuit of each transistor, chosen to give around 0.2V drop at full load current (see Fig.8).

References

Fairchild Semiconductor, *BS170/MMBF170 N-Channel Enhancement Mode Field Effect Transistor*, 1995 Datasheet, **www.fairchildsemi.com/ds/BS/BS170.pdf**.

Alfio Consoli et al. *Thermal Instability of Low Voltage Power-MOSFETs, IEEE Transactions on Power Electronics*, Vol. 15, No. 3, May 2000, pp. 575-581.

Alan Ball, *Thermal Stability of MOSFETs*, ON Semiconductor Application Note AND8199, 2005, **www.onsemi.com/pub_link/Collateral/AND8199-D.PDF**.

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Interfacing PICs to the Internet via Ethernet – Part 5

Over the last few articles we have developed some Ethernet hardware and built 'out of the box' software to provide a simple webserver. Now it's time to write our own software, in the form of an embedded webserver that can provide secure remote control of your electrical appliances – from anywhere in the world. And it's only going to take just a few lines of code and some minor modification to the Microchip-supplied software.

The webserver is going to be based on the hardware design covered in last month's article, which explains why we added a relay into the circuit. Just what kind of appliance you can control will depend very much on the choice of relay, and your hardware skills. We are only interested in the software aspects in these articles, so the hardware and its construction is very much down to you.

Do remember, however, that you *must not* attempt to use this circuit to switch mains voltages unless you know exactly what you are doing, and understand how to build *safe* high voltage circuits. If in doubt, stick with controlling low voltage circuits. The author, for example, has used this circuit to control the on/off button on his computer motherboard. That carries its own risks, but none of them are potentially fatal!

Before we go through the changes required to the software and web pages, we have to work out how to get the existing design from last month to be accessible on the Internet, rather than simply connected to your PC locally.

To do that, we need to understand how the PC connects to the Internet, and how other computers can, or if we wish cannot, connect back to us.

Internet connection

For most of us using a home broadband Internet connection, the physical interface out of the house is through either the BT telephone wires or a coaxial 'cable' wire. Either way, the wire is connected to a modem somewhere in your house.

Some modems provide one or more Ethernet ports for computers to connect to; in this case, the modem is a combined modem+router. Other modems have a single Ethernet connection that connects to a stand-alone router, to which your PC connects. If you're terribly modern, then your modem or router is equipped with a WiFi interface (an *Access Point*) to which your laptop computer can connect wire-lessly.

If you are very unlucky, then your modem is equipped with a USB connection which plugs straight into your laptop. If this is the case then you should skip the rest of these articles because you have no easy way to connect your own designed hardware onto the Internet. Alternatively, go buy yourself a 'proper' modem – they can be purchased for around £20 to £30!

Routers

The job of the router is often two-fold. First, it provides a means of connecting several computers simultaneously to the Internet. Second, it provides for a private, local network. You can share network printers and files locally, without giving the outside world access.

In many cases this is a necessity: your internet service provider, or ISP, typically assigns you a single IP address for accessing the Internet. Each computer must have its own unique IP address, so clearly you cannot have several computers sharing the same one. With a router, each computer can have its own, locally unique and private IP address, and the router provides a means of 'multiplexing' each computer onto the Internet.

IP networking is a complex subject, but we only need to know a small amount to be able to 'get by' and put our embedded webserver onto the Internet. So let's start by having a look at how a typical computer is configured.

Assuming your computer is currently connected to the Internet, open up a command shell on your PC (select Start, then Run, type in **cmd** and then click OK). Type in the command **ipconfig**, then the command **route print**. You should see something similar to Fig.1.

The **ipconfig** command displays the IP address or addresses assigned to your PC's network ports. In our example, the wireless interface has an IP address of 192.168.62.62. The PC also has a built-in wired Ethernet port, but there is nothing currently connected to it, so the command does not bother to show the details.

Below that, the route command shows a lot more information. It explains the different ways in which your computer can connect onward to other devices, through different *gateways*. Gateways are typically other PCs or routers, which can bridge your connection from your local network out onto other networks. The most interesting line is the first, which shows that our computer uses 192.168.62.62 as a gateway. In this case, it is the local, private address of the author's router.

Routers are intelligent pieces of electronics, and have a small, high performance microcontroller inside them. They too have a TCPIP stack inside, and virtually all provide

```
Command Prompt

C:\>ipconfig

Windows IP Configuration


Ethernet adapter Wireless Network Connection:

        Connection-specific DNS Suffix  . :
        IP Address. . . . . . . . . . . . : 192.168.62.62
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 192.168.62.1

Ethernet adapter Local Area Connection:

        Media State . . . . . . . . . . . : Media disconnected

C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2 ...00 11 f5 f1 25 63 ...... Atheros AR5005G Wireless Network Adapter -
0x10004 ...00 a0 d1 32 69 1c ...... Realtek RTL8139/810x Family Fast Ethernet
===========================================================================
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0     192.168.62.1   192.168.62.62     25
        127.0.0.0        255.0.0.0        127.0.0.1       127.0.0.1      1
      169.254.0.0      255.255.0.0    192.168.62.62   192.168.62.62     20
     192.168.62.0    255.255.255.0    192.168.62.62   192.168.62.62     25
    192.168.62.62  255.255.255.255        127.0.0.1       127.0.0.1     25
   192.168.62.255  255.255.255.255    192.168.62.62   192.168.62.62     25
        224.0.0.0        240.0.0.0    192.168.62.62   192.168.62.62     25
  255.255.255.255  255.255.255.255    192.168.62.62           10004      1
  255.255.255.255  255.255.255.255    192.168.62.62   192.168.62.62      1
Default Gateway:      192.168.62.1
===========================================================================
Persistent Routes:
  None

C:\>_
```

Fig.1. A PC's IP and route setup

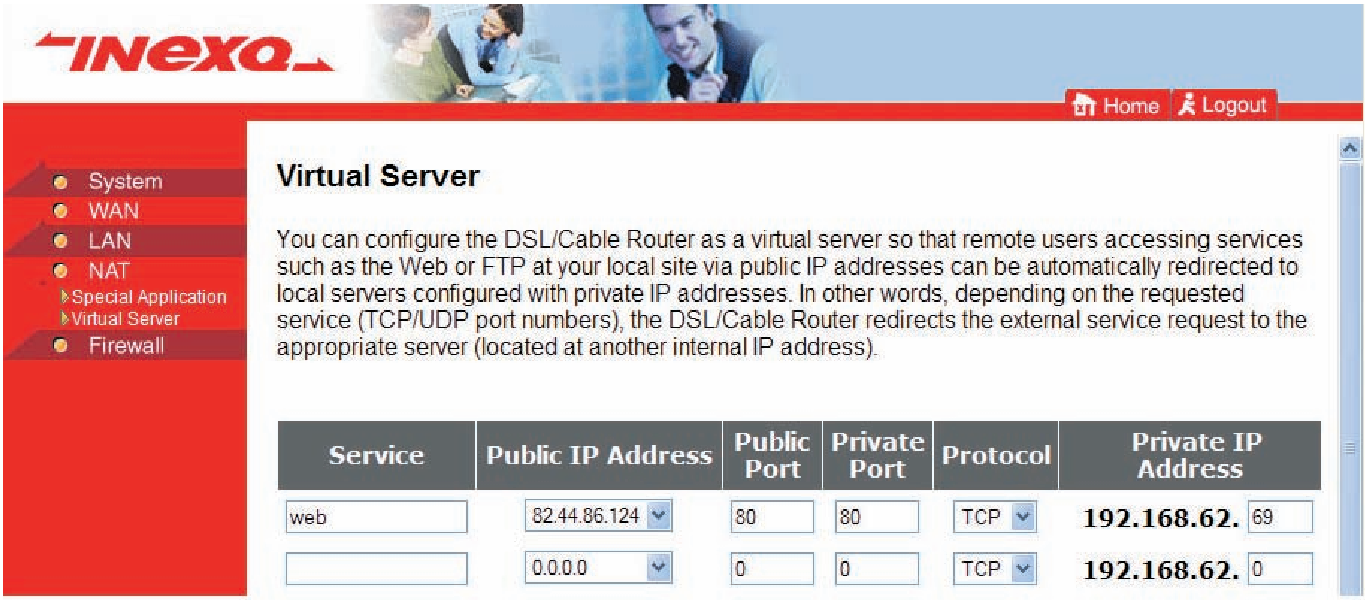

Fig.2. A typical router NAT setup screen

a webserver to which you can attach and make configuration changes. Typing the IP address of the router into your web browser is the normal way to gain access to the router's configuration pages.

Security

One very important task that a router will perform is to stop people remotely accessing your network. Most will do this by default; if they didn't, then your computer would quickly become infected with viruses. But we *want* people to be able to connect into our network – but only to our embedded webserver, of course.

Opening up a safe pathway from the Internet into your network is not an unusual thing to do, and routers provide a mechanism to do this which is quite safe – so long as it is set up carefully. It uses a network address translation table to map specific IP applications such as HTTP (for web browsers) to a single, specified IP address on your private network. You choose the local IP address, program that address into your web server and then your web server becomes accessible to the whole world. A typical router NAT setup screen is shown in Fig.2, and the user manual for your router should explain how to set up the feature.

The public IP Address shown in Fig.2 is the IP address by which you are known on the Internet. It is assigned by your ISP to you automatically when you plug in your modem. For home users, this value is normally dynamic; if you have a power cut, when your modem powers up again it will more than likely be assigned a new public IP address. For normal Internet access this is never important; you initiate all contact with the Internet from home, and the responses work their way back through the path that your request made.

For someone to connect to your embedded server they are going to need to know your Public IP address, which is inconvenient. Most people are used to connecting to web-servers by a name (containing a domain name at the least) and they are certainly not going to be expected to keep track of when your IP address changes.

Solutions

Fortunately, there is a free, reliable service that solves both these problems. *DynDNS* is a service on the Internet that allows you to register your Public IP address, and select a unique domain name that can be used to refer to it. This is how the author set up his demonstration website at **http://mikehibbett.dyndns.org**. When the IP address changes, one simply contacts the *DynDNS* service provider with the new IP address assigned by the ISP and the global mapping of the **dyndns.org** website is changed instantly.

The service is not only free, it is so widely used that many routers provide a means to automatically contact the *DynDNS* service should your public IP address change. You can find more details by going to the website at **www.dyndns.com/** and clicking on 'Free Dynamic DNS'.

When choosing a local IP address for your own PIC webserver device, choose one that is close in value to the value assigned to your PC. Take the PC's address (the four numbers separated by '.' characters) and change the last number to a different value in the range of 1 to 254.

Update the PIC source code with the new value, update your router to point the ISP-assigned public address to this value (as shown in Fig.2) and when your web server is powered up and connected to the router, web page requests made from the Internet to your public IP address will be sent directly to it. You can switch your PC off, and so long as the router is powered up, your webserver will be available 24 hours a day, anywhere in the world.

Next month, we will *finally* complete the practical webserver design, and put a globally accessible (yet secure) appliance switch onto the Internet!

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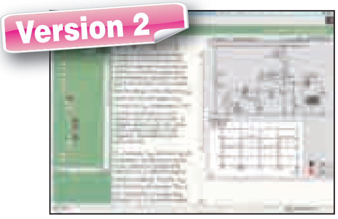
ELECTRONICS PROJECTS


Logic Probe testing

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

ELECTRONIC CIRCUITS & COMPONENTS V2.0



Circuit simulation screen

Electronics Circuits & Components V2.0 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 and 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

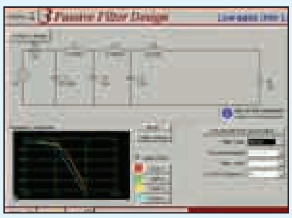
Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM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

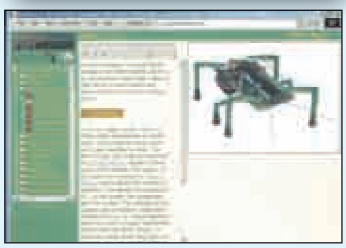
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.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

ANALOGUE FILTERS


Filter synthesis

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

ROBOTICS & MECHATRONICS


Case study of the Milford Instruments Spider

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

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

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Institutional (Schools/HE/FE/Industry)	£99	plus VAT
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SOFTWARE

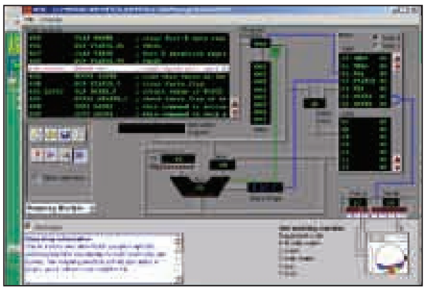
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro micro-controller. this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

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

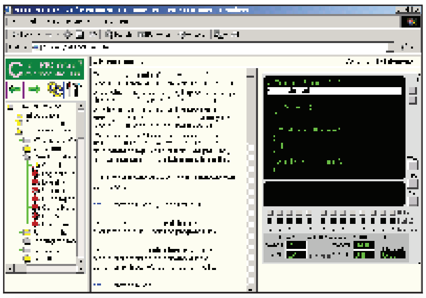


'C' FOR 16 Series PICmicro Version 4

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

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

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



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

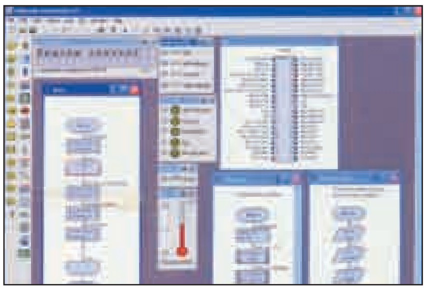
FLOWCODE FOR PICmicro V3

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

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● New features in Version 3 include 16-bit arithmetic, strings and string manipulation, improved graphical user interface and printing, support for 18 series devices, pulse width modulation, I2C, new ADC component etc. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



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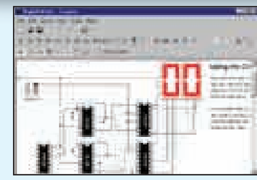
This offer gives you two seperate CD-ROMs in DVD style cases – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

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

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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- ☐ Institutional/Professional 10 user
- ☐ Site licence

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- ☐ TINA Pro V7 Basic + Flowcode V3 Hobbyist/Student
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All letters quoted here have previously been replied to directly

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☆ LETTER OF THE MONTH ☆

Tuning in

Dear EPE,

George Chatley asks in his letter (Linux and more – Dec '08) about ways to receive from a radio mic, so as to overcome his hearing impairment. I suggest the easiest way is to tune an ordinary scanner (scanning receiver) to the radio mic frequency, usually this would be FM mode.

The scanner would then feed headphones that George needs to wear. I expect he'll have to turn the volume up high, so proper headphones with acoustic cups that cover the ears is in order – otherwise, those in the nearby audience will get to hear some of the audio spill-over.

If it's difficult to find the correct frequency, I can suggest some allocations to try (there are specifically reserved frequencies). Before taking this equipment to his club, George should first tune to an ordinary broadcast station and make sure that he can successfully hear that through the intended headphones.

Good luck, hope this helps you to get out and enjoy the club again.

Godfrey Manning G4GLM, via email

Thanks for the tips Godfrey – any more helpful ideas out there?

Registration and IE6

Dear EPE

I have been trying to register on the new website, but I am not getting very far. I click on the 'Register' link and get taken to the Registration page, but I cannot enter any details into the text boxes asking for my details such as name and email address. The only things that work for me are the country and state selection boxes.

I know it does say on the homepage and probably on other pages to use IE7, but I am using IE6 because I find IE7 far too 'over protective' and have to click on lots of boxes and stuff just to get to my own home page.

Please can you let me know where I am going wrong. Thanks.

Mike Brearley, via email

Alan replied to Mike:

I don't run the EPE Online *site myself, but unfortunately I fear you've answered your own question!*

IE6 dates back to 2001, it's full of security holes and it isn't compatible with more modern standards of web code. We do highlight that the EPE Online *site is designed with IE7 in mind. I agree it sometimes nags users, but usually it isn't too onerous and after a while you find the benefits outweigh any drawbacks. We have found that every user who had problems using IE6, and then went on to update their system to IE7, suffered no further problems. An alternative is Firefox, which has plenty to offer, it's free and will run alongside your IE6. IE8 is on the way...*

I'm sorry this is the best I can offer, I hope it doesn't get in the way of your enjoyment of the magazine.

Alan Winstanley
On-line Editor

South Africa calling – or trying to...

Dear EPE

I have tried to register for the *EPE Chat Zone*, which I did approximately a month ago. I never received an email informing me of the outcome of the decision – whether I was accepted or not on the board. While I suspect the email may have been lost I kept checking by logging in. Now, I have discovered that the account I created has been deleted. In this regard I have gone through my spam filters with a fine-toothed comb and to date have not received a confirmation email either way.

This might sound a little bit crazy, but I am beginning to suspect that there is a problem with communications between South Africa and the UK, as I am not able to contact or illicit a response from any one of your advertisers in your magazine. Magenta Electronics is a prime example, I have now given up trying to email them as they do not respond, leading me to think that email communications from my country has been blacklisted by major UK ISPs. It is indeed possible to do this, especially in Linux-based machines that run Spamassassin – it takes one line of code to block an entire country.

I can really understand that this country of mine, quite frankly, has an appalling reputation and is indeed the crime capital of the world, including cyber-crime and that this place is a spammers paradise, but I am quite perturbed that lately only a handful of my emails to the UK reach their recipients, and it seems coincidentally that those who do get my mail, have their sites and accounts hosted outside the UK. This situation is new to me, in the past I've dealt with Greenweld and I've been a longtime customer of Bull Electrical (I am still receiving their catalogue in the mail each year or so).

Be that as it may, I would still like to register for the *EPE Chat Zone*, if I may. I purchase your fine magazine (if and when it is available here, at great expense) to keep me aware of what is going on.

Hoping you can help shed some light on this situation.

Jason Mitchell, via email

Alan replied to Jason:

Many thanks for your email, which is a sorry account of your trials and tribulations!

I am dismayed to read of your difficulties. I have some close contacts in Cape Town, and I have been told about the problems that are a regular feature of South African telecoms.

Some spamblocking services (eg **http://www.sorbs.net/***) reference IP addresses and domains, striving to blacklist any sources of spam. They can affect genuine emails that are screened out erroneously, but it is usually quite rare. There is also the possibility of overzealous spamfilters filtering out mail on the recipient's system. I do, however, email my South African correspondents routinely without any problem, so I think that the fears of SA emails being regularly screened out are probably unfounded.*

As regards the EPE Chat Zone, *even though we use robust forum software that has never been compromised by hackers, this has been a constant target for spammers who try to post spam into* *the forums (hard to believe I know). Only about 1% of applications are genuine, and consequently all new applications have to be pre-approved by myself before the account is opened. I physically screen the list and make a decision based on a number of criteria.*

Sometimes I get it wrong and a genuine Chat Zone application is inadvertently disallowed, but if the user contacts me afterwards I am more than happy to set up an account immediately. If you would like to confirm your choice of username, I will open an account with a temporary password.

Perversely, it is true to say that our automated confirmation emails from the Chat Zone server are treated as spam by some ISPs and never reach their intended destination, in which case I will personally email the logins from my desktop.

So please let me know your choice of username, and we'll see what happens.

Thank you for persevering with this and thank you also for your interest in EPE magazine.

Alan Winstanley,
On-line Editor

Linux PICkit 2 serial coms utility WIP

Dear EPE

I jumped at the chance of a PICkit 2 for a tenner. However, I was a little disappointed that there was no serial coms tool.

So, I've now temporarily hacked away at the linux pk2cmd to make a simple tool. Since I want the convenience of leaving the PICkit 2 in situ and not have to swap the cable from place to place, I have bridged the UART's TX pin (RC6) with a diode to RB7.

My hack is quite happily putting the PICkit 2 into serial mode and receiving data from the PIC's UART when it's running. I haven't done it in the other direction as I want to check out the easiest and safest way to protect RC7 (UART's RX pin) during programming (ideas welcome!).

Making the tool bi-directional with what I know now is not an issue and should be easily implemented.

I want to make it all stand alone from pk2cmd (I'm calling some of its routines for convenience at the moment) and investigate the seemingly undocumented protocols that the PICkit 2 uses to access the PIC's ICD for debugging.

If anyone would like to help out or has any useful suggestions please let me know. I plan to eventually release it as an open source project.

chris_c, via Chat Zone

Good luck with the project chris_c. Can anyone offer assistance?

Net Work

Alan Winstanley

Mail on the move

This month's *Net Work* column discusses trends in mobile email, suggesting an effective anti-spam service, with more discussion and bonus content available by following the *Net Work* link on *EPE* Online.

One of the unstoppable trends in electronics is the drive towards cramming more technology into a smaller size, with lower price breaks and lower power consumption. Compare the carrier-bag sized 'immobile' phones of the 1980s that could barely make a phone call and needed a battalion of Ni-Cad batteries to power them, with today's indispensable, but ever more disposable cellphones. The latest phones use custom lithium ion batteries and apart from SMS text messaging may incorporate email, web browsing, a digital camera or two, a video and MP3 player, GPS and Bluetooth, all displaying on a bright colour LCD, with satnav available as an accessory.

After spending an eternity tethered to a PC and broadband, I decided that the time was ripe to try handling email on the move. It has taken over four months for my new (but already discontinued) HTC Tytn II mobile phone to settle into a usable state. The phone runs Windows Mobile 6.1 and includes mobile versions of Internet Explorer, Microsoft Word, Excel, Notes, Adobe Reader and more. It is a powerful multitasking device and its PDA style has a slide-out mini QWERTY keyboard and touch-sensitive display. The jury is still out on the need for a stylus though.

My HTC Tytn II uses the Orange network, and has built-in WiFi, so it is very good for keeping on top of emails at home, as it relieves me of the chore of firing up a laptop. At other times GPRS handles email and data, at which time an extremely close eye must be kept on tariffs to avoid incurring eye-watering running costs (£30,000 to fetch a movie, as one user found to their dismay.)

If you want to get the best out of your phone then it's wise to check out what others are saying online. There is bound to be a forum dedicated to your phone and this can be a lifesaver. For example, **www.xda-developers.com/** is dedicated to the HTC product line, **www.modaco.com** covers Windows Mobile and Pocket PC phones, and **www.blackberryforums.com/** is there to lend a hand with Blackberry phones.

These forums offer practical tips and pointers to useful software, patches or updates. If you can't find your particular phone mentioned, it may be sold under another brand elsewhere, so a little 'googling' will help pinpoint the name (the HTC Tytn II is also known as Kaiser, AT&T Tilt and P4550). There is plenty online for Apple iPhone owners to check out, too.

Not so mobile email

Having fallen for the seductive appeals of the Tytn II, in practice, although I could fetch POP3 email happily, I had never managed to send a single email on the move, and I gave up after a month or two. Orange did eventually claim that their SMTP server had been down 'for months', and this strange admission would explain why outbound mail was apparently broken.

However, by scouring the forums I learned of a bug with Windows Mobile 6.1 that disabled the sending of mail: if an SMTP server becomes unreachable (eg **smtp.orange.net**) then WM 6.1 would cripple the phone's account setup. Eventually, I learned of a forthcoming Microsoft patch, but this is nothing that Orange knew about (or would admit to at the time). An update was eventually sent to my phone and – lo! – it worked, briefly, before stopping again.

My favourite solution for handling outbound mail remains AuthSMTP (**www.authsmtp.com**), which I configured to run on my mobile phone. All outbound problems have now ceased, and AuthSMTP's technical support remains consistently excellent, helped by the fact that the tech guy uses a Tytn II himself.

My Tytn II is now in constant use for checking email (hardly ever for phoning!), and it fetches the first few kilobytes only: any interesting-looking mails are then fully downloaded manually.

Unsavoury spam

Spam remains an infernal problem that impinges on mobile email. Approximately 87% of all mail I receive on my regular email address is spam, and this alone would drown out the smartest of Windows Smartphones. Spam is the scourge of today's wired world, and it is especially intrusive when trying to check mobile email.

My solution is to utilise the ClearMyMail service on my main work email address. Its statistics show me that out of 4,199 mails it checked, 3,650 of them were spam. ClearMyMail could be the saviour for spam sufferers everywhere and it is extremely efficient at sifting out unwanted mail. The cost of this service is extremely low considering the vast amount of time it saves. More importantly, it also unleashes my mobile email and, in conjunction with AuthSMTP, permits me to handle email correspondence on the move.

Be sure to check my *Net Work* column on *EPE* Online where more bonus material is available, including further details of ClearMyMail, news of the BT IPlate adaptor plate that may boost speeds for some broadband customers. You will also find hyperlinks to support *Net Work* as well. You can email me at **alan@epemag.demon.co.uk**

The HTC Tytn II (discontinued) is typical of PDA mobile phones using Windows Mobile to handle mail, web and satellite navigation on the move

DIRECT BOOK SERVICE

Electronics Teach-In + FREE CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole Teach-In 2006 series (originally published in EPE) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the Teach-In series, the book includes 15 CMOS-based simple projects from the Back-To-Basics series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the Teach-In series.

152 pages + CD-ROM **Order code ETI** **£8.50**

CIRCUITS AND DESIGN

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements.

256 pages **Order code BP53** **£5.49**

MICROCONTROLLER COOKBOOK
Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** **£25.99**

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS AND CDROMS SEE THE SHOP ON OUR UK WEBSITE

www.epemag.com

All prices include UK postage

EASY PC CASE MODDING
R.A Penfold

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages + CD-ROM **Order code BP542** **£8.99**

COMPUTING AND ROBOTICS

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and home editions.

The book was written with the non-expert, busy person in mind. it explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, notepad and paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; how to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

264 pages **Order code BP514** **£7.99**

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages + Large Format **Order code BP901** **£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**

THE PIC MICROCONTROLLER YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages **Order code NE36** **£20.99**

INTRODUCTION TO MICROPROCESSORS AND MICROCONTROLLERS – SECOND EDITION
John Crisp

If you are, or soon will be, involved in the use of microprocessors and microcontrollers, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors and micrcontrollers. Assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern micros.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

222 pages **Order code NE31** **£22.00**

ROBOT BUILDERS COOKBOOK
Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

366 pages **Order code NE46** **£21.99**

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation.

Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

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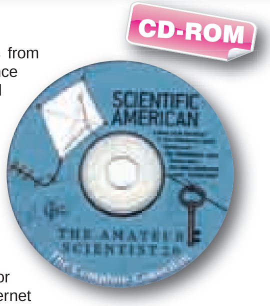
295 pages **Order code NE38** **£35.99**



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BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

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 — **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**

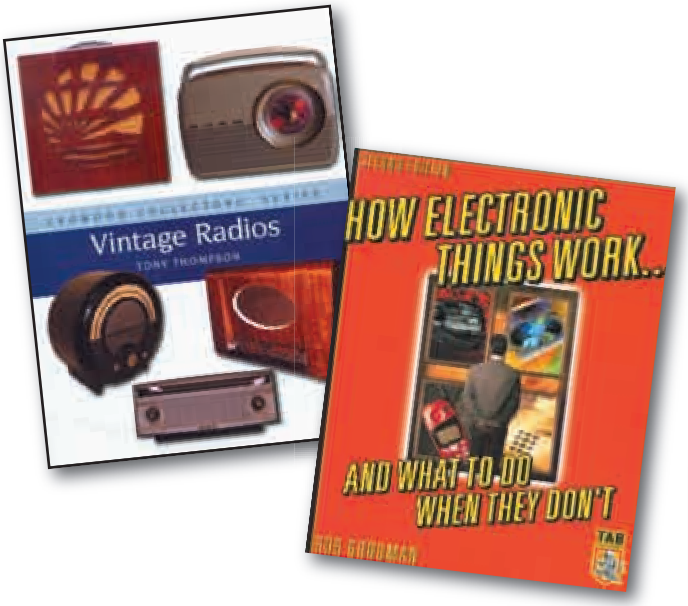
OSCILLOSCOPES – FIFTH EDITION
Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.

This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.

The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscillocopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages — **Order code NE37** — **£24.00**



PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING
Robin Pain

To be a real fault finder, you must be able to get a feel for what is going on in the circuit you are examining. In this book Robin Pain explains the basic techniques needed to be a fault finder.

Simple circuit examples are used to illustrate principles and concepts fundamental to the process of fault finding. This is not a book of theory, it is a book of practical tips, hints and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialised.

The fundamental principles of analogue and digital fault finding are described (although, of course, there is no such thing as a "digital fault" – all faults are by nature analogue). This book is written entirely for a fault finder using only the basic fault-finding equipment: a digital multimeter and an oscilloscope. The treatment is non-mathematical (apart from Ohm's law) and all jargon is strictly avoided.

274 pages — **Order code NE22** — **£33.99**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money

In most applications of electronics, test instruments are essential for checking the performance of a system or for diagnosing faults in operation, and so it is important for engineers, technicians, students and hobbyists to understand how the basic test instruments work and how they can be used.

The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.

206 pages — **Order code PC109** — **£9.95**

DIGITAL 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 explainend, 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 explanation of microprocessor techniques as applied to digital logic.

200 pages — **Order code PC106** — **£9.05**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

228 pages — **Order code NE35** — **£24.99**

HOW ELECTRONIC THINGS WORK – AND WHAT TO DO WHEN THEY DON'T
Robert Goodman

You never again have to be flummoxed, flustered or taken for a ride by a piece of electronics equipment. With this fully illustrated, simple-to-use guide, you will get a grasp on the workings of the electronic world that surrounds you – and even learn to make your own repairs.

You don't need any technical experience. This book gives you: Clear explanations of how things work, written in everyday language. Easy-to-follow, illustrated instructions on using test equipment to diagnose problems. Guidelines to help you decide for or against professional repair. Tips on protecting your expensive equipment from lightning and other electrical damage. lubrication and maintenance suggestions.

Covers: colour TVs, VCRs, radios, PCs, CD players, printers, telephones, monitors, camcorders, satellite dishes, and much more!

394 pages — **Order code MGH3** — **£21.99**

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Tony Thompson

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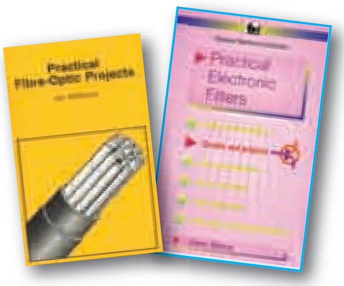

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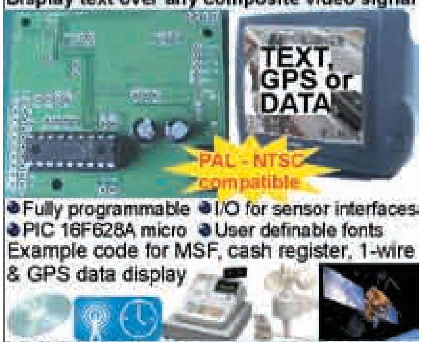

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