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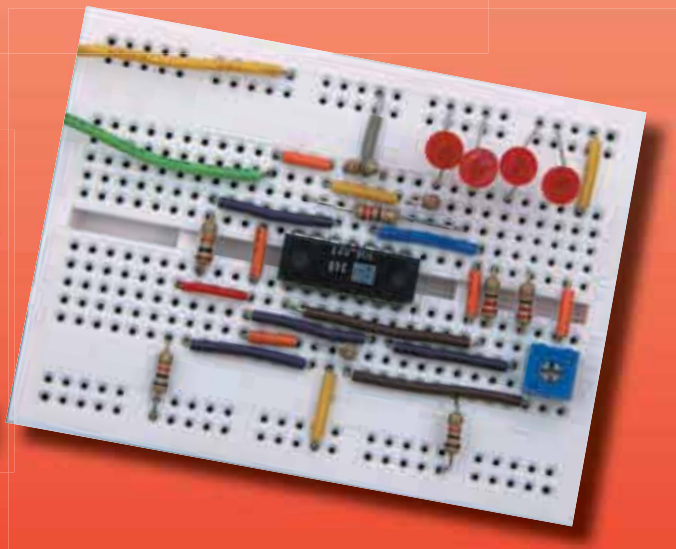

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VOL. 37. No.11 November 2008

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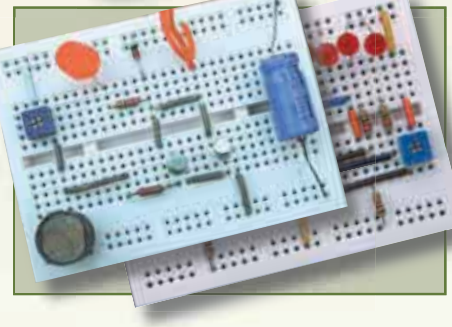

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PIC & ATMEL Programmers

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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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!

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EVERYDAY PRACTICAL ELECTRONICS
FEATURED KITS

November '08

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

Jaycar Electronics

V8 SOUNDING DOORBELL

KC-5405 £25.75 plus postage & packing

Be the envy of your mates as they hear the rumble of a big V8 when they press the button on your doorbell. You may have seen a few commercially available units, but they don't sound anything like this! Not only does it sound like the roar of a V8, but it also has background noise that sounds like tappets and valves working away, for an even more realistic effect. There is a V made from LEDs that light up in sync with the rumble, and a large 100mm speaker ensures that it sounds true. Supplied with silk screened and solder masked PCBs, silk screened and machined case, push button bell switch, speaker, hook up wire, 100mm diameter pipe and all electronic components.

**As published in EPE Magazine October 2007

LUXEON STAR LED DRIVER KIT

KC-5389 £9.75 plus postage & packing

Luxeon high power LEDs are some of the brightest LEDs available in the world. They offer up to 120 lumens per unit, and will last up to 100,000 hours! This kit allows you to power the fantastic 1W, 3W, and 5W Luxeon Star LEDs from 12VDC. This means that you can take advantage of what these fantastic LEDs have to offer, and use them in your car, boat, or caravan. Kit supplied with PCB, and all electronic components.

**As published in EPE Magazine April 2007

SUPER BRIGHT 1 WATT LED STAR MODULES

ZD-0508 £3.00 plus postage & packing

These LEDs are just as bright as the leading brand but cost a whole lot less. They are increasingly finding their way into general and architectural lighting applications and with a service life of 100,000 hours, will virtually never need replacing. They provide up to 25 lumens per watt and are available in a number of colours.

ZD-0500 - Red
ZD-0502 - Amber
ZD-0504 - Green
ZD-0506 - Blue
ZD-0510 - Warm White

COURTESY INTERIOR LIGHT DELAY KIT

KC-5392 £5.95 plus postage & packing

Many modern cars feature a time delay on the interior light. It still allows you time to buckle up & get organised before the light dims and finally goes out. This kit provides that feature for cars which don't already provide it. It has a soft fade out after a set time has elapsed, & features much simpler universal wiring than previous models we have had.

- Kit supplied with PCB with overlay, and all electronic components.
- Suitable for circuits switching ground or +12V or 24VDC (car & truck with negative chassis.)

**As published in EPE Magazine February 2007

MINI THEREMIN SYNTHESISER MKII KIT

KC-5426 £43.50 plus postage & packing

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

**As published in EPE Magazine May/June 2008

3V TO 9V DC TO DC CONVERTER KIT

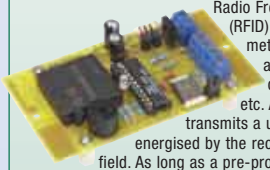
KC-5391 £4.95 plus postage & packing

This great little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no-time! You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell. Kit supplied with PCB, and all electronic components.

**As published in EPE Magazine June 2007

RFID SECURITY MODULE RECEIVER KIT

KC-5393 £28.95 plus postage & packing



Radio Frequency Identity (RFID) is a contact-less method of controlling an event such as a door strike or alarm etc. An "RFID Tag" transmits a unique code when energised by the receiver's magnetic field. As long as a pre-programmed tag is recognised by the receiver, access is granted. This module provides normally open and normally closed relay contacts for flexibility. It works with all EM-4001 compliant RFID tags. Kit supplied with PCB, tag and all electronic components.

**As published in EPE Magazine Augst 2007

AUDIO VIDEO BOOSTER KIT

KC-5350 £31.95 plus postage & packing

When running AV cables for your home theatre system, you may experience some signal loss over longer runs. This kit will boost your video and audio signals preserving them for the highest quality transmission to your projector or large screen TV. It boosts composite, S-Video, and stereo audio signals. Kit includes case, PCB, silk screened & punched panels and all electronic components.

- 9VAC @ 150mA required - Maplin GU09K £9.99

**As published in EPE Magazine March 2006

INTERCOOLER WATER SPRAY CONTROLLER

KC-5422 £3.00 plus postage & packing

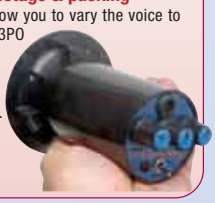
Intercooler water sprays are a very effective and inexpensive way of upgrading intercooler performance. Using a 'dump' system to trigger the spray often results in the need for frequent water top-ups. Simply add these few components to the Smart Fuel Mixture Display Kit (KC-5374) and reduce water consumption by up to two-thirds with no loss in cooling efficiency.

**As published in EPE Magazine March 2008

GALACTIC VOICE KIT

KC-5431 £13.25 plus postage & packing

Effect and depth controls allow you to vary the voice to simulate everything from C-3PO to the hysterical ranting of Daleks. The kit includes PCB with overlay, enclosure, speaker and all components.



**As published in EPE Magazine August 2008

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POPULAR KITS FOR ELECTRONIC ENTHUSIASTS

USB EXPERIMENTER'S INTERFACE KIT

KV-3600 £20.50 plus postage & packing

Interface your computer to the real world. There are five digital and two variable gain analogue inputs. Eight digital and two analogue outputs are available. Supplied with all components, silk screened PCB, assembly manual, and software.

- 5 Digital inputs
- 2 Analogue inputs with variable gain and integrated counters
- Analogue input range 0 to 5VDC
- 8 Open collector digital outputs
- 2 Analogue outputs PWM or 0 to 5VDC
- On-board test buttons for inputs and LED
- USB powered
- Win98SE or above (Not NT)

AVR ISP SERIAL PROGRAMMER KIT

KC-5340 £14.75 plus postage & packing

Program, erase and rewrite the program and data memory in your AVR microprocessor without even removing it from the application circuit. This kit connects to the computer serial port, uses royalty-free software available on the Internet and allows you to program a multitude of micros in the AVR 8-bit RISC family (see website for full listing). Kit supplied with PCB, jiffy box with silk-screened lid and all electronic components.

AVR ADAPTOR BOARD KIT

(To suit KC-5340)
KC-5421 £10.25 plus postage & packing

A low cost method of stand - alone programming for when the application board is unavailable or doesn't include an ISP (or JTAG) header.

Program, erase and rewrite the program and data memory in your AVR microprocessor with this socket board. Kit includes everything you need to support in-system programming, PCB with solder mask and overlay, clock source and microcontroller IC socket. Designed in conjunction with KC-5340 AVR ISP Serial Programmer.

PC LINK FOR AUTOMATIC CONTROL

KV-3590 £18.95 plus postage & packing

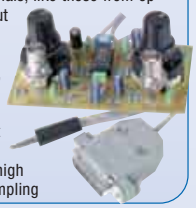
Automate your house and show your friends how clever you are! By using our parallel port controller, you can switch up to eight separate devices on or off. Automate your house, switch on garden lighting, turn on sprinklers or even control your household heating with this terrific kit. Each SPDT relay can handle 10 amps and has an LED to show whether it is on or off. Software is provided on a 3.5 disk. Kit includes PCB, relays, software, and all electronic components.

- 12VDC power required.

FRONT END PRE-AMP FOR PC SOUND CARDS

KA-1811 £9.75 plus postage and packing

Turn your computer into an oscilloscope, audio monitor or spectrum analyser! Plug the kit into your computer's soundcard and measure or monitor just about any audio signal. Most PC sound card inputs have a limited dynamic range, relatively low input impedance and poor overload protection -this kit will eliminate these limitations and allow tiny signals, like those from op-amps, to be measured without degradation.



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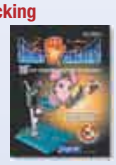

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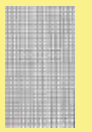

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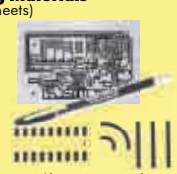

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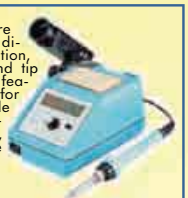

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0-100mA	0Ω65
0-500mA	0Ω12
0-1A	60mΩ
0-3A	20mΩ
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Phone: (01202) 873872. Fax: (01202) 874562.
Email: enquiries@epemag.wimborne.co.uk
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VOL. 37 No. 11 NOVEMBER 2008

Black holes and blue skies

As I write in mid-September, black holes seem to be the concern of the moment. First, the scare that CERN's Large Hadron Collider (LHC) will create a black hole under the cow-filled fields of Switzerland and crunch us all to oblivion. Second, and much more seriously, the financial black hole that carelessness, greed and short memories has created at the heart of the international financial system.

It seems likely that money for everything, including blue skies scientific research, will be in short supply for at least the next few years. Doubtless there will be calls to cut back on projects like the LHC, for which the costs are high and the financial returns far from obvious. This would be a mistake, because blue skies research has a great knack of delivering some of the most profitable and important technical advances, and these in turn help our economy, provide new cures for medicine and enrich our lives in countless other ways.

Take CERN for example – on Christmas Day 1990, Tim Berners-Lee implemented the first successful communication between an HTTP client and server via the Internet at CERN. The result was the World Wide Web. In the extremely unlikely event that CERN contributes nothing else, it has already created one of the landmark technologies of our age. The web wasn't created by IBM, Hewlett Packard or a defence agency, it was created by what the tabloids like to patronisingly call a 'boffin', who worked hard for a modest salary, simply because he thought he had a good idea and not because he was chasing personal or corporate profit.

There will be more inventions and discoveries from CERN and other labs around the world. I have no idea what they'll be, but these unique institutions are much too valuable to be dismissed as a waste of money. Far from creating black holes they represent some of the shining pinnacles of our culture. Remember that next time you click on a link!

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NEWS

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

Nokia and Symbian

Nokia is buying rights to the Symbian operating system for mobiles and making it an open system, like Linux. Barry Fox Reports

"It's an unprecedented move," Kai Oistamo, Executive VP, Nokia told a room of journalists alerted to a last minute press conference by early morning phone calls. "Ten years ago to the day Symbian Ltd was set up to licence the OS. After eight years it was in 100 million mobiles. Now it is in over 200 million, which is 60% of the converged mobile market. Seven device manufacturers and 250 network operators are using Symbian. Now we are going to give it away for free. This will create a magnet for developers, with critical mass like no other".

Nokia is paying 264 million euros to buy out the other partners (including Sony Ericsson, Panasonic, Samsung and Siemens). The planned timescale is that Nokia will acquire Symbian by Q4 this year, the Foundation will launch in the first half of 2009, unify the OS code (all seven million lines of it) and release 'Foundation Code' in the first half of 2010.

Existing Symbian code will be forwards compatible with the Foundation code.

Symbian staff will temporarily become Nokia employees ahead of the creation of an independent non-profit organisation to be called the Symbian Foundation run by Nokia, AT&T, LG Electronics, Motorola, NTT DOCOMO, Samsung, Sony Ericsson, STMicroelectronics, Texas Instruments and Vodafone.

Currently, manufacturers pay a royalty of $5 per phone, dropping to $2.50 for large numbers. Now the source code and licences to use it will be royalty-free. Creation of the Symbian Foundation spells bad news for rival systems Google Android (which is free but unproven) and Microsoft's Windows Mobile (which is expensive at around $14 per mobile).

Asked why Nokia is spending the money for no royalty rewards, Oistamo says simply "To sell more phones".

"But this is not a free-for-all" cautions Nigel Clifford, CEO Symbian Ltd. "The Foundation will control the source code and royalty-free licences to use it. In essence we will be saying, come and play".

RAT-BRAIN ROBOT AIDS MEMORY STUDY

Dr Ben Whalley, from the University of Reading, has carried out tests on the 'rat-brain-controlled' robot. "A robot controlled by a blob of rat brain cells could provide insights into diseases such as Alzheimer's", University of Reading scientists say.

The project marries 300,000 rat neurons to a robot that navigates via sonar. The neurons are now being taught to steer the robot around obstacles and avoid the walls of the small pen in which it is kept. By studying what happens to the neurons as they learn, its creators hope to reveal how memories are laid down.

The blob of nerves forming the brain of the robot was taken from the neural cortex in a rat foetus and then treated to dissolve the connections between individual neurons. Sensory input from the sonar on the robot is piped to the blob of cells to help them form new connections that will aid the machine as it navigates around its pen.

As the cells are living tissue, they are kept separate from the robot in a temperature-controlled cabinet in a container pitted with electrodes. Signals are passed to and from the robot via Bluetooth short-range radio.

The brain cells have been taught how to control the robot's movements so it can steer round obstacles and the next step, say its creators, is to get it to recognise its surroundings.

Once the robot can do this the researchers plan to disrupt the memories in a bid to recreate the gradual loss of mental faculties seen in diseases such as Alzheimer's and Parkinson's.

Studies of how neural tissue is degraded or copes with the disruption could give insights into these conditions.

"One of the fundamental questions that neuroscientists are facing today is how we link the activity of individual neurons to the complex behaviours that we see in whole organisms and whole animals," said Dr Ben Whalley, a neuroscientist at Reading.

Browse ***http://news.bbc.co.uk/1/hi/technology/7559150.stm***

FireBlade radio remote control

RF Solutions has launched its new FireBlade remote control system, which is housed in a rugged IP68 weatherproof enclosure. Supplied with an antenna and delivering a transmitting range of up to 1,000 metres, the FireBlade system can be used in a variety of applications. These include lighting control, remote switching, industrial remote switching and access control. Each individual switch on each of the transmitters may be paired with any or all of the receiver relay outputs. The receiver has the capacity to learn up to 15 transmitter button pairings which are memorised even if the power is removed.

Installation simply requires connections to a power supply and the output relay screw terminals. The output relays are activated by the button press on the transmitter encoder. The decoder is supplied in an IP68 rated enclosure with cable gland and wall mounting lugs. This FireBlade unit is designed to be a fixed installation operated from either 12/24V DC or 230V AC.

Each transmitter has a unique identity; every time a switch is pressed, the transmitter emits a highly secure RF signal (which appears as a random encrypted data stream). The receiver can learn this encrypted signal and allocate it to an output. Any transmitter switch may be paired to one or many of the receiver's outputs or a transmitter single switch may be paired to any number of receiver's outputs to enable a powerful and flexible remote control system. The same transmitter may be taught to any number of receivers to create 'master keys'.

Overall dimensions of the transmitter are 90mm × 54mm (widest point) × 27mm. Visit **www.rfsolutions.co.uk** for more details. Further information from: R.F. Solutions Unit 21, Cliffe Industrial Estate, South Street, Lewes, East Sussex, BN8 6JL. Tel: 01273 898000 Fax: 01273 480661. Web: **www.rfsolutions.co.uk**.

Greenpower Full Throttle

The Bentley Motors Greenpower team has chosen Radiometrix as a technology partner, to aid in its goal of winning the *Green Power Corporate Challenge*. Greenpower is a series of events, in which entrants from schools, colleges, and youth groups from all over the UK have to design, construct and then race electric cars. The aim of these events is to promote greater interest in young people between the ages of nine and twenty-one in following careers in the fields of engineering and technology, and encourage more of them to study these subjects at a higher level.

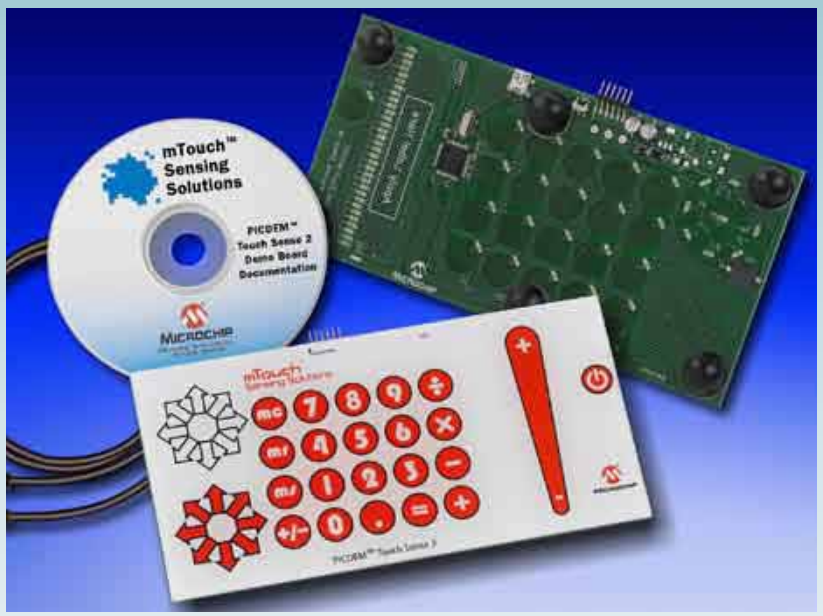
The Bentley team is composed of ten of the company's apprentice staff. The carbon-fibre chassis car runs off a 24V motor supplied by two 12V batteries. The team is utilising several Radiometrix TDi2 interface devices to implement low power wireless data modems capable of sending live values from the data logger to a laptop for analysis. During practice runs the data logging system will be used for measuring wheel speed, motor RPM rates, and temperature levels.

Bentley Greenpower team manager Tom Hodgson stated "We were searching for a product which allowed us to gain instant data from our car, to allow us to make critical strategy decisions around pit stops and battery changes. The TDi2 simply plugs into our datalogger and into our laptop, providing us with all the race information we need live from the car straight to the pits, a distinct advantage over our rivals."

The TDi2 transmits in the 433MHz ISM band. It combines the Radiometrix TDL2A radio module with all necessary interface circuitry (RS232 level shifter, supply regulator, indicators) and connectors (9-pin D type, SMA aerial jack, power header) to provide an easy-to-use medium range (typically 200m) 9600 Baud communication link.

"Involvement in Greenpower is something that we are very proud of. These events are helping to bring greater environmental awareness to the public, and at the same time offer support to Britain's young engineering talent" stated Ken Kangeyan, Managing Director of Radiometrix.

The Greenpower Corporate Challenge, takes place at the Goodwood race course on the 26/27 April. More information on the project is available at **www.bentleygreenpower.com**.



Capacitive Touch Demo Board

Microchip has announced the PICDEM Touch Sense 2 Demo Board (Part # DM 164128) for capacitive touch-sensing applications. Claimed to be easy-to-use, the board comes with the royalty-free mTouchT Sensing Solution software development kit (SDK) and is populated with a 16-bit PIC24FJ256GB110 micro-controller (MCU), which features an integrated Charge Time Measurement Unit (CTMU) peripheral for fast capacitive touch sensing. This is also the world's first 16-bit MCU family with USB On-The-Go (OTG).

The board and supporting materials provide a complete platform for implementing capacitive touch-sensing interfaces, without the need for external components. Additionally, with the PIC 24FJ256GB110 family's rich peripheral integration and 256 Kbytes of Flash memory, and Microchip's broad portfolio of free and low-cost software libraries, embedded designers can use a single MCU to cost effectively implement a wide variety of additional user-interface functions, including QVGA touch-screen displays, speech-based audio prompts and USB connectivity.

Many applications in the consumer, appliance, medical, industrial and automotive markets are rapidly adopting capacitive touch-sensing technology for reasons of aesthetics, maintenance, cost and cleanliness. Expanding on Microchip's existing 8-bit PIC-based mTouch development tools for capacitive touch, and equipped with capacitive touch-sensing keys and sliders, the board allows designers to evaluate this interface in their applications.

Using the Windows-based mTouch Diagnostic Tool, an easy-to-use graphical user interface (GUI) is included in the mTouch Sensing Solution SDK. The software libraries, source code and other support materials that come with the board further shorten development time and reduce design costs.

The PICDEM Touch Sense 2 demo board can be purchased at **www.microchipdirect.com** for $99.99. This price includes the mTouch Sensing Solution SDK and a USB cable. For further information visit **www.microchip.com/mtouch**.

Marmitek's Connect225!

Marmitek asks – have you multiple devices that you want to connect to your TV, but you don't want a bunch of cables coming from behind your TV? Do you never want to change cables behind your TV again, or are you just short of connections? If so, Marmitek say their Connect225 A/V selector is definitely something for you!

There is only one cable from your TV to the Connect225 and you connect your A/V devices once-only. Switching between the connected sources can be done with just one push on the button of your remote control. The unit automatically selects the switched-on source for optimal user friendliness and links the sound of this source automatically to your audio equipment for a complete Home Theatre experience (Dolby Surround).

*The Connect225 is suitable for connecting your TV, surround system, stereo set, game console, camcorder, laptop, DVD-player, DVD-recorder, decoder, satellite receiver and set-top box. It has one RCA and three SCART inputs, and one RCA and two SCART outputs. You can simultaneously watch one source while the signal of a second source is being recorded. The suggested consumer retail price (remote control included) is £39.95. More information can be found at **www.marmitek.com**.*

Low-Cost 50MHz Frequency Meter – Mk.2

By JOHN CLARKE

This update of our very popular compact 50MHz Frequency Meter now has an internal battery pack, or can run from a DC plugpack supply. It also incorporates a 10kHz rounding mode to enable 36MHz radio control transmitters, using pulse position modulation (PPM), to be measured with an unambiguous reading.

SINCE some of our readers will not be familiar with the 50MHz Frequency Meter presented in the September 2006 issue, we are presenting the design in full. Many readers will want to update a meter they have already built. This is easy to do because there are only a few circuit and hardware changes and the PC board itself is unchanged.

As far as the circuit is concerned, the major change is in the PIC microcontroller. We have used a PIC16F628A instead of the originally specified PIC16F84P, because we needed a larger memory. Other changes include an LM2940CT-5 low dropout regulator instead of the 78L05, an additional toggle switch on the front panel and the aforementioned internal battery pack. In other respects, the circuit is unchanged.

In use

Frequency meters are used in virtually all areas of electronics and are invaluable for servicing and diagnostics. Among other things, they are ideal for checking the operation of oscillators, counters and signal generators.

This unit is auto-ranging and displays the frequency in Hz, kHz or MHz. This makes it easy to read, because it automatically selects the correct range for any frequency between 0.1Hz and 50MHz, and inserts the decimal point in the correct place for each reading.

Provision for prescaler

If you want to measure frequencies above 50MHz, then you will need a prescaler that divides the input frequency to a range that the frequency meter can accept. Accordingly, our updated version of the 50MHz Frequency Meter includes a prescaler switch which changes the units from MHz to GHz, kHz to MHz and Hz to kHz.

As already mentioned, for radio control modellers, the 50MHz Frequency Meter Mk.2 can be set to display the reading in 10kHz steps for frequencies above 16MHz. This is an important feature, because when a standard frequency meter is used to measure radio control transmitters, the modulation used will often result in an incorrect value. More information on this feature is detailed in an accompanying panel.

Main Features

- Compact (130 x 67 x 44mm)
- 8-digit reading (LCD)
- Automatic Hz, kHz or MHz indicator units
- Prescaler kHz, MHz and GHz indicator units
- Three resolution modes, including 10kHz rounding
- 0.1Hz resolution up to 150Hz
- 1Hz resolution up to 16MHz
- 10Hz resolution above 16MHz
- Battery or DC plugpack supply

The design is easy to build, since it uses the programmed PIC microcontroller to perform all the complex logic. Apart from that, there's an LCD readout, a couple of low-cost ICs, two transistors, a 3-terminal low dropout regulator and a few sundry bits and pieces.

Note that although we have specified this Frequency Meter at 50MHz maximum, typical units will be capable of measuring frequencies somewhat higher than this. In fact, our prototype meter was good for measurements to above 64MHz.

LCD readout

A 2-line 16-character liquid crystal display (LCD) shows the frequency reading. This has several advantages over LED displays, including much lower current consumption.

In addition, the LCD can show all the units without resorting to the use of separate annunciators, as would be required with an LED display.

Resolution modes

There are three resolution modes:

1) Low-resolution mode with fast updates, suitable for the majority of measurements
2) High-resolution mode for greater precision when required
3) 10kHz rounding up feature.

In low-resolution mode, the resolution is 1Hz for frequencies from 1 to 999Hz, and 10Hz for frequencies above this. The corresponding display update times are 1s from 1 to 999Hz and 200ms from 1kHz to 50MHz.

High-resolution mode provides 1Hz resolution for frequencies from 150Hz to 16MHz. Above 16MHz, the resolution reverts to 10Hz. The display update time is 1s.

Below 150Hz in the high-resolution mode, the display has 0.1Hz resolution and a nominal 1s update time for frequencies above 10Hz. This 0.1Hz resolution makes the unit ideal for testing loudspeakers, where the resonance frequency needs to be accurately measured.

Note that the update time is longer than 1s for frequencies below 10Hz.

The three resolution modes are selected by pressing the Resolution switch. The meter displays 'LOW', 'HIGH' or 'LOW 10kHz@>16MHz' to indicate which mode is currently selected. In addition, the selected resolution mode

Parts List – 50MHz Frequency Meter Mk.2

1 PC board, code 581 for Version 1; 582 for Version 2; 583 for Version 3. All available from the *EPE PCB Service*.
1 plastic case, 130 × 67 × 44mm
1 front panel label to suit version, 125 × 64mm (see Fig. 9 and 10)
1 2-line 16 character (per line) alphanumeric LCD module – see text
1 SPST toggle switch (S1)
1 pushbutton momentary contact switch (S2)
1 miniature SPDT toggle switch (S3)
1 panel-mount BNC socket
1 low-drift 4MHz crystal (Hy-Q HC49/U 4000.00kHz GG03E) (X1)
1 PC-mount 2.5mm DC socket
1 18-pin dual-wipe contact DIP socket (for IC3)
1 28-pin dual-wipe contact DIP socket (for Versions 1 and 2 LCD modules; see text); or
1 14-pin dual-wipe contact DIP socket (for Version 3 LCD module) – see text
1 14-way SIL pin header for the LCD sockets
4 M3 x 10mm countersunk screws
4 M3 nuts
4 M3 x 6mm cheesehead screws
4 M3 x 12mm tapped nylon spacers
4 M3 nylon washers
10 PC stakes
1 300mm length of 0.7mm tinned copper wire
1 60mm length of 75Ω coax cable
1 100mm length of hookup wire
1 1kΩ horizontal trimpot (code 102) (VR1)
1 10kΩ horizontal trimpot (code 103) (VR2)

Semiconductors

1 MC10116N triple ECL differential line receiver (IC1)
1 74HC132 quad Schmitt trigger (IC2)
1 PIC16F628A/P microcontroller (IC3) programmed with *freqenc2.hex;* available for free download from the EPE website at **www.epemag.com.** Pre-programmed PICs are available from Magenta Electronics – see their advert.
1 LM2940CT-5 low dropout voltage regulator (REG1)
1 2N5485 *N*-channel VHF JFET (Q1)
1 BF450 *PNP* transistor (Q2)
3 BAW62 diodes (D1-D3)
1 1N4004 1A diode (D4)

Capacitors

2 100µF 16V PC electrolytic
3 10µF 16V PC electrolytic
1 470nF MKT polyester
1 100nF MKT polyester
8 10nF ceramic
1 470pF ceramic
1 33pF NP0 ceramic
1 22pF ceramic
1 10-60pF trimmer (VC1)

Resistors (1%, 0.25W)

1 910kΩ
1 100kΩ
1 47kΩ
2 10kΩ
2 2.2kΩ
7 470Ω
1 330Ω
4 100Ω
1 15Ω1W (optional)

is stored in memory and is automatically restored if the meter is switched off and on again.

In the 10kHz rounding mode, the frequency is rounded up to just show the next 10kHz frequency band for frequencies between 16MHz and 50MHz. When the display is showing frequency rounding, the second line of the display indicates this with a '(10kHz Rounding)' indication.

In low-resolution mode, the display will show 0Hz if the frequency is below 1Hz. By contrast, in the high-resolution mode, the display will show 'No Signal' for frequencies below 0.1Hz.

If the frequency is below 0.5Hz, the display will initially show an 'Await Signal' indication before displaying the frequency. If there is no signal, the display will then show 'No Signal' after about 16.6s.

Waiting time

The 0.1Hz resolution mode for frequencies below 150Hz operates in a different manner to those measurements made at 1Hz and 10Hz resolution. Obtaining 0.1Hz resolution in a conventional frequency meter normally means measuring the test frequency over a 10s period. And that means that the update time is slightly longer than 10s.

This is a long time to wait if you are adjusting a signal generator to a precise frequency. However, in this frequency meter, the display update period is 1s for frequencies above 10.0Hz, increasing gradually to 10s for frequencies down to 0.1Hz. So, for normal audio frequencies, the display will update at 1s intervals. Just how this is achieved is explained below, when we discuss the block diagrams for the unit.

The Prescaler switch causes the display to show the prescaler units in the LOW and HIGH resolution selections. When selected, the words 'Prescaler units' are shown on the second line of the LCD. The prescaler units feature is not available for the 10kHz rounding feature because it is not required and would confuse the reading.

Block diagrams

The general arrangement of the frequency meter is shown in Fig.1. It's based mainly on the PIC microcontroller (IC3).

In operation, the input signal is processed and applied directly to a divide-by-256 prescaler inside IC3. The divided signal then clocks timer TMR0, which counts up to 256 before clocking Register A, an 8-bit register that counts up to 256 before returning to zero. Combining all three counters (the prescaler, TMR0 and register A) allows the circuit to count up to 24 bits, or a total of 16,777,216.

By counting over a 1s period, it follows that the unit can make readings up to about 16.7MHz. However, if the frequency is counted over a 100ms period, the theoretical maximum that can be measured is just over 167MHz.

As shown in Fig.1, the input signal is amplified (by Q1, IC1 and Q2) and fed to gating stage IC2a. This drives clocking stage IC2b, which is controlled by IC3's RA3 output. Normally, IC2b allows the signal to pass through to the prescaler at IC3's RA4 input.

IC3's RB2 output controls the gating stage IC2a so that the signal passes through for either a 100ms period or a 1s period. During the selected period, the signal frequency is counted using the prescaler, timer TMR0 and register A. Initially, the prescaler, the timer and register A are all cleared to 0 and the RB2 output is then set to allow the input signal to pass through to the prescaler for the gating period (ie, for 100ms or 1s).

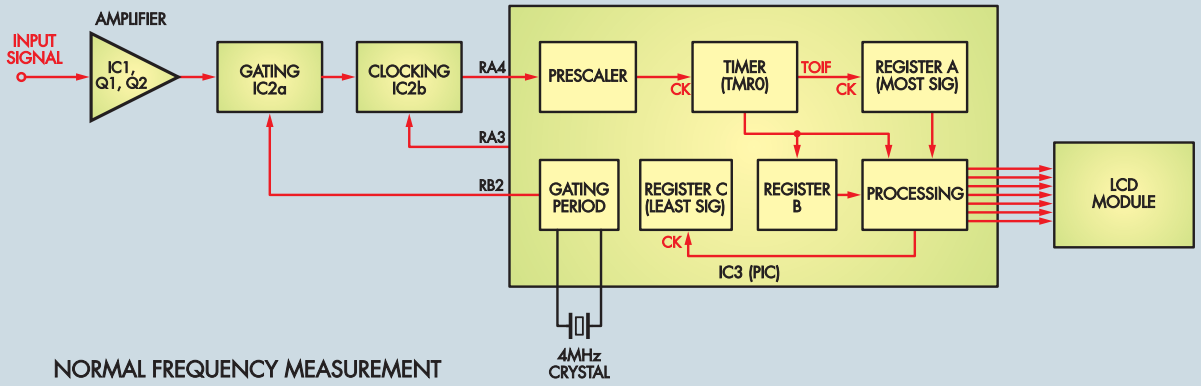


Fig.1: the block diagram of the 50MHz Frequency Meter for 'normal' frequency measurements. The incoming signal is first amplified, then fed through a gating circuit to a clocking stage (IC2b). This then drives a divide-by-256 prescaler inside PIC microcontroller IC3 (ie, at the RA4 input).

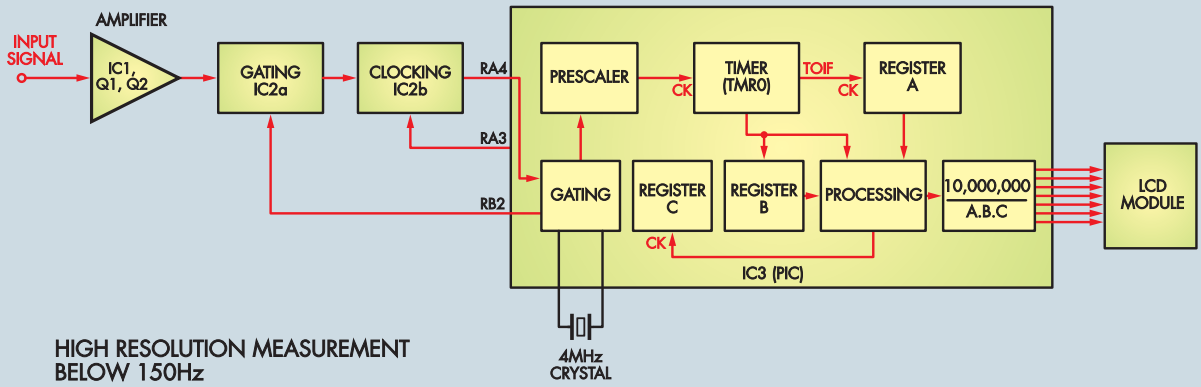


Fig.2: this is the alternative configuration for making high-resolution (ie, to 0.1Hz) measurements below 150Hz. In this case, the input signal is applied to the RA4 input as before. However, the prescaler is no longer clocked by the RA4 input, but by an internal 1MHz clock instead.

During this period, the prescaler counts the incoming signal applied to RA4. Each time its count overflows from 255 to 0, it automatically clocks timer TMR0 by one count. Similarly, whenever the timer output overflows from 255 to 0, it sets a timer overflow interrupt flag (TOIF), which in turn clocks Register A.

Prescaler value

At the end of the gating period, IC3's RB2 output is cleared, thus stopping any further signal from passing through to the prescaler. The value of the count in TMR0 is now transferred to Register B. Unfortunately, the value in the prescaler cannot be directly read by IC3 and so we need to derive the value.

This is done by first presetting register C with a count of 255. That done, the RA3 output is taken low to clock the prescaler and timer TMR0 is checked to see if its count has changed. If TMR0 hasn't changed, then the prescaler is clocked again with RA3.

During this process, register C is decreased by one each time the prescaler is clocked. The process continues, with RA3 clocking the prescaler until timer TMR0 changes by one count. When this happens, it indicates that the prescaler has reached its maximum count. The value in Register C will now be the value that was in the prescaler at the end of the counting period.

The processing block now reads the values in registers A, B and C. Based on this information, it then decides where to place the decimal point and whether to show Hz, kHz or MHz. The required value is then written to the LCD via the data and control lines (RB4 to RB7, and RA0 to RA2).

For the Prescaler units selection, the Hz units are shown as kHz, the kHz units are shown as MHz and the MHz units are shown as GHz.

In the 10kHz rounding mode, frequencies above 16MHz are rounded up to the next 10kHz band. For example, a 36.44659MHz signal is rounded up to 36.450MHz.

Alternative configuration

If the input signal frequency is greater than 16MHz, and the gating period is 1s, register A will initially have overflowed. In this case, the gating period is automatically changed to 100ms. Alternatively, if the high-resolution mode is selected and the frequency is below 150Hz, the frequency meter changes its configuration to that shown in Fig.2.

In this case, the input signal is applied to the RA4 input as before.

Specifications

- **Input sensitivity:** typically less than 20mV RMS from 1Hz to 100kHz, rising to 50mV at 20MHz and 85mV at 50MHz.
- **Input impedance:** 1.1MΩ in parallel with about 10pF
- **Frequency range:** 0.1Hz to 50MHz or better
- **Untrimmed accuracy:** ±20ppm, equivalent to 1000Hz at 50MHz
- **Trimmed accuracy:** ±10ppm from –20°C to 70°C
- **Resolution:** High-resolution mode: 0.1Hz from 0.1 to 150Hz; 1Hz from 150Hz to 16MHz; 10Hz from 16 to 50MHz. Low-resolution mode: 1Hz from 1 to 999Hz; 10Hz from 1kHz to 50MHz
- **Update time (approx):** 200ms for 10Hz resolution; 1s for 1Hz resolution; 1s for 0.1Hz resolution down to 10Hz, increasing to 10s at 0.1Hz
- **Display units:** Hz from 0.1 to 999Hz; kHz from 1 to 999.999kHz; MHz from 1 to 50MHz
- **Current consumption:** 65mA with 7.5 to 12V input

However, the prescaler is no longer clocked by the RA4 input, but by an internal 1MHz clock.

Basically, what happens is that the RA4 input is monitored for a change in state – ie, from a low voltage to a high voltage – which indicates a signal at the input. When this happens, the prescaler is cleared and begins counting the 1MHz internal clock signal. The overflows from the prescaler and timer TMR0 are carried to register A as before.

Counting continues until the input signal goes low and then high again, at which point counting stops. If the counting causes register A to overflow, then the display will show no signal (this will happen after 16.7s if the signal does not go low and high again). Conversely, if the counting is within range, the prescaler value is determined by clocking IC2b using the RA3 output as before.

From this, it follows that if the input frequency is 1Hz (ie, a 1s period), the value in the A, B and C registers will be 1,000,000. That's because the prescaler is clocked at 1MHz for 1s. Similarly, the count will be 100,000 for a 10Hz signal and 10,000 for a 100Hz input signal.

Finally, the value in the registers is divided into 10,000,000 and the decimal point placed immediately to the left of the righthand digit. This gives a direct readout in Hz with 0.1Hz resolution on the LCD.

This technique cannot be used for measuring very high frequencies because the value in the counter becomes smaller as the frequency increases, and so we begin to lose accuracy. For example, at 500Hz, the counted value would be 2000 and at 500.1Hz the counted value would be 1999. The result of the division of 1999 into 10,000,000 would be 500.2 instead of the 500.1 required.

Hence, the 0.1Hz resolution has been restricted to readings below 150Hz to ensure accuracy of the calculation.

Circuit details

Refer now to Fig.3 for the full circuit details. The input signal is AC-coupled to the unit via a 470nF capacitor to remove any DC component. This signal is then clipped to about 0.6V peak-to-peak using diodes D1 and D2, with current limiting provided by the 100kΩ series resistor. The 22pF capacitor across the 100kΩ resistor compensates for the capacitive load of the diodes.

From there, the signal is fed to the gate (G) of Q1, a 2N5485 JFET. This transistor provides high input impedance, which is necessary to ensure a wide frequency response.

Q1 is self-biased using a 910kΩ resistor from the gate to ground, and a 470Ω source (S) resistor. It operates with a voltage gain of about 0.7, which means that the signal is slightly attenuated at the source. This loss is more than compensated for in the following amplifier stages.

Next, the signal is AC-coupled to pin 4 of amplifier stage IC1a via a 100µF electrolytic capacitor and a parallel 10nF capacitor. The 100µF capacitor is sufficiently large to allow for a low frequency response of less than 1Hz. However, this capacitor loses its effectiveness at higher frequencies due to its high internal inductance and the signal is coupled via the 10nF capacitor instead.

Fig.3 (right): the circuit is based on microcontroller IC3. This processes the signals from the preceding amplifier stages and drives the LCD. Power comes either from a 9V to 12V DC plugpack or from a 7.5V battery.

Differential line receivers

IC1a is one of three differential line receivers in an MC10116N IC. It's biased via the DC output at pin 11 and this is decoupled using a 10µF electrolytic capacitor and a paralleled 10nF ceramic capacitor. The voltage is then applied to the wiper of trimpot VR1 (offset adjust) and this allows adjustment of the input bias voltage.

In operation, IC1a is run open-loop (ie, without feedback) so that it provides as much gain as possible. Even so, it only operates with a voltage gain of about seven. Its differential output signals appear at pins 2 and 3, and are applied to the differential inputs (pins 12 and 13) of IC1b.

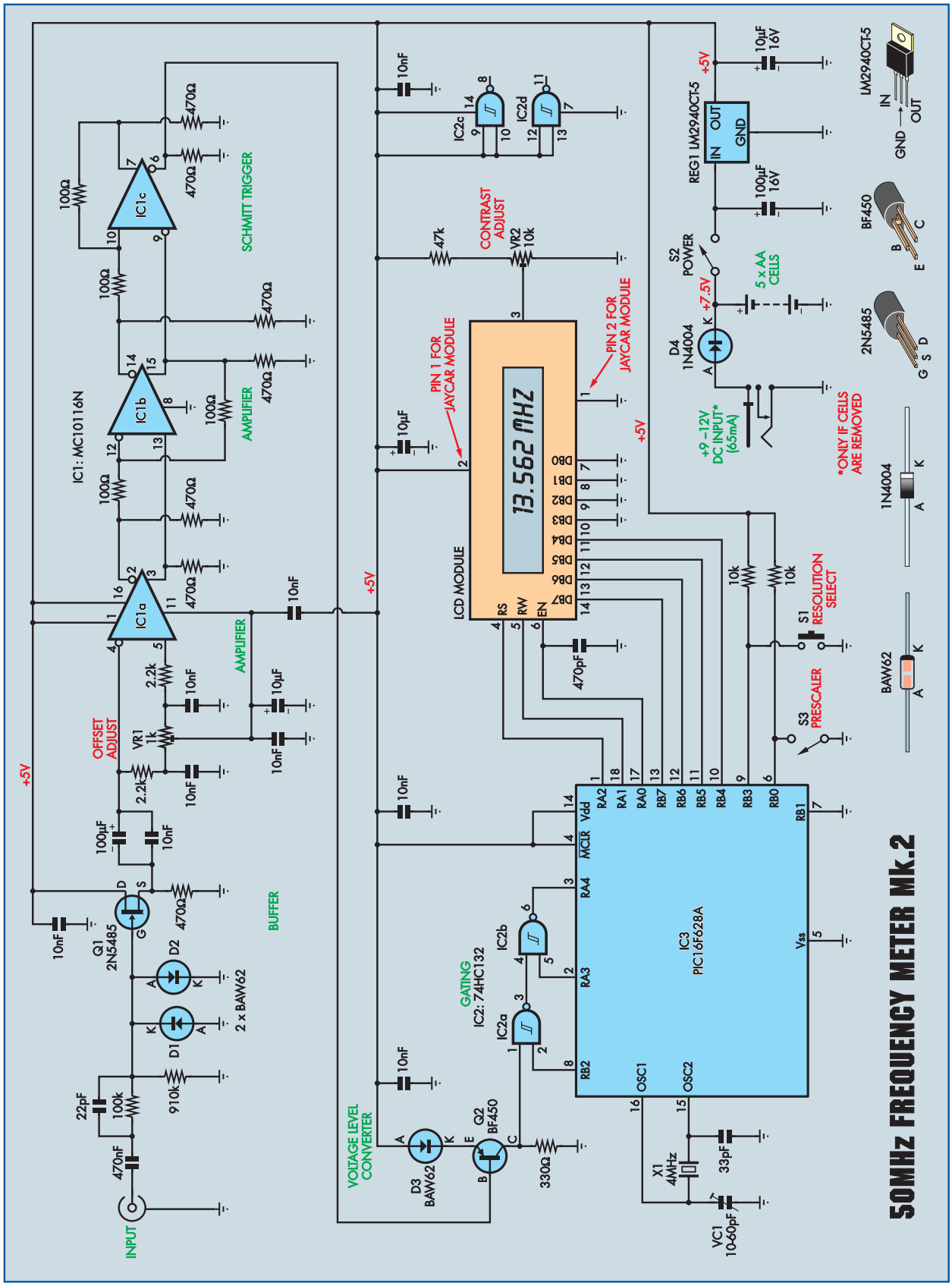
Note that the differential outputs have 470Ω pull down resistors, because they are open emitters. In fact, the MC10116 IC is an emitter-coupled logic (ECL) device.

Unlike IC1a, IC1b has negative feedback provided by the two associated 100Ω resistors. This reduces the gain of this stage to just below two.

The third stage using IC1c employs positive feedback, and so it functions as a Schmitt trigger rather than as an amplifier. Its hysteresis is around 450mV, while this means that the signal swing on its differential inputs must be greater than this in order to provide an output.

In operation, the output signal at pins 6 and 7 of IC1c swings from 4.3V when high to 3.4V when low. This needs to be level-shifted to provide normal CMOS input levels to the gating circuit (IC2a), this is done using *PNP* transistor Q2.

IC2a is a Schmitt NAND gate. It inverts the signal on its pin 1 input when pin 2 is held at +5V by IC3's RB2 output (ie, the signal passes


50MHz FREQUENCY METER Mk.2
IC1: MC10116N
IC1a
IC1b
IC1c
SCHMITT TRIGGER
AMPLIFIER
AMPLIFIER
BUFFER
OFFSET ADJUST
VR1 1k
INPUT
Q1 2N5485
2 x BAW62
D1
D2
VOLTAGE LEVEL CONVERTER
D3 BAW62
Q2 BF450
GATING
IC2: 74HC132
IC2a
IC2b
IC2c
IC2d
IC3 PIC16F628A
X1 4MHz
VC1 10-60pF
LCD MODULE
13.562 MHZ
CONTRAST ADJUST
VR2 10k
PIN 1 FOR JAYCAR MODULE
PIN 2 FOR JAYCAR MODULE
S1 RESOLUTION SELECT
S3 PRESCALER
S2 POWER
5 x AA CELLS
REG1 LM2940CT-5
D4 1N4004
+9 – 12V DC INPUT* (65mA)
*ONLY IF CELLS ARE REMOVED
LM2940CT-5
BF450
2N5485
1N4004
BAW62
+5V
+7.5V

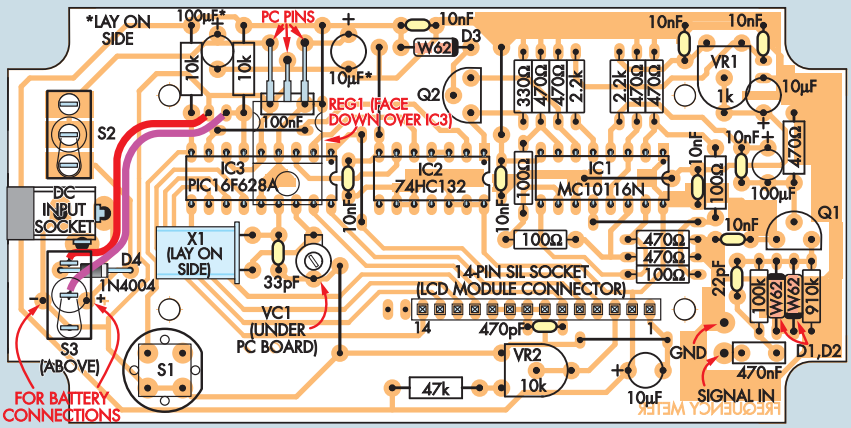


Fig.4: this is the layout to use to upgrade an existing Mk.1, Version 1 module.

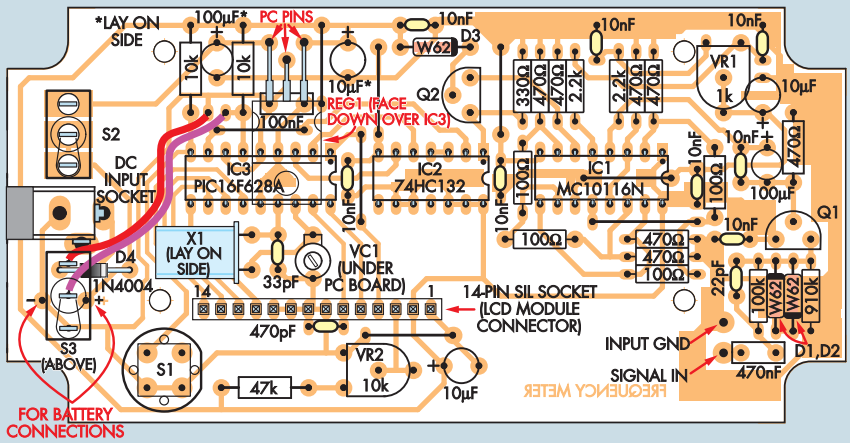


Fig.5: follow this layout diagram to build Version 2. Note that trimmer capacitor VC1 mounts on the track side of the board – see photos.

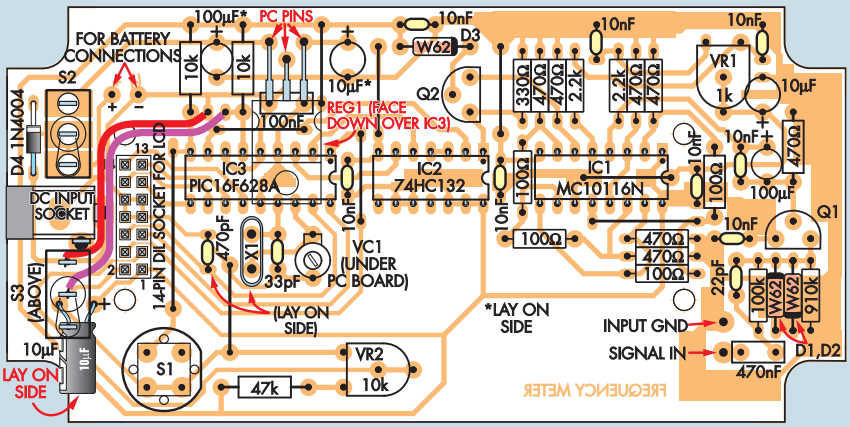


Fig.6: this is the layout to follow if you are building Version 3.

through to the pin 3 output, but is inverted). Conversely, when RB2 is at 0V, IC2a's pin 3 output remains high, and the input signal is blocked. So, in summary, the signal is allowed through to IC2b when RB2 is high, and is blocked when RB2 is low, as described previously.

IC2b normally has its pin 5 input held high via IC3's RA3 output, so that the signal from IC2a is again inverted at pin 6. When RB2 is brought low, pin 3 of IC2a remains high, and so pin 4 of IC2b is also high. This allows RA3 to clock the RA4 input via IC2b.

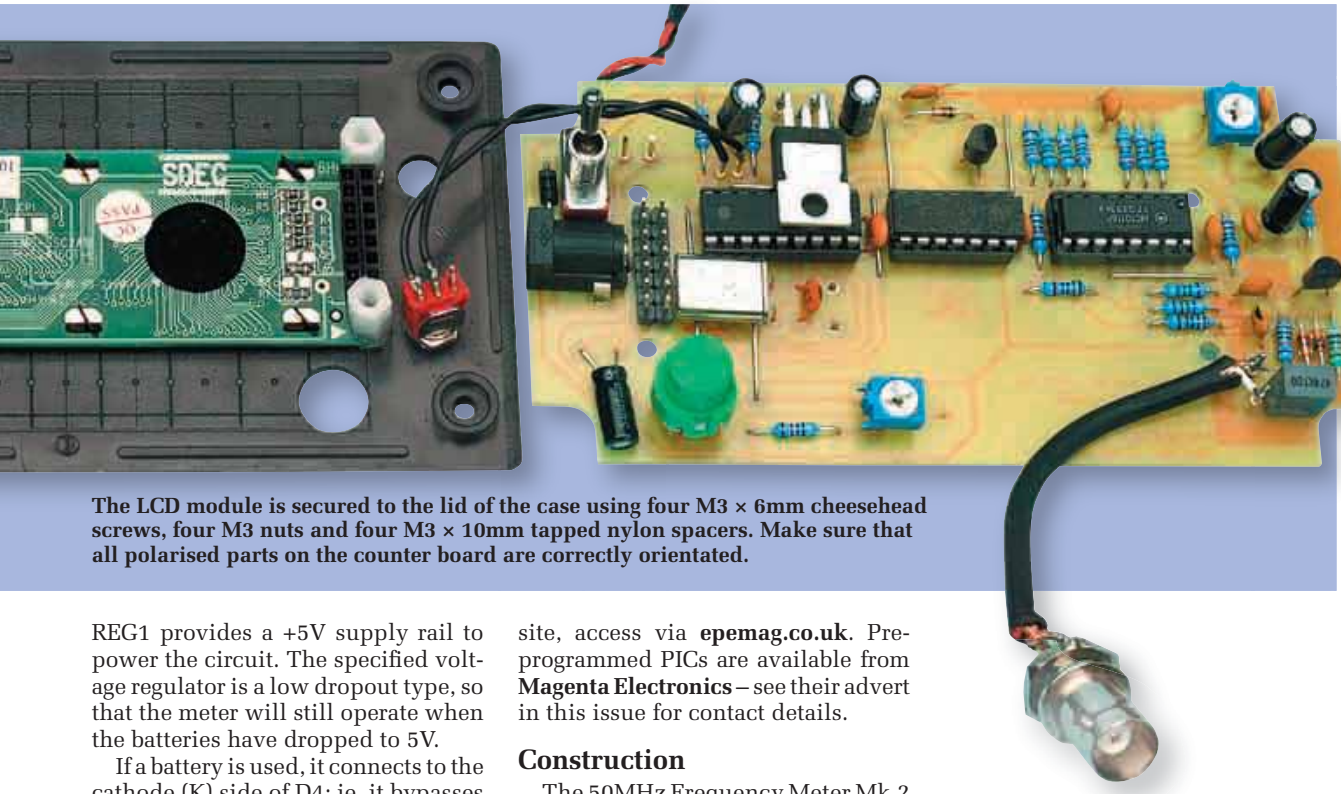
Driving the LCD

IC3's RA0 to RA2 outputs drive the control inputs to the LCD module and select the line and the position of the character to be displayed. Similarly, RB4 to RB7 drive the data inputs (DB4 to DB7) on the LCD module. A 470pF capacitor on the E (enable control line) is included to slow down the rise and fall times of the square wave from IC3.

A 4MHz crystal (X1) connected between pins 15 and 16 of IC3 provides the clock signals for IC3. The recommended crystal has low drift, but a standard 4MHz crystal could be used if accuracy is not critical. The capacitors at pins 15 and 16 provide the necessary loading for the crystal, while VC1 allows the clock frequency to be 'tweaked' slightly to provide calibration.

Power supply

Power for the circuit is derived from either a 9V to 12V DC plugpack or a 7.5V battery, made up using five AA cells. **You can choose to operate from batteries or a DC supply – but not both.** Diode D4 protects the circuit against reverse polarity protection when using a plugpack supply, while regulator



The LCD module is secured to the lid of the case using four M3 × 6mm cheesehead screws, four M3 nuts and four M3 × 10mm tapped nylon spacers. Make sure that all polarised parts on the counter board are correctly orientated.

REG1 provides a +5V supply rail to power the circuit. The specified voltage regulator is a low dropout type, so that the meter will still operate when the batteries have dropped to 5V.

If a battery is used, it connects to the cathode (K) side of D4; ie, it bypasses the reverse polarity protection. This means that D4 can be left out of the circuit (along with the DC socket) if the unit is to be battery powered.

If you wish to use rechargeable cells, then it is recommended that you use an extra cell to obtain more voltage. In this case, you could replace D4 with a 15Ω 1W resistor to enable charging. Make sure you get the polarity correct. If you are concerned about polarity, a Schottky diode (1N5819) could also be included in series with the resistor.

Software

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

Construction

The 50MHz Frequency Meter Mk.2 can be made in one of three versions, depending on what display module you buy. That's because different suppliers sell different LCD modules, so a different PC board has been designed to suit each module. These boards are coded 581 Version 1, 582 Version 2 and 583 Version 3. (All available from the *EPE PCB Service*.)

If you are buying a kit, make sure you get the updated version and not the original version described in Sept '06. If you are modifying an existing kit, you will need a new programmed PIC16F628A, a miniature SPDT toggle switch and an LM2940CT-5 low dropout regulator. In addition, you will need to drill an extra hole in the front panel to accommodate the additional switch.

Table 2: Capacitor Codes

Value	µF code	EIA Code	IEC Code
470nF	0.47µF	474	470n
100nF	0.1µF	104	100n
10nF	.01µF	103	10n
470pF	NA	471	470p
33pF	NA	33	33p
22pF	NA	22	22p

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	910kΩ	white brown yellow brown	white brown black orange brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	7	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	330Ω	orange orange brown brown	orange orange black black brown
❑	4	100Ω	brown black brown brown	brown black black black brown
❑	1	15Ω	brown green black brown	brown green black gold brown

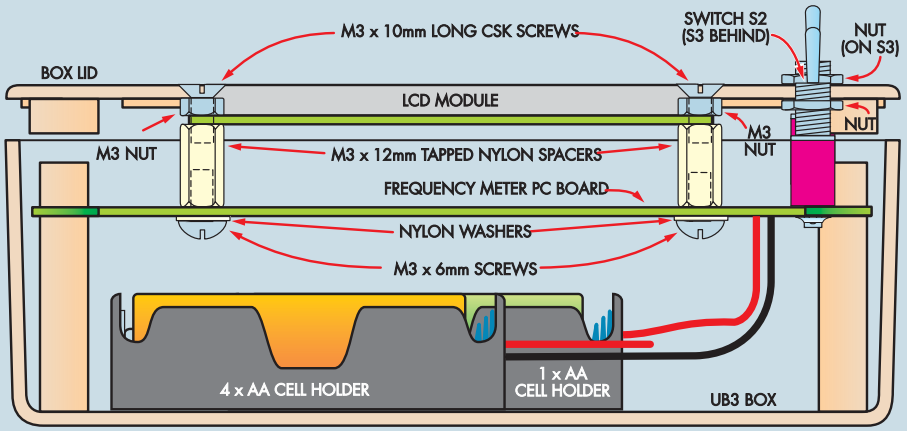


Fig.7: this diagram shows how the unit is installed inside the case. Be sure to use nylon spacers and washers where indicated.

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Each LCD plugs directly into its intended PC board, which means that there are no external wiring connections except to the BNC input socket, switch S3 and the battery holders.

The unit is housed in a plastic case measuring 130 × 67 × 44mm, with the LCD module protruding through a cutout in the front panel. Version 1 has the power switch mounted on the righthand side and the signal input applied to the BNC socket at the top left of the box. By contrast, both Version 1 and 2 have the power switch at the top left, while the input socket is mounted on the top right of the box.

This difference comes about because the display readout for the Version 1 LCD module is upside down compared to the other two modules in relation to the input terminals. Note that the unit shown in the photos is Version 1, but both Version 2 and 3 modules were fully tested.

Circuit boards

Figs.4 to 6 shows the PC board layouts for the three versions. Begin by checking that you have the correct PC board for the LCD module you are using. That done, check the mounting holes for the LCD module against those on the PC board (the holes must be 3mm in diameter). Check also that holes are large enough to mount switch S2 and the DC input socket.

Next, install all the wire links and resistors, using the accompanying resistor colour code table as a guide to selecting each value. It's also a good idea to check the resistors with a digital multimeter, just to make sure.

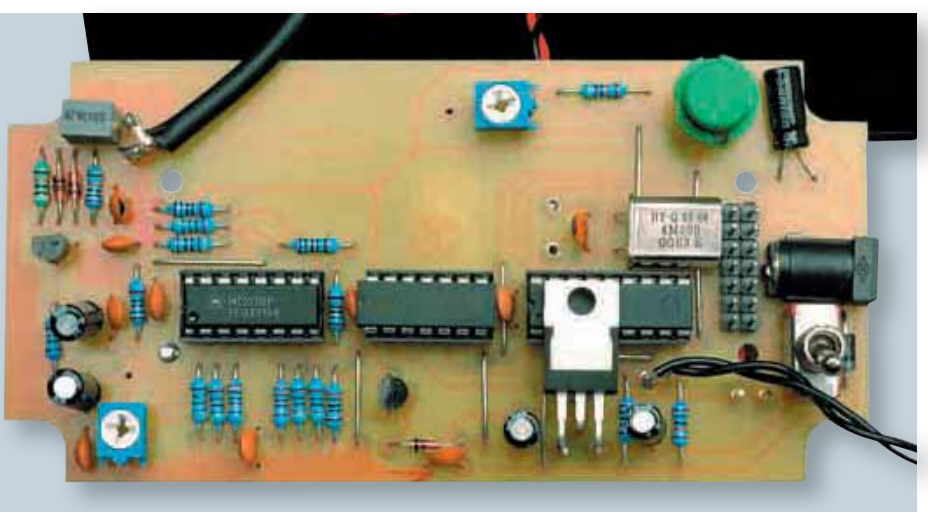
IC1 and IC2 can go in next, taking care to ensure that they are correctly oriented. Then install a socket for IC3, but *do not* install the microcontroller yet.

The diodes and capacitors can now all be installed, followed by REG1 and transistors Q1 and Q2. Note that REG1 mounts using PC stakes and is mounted horizontally to cover IC3 (see photo below). **Note also that some of the parts must sit with their bodies parallel to the PC board. These include crystal X1, its adjacent 470pF capacitor and the 10µF capacitor adjacent to switch S1 on Version 3 (so it doesn't later foul S3), plus the 10µF and 100µF capacitors on Version 2 (so that they don't foul the LCD module).**

It's just a matter of bending their leads at right angles before installing them on the board.

Similarly, the top of transistor Q2 must be no higher than 10mm above the PC board so that it doesn't interfere with the LCD module (all versions).

The next step is to install the socket for the LCD module. Both Versions 1 and 2 use a 28-pin DIL IC socket that is cut in half to obtain a 14-way strip



Here's another view of the completed PC board. Note how regulator REG1 is mounted face down over IC3 and the adjacent 100nF capacitor, with its three leads soldered to PC stakes.

socket which is then soldered in place. By contrast, Version 3 uses a 14-pin IC socket which is cut into two 7-way strips, which are then installed side-by-side (Fig.6.).

Once the sockets are in, install PC stakes for the '+' and '–' supply connections (near D4) and for the signal input and GND connections. These PC stakes should all be installed from the copper side of the board.

PC stakes are also used to mount switch S1. These should be trimmed so that when the switch is mounted, its top face is 20mm above the top surface of the PC board. Be sure to orient S1 with its flat section facing towards the right, as shown in Figs.4 to 6.

The remaining parts can now be installed on the board. These parts include switch S2, the DC socket, trimpots VR1 and VR2, crystal X1 and trimmer capacitor VC1.

Note that VC1 is mounted on the underside of the PC board, so that it can be adjusted without having to remove the LCD module.

Front panel

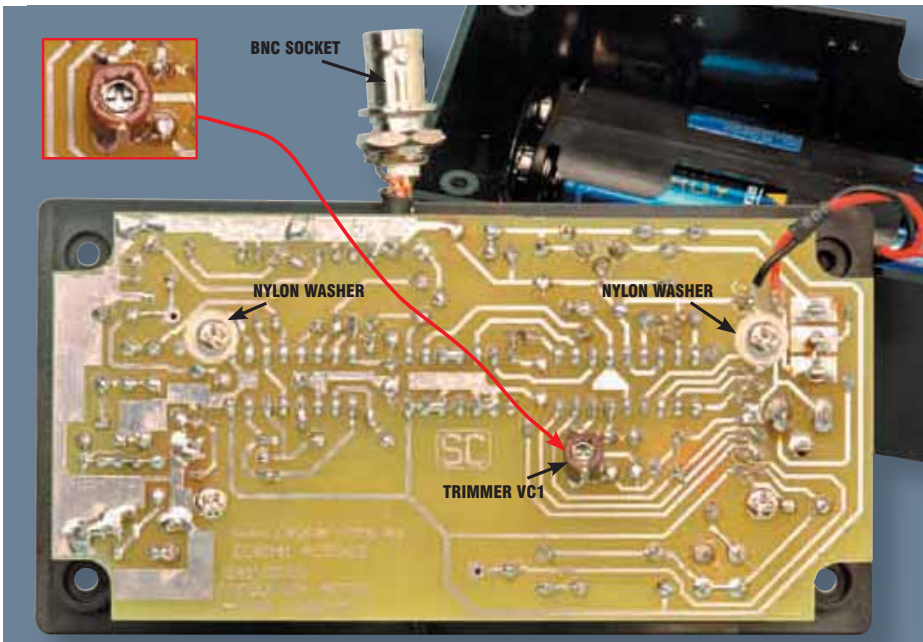
The front panel (ie, the case lid) must be drilled and a cutout made to accommodate the three switches and the display. However, if you have purchased a kit, then you probably won't have to worry about this.

It will also be necessary to drill the mounting holes for the LCD module. Note that these should be countersunk so that the intended screws sit flush with the surface of the lid – see Fig.7. That done, the label (see Figs.9 and 10) can be attached to the panel with the cut-outs made using a utility knife.

Testing

Now for an initial test before IC3 or the LCD are plugged in. Apply power and check that +5V is present on pin 16 of IC1, pin 14 of IC2 and pins 4 and 14 of IC3. If this is correct, disconnect power and install the ready-programmed PIC microcontroller (IC3) in its socket, taking care to ensure it goes in the right way around. Plug the LCD module into its matching socket and temporarily fit a couple of 12mm tapped nylon spacers to support it on the PC board.

Apply the power again and check that the display shows either 1Hz or 0Hz. If not, adjust VR2 for best display contrast. Trimpot VR1 should be adjusted so that the display shows 0Hz when the signal input terminals are shorted.



The PC board is secured by plugging it into the matching header pins on the LCD module and installing four screws to fasten it to the spacers. Note the nylon washers under the top two screw heads – these are necessary to prevent shorts to adjacent tracks. The inset at top-left shows an enlarged view of VC1.

Now press the Resolution switch – the display should show HIGH. It should then show Await Signal when the switch is released. If the switch is then pressed again, the display should show LOW. A third press will bring up the LOW 10kHz@>16MHz mode.

Final assembly

Refer to Fig.7 for the final assembly details. As shown, the LCD module is secured to the case lid using four M3 × 10mm countersunk screws, four M3 nuts (used as spacers) and four 12mm-long tapped nylon spacers. The PC board is then secured to the bottom ends of the four spacers. Use nylon washers for the underside of the PC board to prevent shorting any tracks with the screws (see photo above).

You will have to drill a 9mm diameter hole in one side of the box to

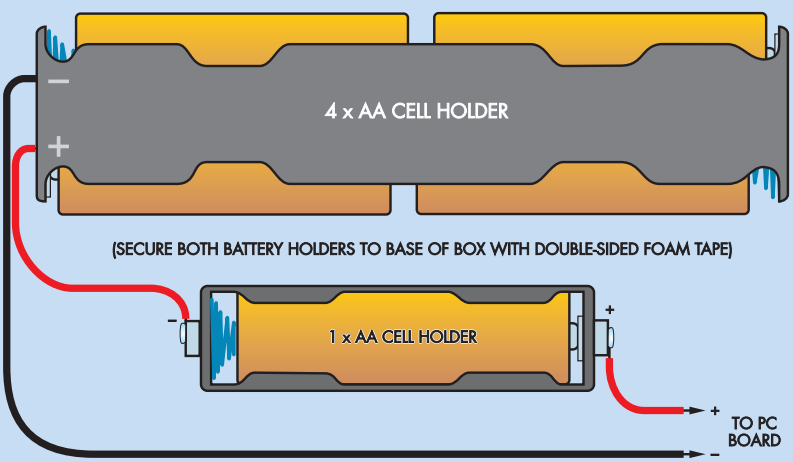


Fig.8: the two battery holders (4 × AA and 1 × AA) must be wired in series as shown here. Add an extra AA holder if you are using rechargeables.

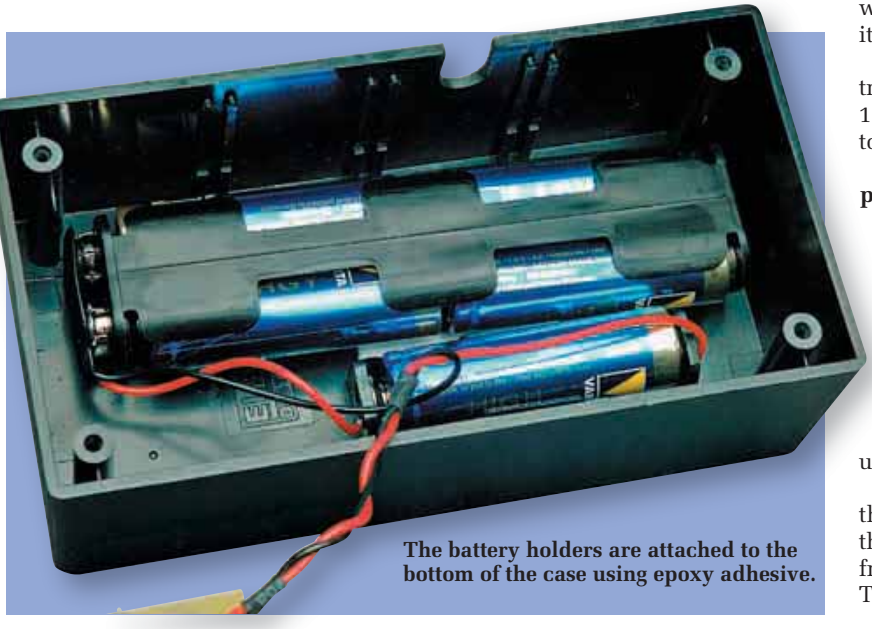
Checking the frequency of radio control transmitters

WHEN MODEL ENTHUSIASTS get together, they often want to fly their radio-controlled aeroplanes (or drive their radio-controlled cars or boats) in a competition-based meet. With so many radio controls being used they must each operate on a different band to avoid interference between the controllers. Having a device that can immediately check each transmitter's operating frequency is a great asset, because it can tell immediately if there is going to be a frequency conflict. In that case, they can change the crystal frequency on one of the transmitters and its receiver.

Radio transmitters operate on the 27MHz, 29MHz, 36MHz and 40MHz bands. However, the synthesised modules (crystal controlled) are only available on the 36MHz band and this is by far the most popular band. On this band, PPM (pulse position modulation) and PCM (pulse code modulation) are used for the transmission. With PCM, the frequency reading on a meter will be correct because the modulation is symmetrical and the frequency swings will average out. For PPM, the frequency reading on a meter will be a few kHz low because of the asymmetrical dwell times on the high-low parts of the modulation.

The PPM frequency reading can be most confusing at times. To understand why, let's consider an example. The 36MHz band runs in 10kHz steps from 36.010MHz to 36.590MHz. If we have a crystal in the transmitter that is set at 36.450MHz, the reading on a standard frequency meter will show a lower value at say, 36.44646MHz. But with our frequency meter in 10kHz rounding mode, it converts the 36.44646MHz count to 36.450MHz.

There is no need to connect the RC transmitter directly to the frequency meter for these readings. Just bring the transmitter's antenna close to an antenna that's connected to the meter, as shown in the title page photo. The antenna was made from an old ethernet cable. Just cut the cable so that you have a length of about 200mm or so from the BNC socket, then strip off the other sheath insulation and the woven shield, leaving just the inner insulated wire. This can then be covered with a length of heatshrink sleeving to provide extra stiffening and protection.



The battery holders are attached to the bottom of the case using epoxy adhesive.

provide access to the DC socket if you are powering the unit from a plugpack. This hole should be positioned mid-way along one side and about 10mm down from the top edge of the case.

If the unit is to be battery-powered, you will need to solder the battery leads to the supply PC stakes on the underside of the board. The batteries can be secured to the bottom of the case by mounting them in suitable holders. Our model used a 4 × AA holder and a single AA holder – see Fig.8 and photo below. Use an extra AA holder if you are using rechargeables.

The BNC input socket is mounted in a slot in the top side of the case (see photo below) and is wired using 75Ω coax cable to the two signal input PC stakes on the underside of the PC board. The screen (braid), of course, goes to the GND stake. In practice, the slot must be made so that the socket can be slid in or out, along with the PC board and display assembly.

The slot was made just wide enough to allow the 'flat' side of the BNC socket to fit. This prevents the socket from turning in the slot when an input connector is attached.

Finally, switch S3 is wired to its terminals using hookup wire as shown.

Calibration

The completed 50MHz Frequency Meter Mk.2 can be calibrated against the 15.625kHz line oscillator frequency in a colour TV set. Fortunately, you don't need to remove the back of the set to do this. Just connect a long insulated wire lead to the input socket and dangle it near the back of the TV set.

It's then just a matter of adjusting trimmer VC1 so that the meter reads 15.625kHz when the resolution is set to 'High'.

Note: the TV must be showing a PAL program, not NTSC (15.750kHz).

If there is insufficient adjustment on VC1 to allow calibration, the 33pF capacitor at pin 15 of IC3 can be altered. Use a smaller value if the frequency reading is too high and a larger value if the frequency reading is too low.

Usually, the next value up or down from 33pF will be sufficient; use either 27pF or 39pF.

If you require greater accuracy, the unit can be calibrated against the standard 4.43MHz colour burst frequency that's transmitted with TV signals. The best place to access

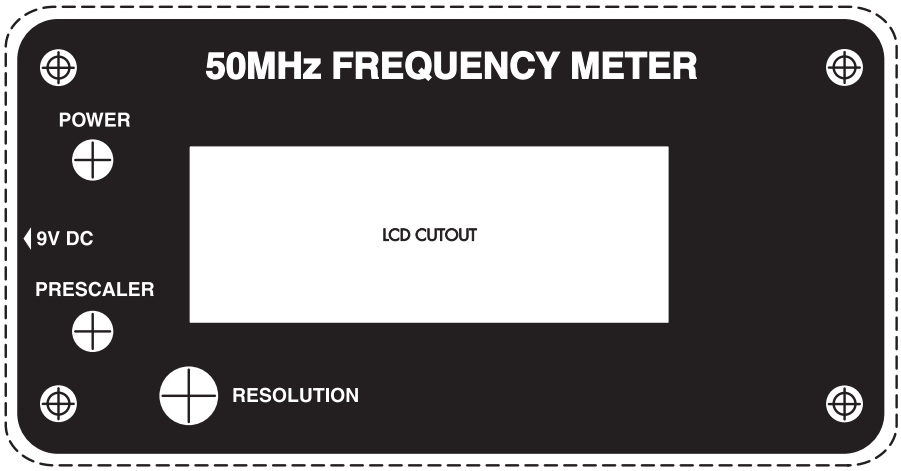


Fig.9: this front-panel artwork suits both Versions 2 and 3.

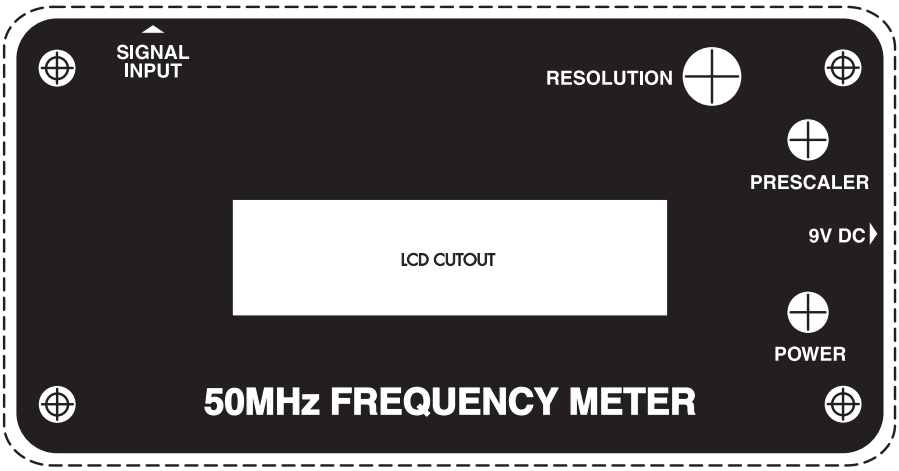


Fig.10: use this artwork to upgrade an existing Mk.1 Version 1.

this frequency is right at the colour burst crystal inside a colour TV set. This crystal will usually operate at 8.8672375MHz (ie, twice the colour burst frequency), although some sets use a 4.43361875MHz crystal.

Be warned: the inside of a colour TV set is dangerous, so don't attempt to do this unless you are an experienced technician. There are lots of high voltages floating around inside a colour TV set and you could easily electrocute yourself if you don't know what you are doing.

In particular, note that much of the circuitry in a switchmode power supply circuit (as used in virtually all late-model TV sets) operates at mains potential (ie, many of the parts operate at 230V AC). In addition, the line output stages in some TV sets also operate at mains potential – and that's in addition to the lethal EHT voltages that are always present in such stages.

Note too, that some TV sets (particularly older European models) even have a 'live' chassis, in which all the circuitry (including the chassis itself) operates at mains potential (ie, 230V AC). Usually, there will be a label on the back of the set advising of this, but never take it for granted. Don't even think of messing about with this type of set.

In short, don't attempt the following calibration procedure unless you are very experienced and know exactly what you are doing.

Assuming that you know what you are doing (and the set has a grounded chassis), you will need to make up an insulated probe with a 10MΩ resistor in series with the input, plus a ground lead. This probe can then connect to one side of the colour burst crystal and VC1 is adjusted so that the meter reads either 8.867237MHz or 4.433618MHz (resolution set to High mode).

Make sure that the probe has no effect on the colour on the TV screen when it is connected to the colour burst crystal. If it does, it means that the probe is loading the crystal and altering its frequency. In that case, try connecting the probe to the other terminal of the crystal.

That's it – your new 50MHz Frequency Meter Mk.2 is now calibrated and ready for action. ***EPE***

Footnote: a complete kit of parts for the 50MHz Frequency Meter MK.2 is available from Jaycar Electronics (Cat. KC-5440).

Potpourri

TechnoTalk

Mark Nelson

Potpourri is a mixture of dried, naturally fragrant plant material, generally employed to provide a gentle natural scent in houses. This article has nothing to do with dead plants, but it does deal with nice smells. All is explained by Mark Nelson.

To me, potpourri has always seemed a strange expression. Its literal meaning is a perished or putrid pot, which does not sound very nice. But maybe I'm taking this all too literally. Potpourri's less literal meaning is a hotchpotch or jumbled mixture, which describes this article exceedingly well.

It also describes my desk, my workshop and my whole life. But enough of this personal self-indulgence – let's concentrate on what this article can do for you, sifting and selecting some interesting aspects of applied electronics, with a frequent emphasis on the more unusual and even bizarre applications.

Uncommon scents

Talking of smells, do you enjoy the fragrance of resin-cored solder? Or if you are American, rosin-cored soder. I like sniffing solder fumes, even though they are alleged to be carcinogenic in large quantities. Occasionally, I disassemble pre-war electronic 'junk' to re-use the components and then the pleasure begins. Desoldering a joint with a large gobby lump of resin in this process can sometimes release a sudden whiff of pre-war solder, with an exquisitely perfumed scent. Suddenly you are transported back seventy years – but only for an evanescent instant. Then it's gone, lost forever.

By the way, if you have used Soder-Wick desoldering braid you may have wondered why there is no L in the trade-name. It appears that many Americans pronounce the word 'soder' or 'sodder'. Effectively they 'swallow' the L, just as cultured people do with golf ('goaf'), salt ('sawt') and the name Ralph ('Rafe') in British Received Pronunciation. Some Londoners say 'miwk' for milk but that's another matter.

Power for nothing...

'..And your volts for free', as Dire Straits might have sung (but probably would not, even if they had invented a remarkable new energy source). Regular readers will know this column's obsession with alternative energy systems, but this latest one beats all others for sheer ingenuity.

Conceptually, it reeks of a 'perpetual motion machine', but I won't spoil your fun. Instead, you can deconstruct and disparage the principles on which it operates. On the other hand, it might be entirely legitimate and then you can pride yourself on being one of the first to be 'in the know'.

The inventor of this advanced thermionic technique is Australian geophysicist and electrical engineer Philip Hardcastle, who revels in a passion for physics and invention.

Converting heat to electricity could be a pollution-free way of solving the energy crisis, if only a cheap and efficient means could be discovered. As Philip says, thermionics experts know that a generator could produce electricity from room temperature if there was a way of achieving a work function of 0.3 electron-volts or less.

A device of this kind, he declares, is the holy grail of physics. It could change the world in amazing ways and even better, by logic and imagination he claims to have stumbled on a way of doing this, able even to extract electricity from the heat in ambient air.

He challenges physicists to demonstrate his concept is wrong and currently he is petitioning Microsoft's Bill Gates to take an interest in his concept, for which he does not want any financial reward. So how does it work? The best way is to look at the website **www.thermionicrevolution.com,** but in a nutshell his Rotating Thermionic Generator induces electrons to depart from the metal surface of a Faraday disc machine to create a flow of current.

Electrons are flung from the outer rim of a doughnut-shaped spinning disc of metal and then sucked back into the hollow central core. As one commentator states, if the electrons can be removed by centrifugal force with less energy than needed to supply that force, then he's on to something. You can read a more detailed critique of his notion at **www.alternatefuelsworld.com/8-10-news.htm**

What worries me slightly is that Philip Hardcastle claims to have invented the pause function on the VCR, which I feel sure will be news to JVC, Sony and many other manufacturers. Not to Philips, though, whose early machines had no pause function.

Battery bonus

Have you been to Battery University? Until recently nor had I. But I do recommend a short visit, or maybe even a longer one. Battery University is an authoritative, interesting and reader-friendly on-line resource about batteries. It provides practical battery knowledge for engineers, educators, students and battery users alike.

Don't let the academic lingo put you off. Although the website talks about 'papers' and handbooks, in truth the information is no different from a giant FAQ file written in everyday language (and without sales talk, even though the 'university' is sponsored by a battery company). Everything is in bite-sized chunks, extremely well indexed, and you can drill down rapidly to the part you need without having to trudge through acres of verbiage first (although I challenge you not to get side-tracked in the other interesting articles!).

So what's in the university? The papers address battery chemistries, best battery choices and ways to make your battery last longer. There's also a short section on history – did you know that NiCads go back over a century?

Apparently, the Swedish scientist Waldmar Jungner invented the nickel-cadmium battery in 1899. All commonly found battery technologies are covered; you won't find sodium-sulphur technology, but you can't buy these anyway. You do get an interesting discussion on the battery technologies of the future, however. On the other hand, I was expecting to read about nickel-iron batteries (NiFe cells), which still have an edge on robustness and longevity (**www.mpoweruk.com/nickel_iron.htm**)

All in all, a very creditable website that demonstrates what the Internet was designed for – top class. The URL is **www.batteryuniversity.com/**

Retrovision or hindsight

Do you have a sneaking nostalgia for the golden age of television, when sets took two minutes to come on and gave out that unique aroma of burning dust as the valves warmed up?

These were the days when the dog left the room because it couldn't endure the 10,125 cycles line frequency whistle and pictures were in restful black and white. 'A choice of viewing' was between just two channels, BBC and ITV and … (sorry, I got carried away).

If this strikes a chord or arouses your curiosity, you may care to look at the new website of the British Heritage Television Group. This enterprising volunteer organisation wants to create a 'television centre' at the historic Alexandra Palace transmitter site in London to become a major resource, attracting visitors from far and wide.

Their aim is to create interactive exhibits, examples of television technology down the ages, vintage-style programme-making, and perhaps even low-power 405-line transmissions on the original Channel 1. For this last purpose, their technician Sean Williams (M1ECY) is currently restoring a genuine 1950s BBC television transmitter back to a operating condition.

If this has aroused a pang of nostalgia or simply plain curiosity, take a look at the BHTG's website, **www.405-line.tv/**, and also the forum at **www.405-line.tv/phpBB3/**. There's further information and FAQs at the 405 Alive website **www.bvws.org.uk/405alive/** and some superbly restored tellies at **www.radiocraft.co.uk/vintage_television/index.shtml**.

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2445 4 Ch. 150MHZ Delay Sweep. Cursors etc £195
2445A 4 Ch. 150MHZ Delay Sweep. Cursors etc £225
2445B 4 Ch. 150MHZ Delay Sweep. Cursors £250
2445B With DMM 4 Ch, 150MHZ Delay Sweep .Cursors £250
2465 4 Ch. 300MHZ Delay Sweep. Cursors etc £300

2465A 4 Ch. 350MHZ Delay Sweep. Cursors etc £400
2465B 4 Ch. 400MHZ Delay Sweep. Cursors etc £500
2465B Rack Mount 4 Ch. 400MHZ Delay Sweep. Cursors etc £400
2467 4 Ch. 350MHZ Delay Sweep. Cursors etc £400
TAS 465 Dual Trace 100MHZ Delay. Cursors £195
TAS 485 4 Ch. 200MHZ Delay. Cursors £275

HP

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54600A Dual Trace 100MHZ 20 MS/S £195
54600B Dual Trace 100MHZ 20 MS/S. £225

PHILLIPS

PM3052 Rack Mount Dual Trace 60MHZ £75
PM3055 2+1 Ch. 60MHZ dual TB/Delay. Autoset £95
PM3065 2+1 Ch. 100MHZ dual TB/Delay. Autoset . . . £125
PM3084 4 Ch. 100MHZ Delay TB £140
PM3335 Digital Storage Dual Trace 60MHZ 20 MS/S £125
PM3337Rack Mount Digital Storage Dual Trace 60MHZ 20 MS/S £125
PM3365A Digital Storage Dual Trace 100MHZ 100 MS/S £150

HITACHI

V222 Dual Trace 20MHZ DC Offset, Alt. Mag £50
V522 Dual Trace 50MHZ DC Offset, Alt Mag £65
V665 Dual Trace 60MHZ Delay Sweep. Cursors etc . . £75
V1065 Dual Trace 100MHZ Delay Sweep. Cursors etc £85
V1065A Dual Trace 100MHZ Delay Sweep. Cursors etc £95
V1150 4 Ch. 150MHZ Delay Sweep. Cursors. DVM etc £125

HAMAG

203.4 Dual Trace 20MHZ Component Tester £75
203.6 Dual Trace 20MHZ Component Tester £85
305 Dual Trace 03MHZ Analogue/Digital 40 MS/S per Channel Component Tester £140
604.2 Dual Trace 60MHZ Component Tester £125

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Using the Microchip PICkit 2 Debug Express to build a 'Theremin'

By Colin Greaves

Just three extra components give the 'feel' of a Theremin

THE very compact PICkit 2 debugger from Microchip might remind you of a key-fob, but inside it has everything you need to help you develop a project on a microcontroller from scratch.

The PICkit 2 Debug Express kit was reviewed in the June '07 issue of *EPE*, showing the development environment (MPLAB®), the features of the debugger and the small development target board that comes with the kit.

The author decided to look at some of these functions, by creating a simple project using not much more than what comes with the kit. By adding just three simple components, which most engineers will have on their desk anyway, a simple sound controller could be created, giving a sort of 'feel' of a Theremin – something featured in magazines from time to time as a complex project. This simple approach lets the micro do all the work!

Small steps

A good way to develop a project is to break it down into small steps. Most engineers will often start with flashing an LED to prove that the kit is working, the code is compiling, and the microcontroller is doing its job. Once you have this in place, you have a stable place to start from. The demo board comes with a handy set of LEDs already built in, and connected to PORT D of the microcontroller. This is where we start.

The development environment provided by Microchip is MPLAB. This is the user interface for all the features, for all of their micros. It is supplied with the kit on a CD, for ease of access, but it is always a good idea to check their website for the latest copy.

Running the Project Wizard within MPLAB is a quick way to set up a new project. The processor on the demo board is a PIC16F887, so this was selected from the wizard. Next the toolsuite was selected – MPASM™ in this case, as the project will be written in assembly language. If you have installed a C compiler, this could also have been an option.

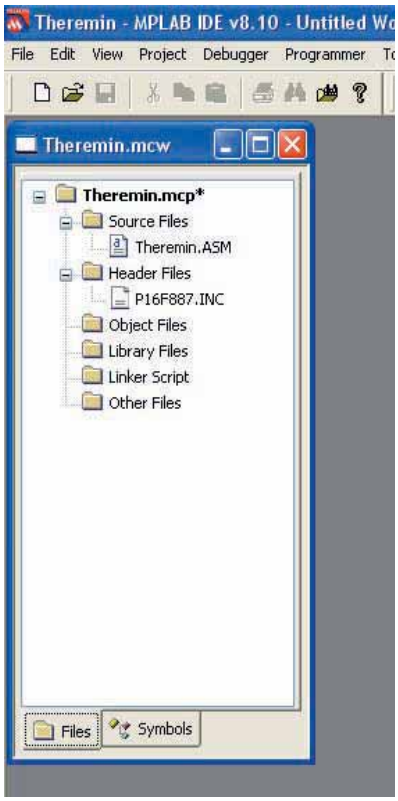
The project folder was selected next. One was created in the root directory, called Theremin, and the project file name of Theremin was also given. This will create the project file (Theremin.MCP) and the workspace file, which is where your personal arrangement of the windows in MPLAB is saved.

There are no existing project files at the moment, so the 'add files' part was skipped, and the Wizard was finished. These project files must be created by the user, but not necessarily from scratch. We need a source file (*.ASM) and an include file, to define all of the useful register and bit names for us, which the datasheet refers to.

The ASM file can be created by looking on your hard drive for C:\Program Files\Microchip\MPASM Suite\Template\Code. This folder has a basic template for every processor, and by copying the 16F887TEMP.ASM file into our newly created C:\Theremin folder, we can save a lot of typing. After copying it, rename it to Theremin.ASM to make it more recognisable.

Project

View Project in MPLAB will open the project overview window, and the Theremin.MCP project will be displayed. Right-click on source files, and select add files. Browsing to the project folder, we can select the Theremin.ASM as our source code, and then add a suitable include file for the 16F887. Right click on the header Files, **add files**, the browse to C:\Program Files\Microchip\MPASM Suite, and select the P16F887.INC file. Our project is complete, we can try a build!



Project overview window in MPLAB

Project Build All will attempt to assemble the template file, and should result in an output window being opened, with the message 'Build Succeeded' at the bottom. If it failed, it may be that the wrong files were used – check that the 887 files were selected, not the 877 – a common error.

Opening the source file, Theremin.ASM, we can see what was actually assembled. The first point of interest is the CONFIG settings. These are initialised for you in the template, but always check that they are in the state required. Important ones are the type of oscillator, the MCLR control (reset pin) and the watchdog setting.

We need the oscillator to be internal, the MLCR to be enabled and the watchdog to be disabled. These states are all set by default, so we need not change these settings.

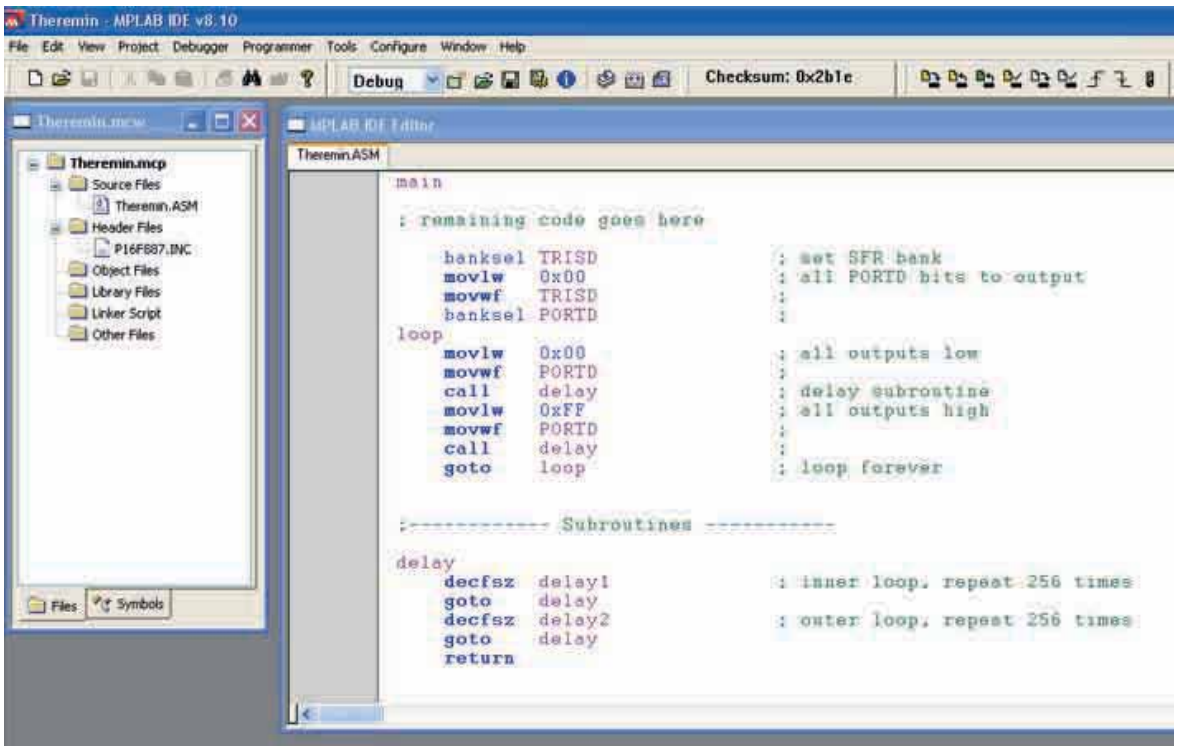
Next, our variable definitions – we are going to create more variables later, so take note of this block. The reset vector and interrupt routine are set up for you. The reset is set to jump to a label called 'main' so we can use this. The interrupts will not be used, so we can ignore this code. This is pretty much the whole template – a simple, basic framework to start adding your own code.

First step

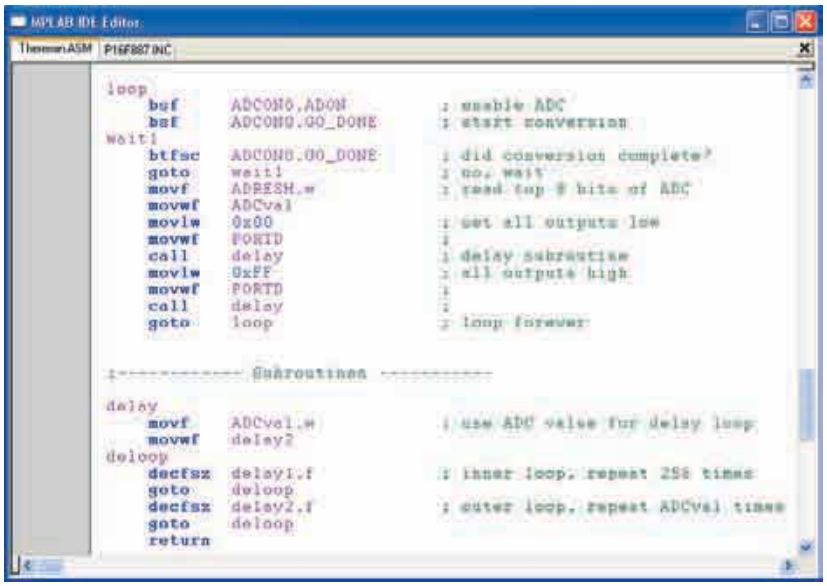
The first step is to set up the input/output ports. PORTD is connected to the LEDs, so this is our output port. The register controlling whether the port is an input our output is called TRISD. By writing a 0 into all of its 8 bits, we can set all of the port bits to be output.

Note: the control registers of the micro are arranged in banks, so it is important to select the correct bank of registers when reading or writing from a register. This has been made simple with the use of the 'banksel' command. Before writing to TRISD for example, precede the command with a 'banksel TRISD' to ensure that this is set up correctly.

A simple loop is created next, writing 0 and 1 into the output bits in turn. To enable us to see the LEDs changing, we need to slow the whole process down, so we add a delay function into the loop, positioned after each change. The delay function is a subroutine, created outside the main program flow, called 'delay'.



Code 1 – adding user code to the template to drive the LEDs



Code 2 – ADC setup and usage

This code can be accessed by the micro when a 'call' command is issued, and will simply count down a number from 255 to 0 before returning to the place where the 'call' was issued.

As this delay is still a short time period (the PIC is running at 8MHz internally!) a second loop can be used, making the whole delay process 255×255 instructions; much better.

Rebuild the project, and see how it looks. This can be done as a check to see where we are up to, and what bits of the code might not be correct. Sure enough, we see a couple of errors – the variables used in the delay subroutine have not been recognised – we didn't set them up. These variables are used to hold the numbers that the delay function uses to count down and must be defined in the Variable definition block we saw at the top of the source code. Add these in now – and select a memory location for them.

A quick look at the data sheet (around page 25) shows the table of special function registers, and at the bottom of the first bank, registers 20h onwards are free. This is a good place to put our variables. (The datasheet can be found on a CD in the kit, along with a whole set of other useful application notes, tips and tricks, and so on.)

Of course, it is always a good idea to get the most recent copy from Microchip's website. On this point, it is also a very good idea to check for an errata sheet for the microcontroller you are going to develop with – sometimes changes are made to the functions, as devices or manufacturing processes are developed, and this is a way to help you keep track of whatever changes there may be. Always check errata!

Rebuild

Now we have the variables defined, we can try to build again. Tweaking and building is a bit of a lazy way to get code written, but, it does seem to get you to a working project fast. Sure enough, our project now builds, with a welcome success message. We have a working application and can try to program the target board with it.

Connect the PICkit 2 debugger to the target demo board, and to the PC by a USB cable. The USB port will power the target demo board quite easily. When peripherals are connected to your PC for the first time, Windows will almost certainly ask you to provide a driver, so that it knows what to do with it.

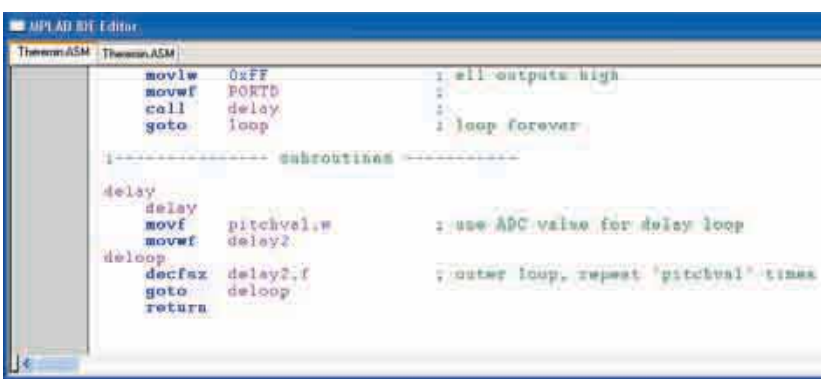
Microchip supply the drivers for their development kits, so don't use Windows standard drivers. These are located in the Microchip\MPLAB IDE folder, and each dev kit item has its own driver folder. However, the PICkit 2 is a standard HID device, so it will just plug-in and work.

Once connected, the PICkit 2 can be selected as the programming tool. Go to Programmer, select programmer, PICkit 2. The output window will report progress, as the PICkit 2 is connected, initialised and any OS upgrades made. Selecting Programmer, Program will download your code into the target demo board.

Again, the output window is used to monitor this progress. Any failure at this point would almost certainly be due to a bad connection – check alignment of the PICkit 2 pins connecting to the target board.

Now select Programmer, release from reset, and you should immediately see the LEDs flashing away at about two to three cycles per second. The development environment is working.

Incidentally, all of the menu selections we have been making



Code 3 – finishing the code changes using a controlled delay loop

are accessible from icons within MPLAB, it might be worth checking the function of these to speed up selection.

Debugger

It would be useful at this point to have a look at how the debugger can give us some feedback on what the program is doing. Reset the PIC microcontroller by clicking the negative clock edge icon, (or selecting Programmer, Hold in Reset) and stop the flashing LEDs. The PICkit 2 can be set into debug mode by selecting Debugger, Select Tool, PICkit 2.

You may see a warning that the tool cannot provide debug and programming modes simultaneously. Debug mode uses a small bit of code to communicate the status of the registers and I/O back to MPLAB. This must be programmed into the PIC microcontroller by re-programming your code into it while in debug mode. Once programmed, we have a new set of icons for the PICkit 2 to play with, including Run, Step and Reset. Use the RUN icon to make sure the code is still performing, then hit the HALT icon to stop the PIC microcontroller.

As the program spends 99 per cent of its time running the delay subroutine, it will almost certainly stop with the green arrow in the source code window pointing to an instruction in this subroutine. This is the next instruction to be executed, and hitting the Step Into icon will step the PIC microcontroller on by one instruction.

Hover your mouse pointer over the delay1 and delay2 variable names, and it will display their current values. It will take a lot of stepping to get back to our main program code, and running and stopping will almost always end up where we are now, so a neat way to stop the execution at the main bit of code is to use a breakpoint.

Double click on the line below the 'loop' label – the movlw 0x00 instruction. A red circled B will appear next to the line to show that a breakpoint has been set. Click the RUN icon again, and the PIC microcontroller will execute until that breakpoint is reached. A mouseover of the PORTD register name in the program listing will show a value of 0xFF (all 1s) and the LEDs will be all on. Now, clicking the single step will turn off the LEDs as the next instruction is executed, and the PORTD value will reflect 0x00.

Special function registers

While we are enjoying this control of our hardware, let's go one step further – have a look at the Special Function Registers inside the PIC microcontroller by selecting View, Special Function Registers. These are all of the control registers and their status, displayed for our reference. Select the register PORTD register, which probably still displays our 0×00 value (or 00000000 in the binary column) and double click it.

Try changing one of the binary bits from a 0 to a 1, you should be able to edit it directly. Now check the board – the LED lit! This access to the program, I/O bits and everything else is just what a developer needs to understand what's going on, and debug the project.

'Theremin'

To create our 'Theremin', we will need some sort of analogue interface. An easy solution would be a potentiometer connected to one of the PIC16F887 analogue input pins, but in keeping with the feel of a Theremin, a better solution would be an optical sensor, used to detect the proximity of the user's hands. A simple light dependent resistor (LDR) set up as a potential divider would do nicely.

Such a device was found (literally) on the author's desk, and the values checked for room light levels. With a hand almost covering the LDR, its value was about 200kΩ to 300kΩ, and exposed to room light, a value of about 2kΩ was seen. In order to give a good voltage swing at the A/D input, a value of about 20kΩ was chosen as the fixed resistor for the potential divider. This would be 10× smaller than the largest, and 10× bigger than the lowest LDR reading.

Circuit

The circuit for this is very simple (see Fig.1) and a position on the board was found to make assembly easy. The RE0 pad was close enough

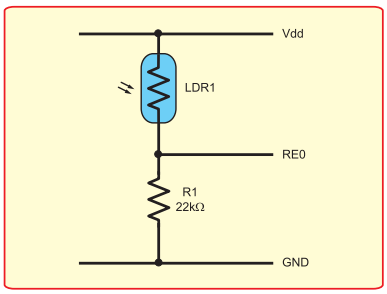
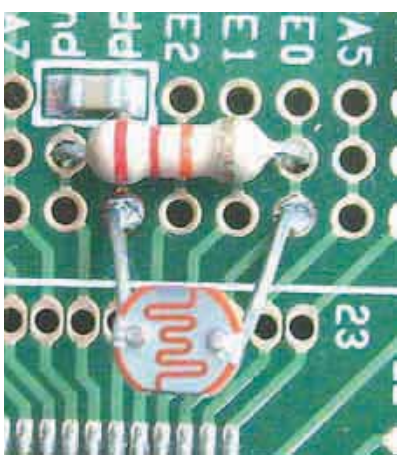


Fig.1. Light/hand sensor using just two components

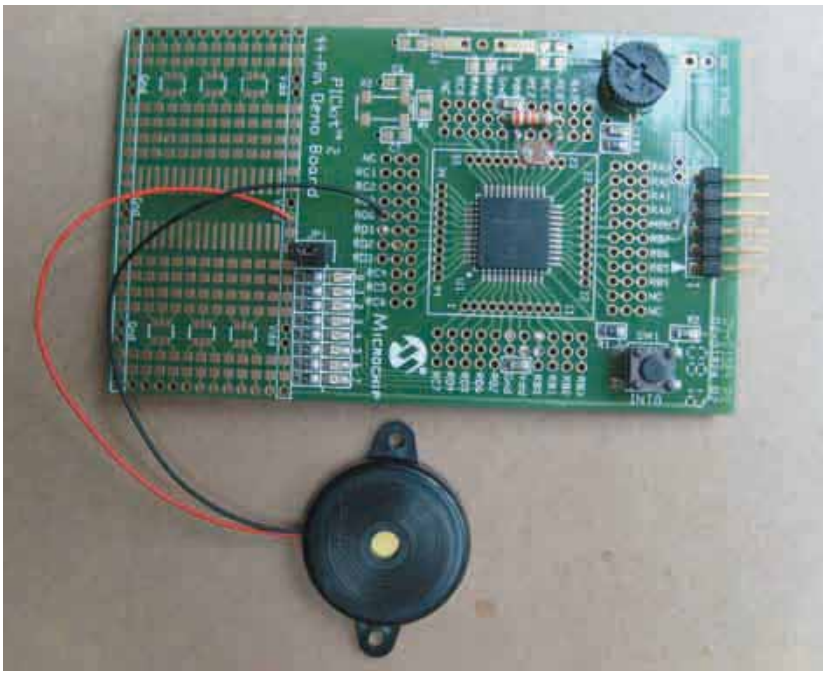
to mount the components to V_{dd} and Gnd without any use of jumper links (see the photo below). RE0 was also selected as one of its functions was an analogue input, AN5. The A/D converter (ADC) on this device has fourteen channels, selectable via a multiplexer. We will be using channel 5.

Section 9 of the PIC16F887 datasheet covers all the details relating to the ADC. The options include what speed it is clocked at, how the results are formatted, what reference is used to make a measurement, and so on. The usage of the ADC functions is common across many of the PIC microcontroller devices, so time spent reading here is a good investment.

As a quick summary, it was decided that we only really need an 8-bit value, so the output was formatted to be left justified (high bits all in one register, so the low bits can be ignored), clock speed set to $F_{osc}/2$ (4MHz) and use V_{dd} as a reference



Convenient mounting locations for the LDR and resistor R1



The PICkit 2 demo board. The only additions are the LDR, resistor R1 and a piezo sounder

– we do not need anything particularly accurate or stable. This will give us an 8-bit value as the analogue level on AN5 varies between V_{dd} (+5V) and Gnd.

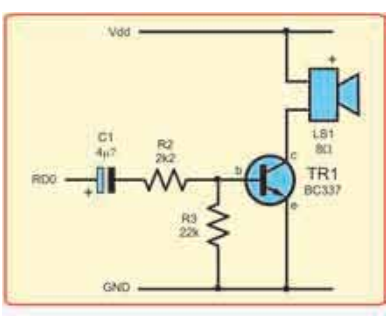
The code for setting up the ADC (see code 2) is based around three control registers, ADCON0, ADCON1 and ADSEL. Ensure that banksel commands are used where necessary. This was followed by a quick 'build all' to check syntax.

ADC conversion

The ADC is now set up to run, and we can change our LED flashing loop to use the ADC input. An ADC conversion is started by writing to ADCON0. First it is enabled, and then the conversion is started. These two control bits (enable, then start the ADC) are in the same register, but they must be given in two separate instructions; first the enable, then the start. Writing a 1 to the GO_DONE bit starts the conversion.

The ADC will make the measurement, then present the result in the ADRESH and ADRESL registers (it is a 10-bit convertor.) Once it is complete, the GO_DONE bit will go to a 0, and the result can be read. We only need to read ADRESH because we are just interested in the upper eight bits of the result. Read this value and save it in a register with a meaningful name, pitchval. This is the value we are going to use to control the pitch of our 'Theremin'.

The last part of the main loop, we can leave – the outputs are going to toggle, with a delay value determined by our ADC result. A quick 'build all' reveals an error – go back and define our new variable, pitchval at the top of the code. Following on from the two delay variable definitions, 0×22 is a good choice.



Improved sound output circuit

Finally, to make the output switching rate vary with the pitchval value, we must add it to the delay loop. The delay routine is changed to be just one loop, not a loop within a loop. We need the output to switch at audio frequencies, not just a few hertz to make the switching visible. The delay subroutine becomes simple then; just a couple of instructions to load the pitchval value into the delay2 variable, then a simple loop, counting down this value to zero. A quick 'build all' reveals no problems, and… the code is finished!

Programming the device takes a second, and the project is running. A simple piezo sounder was connected to one of the PORTD outputs (RD0 was used) and a tone was heard, varying as a hand was moved nearer to the LDR. The delay loop was tweaked by placing NOP (No Operation) instructions after the deloop label. This allows the tone to be tweaked to make it more in line with the author's hearing range!

Loudspeaker driver

Before sharing this musical masterpiece with friends, it might be an idea to add a loudspeaker driver to the output. The piezo sound quality is pretty dire.

A simple driver was constructed around a BC337 transistor (Fig.2) and a couple of resistors. (Run this driver from a separate supply, because the USB port will not be able to supply so much current.) A capacitor was added to prevent burnout, just in case the PIC microcontroller was stopped with all the outputs high. A cheap 8Ω loudspeaker gives pleasing results.

Don't forget to program the PIC microcontroller to run in standalone mode (with no PICkit 2 connected) you should program it in programmer mode, not in debug mode. Once the program is debugged and working, debug mode is no longer needed.

The author is now a fully competent Theremin musician, the *Dr Who* theme tune being a specialty…

Special offer

To start designing your 'Theremin', or another exciting project, see the extra special offer from Microchip and *EPE* on the next page! ***EPE***

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20W Class-A Amplifier Pt.2

This fully assembled chassis shows what the Stereo Class-A Amplifier will look like. The preamplifier/remote volume control module and the loudspeaker protection module will be described in following issues.

This month, in Part 2, we present the construction details for matching left and right channel mirror-image modules, together with the circuit and construction details of the power supply.

Part 2: By Leo Simpson

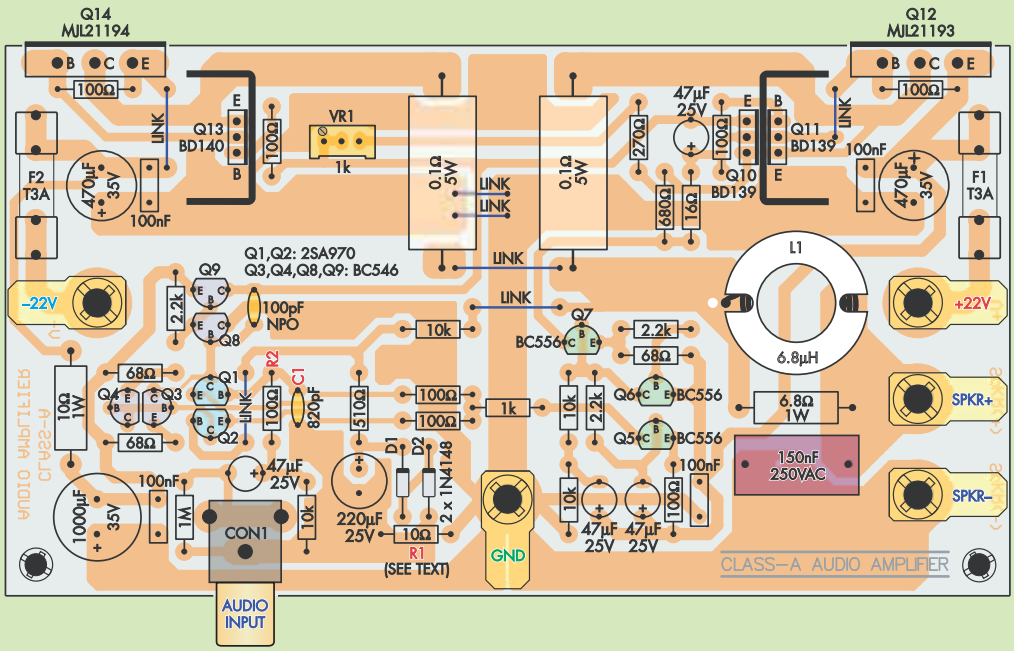


Fig.6: follow this parts layout diagram to build the left-channel power amplifier module. Be sure to use the correct part at each location and make sure that all polarised parts (transistors, diodes and electrolytic capacitors) are correctly installed.

THE PC boards are longer than the early original prototypes. This is mainly to spread the two power output transistors further apart on the large single-ended heatsinks. This has the effect of spreading the 'hot spot' and allows us to use the heatsinks more efficiently.

We have also designed mirror image PC boards, for the left and right channels. This has been done to achieve a better wiring layout within the amplifier chassis and also to optimise the residual noise performance in both channels.

Both PC boards measure 146 × 80mm and are coded 687 (left) and 688 (right). (These boards, including the power supply PCB, are available from the *EPE PCB Service*.) To ensure reliable connections to the PC boards, we have specified chassis-mount 'quick-connect' single-ended male spade terminals, which have a mounting hole for an M4 screw.

These connectors are normally used for high current connections, but we are using them here because we want to ensure very low resistance connections. They have the advantage over normal soldered connections to a PC board being able to be repeatedly connected and disconnected without problems, when an amplifier is being assembled and checked.

By the way, we do not recommend staked quick-connect spade lugs for this application, as they are not as reliable, particularly after they have been reconnected a few times.

With the same thought in mind about reliable terminations, the audio signal connection to each module is made via an on-board RCA phono socket. This is much better than using soldered connections for shielded cable, as they are bound to look messy after being disconnected and reconnected just once.

One module or two?

Before we start on the assembly details, there are a few other points to note. The first pertains to whether or not you are building a single PC board module to be used as a mono amplifier (unlikely, but we have to consider it). If so, note that R1 is a 0Ω link, as shown on the circuit diagram of Fig.5 in last month's issue.

Alternatively, if you are building left and right modules for a stereo amplifier, **R1 must be changed to a 10Ω resistor (in each channel).** This is done to reduce the possibility of circulating currents in the completed stereo amplifier, which could compromise the performance, particularly separation between channels.

Transistor quality

To ensure the published performance figures, the MJL21193 and MJL21194 power transistors must be On Semiconductor branded parts, while the 2SA970 low-noise devices must be from Toshiba. Be particularly wary of counterfeit parts, as reported in the past. We recommend that all other transistors used in this project be from reputable manufacturers, such as Philips, On Semiconductor and ST Microelectronics. This applies particularly to the BD139 and BD140 output drivers.

Construction

The component layouts for the mirror reverse boards are shown in Fig.6 (left) and Fig.7 (right).

Begin each board assembly by installing the wire links, the two 1N4148 diodes (D1 and D2), and the resistors and capacitors. The resistor colour codes are shown in Table 1, but we strongly advise

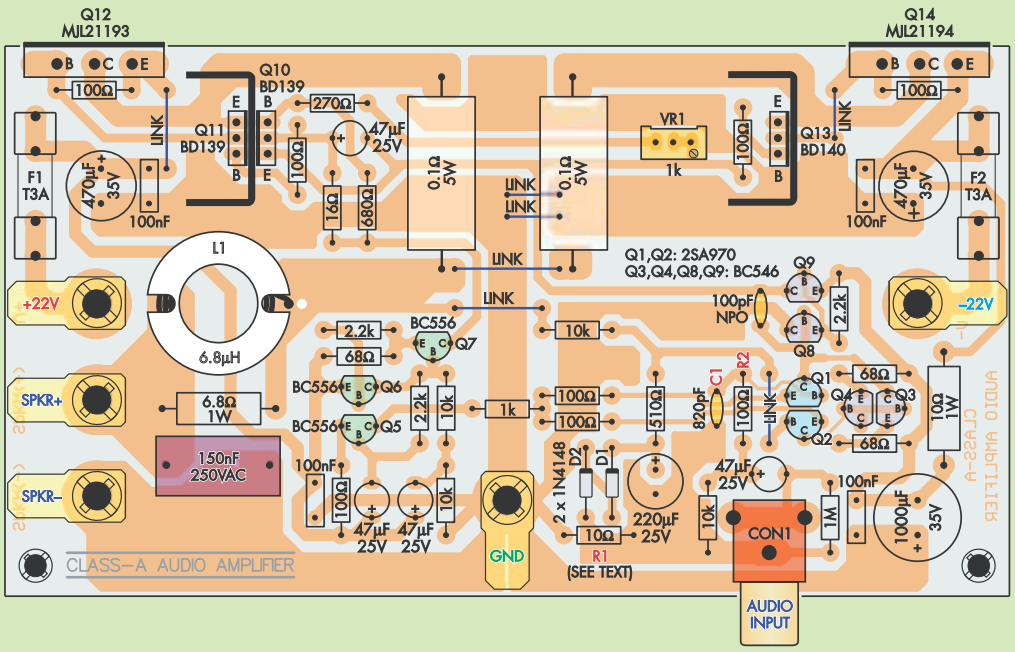


Fig.7: this is the layout for the matching right-channel power amplifier module. It's almost a mirror image of the left-channel board.

that you also check each value using a multimeter before it is installed.

Make sure that the diodes and electrolytic capacitors are installed with the correct polarity.

That done, you can then install the fuse clips. Note the each fuse clip has a little lug on one end which stops the fuse from moving lengthways. If you install the clips the wrong way around, those lugs will stop you from fitting the fuses.

Next, install the two 0.1Ω 5W resistors, followed by trimpot VR1. Trimmer VR1 must go in with its adjustment screw oriented as shown.

The small-signal (TO-92) transistors (2SA970s, BC546s and BC556s) can now be installed. As supplied, these transistors usually have their leads in a straight line, although the centre lead may sometimes be cranked out. They have to be splayed outwards and cranked to fit nicely into their allocated positions.

The way to do this is as follows. First, grip the three leads adjacent to the transistor body using a pair of needle-nose pliers and bend the centre lead back and up by about 70°. That done, grip each of the two outer leads in turn and bend it outwards and up by about 70°. Finally, grip each lead in turn at the end of the pliers and bend it downwards again – see photos.

Install each transistor on the PC board after dressing its leads. Note that transistor pairs Q1 and Q2, and Q3 and Q4 are installed with their flats facing each other.

Make sure that you don't install the TO-92 transistors in the wrong positions. Inadvertently swapping 2SA970s for BC556s will not have any dire consequences, except that the amplifier will not be as quiet as it would have been. But swapping BC546 *NPN* transistors for BC556 or 2SA970 *PNP*

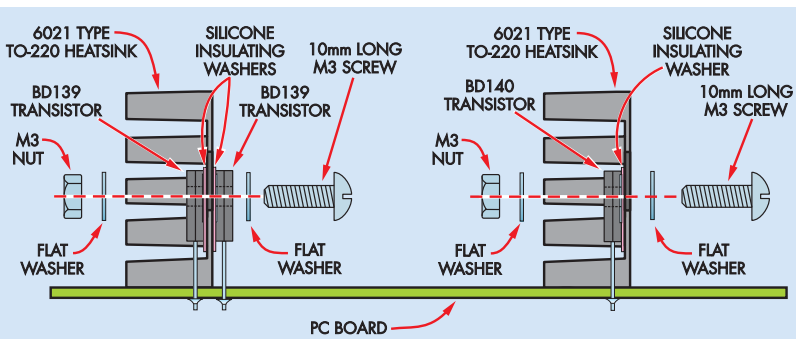
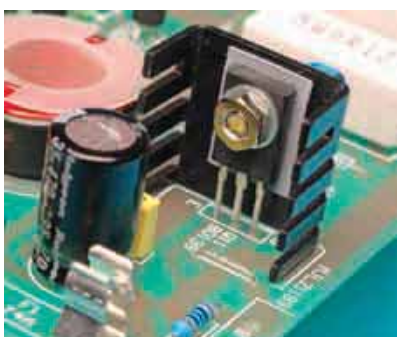
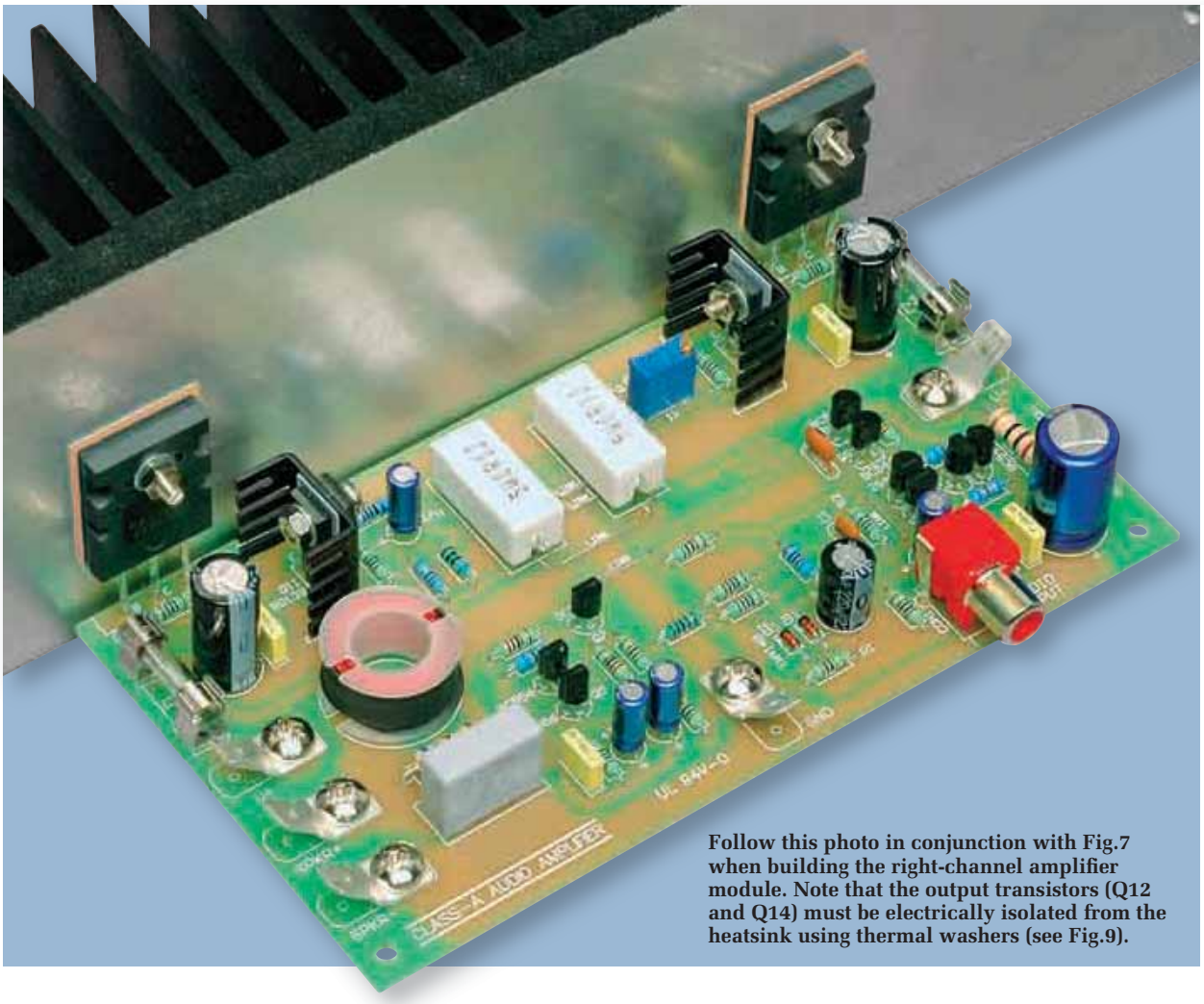


Fig.8: follow this diagram to attach the BD139 and BD140 transistors to their respective heatsinks. Note that each transistor is electrically isolated from its heatsink using a silicone insulating washer.



This close-up view shows one of the BD139 transistors (left-channel amplifier board). A second BD139 mounts on the other side of this heatsink.



Follow this photo in conjunction with Fig.7 when building the right-channel amplifier module. Note that the output transistors (Q12 and Q14) must be electrically isolated from the heatsink using thermal washers (see Fig.9).

transistors will cause serious damage when the amplifier is first powered up. ***You have been warned!***

The idea is to work carefully and patiently through the assembly process. Check each step against the diagrams and photos as you go. Care and patience now will be rewarded later when you turn the amplifier on.

The TO-126 transistors Q10, Q11 and Q13 are fitted to U-shaped finned heatsinks before they are soldered to the PC board. More specifically, Q10 and Q11, both BD139s, are mounted on opposite sides of the same heatsink (see Fig.8) while Q13, a BD140, is mounted on a separate finned heatsink. **Note that each transistor must have a silicone rubber pad to isolate it from the heatsink – see Fig.8 and the photos.**

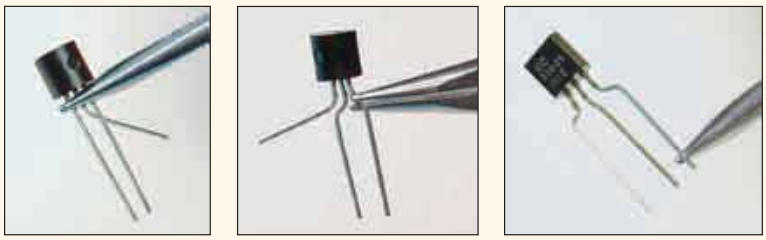
Note also that the 100pF ceramic capacitor at the collector of Q9 should be an NP0 type (ie, with zero temperature coefficient). NP0 capacitors have a black spot or strip across the top. If your 100pF capacitor does not have this black labelling, it is not NP0.

Other types may change their capacitance markedly with temperature, which is undesirable.

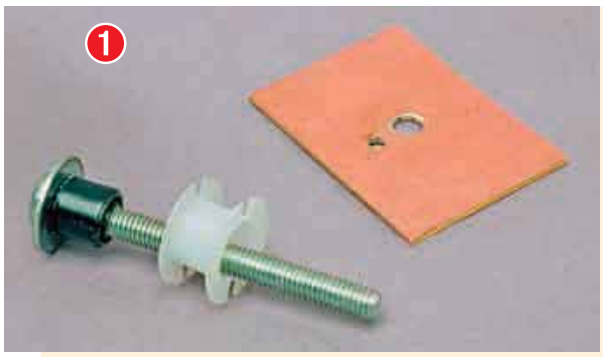
Winding jig

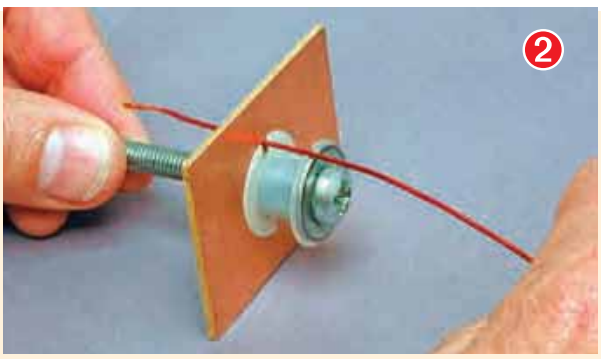
The next step is to wind the 6.8µH inductor L1. To do this, you need about 1.5m of 1mm enamelled copper wire, which is close-wound onto a plastic bobbin. This bobbin may have an internal diameter of either 11.8mm or 13.8mm, depending on the supplier.

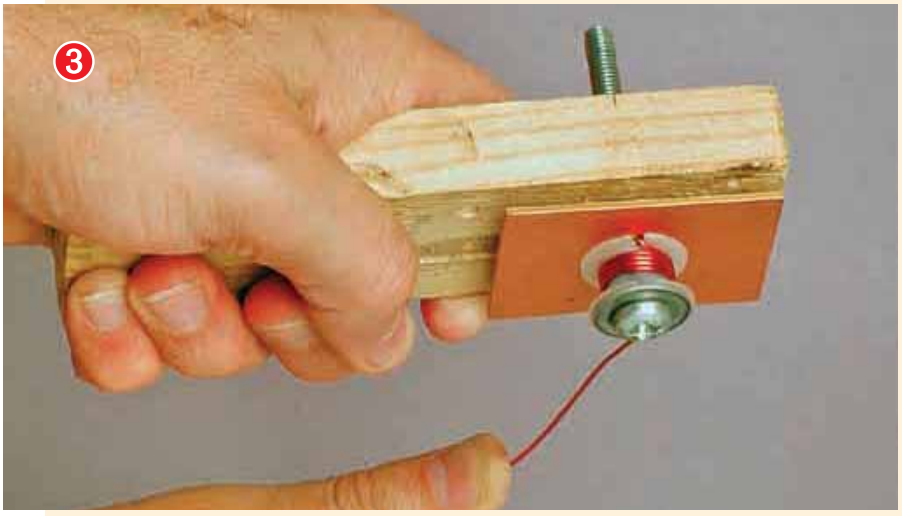
As shown in the photos, we made up a small winding jig for the bobbin, as this enables a really neat job. It consists of an M5 × 70mm bolt, two M5 nuts,

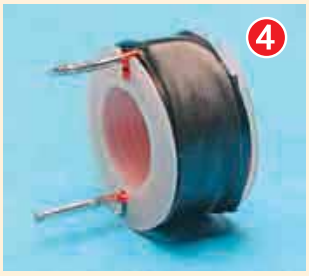


The leads of the TO-92 transistors are cranked to fit the PC board using a pair of needle-nose pliers. These photos show how it's done.









Above: these photos show how to make a simple jig from scrap material to wind the 6.8µH inductors (see text). First, the bobbin is slipped over the collar on the bolt (1), then the end cheek is attached and the wire threaded through the exit slot (2). The handle is then attached and the coil wound using 25.5 turns of 1mm enamelled copper wire (3). The finished coil (4) is secured using a couple of layers of insulation tape and a band of heatshrink tubing.

an M5 flat washer, a piece of scrap PC board material (40 x 50mm approx.) and a scrap piece of timber (140 x 45 x 20mm approx.) for the handle.

In use, the flat washer goes against the head of the bolt, after which a collar is fitted over the bolt to take the bobbin. This collar should be slightly less than the width of the bobbin and can be wound on using insulation tape.

Wind on sufficient tape so that the bobbin fits snugly without being tight.

Next, drill a 5mm hole through the centre of the scrap PC board material, followed by a 1.5mm exit hole about 8mm away that will align with one of the slots in the bobbin. That done, the bobbin can be slipped over the collar and sandwiched into position between the washer and the PC board (which acts as an end cheek).

Align the bobbin so that one of its slots lines up with the exit hole in the end cheek, then install the first nut and secure it tightly. The handle can then be fitted by drilling a 5mm hole through one end, then slipping it over the bolt and installing the second nut.

Winding the choke

Begin by feeding about 40mm of the wire through one of the bobbin slots and the exit hole in the jig (loosen the handle if necessary to do this). Bend this end back through 180° to secure it, then tighten the handle and wind on 25.5 turns as evenly and tightly as possible. Finish by bending the remaining wire length through 90° so that it aligns with the opposite slot.

Here's another view of the fully-assembled right-channel power amplifier module, attached to its heatsink. After mounting the output transistors, it's a good idea to use a multimeter (set to a high ohms range) to confirm that they are correctly isolated from the heatsink. You should get an open-circuit reading between the heatsink and each of the transistor leads.

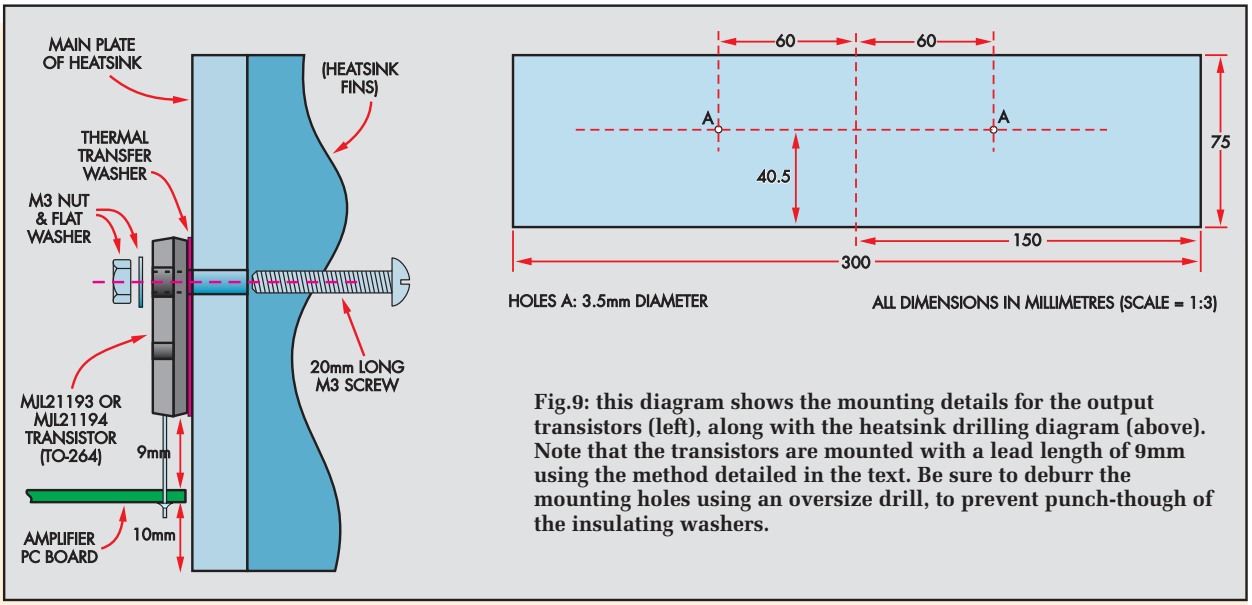


Fig.9: this diagram shows the mounting details for the output transistors (left), along with the heatsink drilling diagram (above). Note that the transistors are mounted with a lead length of 9mm using the method detailed in the text. Be sure to deburr the mounting holes using an oversize drill, to prevent punch-though of the insulating washers.

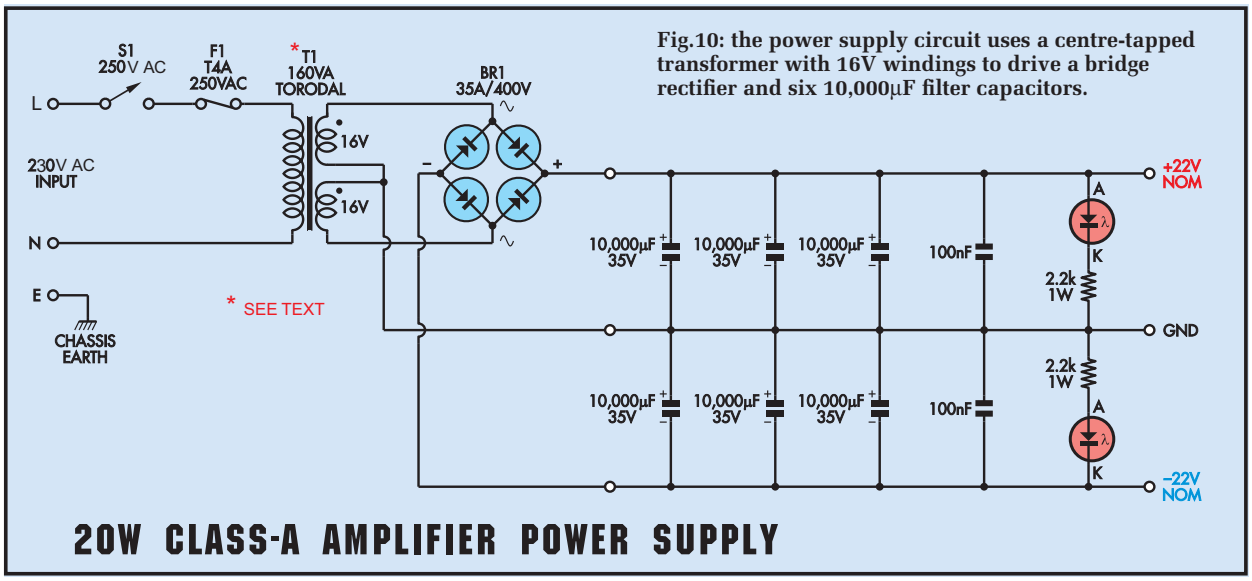


Fig.10: the power supply circuit uses a centre-tapped transformer with 16V windings to drive a bridge rectifier and six 10,000µF filter capacitors.

The windings can now be secured using a couple of layers of insulation tape, after which the bobbin can be removed from the jig. Cut off the excess wire at each end, leaving about 10mm protruding.

Finally, complete the choke by fitting some 20mm diameter (9mm wide) heatshrink tubing over the windings. Be careful when shrinking it down with a hot-air gun – too much heat will damage the plastic bobbin.

You can now test fit the finished inductor to its PC board, bending its leads as necessary to get the bobbin to sit down flush on the board. It's then just a matter of stripping the enamel from the wire ends and tinning them before soldering the choke in place.

Power transistors

The two output transistors must be installed with their plastic bodies exactly 9mm above the surface of the PC board. In practice, you have to first mount the two transistors on the heatsink.

The mounting details for each device is shown in Fig.9. **Note that it is necessary to use a thermal insulating washer to electrically isolate each device from the heatsink.**

First, check that the mounting areas are smooth and free of metal swarf (deburr the holes if necessary using an oversize drill), then loosely secure each device to the heatsink using an M3 × 20mm machine screw, flat washer and nut. That done, cut a couple of 9mm wide cardboard spacers about 40mm long – these will be used to space the transistor bodies off the PC board.

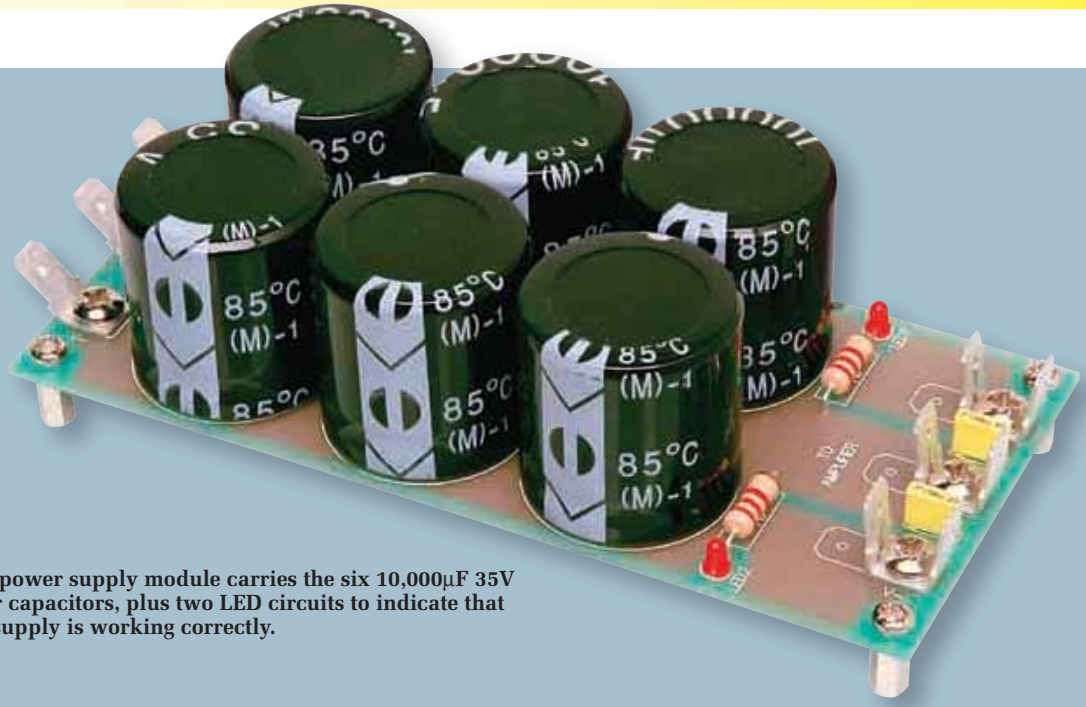
Next, turn the heatsink assembly upside down and slip the PC board (upside down) over the transistor leads. Push the board down so that the cardboard spacers are sandwiched between the board and the transistor bodies, then line everything up square and lightly tack solder the centre lead of each device.

It's important to now check that everything lines up correctly. The PC board should sit exactly 10mm below the edge of the heatsink, while each end of the board should be 77mm from its adjacent heatsink end (it helps to mark these points beforehand).

Make any adjustments as necessary, then complete the soldering and trim the device leads. That done, you can

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	3	2.2kΩ	red red red brown	red red black brown brown
❑	1	2.2kΩ 1W 5%	red red red gold	NA
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	1	510Ω	green brown brown brown	green brown black black brown
❑	1	270Ω	red violet brown brown	red violet black black brown
❑	8	100Ω	brown black brown brown	brown black black black brown
❑	3	68Ω	blue grey black brown	blue grey black gold brown
❑	1	16Ω	brown blue black brown	brown blue black gold brown
❑	1	10Ω 1W 5%	brown black black gold	NA
❑	1	6.8Ω 1W 5%	blue grey gold gold	NA



The power supply module carries the six 10,000µF 35V filter capacitors, plus two LED circuits to indicate that the supply is working correctly.

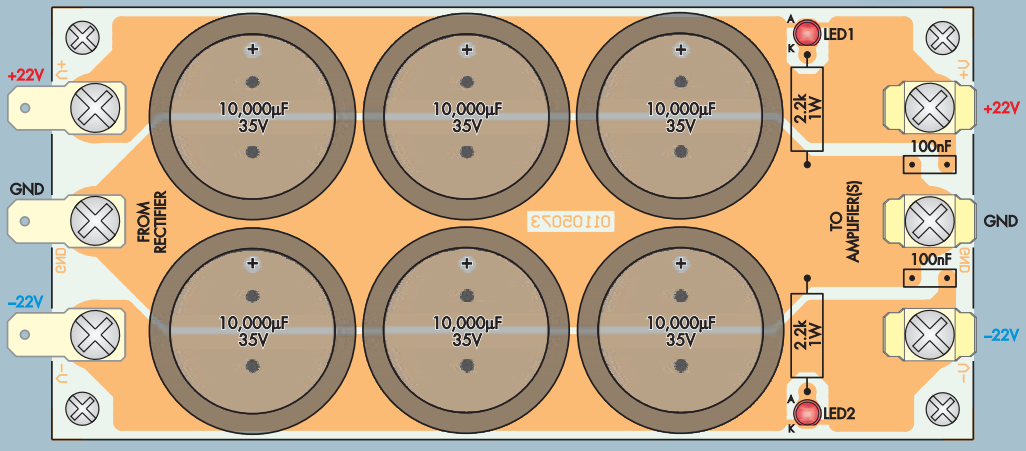


Fig.11: here's how to build the power supply board. Install the quick-connect terminals first so that there's no risk of damaging the expensive 10,000µF capacitors if a tool slips while tightening the screws. The capacitors can then go in, followed by the resistors and the LEDs.

tighten the mounting screws that secure the transistors to the heatsinks, making sure that the insulating washers are correctly aligned. These screws should be tight to ensure good thermal coupling between each device and the heatsink.

Finally, check that each device is electrically isolated from the heatsink using a multimeter. You should get an open-circuit reading between each device lead and the heatsink metal.

By the way, we recommend high-efficiency thermal insulating washers for the MJL21193 and MJL21194 output devices (see last month's parts list). Typical low-cost silicone rubber washers performed poorly in tests, resulting in at least 5°C higher transistor running temperatures.

On a similar theme, adequate airflow up through the heatsink fins is vital to amplifier survival and long-term reliability. This means that the amplifier must be operated in a well-ventilated area – those heatsinks do get hot (typically 30°C above ambient).

That completes the assembly details of the power amplifier modules. Next, we need to discuss the power supply circuit and construction of the power supply module.

Shielded power transformer

As noted last month, this design dispenses with a regulated power supply and uses a bridge rectifier and a bank of filter capacitors. Fig.10 shows the circuit diagram. As can be seen, it employs a centre-tapped transformer with 16V windings to drive a bridge rectifier and six 10,000µF 35V electrolytic capacitors (30,000µF on each side) to provide balanced ±22V DC supply rails.

Also included in the power supply circuit are two LEDs and two 2.2kΩ resistors to provide a visible indication

continued on page 40

Measuring ultra-low harmonic distortion

How good are our new Class-A audio amplifier modules? Well, they are too good to measure on our Audio Precision test gear, as we explain.

In a previous class-A amplifier article, we noted the great difficulty in measuring the very low distortion of the circuit. The main problem is that at lower power levels, circuit noise tends to completely obliterate the measurement. Even at full power (20W), the noise in the signal is quite significant.

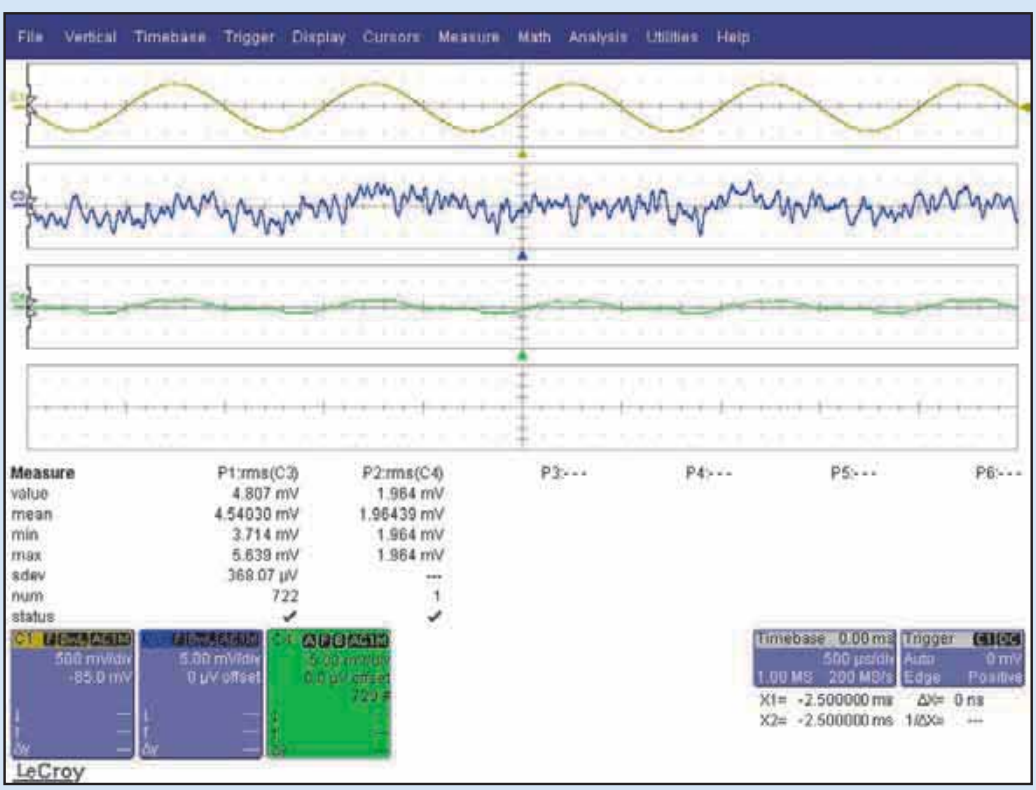
To put that into perspective, the signal to noise ratio of the new amplifier with respect to full power is –115dB unweighted (ie, with a noise bandwidth from 22Hz to 22kHz) which is very, very low. How low? Think of a noise signal which is only 22 microvolts! Compare that with the total harmonic distortion which is typically 0.0006% (–104dB or 76µV) and you can see that noise is a significant part of the measurement.

In the previous article we demonstrated a method to remove the noise component of a THD (total harmonic distortion) signal using the averaging feature of a Tektronix TDS360 digital scope. The noted audio designer Douglas Self devised this method. This technique can filter out virtually all the random noise signal to leave the harmonic content displayed.

Fast-forward to the present, and we can do the same procedures using our vastly more capable LeCroy WaveJet 2Gs/s 200MHz digital oscilloscope. We often feature screen grabs from this scope to demonstrate circuit performance. However, the LeCroy WaveJet does not allow us to perform normal sampling and averaging on the same signal simultaneously and we wanted to do this in order to more clearly demonstrate the dramatic effect of noise averaging using a digital scope. What to do?

It turns out that LeCroy have a much higher performance scope which would let us do this procedure. We managed to gain access to a LeCroy WaveRunner 10Gs/s 600MHz scope.

We performed three tests to demonstrate the extremely high performance of our new amplifier. The accompanying three scope screen grabs each show three signal traces. In each case, the top trace is the fundamental – ie, a 1kHz sinewave. The trace below that is the residual THD signal after the fundamental 1kHz sinewave has been nulled out by our Audio Precision automatic distortion test set. Both these



Scope1: the THD measurement of the amplifier at 1kHz and 20W. Note the much cleaner averaged bottom trace (green).

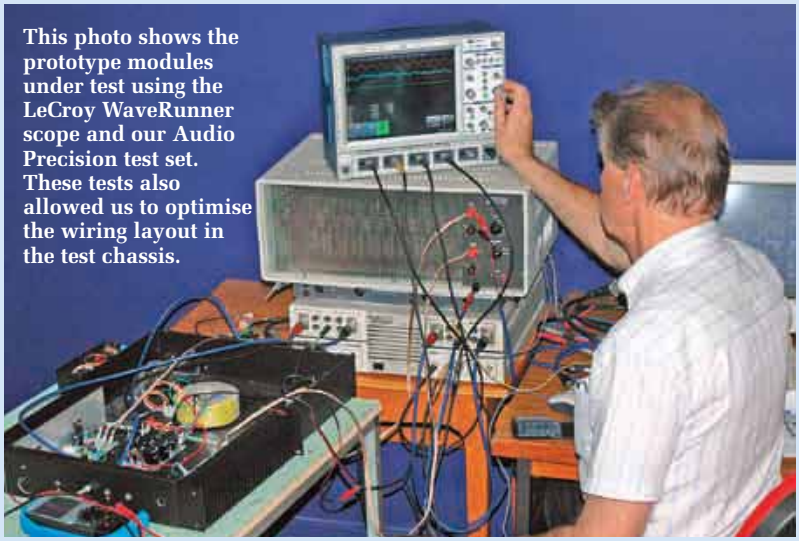
traces are displayed using normal scope sampling, so all the noise in the signal is clearly shown as a large random component.

The bottom trace is displayed using the averaging technique and is in fact the average of 128 sweeps of the trace. Furthermore, we have applied a degree of digital filtering to limit the noise in the displayed signal.

Scope1 shows the measurement of the new amplifier at 20W. The total harmonic distortion was 0.00056%.

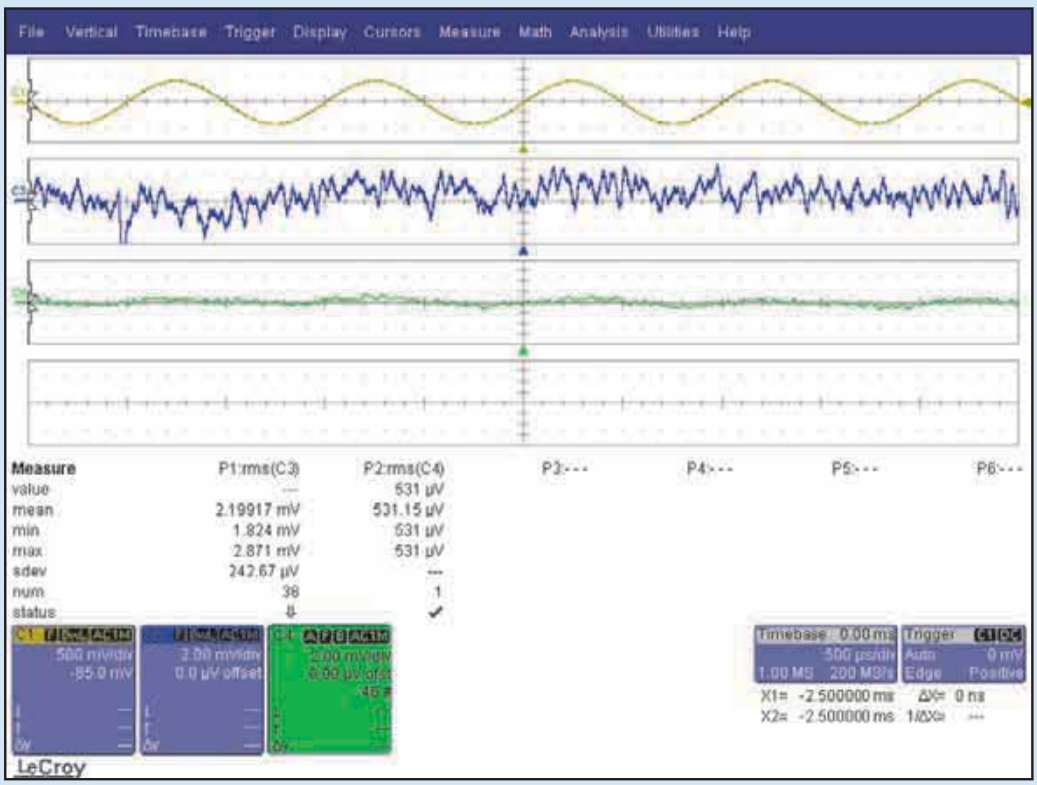
To explain this, the middle trace represents an RMS voltage which is 0.00056% of 12.69V, the signal level needed for 20W into an 8-ohm load. As presented on the scope, the middle trace has a mean (ie, average) value of 4.54mV RMS. Now look at the averaged trace (bottom). Not only is it almost completely devoid of random noise (revealing the true harmonic content) but its RMS value is only 1.96mV RMS. This enables us to recalculate the true harmonic distortion to around 0.00024%! Wow.

By the way, the scope displays a full set of measurements for channel 3 (blue) and channel 4 (green), including instantaneous value, mean, min, max and standard deviation.

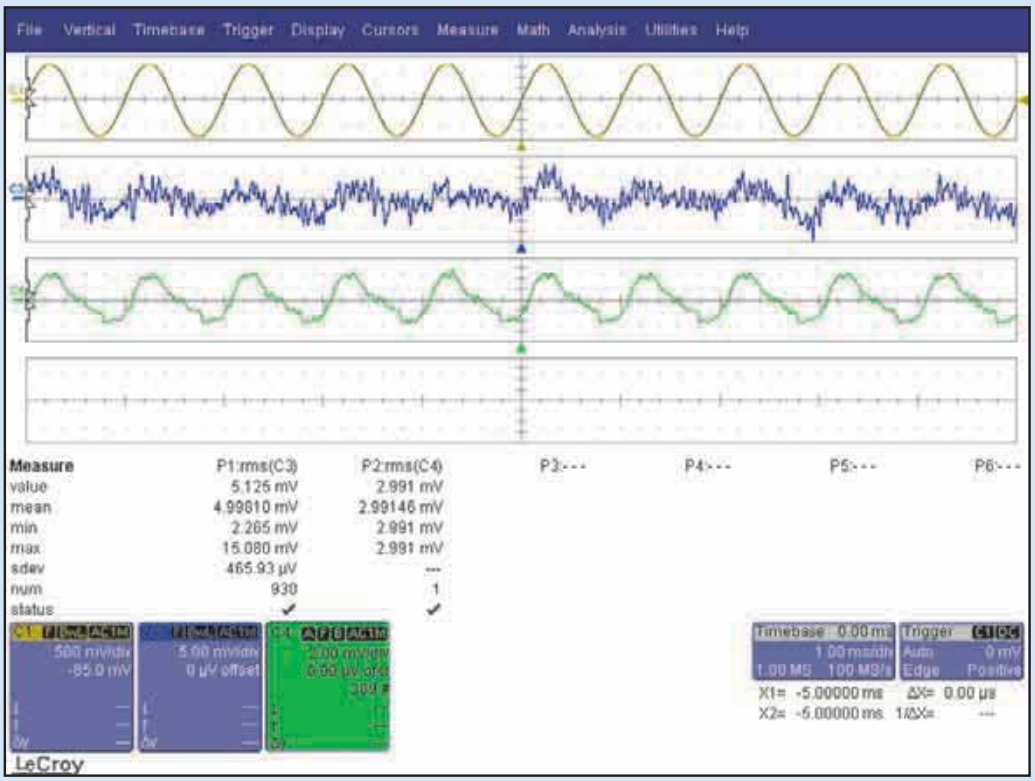


This photo shows the prototype modules under test using the LeCroy WaveRunner scope and our Audio Precision test set. These tests also allowed us to optimise the wiring layout in the test chassis.

Scope2 is even more dramatic, as it demonstrates the THD measurement at a power level of 1W. Here, the measurement is 0.001%, much worse than for full power, but in this case the fixed residual noise level of around 22µV is much more significant compared to the THD residual, which is 56µV. In this case, the THD trace is 2.2mV RMS compared to the averaged trace (bottom) of 531µV. Recalculating the harmonic distortion in the same way again gives



Scope2: the THD measurement of the amplifier at 1kHz and 1W. Here the residual noise (trace 2 – blue) is much greater and the averaged trace (green) is much cleaner.



Scope3: the THD measurement of the Audio Precision test set at 1kHz and 600mV.

Measuring ultra-low distortion: continued from previous page

a result of 0.00024%. This clearly shows that the harmonic distortion does not increase when the power level of the amplifier is reduced.

Well, that's great, but it is not the whole story, because when we measure the Audio Precision distortion test set itself, its THD is 0.0004% at 1kHz at a level of 600mV. Scope3 shows the equivalent process and after averaging the harmonic distortion, the reading is 0.00024%. But isn't that the same as the above readings for the amplifier? Yep. So in fact, we don't know how good the amplifier really is. Based on these figures, it might be less than 0.0001% but we have no way of knowing.

As a further exercise, we were able to do spectrum analysis using the LeCroy WaveRunner's FFT facility. However, while that showed the first harmonic content at down below 0.0001% for the Audio Precision's generator and similar low figures for the amplifier, the tests simply did not let us make any further estimates.

By the way, measuring a level of 0.0001% with respect to a 600mV signal actually refers to a signal component of just 6µV. The FFT analysis was able to measure harmonics out to the 19th, at much lower levels, so we were looking at harmonic components as little as −130dB with respect to the fundamental signal level. This is far below the amplifier's residual noise level; such is the capability of the LeCroy WaveRunner oscilloscope. It has 11-bit precision, enabling accurate measurements even at just a few microvolts.

So when you look at the overall harmonic distortion figures published in Part 1 (and to be published in future months for the completed stereo amplifier) remember that they don't tell the true story. This amplifier is actually too good for us to measure properly.

that power is present on the supply rails. This is very handy when you are working on the amplifier. Finally, there are two 100nF MKT polyester capacitors to provide a high frequency bypass filter on each supply.

However, the real feature of the power supply is the magnetically-shielded toroidal power transformer. Most people would be aware that standard toroidal power transformers have quite a low leakage inductance and therefore little hum radiation when compared to conventional EI laminated transformers. That is correct, but the hum radiation from a standard toroidal power transformer is still not low enough when used in conjunction with these high performance class-A amplifier modules.

Because of the constant power demand of about 100W drawn by the two modules, the transformer still has quite a significant hum field and this is a real problem when it is operated in close proximity to the amplifier modules. Our solution in an earlier design was to use a separate power box, to keep the transformer well away from the modules.

This life-size view shows the fully assembled left-channel amplifier module. Note that some minor changes were made to the PC board (just to the right of the audio input phono socket) after this module was assembled

However, this time around, we are specifying a shielded toroidal transformer, to keep the leakage inductance much lower. This employs a number of long strips of grain-oriented steel wound around the outside of the finished transformer and then covered in several layers of insulation. The unit looks just like any other toroidal transformer, but the hum field is much lower.

In addition, the transformer is oriented to give the best performance when it is finally installed in the chassis. As shown in the Performance panel last month, the end result is excellent, with extremely impressive signal-to-noise ratios and harmonic distortion figures.

The 16V + 16V 160VA magnetically sheilded toroidal transformer used in the model came from Altronics (**www.altronics.com**), who also supply kits for this project.

Power supply assembly

The PC board for the power supply accommodates the capacitors, the two LEDs, their resistors and that's it. The 35A bridge rectifier mounts on the chassis, which is necessary to remove the significant amount of heat it produces.

The power supply PC board is coded 689 and measures 135 x 63mm. As with the amplifier modules, all the connections to it are made via chassis-mount 'quick-connect' male spade terminals, which have a mounting hole for an M4 screw.

Fig.11 shows the component layout on the PC board. Install the quick-connect terminals first. As shown, three doubled-ended terminals are installed at the DC end of the board (ie, the same end as the LEDs), while three single-ended terminals are installed at the bridge rectifier end.

Once all the quick-connect terminals have been tightly secured to the PC board, you can then install the six PC-mount electrolytic capacitors. Make sure that you mount them with the correct orientation, otherwise there will be an almighty bang when you first turn on the power!

Finally, mount the MKT capacitors, the resistors and the two red LEDs. That's it – the power supply board is complete.

Next month

Next month, we will describe and construct the Loudspeaker Protector module. In the meantime, **don't be tempted to power up the amplifier modules** – there's a set procedure to follow with regards to setting the quiescent current through each output stage. ***EPE***

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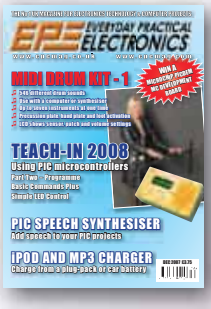

OCT '07

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

NOV '07

PROJECTS • Vehicle Multi-Voltage Monitor • USB Electrocardiograph • Experimenter's Audio System • Inductance & Q- Factor Meter – Part 2.
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DEC '07

PROJECTS • MIDI Drum Kit – 1 • PIC Speech Synthesiser • A Charger For Your iPod or MP3 Player • AVR ISP Socketboard
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JAN '08

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FEB '08

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

MAR '08

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

APR '08

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

MAY '08

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FEATURES • Circuit Surgery • Techno Talk • Teach-In 2008 – Part 7 • Practically Speaking • Net Work – The Internet Page

JUN '08

PROJECTS • Universal High-Energy LED Lighting System – Part 1 • Starship Enterprise Door Sounder • Mini Theremin – Part 2 • Monopoly Money
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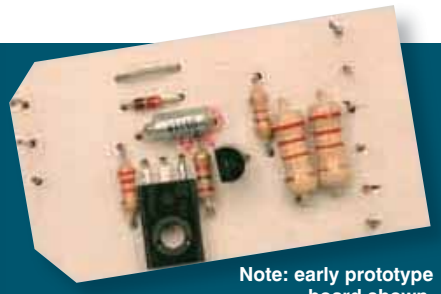
CAR PROJECT 1

Simple Variable Boost Control For Cars With Turbochargers



Note: early prototype board shown.

Quite a few cars have turbochargers these days and these can provide even more performance if the turbo boost pressure is increased. However, you don't want permanently increased turbo boost because it increases wear on the engine, so you need a variable boost control, as presented here.

Design by DENIS COBLEY

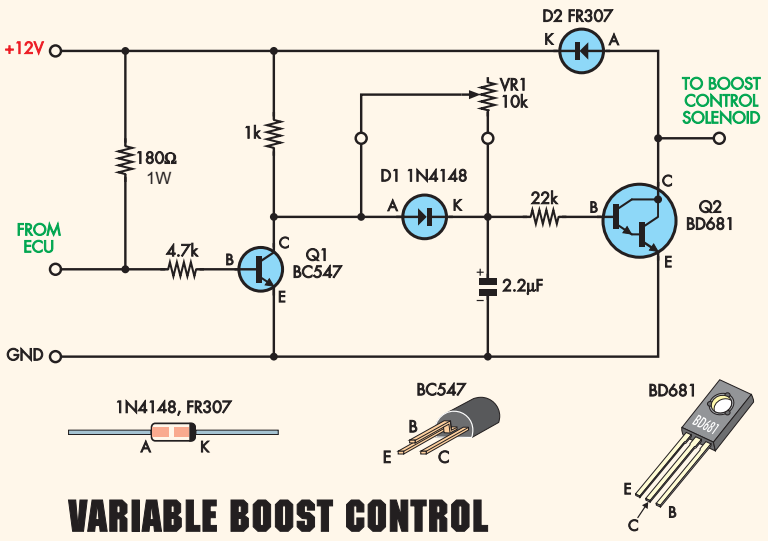


Fig.1: the circuit is based on just two transistors and a couple of diodes. It intercepts the standard boost signal from the car's engine management computer (ECU) and stretches it so that the signal to the boost control solenoid has a longer duty cycle

THIS VARIABLE Boost Control is a simple circuit to modify the factory boost levels. It was originally designed to suit a Subaru WRX, but it could be adapted to many other cars and four-wheel drive vehicles (FWDs) fitted with turbochargers. It employs a small PC board and requires only four wire connections to the car's electrical system.

Before we go any further, we should warn you that if you want to fit this project, you *must* have a turbo boost gauge permanently fitted in your vehicle. Operating variable boost above factory set levels can blow your engine if you don't know what the boost level is.

You should also check that you are not invalidating any manufacturer's or purchase warranties that may still be running

How it works

The Variable Boost Control is a simple interceptor – it 'intercepts' the standard boost signal to the Boost Control Solenoid from the car's engine management computer (ECU) and stretches it so that the solenoid signal has a longer duty cycle.

Most factory boost control systems use a variable width pulse signal to control the boost solenoid. This operates at about 14Hz to suit a Subaru WRX (1998 model).

While the circuit of Fig.1 looks simple, it works quite well and has been fitted to several cars.

The ECU boost pulse waveform is fed to the input, which has a 180Ω 1W pull-up resistor. This is sensed by the ECU as the boost solenoid's coil. From there, the signal is fed via a 4.7kΩ resistor to the base of transistor Q1, which inverts the signal at its collector (C).

The inverted signal charges a 2.2µF capacitor via a 1kΩ resistor and diode D1, only to be discharged via a 10kΩ trimpot (VR1) each time the signal at

the collector of Q1 is pulled down to 0V. The net result is a roughly sawtooth waveform with a slightly rounded leading edge and gently sloping trailing edge, the steepness of slope being dependent on the setting of VR1.

This fairly rudimentary pulse signal is fed to the BD681 Darlington transistor (Q2) via a 22kΩ resistor, which drives the boost control solenoid. Fast recovery diode D2 is connected from the collector of Q2 to the +12V line. It is included to damp the spike voltages generated each time Q2 is turned off. Incidentally, Q2 inverts the signal back to the same polarity as the input, so that it drives the boost control solenoid correctly.

A BD681 Darlington transistor is specified for Q2 since it has a high collector voltage, high gain and an adequate collector current rating (4A) to carry the currents of typical boost control solenoids. Note that in some cases Q2 may need a small 'flag' heatsink.

This circuit has no protection against reversed supply voltage, so if you connect the supply leads the wrong way, both diode D2 and Darlington transistor Q2 are likely to be instantly destroyed. The current path will be via the Darlington's internal reverse diode and D2. ***You have been warned!***

On screen

The circuit operation is clearly demonstrated in the scope waveforms of Fig.2.

The top waveform (yellow trace) is the input signal, a series of negative-going pulses. The middle waveform (purple trace) is present at the cathode (K) of diode D1, while the bottom trace (cyan) is the output waveform at the collector (C) of Darlington transistor Q2. Note that the negative-going pulses of the output waveform are substantially longer than those of the input waveform.

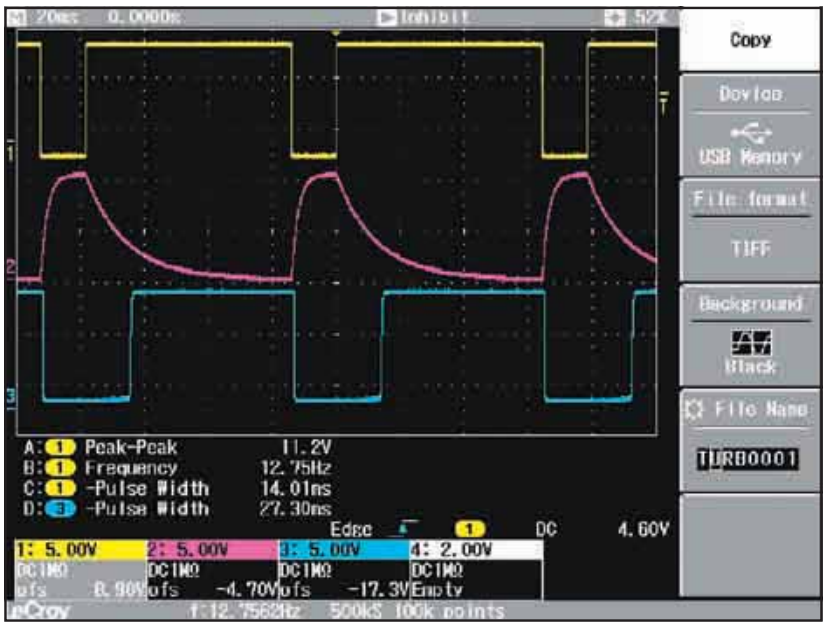


Fig.2: the top waveform (yellow trace) is the input signal (a series of negative-going pulses). The middle waveform (purple trace) is the signal at the cathode of D1. The bottom trace (cyan) is the output waveform at the collector of Q2.

Our test waveforms were made while the circuit was driving a resistive load rather than a boost solenoid, but the operation was otherwise the same as would occur in a car.

Building it

The Variable Boost Control is assembled onto a small PC board measuring just 38 × 30mm. This board is available from the *EPE PCB Service,* code 690.

The component layout and wiring diagram is shown in Fig.3 and the full-size copper foil master pattern in Fig4. .Note that the BD681 should be laid flat on the PC board so that the whole assembly can be sheathed in a piece of heatshrink sleeving.

Wiring up

Apart from two wires being needed to connect the 10kΩ potentiometer

Parts List

1 PC board, code 690 (boost) available from the *EPE PCB Service*, size 38 x 30mm
1 BC547 *NPN* transistor (Q1)
1 BD681 *NPN* Darlington power transistor (Q2)
1 1N4148 signal diode (D1)
1 FR307 3A fast recovery diode (D2)
1 2.2µF 16V PC electrolytic capacitor
1 10kΩ potentiometer (VR1)

Resistors (0.25W 1%)
1 22kΩ 1 1kΩ
1 4.7kΩ 1 180Ω 1W

Coloured connecting wires – see Fig.3. Male and female 'bullet' connectors – see text

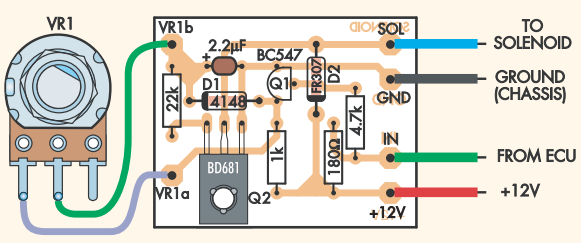


Fig.3: here's how to install the parts on the PC board. Take care with the polarity of the transistors and diodes.

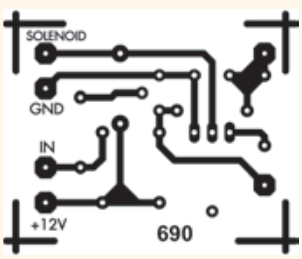


Fig.4: this is the full-size etching pattern for the PC board.

(VR1), you will need four wires to connect the Variable Boost Control to your car. These are as follows:

- +12V IGN – Red
- Earth (chassis) – Black
- Boost wire from ECU – Green
- Output to Boost Solenoid – Blue

The +12V IGN wire can be tapped from any point that is switched by the ignition switch. The earth wire can be run to any convenient point on the car's chassis. Then you will need to identify the wire from the ECU to the boost control solenoid and cut it. This should be done around 50cm or more from the ECU to make it difficult to detect.

The end going to the ECU goes to the green wire on the Variable Boost Control, while the end going to the boost solenoid goes to the blue wire on the Variable Boost Control.

Note that these connections should be made with male and female bullet or quick connect crimp connectors to ensure the integrity of the connections. Using these also means that you can quickly restore the standard boost connection, if you need to.

The Boost control pot VR1 needs to be installed on your car's instrument panel.

Setting the boost level

As already noted, you MUST have a boost gauge fitted at all times to monitor the boost levels. Drive the car up a long hill in third gear and set VR1 to provide the required boost level. **Warning: exceeding factory boost levels can reduce the life of the engine and transmission.**

Finally, note that you may need the companion *Fuel Cut Defeater,* described below, to remove the factory fuel cut, which is typically set to activate at boost levels above about 16 or 17psi. ***EPE***

CAR PROJECT 2

A Fuel Cut Defeater For Cars With Variable Boost Control

Note: prototype board shown.

Are you intending to build the Variable Boost Control described earlier? If so, you will need to build this simple Fuel Cut Defeater (FCD) to eliminate the standard factory fuel cut, which typically occurs at boost levels of about 16 to 17psi. The unit is not adjustable, so no external controls are required.

Design by DENIS COBLEY

THE FUEL CUT DEFEATER is another simple 'interceptor' design. It modifies the signal from the engine's MAP (Manifold Absolute Pressure) sensor and stops it from exceeding a particular level before feeding to the ECU. Therefore, the ECU does not sense the over-boost condition brought about by the Variable Boost Control and hence does not cut the fuel supply via the injectors.

The circuit is built on a small PC board and there are just four external connections: ie, +12V, 0V (chassis), MAP sensor and the output to the ECU.

The full circuit diagram shown in Fig.1 is very simple and is based on a TL072 dual FET-input op amp IC (integrated circuit). IC1a is connected as a unity gain buffer (with its output connected directly to the inverting input) so that there is negligible loading of the MAP sensor signal.

Input protection for IC1a is provided by the 10kΩ series resistor and by diodes D1 and D2, which clamp any large signal transients.

Level clamp

Op amp IC1b and diode D3 act as a level clamp once the output signal from IC1a exceeds the threshold at pin 5 of IC1b, as set by the three resistors and the 5.6V Zener diode ZD1. In fact, IC1b works as an inverting comparator, with the voltage at pin 5 set to around +3.9V.

For output signals from IC1a of less than +3.9V, the output of IC1b will be close to +12V and diode D3 will be reverse-biased. Hence, IC1b has no effect on the output signal from IC1a and it passes unmodified to the ECU, via the 1kΩ and 680Ω resistors.

However, once the signal at pin 6 of IC1b exceeds +3.9V, IC1b's output goes low (0V) and diode D3 will be forward

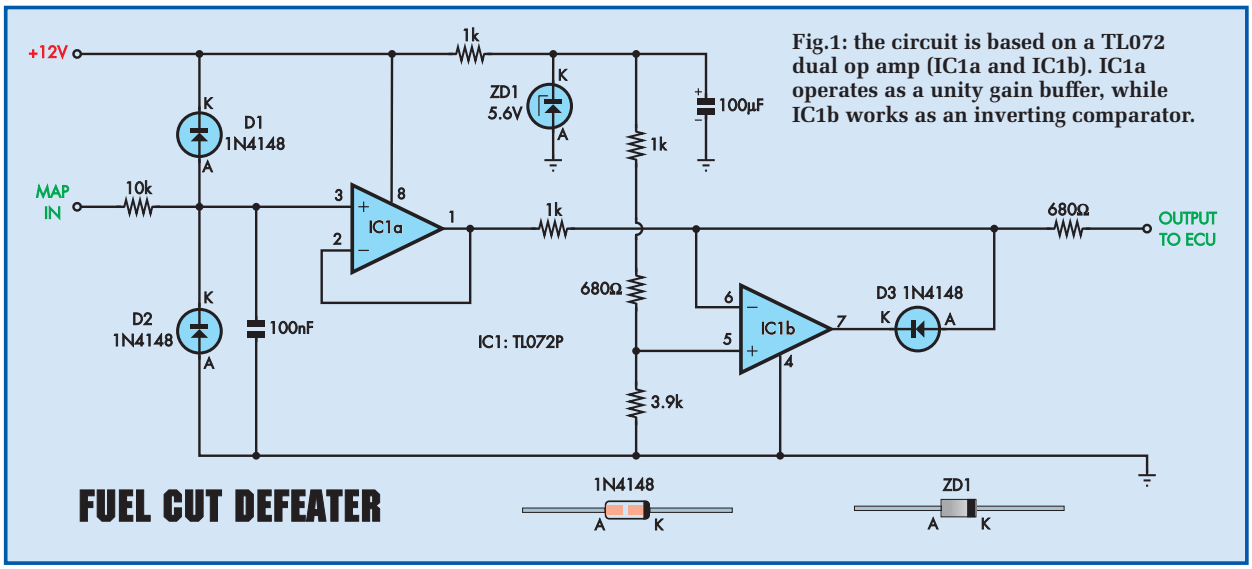


Fig.1: the circuit is based on a TL072 dual op amp (IC1a and IC1b). IC1a operates as a unity gain buffer, while IC1b works as an inverting comparator.

biased and it will conduct to shunt the output signal to the ECU, clamping it to a level of about 1.4V. Thus, the ECU does not see MAP signals above a certain threshold and so it cannot cut fuel as it normally would in an over-boost situation.

This last factor means that it is *extremely important* to ensure that you always monitor the turbo boost on your car if you are using this Fuel Cut Defeater in conjunction with the Variable Boost Control.

Assembly and fitting

Assembling the PC board (see Fig.2) is straightforward, but make sure that you install op amp IC1 and the diodes the right way around.

When you have finished the assembly, check all your work and then connect a 12V supply to the PC board. Make sure that you connect the supply with the correct polarity, otherwise you are likely to damage diodes D1 and D2 and the op amp.

Check that the voltage at pin 8 of IC1 is +12V (or close to it) with respect to pin 4. The voltage at pin 5 should be close to 3.9V. Note that this setting is designed to suit a Subaru WRX and may possibly need adjustment to suit the MAP sensors in other vehicles.

When installing the PC board in your car, the +12V wire can come from any point which is switched by the ignition switch. The earth wire can be run to any convenient point on the car's chassis. You will then need to identify the wire from the MAP sensor to the ECU solenoid. The one to use has about 1.4V on it at idle.

Cut this wire at around 50cm or more from the ECU to make it difficult to detect. The end going to the MAP sensor ECU goes to the green wire on the Fuel Cut Defeater (FCD). The end going to the ECU goes to the blue wire on the FCD.

Note that these connections should be made with male and female bullet or quick connect crimp connectors to ensure the integrity of the connections. Using these also means that you can quickly restore the standard boost connection, if you need to. **EPE**

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Parts List

1 PC board, code 691 (fuel cut), available from the *EPE PCB Service*, size 50 x 33mm
1 TL072 dual FET-input op amp (IC1)
3 1N4148 small signal diode (D1,D2,D3)
1 5.6V 400mW Zener diode
1 100µF 16V PC electrolytic capacitor
1 100nF MKT polyester

Resistors (0.25W 1%)
1 10kΩ 3 1kΩ
1 3.9kΩ 2 680Ω

Coloured connecting wires – see Fig.2. Male and female 'bullet' connectors – see text

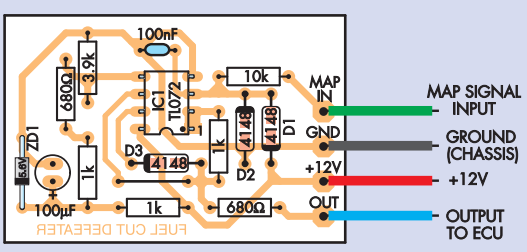


Fig.2: follow this parts layout diagram to build the Fuel Cut Defeater. Note that diodes D1 and D2 face in opposite directions.

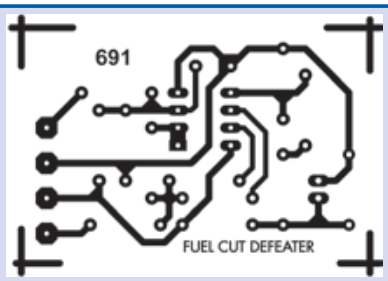
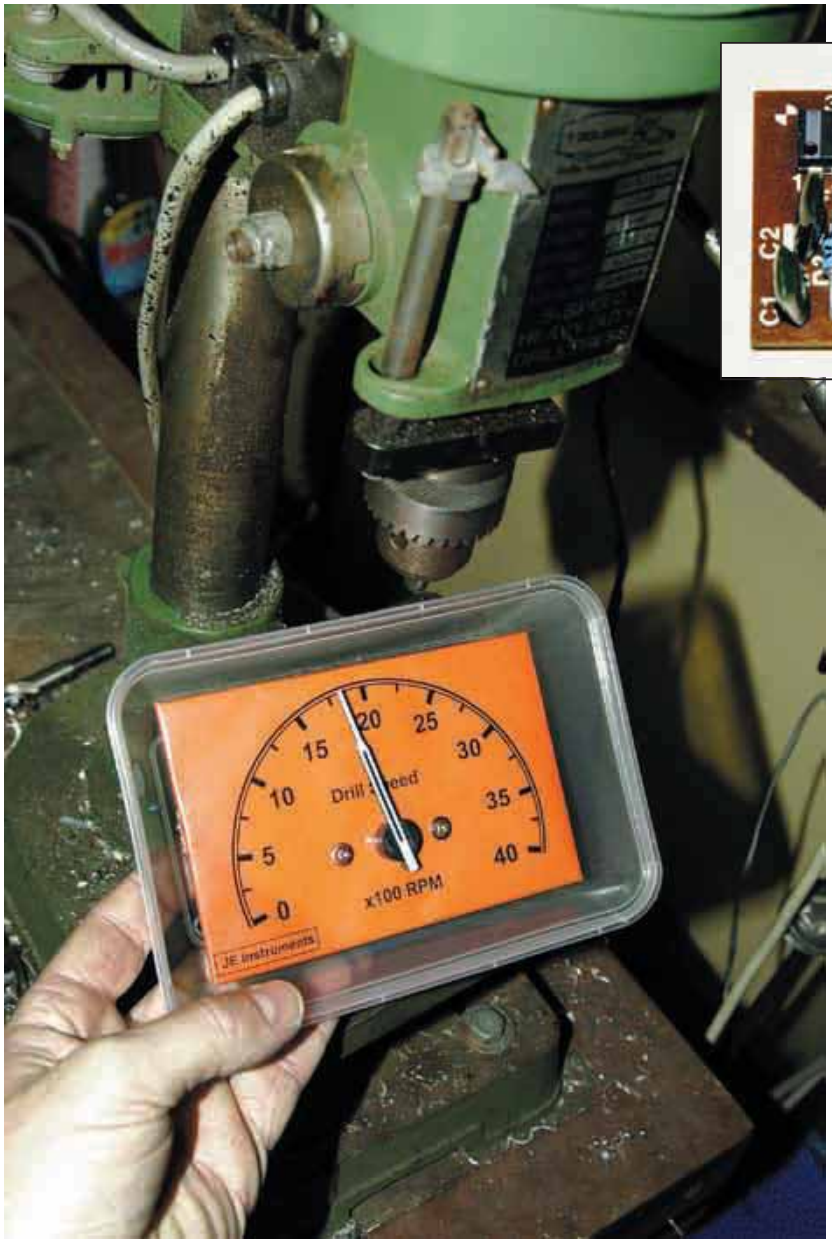


Fig.3: this is the full-size etching pattern for the PC board. Check the board for etching defects before installing the parts.

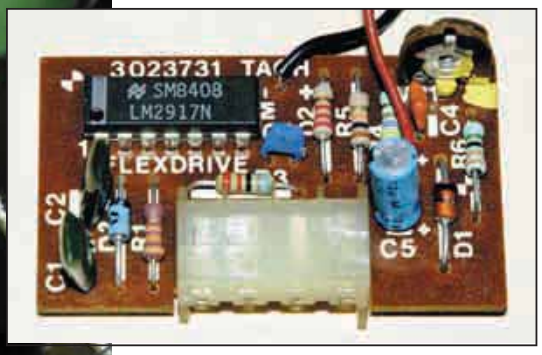
Recycle It!

BY JULIAN EDGAR

A £10 lathe and drill press tachometer



It's easy and cheap to make a tachometer that measures the rotational speed of your drill press or lathe. The project uses just a few low-cost components and a re-scaled tachometer from a car.



In essence, this tacho is a simple frequency-to-voltage converter driving a moving coil meter. The standard adjustment pot is shown top right.

Want to know the chuck speed of a lathe or drill press? A car tachometer can easily be adapted to do the job for less than 10 pounds.

A READOUT of chuck speed on variable-speed drill presses and lathes can be very useful. That particularly applies if you use an electronic speed controller, but even if you have to swap gears or pulleys, it's still good to have a display showing the tool's rotational speed.

In fact, wouldn't it be good if you could have a big dial displaying revs per minute? Hmm, cars have one of those – it's called a 'tachometer'. And modern tachos are driven by a simple pulse input, so it's quite easy to adapt one to do the job.

The components

To make this speed display you'll need to scrounge a tacho from a car. When sourcing many secondhand parts, you don't want to go along to a wrecking yard and ask for the tacho from a specific model – not unless you want to pay 'top dollar', anyway. No, what you want is an orphan that's going cheap or perhaps it's part of a dash display that's been discarded because the faceplate is scratched. The one shown here came from a Nissan from the mid-80s.

In addition to the tachometer, you'll also need a 12V DC plugpack, a reed switch (eg, from the speedo of the same instrument panel), a small magnet, a 10kΩ trimpot, a 33kΩ resistor, a 1000μF capacitor and a box to mount it all in. To make a new scale, you'll need a PC, scanner and printer.

Building it

Fig.1 shows how it all goes together. A reed switch is briefly closed each time a magnet mounted on the driven pulley passes by. This reed switch is fed with a nominal +5V at one end, derived from potentiometer VR1, which is across the +12V supply.

Therefore, each time the reed switch closes, a +5V pulse is fed to the tacho's signal input. Conversely, when the reed switch opens, the tacho's input is pulled to 'ground' (0V) by a 33kΩ resistor.

Note that the tacho assembly shown here has a separate PC board for the electronics, which is actually a frequency-to-voltage converter. This particular one uses an LM2917N as the frequency-to-voltage converter chip and the datasheets for this are available on the web.

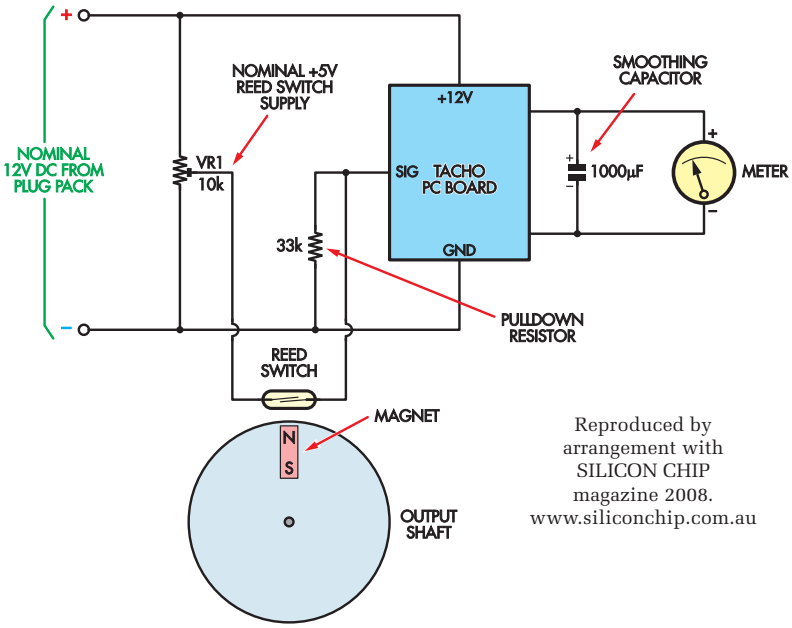


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Fig.1: the drill press tacho uses a tachometer that's been scrounged from a car. As shown, a reed switch is fed with +5V DC, derived from trimpot VR1 which is across the 12V plugpack supply. The reed switch briefly closes each time a magnet attached to the machine tool's output shaft passes close by and feeds an input pulse to the tacho's input terminal. The 33kΩ pull-down resistor ensures that the signal input is low when the reed switch is open, while a 1000μF capacitor smooths the signal that's fed to the meter.

Speeding

As calibrated from the factory, it's likely that the tacho speed range will be too high for the new application – there aren't many cases where you want the lathe or drill press doing 8000 RPM! This means two things: first, the frequency input range of the tacho will have to be altered; and second, a new scale will need to be made for the meter.

In our case, the on-board pot gave plenty of adjustment. In fact, with just one input pulse per revolution

The reed switch was salvaged from an old film processor at the local tip. Here it can be seen mounted directly above the output pulley of the drill press.

The reed switch is triggered by this magnetic washer which is glued to the pulley. This washer was extracted from a salvaged stepper motor.

Here's the original instrument panel and an early draft of the scanned and re-scaled drill press tacho scale. It's printed out 1:1 and so is a perfect size match for the original instrument.

of the drill-press, the needle could be adjusted for full scale deflection even at the slowest drill press speed. However, we're getting ahead of ourselves.

Tacho connections

The tacho should have three connections: +12V, ground (0V) and signal (frequency) input. If you buy the tacho with the whole instrument panel intact (the best approach), look very closely at the tracks on the flexible PC board on the back of the panel. In many cases, +12V and ground (earth) will be marked, leaving only the third pin which must then be the signal input.

Conversely, if the board isn't marked, you may need to seek the help of an automotive instrument repairer to get the pin-outs right. Alternatively, you can usually figure it out by tracing the supply connections.

Once the wiring connections are sorted, it's best to do some experimentation. Use good quality glue to hold the magnet in place on the driven pulley or gear and mount the reed switch so that the magnet passes close by it on each rotation of the shaft. We used a small 'washer-shaped' magnet, taken from the middle of a salvaged stepper motor.

Once the magnet is installed, wire up the rest of the circuit as shown in Fig.1. Trimpot VR1 should then be adjusted to provide a nominal +5V to the reed switch. Don't forget to install the pull-down resistor.

The capacitor across the meter's drive damps the jerky movement that occurs when the input frequency is lower than it would normally be in a car. Note the polarity of the capacitor – you can work out the meter's polarity by disconnecting it from its drive circuit and applying a low voltage (eg, 1V) to its leads. When it's connected so that the needle moves in the correct direction, take note of the polarity of the supply.

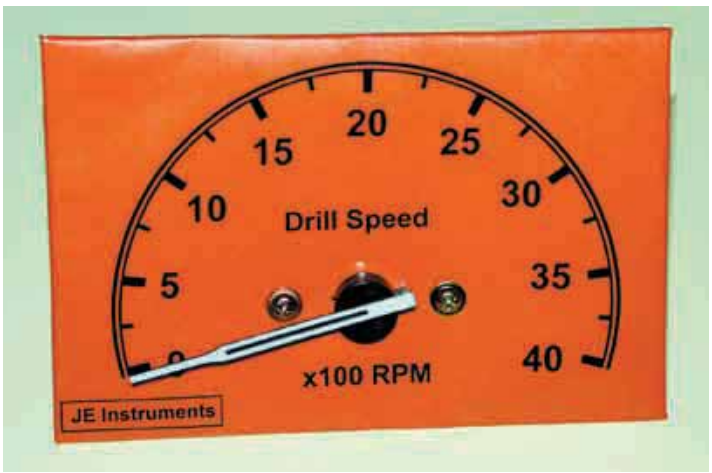
Testing

Once you've wired up the circuit, start the machine tool and make sure you get at least some needle deflection on the tacho. If you don't get any, experiment with the value of the pull-down resistor. This is easily done if you use a 10kΩ pot wired as a variable resistor and adjust it up and down.

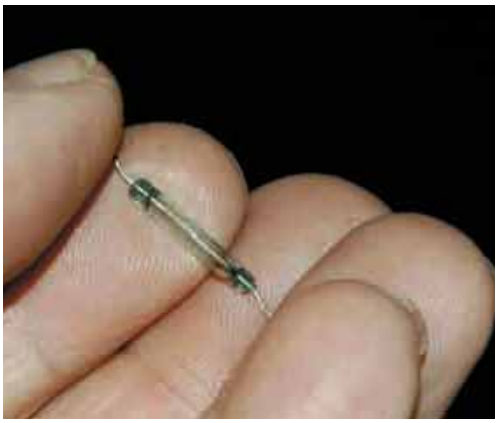
If there's still no joy, try increasing the voltage going to the reed switch.

Finally, if you still get no needle movement, add a second magnet directly opposite the first so that there are more pulses per revolution.

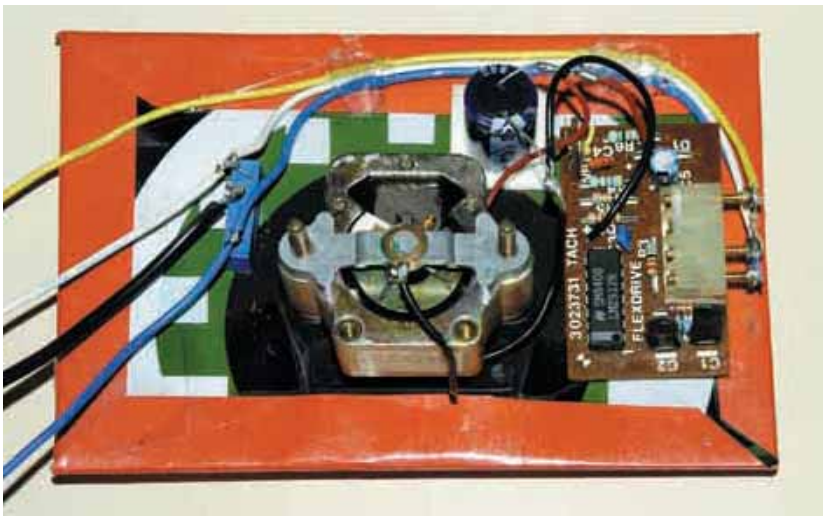
Once the needle is registering something, run the machine at its fastest speed and try adjusting the on-board pot to get full-scale deflection. If you can't get there with the built-in adjustment, add more magnets to the shaft of the drill-press or lathe.



The revised and modified scale, printed out on orange paper and covered in clear self-adhesive film. But just who is behind the 'JE Instruments' company?



A reed switch from a speedo was initially used but some dummy bent a lead too close to the glass envelope and broke it! Another salvaged component was then used instead – the reed from a float switch.



The rear of the modified assembly. At left is the pot providing the +5V reed switch supply, at top-right is the new smoothing capacitor, and at right is the PC-board from the original tacho. The 33kΩ pull-down resistor is just visible at far right and connects the signal input to ground.

Calibration

If you know the fastest and slowest speed of the machine, you can calibrate the scale to those revs – everything in between will then fall into place since the meter response is linear.

You can use your PC and a printer to make a new scale. First, scan in the original car tacho scale and use image manipulation software (eg, Photoshop or Paintshop Pro) to alter the numbers and to delete other markings you don't want. Of course, at this stage you can also add whatever labels are suitable.

Finally, print it out at full size and it's then just a case of sticking it over the original. We used clear adhesive film to protect the paper scale. ***EPE***

Alternative Calibration

Another good way of calibrating the unit is to first use a frequency measuring multimeter to measure the speed of the tool. The meter will measure in Hertz (cycles per second), so to calculate the tool's rotational speed in RPM, just multiply by 60. Note: this assumes that you have just the one magnet on the output pulley.

If the meter jumps around a lot, try temporarily adding small value capacitors in parallel with the reed switch to dampen the bounce that occurs when the switch closes.

Alternatively, if you have a scope, it's ideal for reading the frequency.

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 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!

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Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

Summer, or what there was of it, should be well and truly over when this magazine appears on the bookstalls, and outdoor pursuits should be giving way to indoor activities, such as building electronic projects. I do not know if it still applies, but this is traditionally the time of year when many newcomers enter the hobby of electronic gadget building. Anyway, this feature will offer some advice for those of you who are complete beginners and help you to get started.

This column usually explains how to tackle a particular aspect of electronic project construction, but on this occasion the emphasis is on what you should not do rather than what you should do. Learning from your mistakes is important, but learning from the mistakes of others is a better way of doing things. Avoid the pitfalls described here and you should find this absorbing hobby relatively frustration free.

Going, going…

A common way for people to enter this hobby is to have their interest sparked when someone gives them some old electronics magazines. When building projects that are more than a few months old it is always advisable to check the availability of *all* the components *before* actually buying any of them. Otherwise, there is the risk of purchasing most of the parts only to discover that the rest of them are no longer available. Bear in mind that it only needs one crucial part to become unavailable to render a project unviable.

Product rationalisation has resulted in many popular components of the past becoming unavailable. It is not only some 'golden oldie' devices that are troublesome. Components that fail to 'make the grade' and disappear soon after they were introduced have always been a problem.

Hence, it is not only old projects that can suffer from supply difficulties. Even when considering a design that is relatively recent it is still a good idea to check availability first before actually going ahead and buying any of the parts.

It is important to obtain as many catalogues and price lists as you can. Apart from maximising your chances of tracking down any crucial but unusual parts, it is useful to be able to compare prices from several suppliers.

Most electronic component suppliers now have excellent online catalogues at their websites, and these are generally more up to date than their printed counterparts. Well-written project articles (like ours!) should give a source for any highly specialised component that is not available from the usual sources.

Small is beautiful

I suppose it is stating the obvious to say that beginners should build beginners' projects, but it is easy to be seduced by large and exciting projects that will impress your family and friends. It is advisable to bear in mind that the chances of making a mistake rapidly escalate with increasing project size, and comp-lexity. A large project is impressive, but only if you can get it to work. One of more modest size is much more likely to work first time. Also, if the worst should happen and the newly constructed circuit fails to work at the first attempt, finding the mistake and correcting it is much easier with a small project. *(The designs in our* Breadboarding Projects *series would make a good starting point – Ed.)*

Beginners, are usually concerned that they will not be able to get newly constructed gadgets to work. Provided you start with simple projects there is an excellent chance that they will all work. It might be necessary to sort out one or two simple mistakes in your first few projects, but there should be no major problems.

Another good way to get into difficulties is to build a project that is reasonably simple, but has some highly technical or obscure function that you do not fully understand. If you look back at the projects featured in *EPE* over the last few years there is an amazing assortment of gadgets on offer. This makes the hobby more diverse and interesting than ever before, but before trying something new it is essential to grasp the basics of the subject.

Letters from readers who were having problems with a project simply because they had misunderstood the exact function were a fairly regular occurrence at one time, but these type of hitches are relatively rare these days.

Tools for the job

Many of the tools needed for electronic project construction are commonly found in the average household toolkit. The mechanical side of project construction requires tools like hacksaws, drill-bits in a range of sizes, files, pliers, adjustable spanners, and screwdrivers. A potential problem here is that most do-it-yourself tasks are on a much larger scale than project building. Miniaturisation of electronic circuits has resulted in much project construction being more like watch making than fitting shelves on a wall or assembling a wardrobe.

Fig.1. Proper wire strippers and cutters are essential tools for project construction, and an inexpensive combination tool (left) does both jobs quite well. It is also worthwhile augmenting these with a small pair of cutters (right) for intricate work and for cutting fine wires

A power drill that is perfect for drilling holes through a wall is certainly much too powerful and cumbersome for making tiny holes in a plastic or aluminium case. Many of the tools in your existing toolkit will have their uses when building electronic projects, but smaller versions will be needed for many jobs. Trying to improvise using tools that are ill suited to the job is unlikely to produce good results, and in some cases it could be dangerous.

It is probably best to buy the more specialised items of equipment as and when they are needed, but there are some tools that it is advisable to have at the outset. A good quality electric soldering iron with a miniature bit of about 2.5mm to 3mm in diameter is an essential item. An iron with a rating of about 15W to 20W is ideal. Buy a matching stand rather than trying to improvise something than might not be entirely effective or safe.

Ordinary files and screwdrivers will be needed, but it is advisable to have a set of miniature files and some small electrician's screwdrivers as well. It is a good idea to have a small hacksaw in addition to a standard type.

Wire cutters and strippers are essential. These can be separate tools, but an inexpensive stripper and cutter tool should be perfectly adequate (Fig.1). Improvising with implements such as knives and scissors should be avoided. Such 'short cuts' ruin the tools, tend to result in the wires breaking, and are decidedly dangerous.

One of the lower power rechargeable drills is adequate for most electronic project work and is easier to use than a large power drill. A hand-drill tends to be slow, but gives the ultimate in control when drilling into the relatively soft materials that are often encountered when building electronic gadgets. It is normally advisable to buy tools of the highest quality, but inexpensive drill bits seem to last well in project applications provided it is not necessary to work on steel cases.

Softly, softly

Project cases are mainly made from thin aluminium that is easily scratched and distorted, or plastics that are either soft or brittle. Some circuit boards are quite brittle, and few electronic components could truly be described as tough.

Applying the 'hammer and tongs' approach to project construction is a good way to produce a collection of battered and cracked cases, circuit boards, and other parts. Always proceed slowly and carefully when working on cases and circuit boards, using no more than moderate pressure. As already pointed out, small cordless power tools and hand tools are more appropriate than large power tools for most project work. If you really must use large power tools, proceed very carefully.

You also need to take a restrained approach when tackling the 'nuts and bolts' side of assembly. There are exceptions, but most front panel components are mounted by way of a threaded bush on the component itself, and a fixing nut. Even with the larger components that have metal bushes, tightening the nuts as if they were wheel nuts on a car will quickly strip threads.

Smaller components such as miniature switches are easily damaged, as are those that have plastic bushes. A certain amount of force has to be used in order to secure these components reliably, but going at things in an unrestrained manner will almost certainly produce some sheared threads. Getting overzealous with the fixing nuts on smaller components can result in them breaking into pieces.

A bit of advice

Practice makes perfect, and it is a good idea to learn the art of soldering before starting your first soldered project, rather than trying to master the technique as you go along. Gain some experience by soldering some wires or cheap components to a scrap of stripboard. This will cost very little, but will probably save wasted time and money and avoid a lot of frustration later.

The *EPE* website (**www.epemag.com**) is the place to go if you would like to know how to solder properly. There you will find a comprehensive and fully illustrated guide to soldering properly.

Some soldering irons require a small amount of solder to be applied to the bit as soon as it starts to approach its normal operating temperature. Failure to do this can result in a coating on the bit that causes the solder to run straight off, making it impossible to use the iron.

It is best to assume that the iron has a bit of this type and to 'tin' the bit as soon as it is hot enough to melt the solder. If the bit should become coated, let the iron cool, clean the end of the bit with something abrasive such as fine sandpaper, and then try the heating and tinning process. This will usually get the bit into usable condition, but is best avoided as it is likely to reduce its operating life.

Two common mistakes are often made when people first try their hand at soldering. The 'obvious' way of doing things is to first melt the solder on the tip of the iron, and then transfer the molten solder to the surfaces that are to be joined.

Unfortunately, the obvious method is definitely the wrong way of doing things. Electrical solder contains cores of flux that help the solder to flow over the wires, copper pads, or whatever, so that a reliable joint is obtained. Applying the solder to the bit first and then to the joint second lets the flux burn away before the solder reaches the joint, compromising the effectiveness of the joint. Also, it is unlikely to supply sufficient solder, resulting in a 'dry' joint. The correct method is to apply the iron bit to the joint and then feed in the solder.

The second common soldering problem is simply taking too long over each joint. This can result in components becoming overheated and damaged. Some soldering practice before tackling your first project is invaluable. With experience you will be able to complete soldered joints very rapidly with the process becoming largely intuitive. Things will inevitably be slower at first, but try to get up to a reasonable speed before launching into your first project.

Zapping components

Once the components for a project have been obtained there is a temptation to unwrap them all and take a good look at each part. In general, this is a good idea, as it enables you to check that everything is present and in an undamaged condition. It also helps the process of familiarisation, so that you can easily identify each component when you start building the project.

There is a potential problem though, and this is because many modern semiconductors are vulnerable to damage by static electricity, and by handling these it is possible to zap them. Even quite small static charges are sufficient to damage some components, and with these you would probably not be aware that anything had happened. The problem would only become apparent when the newly constructed project failed to work.

The project article should make it clear if there are any components that are vulnerable to static charges, and brief details of the necessary handling precautions should be given. This is basically just a matter of leaving the components in their special packaging until it is time to fit then into place.

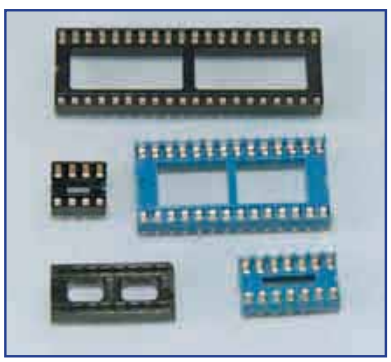


Fig.2. Integrated circuit holders help to avoid damage to components due to static discharge and overheating. A full range of sizes is available, and the ones shown here range from 8 to 40 pins

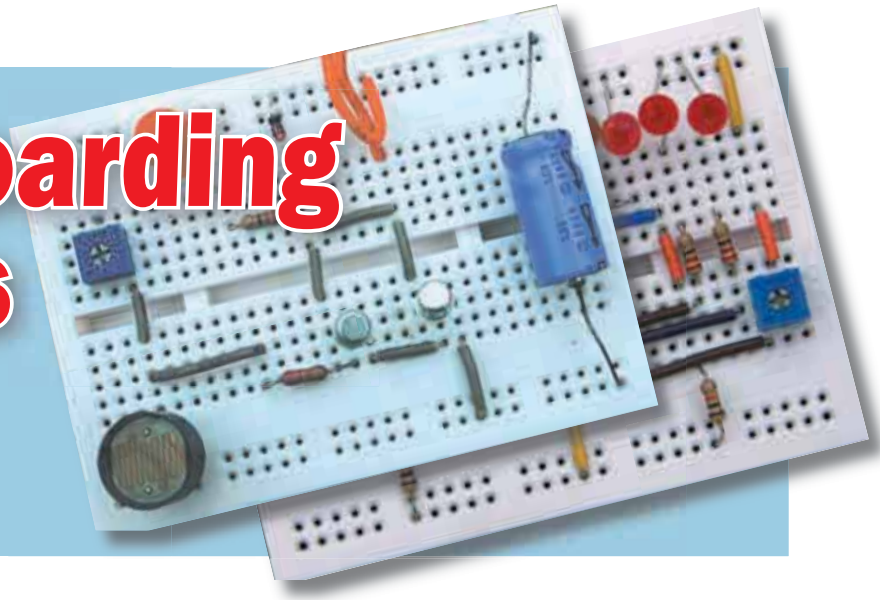
When fitting the components it is important to keep away from any obvious sources of static electricity and to avoid touching the pins as far as possible. Use holders for integrated circuits (Fig.2). Apart from reducing the risk of damage due to static electricity, it avoids the possibility of overheating the component when soldering it to the circuit board. The holder is soldered to the board, and the integrated circuit is plugged into place later.

Do it

The biggest mistake of all is to always be about to build a project, but to never actually get around to it. Starting is the hardest part of any creative hobby, but once underway you should be at the start of a hobby that will be educational and provide countless hours of fun.

Breadboarding Projects

by Dr Malcolm Plant



A beginner's guide to simple, solder-free circuit prototyping
Part 2: Dark Switch and Moisture Monitor Mk.1

This month, in part 2, we present a couple of interesting circuits for building on breadboard – a light dependent switch and the first of two moisture monitors.

Project 3:

Dark Switch

ALTHOUGH integrated circuits were in general use from the 1960s, individual transistors are still widely used in projects, mainly in applications where the circuit designer needs to control a higher current than integrated circuits can deliver. The Dark Switch uses two common and cheap general purpose bipolar transistors in a semiconductor switch that responds to changes of light intensity falling on the light-dependent resistor, LDR1. The circuit diagram is shown in Fig.2.1.

Darlington configuration

The two transistors are coupled together in an arrangement known as a Darlington pair, the name honouring its inventor Sydney Darlington, who worked at the Bell Laboratories in the United States in 1953. The advantage of coupling two transistors together as shown is that the current gain of the combination is the *product* of the individual gains. This reduces the base

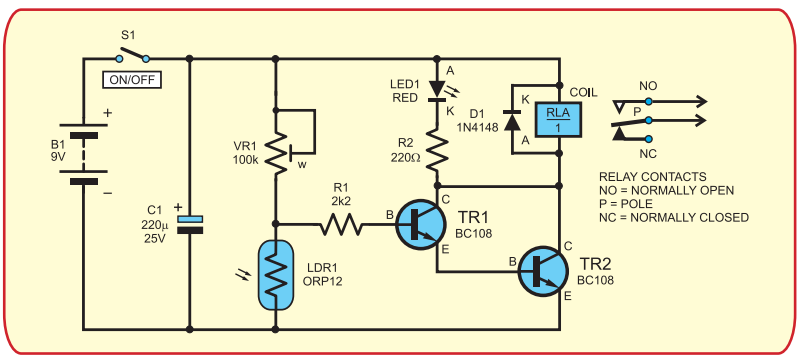


Fig.2.1: Dark Switch circuit diagram

Components needed...

Transistors, TR1 and TR2: type BC108 or similar general purpose types in a TO18 style package
Light-dependant resistor, LDR1: type ORP12 or similar
Light emitting diode, LED1: red suggested
Diode, D1: type 1N4148 signal diode
Potentiometer, VR1: miniature preset type, value 100kΩ for dark-operated version. A higher value may be necessary for the light-operated version – see text
Relay, RLA: low voltage 6V type, single-pole changeover contacts
Resistors, R1 and R2: values 2.2kΩ and 220Ω respectively, both 0.25W carbon film
Capacitor, C1: axial electrolytic type, value 220µF 25V
Switch, S1: single-pole single throw (SPST) (optional)
Battery, B1: 9V and connecting leads
Protobloc and wire links

Component Info

TR1 and TR2, *NPN* transistor, type BC108.

Seen from below, the emitter lead is next to the small metal tag. Clockwise from the tag are the base, and collector leads

LDR1, light-dependent resistor type ORP12.

It does not matter which way round the LDR is connected

VR1, potentiometer

This is a preset type that can be inserted directly into the Protobloc and its value adjusted with a small screwdriver

RLA, relay 6V energizing voltage.

This has single pole changeover switching contacts for switching on and off a separate circuit from the electronic one. **It must not be used to switch mains-operated devices**

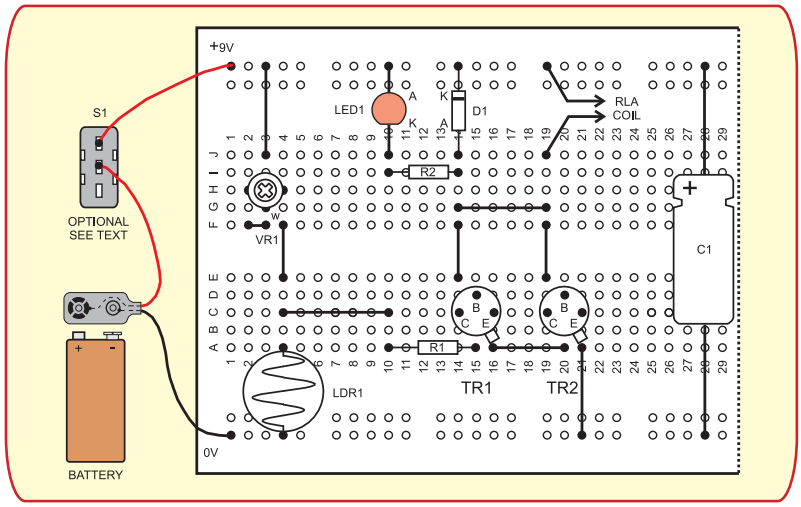


Fig.2.2: Assembly of the Dark Switch on Protobloc

current drawn by *NPN* transistor TR1, thus making the combination very sensitive to changes of input voltage compared with the use of a single transistor. In turn, in this project it makes the circuit very sensitive to changes of light intensity on the LDR.

Note that the emitter terminal of TR1 is connected to the base terminal of TR2, while their collector terminals are connected together. Thus, the emitter current of TR1 provides the base current of TR2.

Building blocks

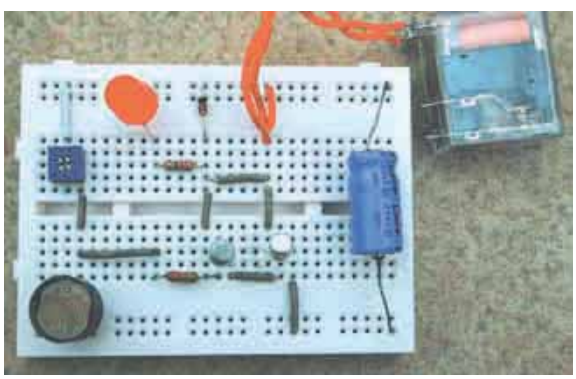
The circuit can be regarded as made up of three interlinked building blocks. Building block 1 is the input to the system, the dark sensing function, which is based on VR1 and LDR1. Together these act as a voltage divider. The voltage at the junction of these two components rises and falls according to the amount of light falling on the LDR. The voltage divider is followed by building block 2, based on TR1 and TR2 acting as a sensitive switch which provides sufficient current to energize building block 3, comprising LED1 and the relay connected in parallel.

As the light level decreases below a critical point, the relay energizes and its normally open (NO) switch contacts close. These contacts can then be used to switch on low voltage motors or lamps, for example. The light intensity when switching occurs is determined by the setting of potentiometer VR1.

An alternative use is made of the circuit by interchanging LDR1 and VR1, which causes the relay to energize when the ambient light level rises above a particular intensity. The circuit shows the dark-operated version, where the relay can switch on a motor, a buzzer or a lamp when the light level falls, such as at dusk.

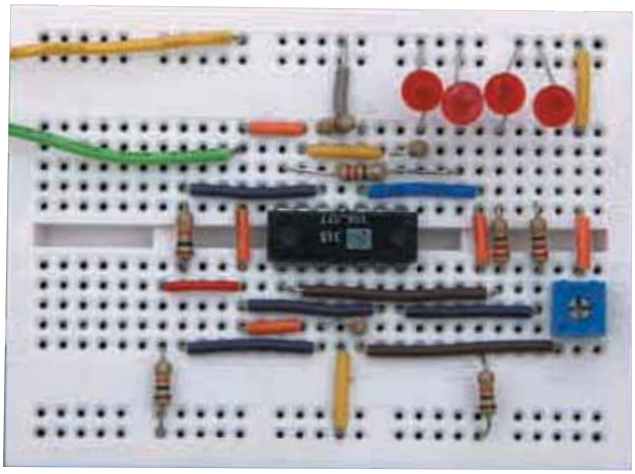
Notes

- Do not use the relay to control power from the mains supply. If you want to use it for controlling mains-operated devices you should seek the help of a qualified electrician
- Use the *Circuit Tester* from last month to identify the base leads of the two transistors and to confirm that they are both *NPN* transistors. See Using the Circuit Tester notes last month
- A variety of general purpose *NPN* transistors will work in this circuit. You could replace the two transistors by a single *NPN* Darlington pair. A suitable replacement device being a MPSA13, which has three leads that are thin enough for insertion into the Protobloc. Do not try and use the physically larger Darlington pair packages because their pins are two thick for use with Protobloc
- Diode D1 is essential to short-circuit the back-EMF generated when the relay de-energizes, which could damage the transistors
- Note that S1 will not be needed for a Protobloc assembly, but would be needed for a permanent circuit
- Fabricate a paper tube to fit round the LDR to provide better directional light sensing
- Light emitting diode LED1 is useful since by lighting up it indicates that the relay coil has been energized
- Transistor TR2 carries most of the current flowing through the relay coil and the LED, so it is usual to choose a transistor that has a higher current rating than TR1; for example, a BFY51.



Project 4:

Moisture Monitor Mk.1



Moisture Monitor Mk.1 assembled on Protobloc

The complete circuit diagram for the Moisture Monitor is shown in Fig.2.3.

This circuit lights one to four light emitting diodes (LEDs) depending on the electrical resistance between probes P1 and P2.

When these probes are pushed into soil, eg a plant pot, the number of LEDs which light depends on the resistance between the probes, which depends on the moisture content of the soil. The circuit is designed so that moist soil lights up more LEDs than dry soil. Moist soil has a lower resistance than dry soil.

Op amps

The circuit is based on four operational amplifiers (op amps), IC1a to IC1d, all contained within one dual-in-line (DIL) integrated circuit package. These op amps are used as comparators rather than voltage amplifiers. A 'ladder' of increasing reference voltages is placed on the non-inverting inputs (marked '+') of the op amps. This is done with the voltage divider action of resistors R1 to R4 and preset potentiometer VR1 (wired as a variable resistor), all connected in series. Each op amp has an LED connected between its output pin and the positive supply line so that when an op amp's output voltage drops to zero, the LED lights.

This occurs when the voltage on the inverting input (marked '–') rises above that on its non-inverting input (marked +). When the probes are in air or in very dry soil, the voltages on all four outputs are high and the LEDs are off. As the resistance between the probes decreases with increasing moisture, the voltage on the common connection to the inverting inputs of the op amps decreases. Then, one after another, LED1, LED2, LED3, and then LED4, light until all four are lit in the wetter soil.

The Protobloc component layout is shown in Fig.2.4.

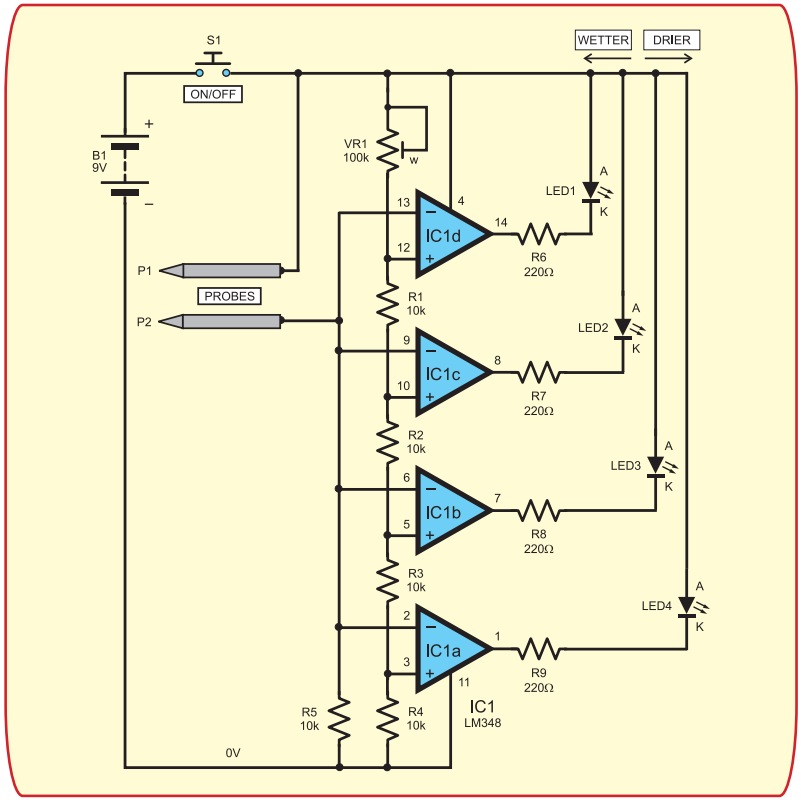


Fig.2.3: Moisture Monitor Mk.1 circuit diagram

Notes

- The preset variable 'resistor', VR1, enables the response of the circuit to be adjusted so that the LEDs light according to the amount of moisture between the probes.

Components needed...

Integrated Circuit, IC1: type LM348 quad operational amplifier (op amp)

Light emitting diodes, LED1 to LED4: any colour, but use 3mm diameter types

Potentiometer, VR1: miniature preset type, value 100kΩ

Pushswitch, S1: push-to-make, release-to-break type

Resistors, R1 to R5 and R6 to R9: values 10kΩ (R1-R5) and 220Ω (R6-R9), all 0.25W carbon film

Battery, B1: 9V and connecting leads

Probes, P1 and P2: *two 50mm or 100mm long nails or similar metal rods to act as probes*

Protobloc and wire links

Basic assembly rules

To ensure trouble-free assembly and a successful working project when using Protobloc, you should try and follow these basic rules

1. 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. Wire links already cut to length with bare ends and bent at right angles are available from some suppliers.

2. 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.

3. 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. You should use snipe nose pliers to straighten any leads that are kinked.

4. Make sure that the arrangement of components and wire links is tidy, with components fitting snugly 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. Your finished assembly should be a tidy work of art!

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

6. 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.

If you don't have access to a soldering iron, then resort to the less satisfactory solution of using leads with crocodile clips on the ends. Some leads, such as the battery connectors, can be prepared by connecting them to a single section of terminal block and anchoring short lengths of 0.6mm diameter wire to the other side of the block, as shown in Fig.1.2, last month.

● Note that the power supply pins of IC1 are not at pins 7 and 14, but pins 4 and 11.

● If you are not sure, use the *Circuit Tester (Part 1, last month)* to identify the anode leads of the LEDs.

● Switch S1 will not be needed for a Protobloc assembly but would be for a permanent circuit.

● Resistors R1, R3 and R9 are mounted vertically on the Protobloc.

● Set up is simple. You need three samples of soil. Say, three plants in pots containing soil or peat with three different amounts of 'wetness': dry, medium and wet. By trial and error make adjustments to VR1 until the LEDs respond as required.

Next Month: A simple Thermostat and a Games Timer

Please Take Note

Part one: page 48, Fig.1.5. The value of the resistor should be 220Ω and not 200Ω as shown.

Component Info

IC1, type LM348 quad op amp.

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 14 opposite pin 1.

Pushswitch, S1

push-to-make, release-to-break

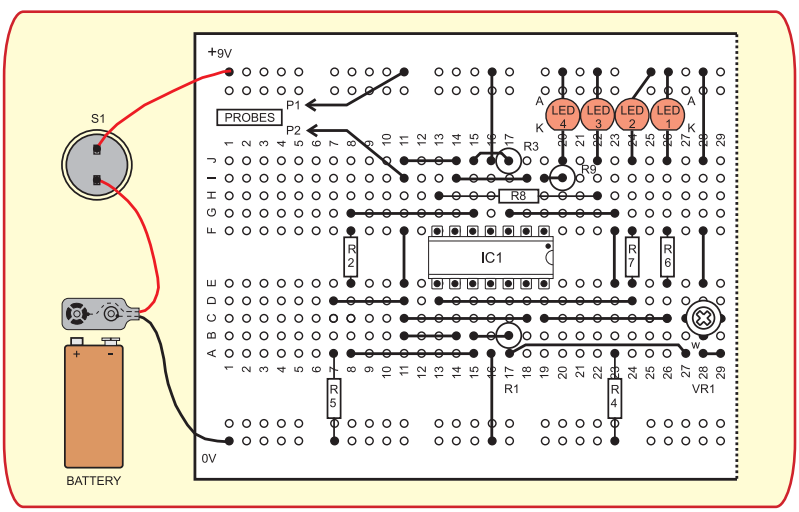


Fig.2.4 Assembly of the Moisture Monitor Mk1 on Protobloc

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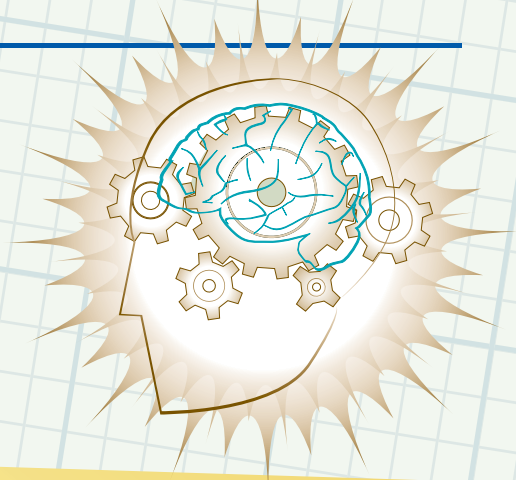
Our regular round-up of readers' own circuits



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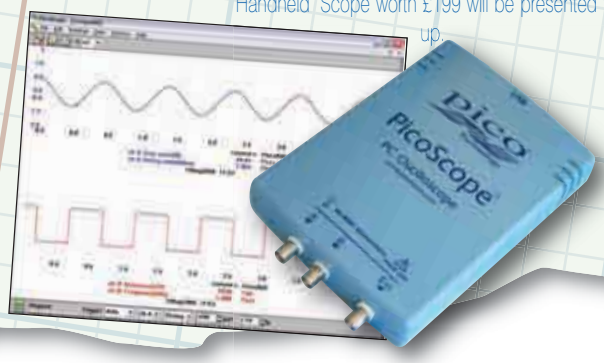

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Emergency Flash – *Blue rider*

THE circuit pictured in Fig.1 simulates an emergency flash that one frequently sees on emergency vehicles. This is a rapid-fire blue flash that alternates between the right and left sides of the vehicle. The Emergency Flash could be used in models, or as a unique LED flasher.

A single oscillator-divider IC1 provides the flash frequency through output Q5 (pin 5). This is split up between IC2b and IC2c by means of the 'switching/inverting' action of IC2a, which receives its timing from IC1 output Q9 (pin 13). Thus, the frequency at IC1 ouput Q5 is alternated between LEDs D2 and D3 via bilateral switches IC2b and IC2c.

Diodes D1, D4, and capacitor C2 serve both to conserve power and to 'sharpen' the flash to make it look more like that of the emergency flash described earlier. D1, D4 and C2 could be omitted.

Any colour LEDs may be used in this circuit. The frequency of the flash may be adjusted by means of R2 and C1. As shown, the circuit draws about 4mA, which would provide two or three weeks' continuous use off AA batteries.

The brightness of the LEDs may be varied by altering the value of C2, but *not* by reducing the value of R4. A lower value for C2 would also conserve power.

For experimentation, IC1 has many other outputs of different frequencies. Further, IC2 has a spare gate, IC2d, which could be used to flash a third LED with any desired output from IC1. If the frequency of the circuit is increased, it could alternately pulse two piezo sounders, instead of LEDs. The piezo sounders would replace the diodes in the circuit.

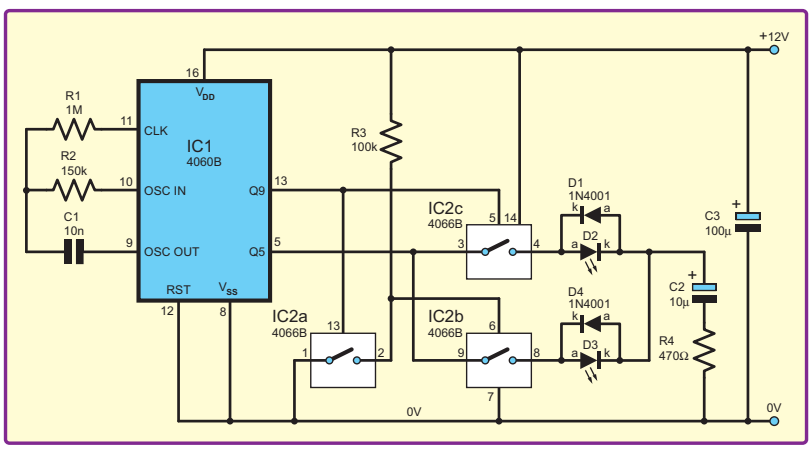

Fig.1. Circuit diagram for the Emergency Flash

Thomas Scarborough, South Africa

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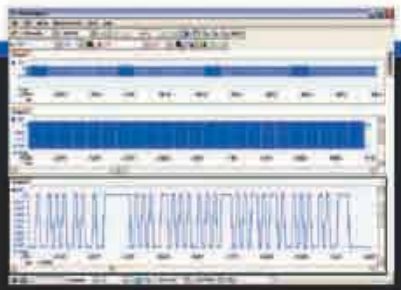

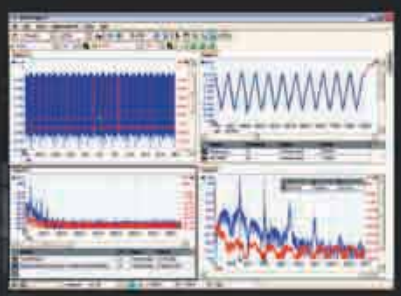

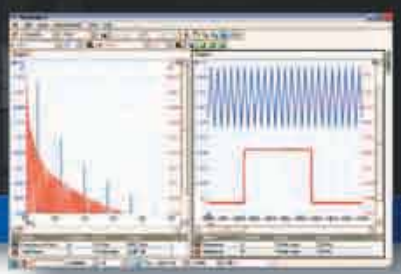

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BY IAN BELL

Switching inductive loads

READER ***Steve Thackery*** emailed *EPE* to take issue with some aspects of our recent *Circuit Surgery* article on Switching Inductive Loads. Steve writes:

I think the Circuit Surgery *article on 'Switching inductive loads' in* EPE *September 2008 was a bit misleading, and three points in particular seem questionable.*

First, the text says 'the freewheeling diode must have sufficient switching speed ... to cope with the energy from the back-EMF'. In fact, 'switching speed' refers to how quickly a diode will switch off when reverse biased. Diodes don't have a switching speed associated with switching on, not least because their equivalent circuit includes a capacitance between the terminals. A slow old 1N400x works just fine as a flywheel diode for load currents up to 1A.

Incidentally, the term 'freewheeling diode' is a new one on me! I've always heard them referred to as a 'flywheel diode'. Is that what you meant to write?

Later on, the text says '... the reverse voltage spike from the inductor ...'. This is a common mistake: the voltage spike from the inductor in the circuit layout shown (Fig 6, page 57 Sept '08) is not a reverse voltage. Without the diode, the collector of the transistor experiences a high positive-going voltage when switching off; ie the same polarity as the normal supply voltage.

Only if the load is 'downstream' of the switching transistor (such as with an inverted PNP *transistor connected to the positive rail) will the induced EMF be negative-going, or a true 'reverse voltage', when the transistor switches off.*

Finally: 'the integral body-drain diode in a power MOSFET can sometimes be used as a freewheeling diode ... The diode conducts when the reverse polarity back-EMF voltage is applied to the device.' Again, the back-EMF is only reverse polarity when the load is downstream of the transistor, and in that case the body-drain diode is in the wrong place (and facing the wrong way) to act as a flywheel. In fact, I can't think of a circuit configuration whereby the integral parasitic diode can be used as a 'flywheel diode', although I'm always keen to learn!

Freewheeling

Steve's comments relate to circuits such as the one shown in Fig.1. The back-EMF from the inductor as it is switched off may result in damage to the semiconductor used as a switch. In Fig.1 this is a bipolar transistor, but it may also be a MOSFET, IGBT (Insulated Gate Bipolar Transistor) or other device. The diode across the inductor conducts when the back-EMF is applied to it, preventing large voltage spikes from damaging the switching device.

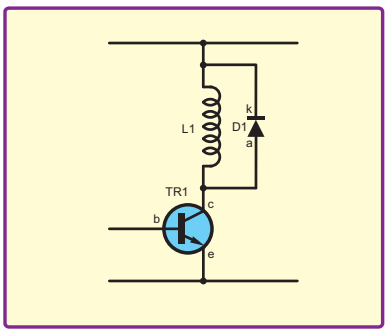

Fig.1. Basic inductive load switching circuit with freewheeling diode

We will return to look at the operation of this and other 'freewheeling' circuits in more detail later in order to respond to Steve's main comments. However, we will start by addressing Steve's point about the name. As was stated in the original article, both freewheeling diode and flyback diode are used to describe a diode employed in this way, but we were interested to see if one term was more widely used than the other.

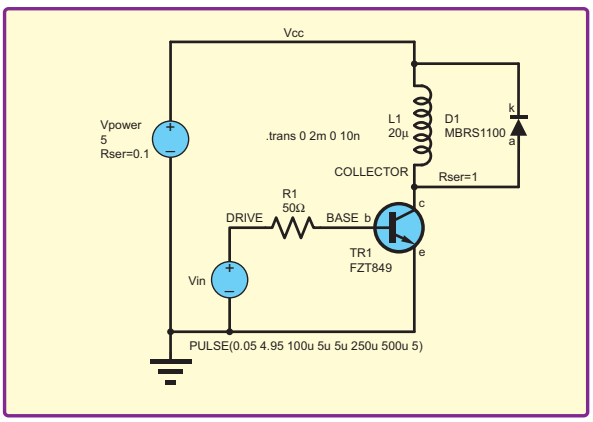

Fig.2. Circuit used to simulate transistor switching inductive load (LTSpice). Results are shown in Fig.3 and Fig.4

A search of the IEEE's (Institute of Electrical and Electronics Engineers (**ieee.org**) online digital library (IEEE Xplore at **ieeexplore.ieee.org**) found 71 documents with the phrase 'freewheeling diode', but only five with the phrase 'flyback diode' out of 1,871,566 documents. This collection contains the world's highest quality technical literature in electrical engineering, computer science, and electronics.

A search of Google Books (**books.google.co.uk**) found 621 books using the phrase 'freewheeling diode' and 180 books containing 'flyback diode'. Google Book Search is a web-based search from Google that searches the full text of books, although they do not seem to reveal the total number of books in their database.

These results show that both terms are widely used, with 'freewheeling diode' apparently being the more popular term. A search of a number of semiconductor manufacturers' literature found typically that both phrases occurred within their datasheets and application notes; that is, companies did not seem to standardise on one term. These quick searches did not indicate if there had been a trend in which term is favoured over time, or if particular terms are favoured in particular industrial sectors; but if anyone knows more we would be interested to hear from them.

This is a component with many names; other terms which seem to have been used for it include: *commutating diode, damper diode, feedback diode, snubber diode, reactive diode, suppressor diode, catch diode*, and there may be more! The generic phrase 'protection diode' might also be used, but in practice this usage is more commonly associated with ESD (electrostatic discharge) protection of integrated circuits and other semiconductor devices, rather than back-EMF protection.

Waveforms

Returning to the circuit in Fig.1, it is instructive to look as some waveforms to see what is happening in the circuit. Fig.2 shows a schematic used for an LTSpice simulation of the circuit in Fig.1. Fig.3 shows the waveforms obtained from the circuit in Fig.2 with the diode removed from the circuit. Fig.4 shows the waveforms obtained from the circuit in Fig.2, with the circuit exactly as shown.

LTSpice, also known as SwCAD III (SwitcherCAD) is an analogue circuit simulator optimised for power switching circuits and available as a free download from Linear Technology (**www.linear.com/designtools/software/switchercad.jsp**)

The circuit uses a Zetex FZT849 transistor (max ratings V_{CEO} = 30V and I_C = 7A) for the switch and a Motorola MBRS1100 Schottky diode for the freewheeling diode. The components chosen are conveniently part of the library provided by Linear Technology with the LTSpice software and were selected in a fairly arbitrary way to give a reasonably typical looking waveform.

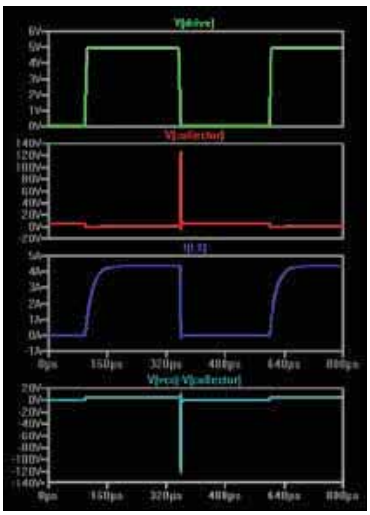

Fig.3. Waveforms for the circuit in Fig.2 with the freewheeling diode removed. Note the approximately 130V spikes caused by the back-EMF from the inductor. The waveform at the bottom is the voltage across the inductor. All other voltages are ground referenced

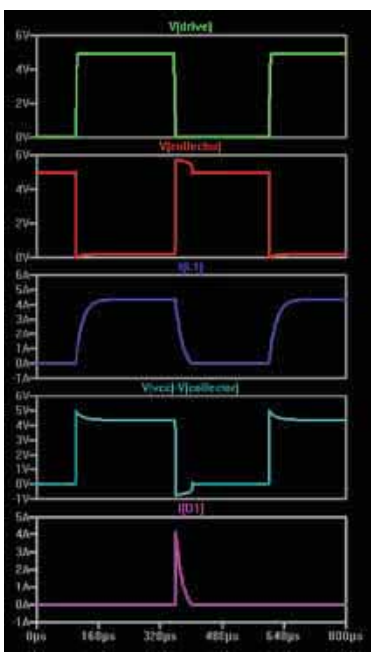

Fig.4. Waveforms for the circuit in Fig.2. Note the large voltage spikes seen in Fig.3 are not present here. The fourth waveform is the voltage across the inductor. All other voltages are ground referenced

The inductor is 20μH with a 1Ω series resistance. The supply voltage and switching drive to the transistor's base are both 5V. The pulse waveform has a rise and fall time of 5μs and a period of 500μs. These values were chosen to give a waveform which was reasonably clear to view, specifically so that the voltage spikes where not so large that you could not also see the switching pulse.

In Fig.3 we see the back-EMF voltage spike produced by the inductor when it is switched off by the transistor. In this case it is around 130V, but can easily be much larger in real applications. As indicated by Steve, the back-EMF appears as a positive voltage spike at the collector of the transistor. If this voltage is large enough it will cause a breakdown to occur in the transistor and a high current will flow, possibly damaging the device. The transistor will be damaged if it is taken outside it Safe Operating Area (SOA). Last month we discussed SOA in the context of linear regulator protection and saw that the SOA is defined in terms of voltage, current and duration of overload.

The fourth waveform in Fig.3 is the voltage across the inductor referenced to the collector (i.e. $V_{VCC} - V_{collector}$).

Here we see the 'normal' operation of the circuit as it switches +5V on and off across the inductor, but on top of this, as the inductor switches off it produces a large reverse voltage (of around –130V).

Fig.4 shows the same circuit, supply and input drive conditions, but with a freewheeling diode in place. When the back-EMF occurs a small overvoltage of less than 1V occurs at the collector – the turn on voltage of the diode. The waveforms also show the diode current, which clearly indicates when it is conducting to suppress the back-EMF spike.

Spikes

The original article contained the phrase 'the reverse voltage spike from the inductor ...', which could also have been written as 'the back-EMF from the inductor ...', In both cases 'back' and 'reverse' refer to the inductor, not the transistor. So 'reverse voltage' was acting as a synonym for 'back-EMF'.

The fact that the previous article states that the freewheeling diode is forward biased by the back-EMF should clearly indicate that it was understood that the resulting voltage at the transistor's collector must be positive with respect to ground, and larger than the supply voltage. However, this was not explicitly stated in the article, and we agree with Steve that some readers may have interpreted 'reverse voltage' as being relative to the transistor rather than the inductor. Hopefully, if anyone did make this mistake, the discussion and waveforms presented this month have made the situation clearer.

Switching

Steve comments on the statement in the previous article which says 'the freewheeling diode must have sufficient switching speed ...'. This statement does not explicitly refer to diode turn-on speed, but was intended to indicate that diode switching characteristics in general can be of importance when using freewheeling diodes. This is expanded on later in the article when it says 'A key problem is that the internal diode does not have a fast enough recovery time ... '. Steve also points out that it is the reverse recovery behaviour which is usually of most importance in diode switching circuits.

The choice of diode for freewheeling in relatively low voltage, low power, and slow circuits is not particularly critical, as long as the basic current handling and power dissipation ratings are not exceeded. For high voltage, high power circuits, particularly those operating at high speeds, freewheeling diode switching characteristics do become important.

If a diode is conducting (forward biased, hence positive forward current) and the applied voltage is switched very rapidly to a reverse bias then, at the instant just after switching, the diode will still contain the charge it was conducting at the time of switch off. Thus, it will continue to conduct even though reverse biased until this charge is removed.

After switch-off, a diode's current decreases at a constant rate, eventually becoming negative and continues until it reaches a peak (called the *peak reverse recovery current*, I_{RM}) before decreasing to the near-zero negative value of normal reverse bias. As a result of the high peak current, the reverse voltage across the diode also peaks before falling to a steady value.

The time from the current going negative until it drops back to 10% of I_{RM} is called the *reverse recovery time*. Other more complex definitions are also used due to the variety of possible recovery behaviours, which may be soft, abrupt or oscillatory.

The higher diode voltage and current during turn-on result in increased diode power dissipation. The fact that a freewheeling diode continues conducting after it should have switched off results in a high transient current in the switching transistor(s). This causes unwanted power dissipation (losses) and may even lead to failures.

In general, shorter recovery times reduce the period during which the transistor is stressed and provide better efficiency and reliability. Thus, in high performance circuits the speed of freewheeling diodes is important and diodes with the right recovery characteristics should be used.

Diodes do have a turn on time (no electronic component is infinitely fast) and it is of importance in a few applications, but it is not specified for every diode. When a diode switches on (into forward bias) the voltage across it may first increase to a peak forward voltage (V_{PF}) before it settles to the normal forward voltage (V_F). The time from V_{PF} to 1.1V_F is the forward recovery time. Like reverse recovery, forward recovery may result in increased losses. Diode switching, both on and off, is discussed in more depth in STMicroelectronics (**st.com**) application note AN601[1], which concerns their high voltage ultra-fast Turboswitch diodes.

MOSFET diodes

Steve also asks about the use of power MOSFET body-drain diodes as freewheeling diodes. The body diodes are an inherent part of the device and are often

depicted as part of the schematic symbol, as shown in Fig.5.

If we use an *N*-channel power MOSFET in place of the BJT in the circuit in Fig.1, then clearly, as Steve points out, the body-drain diode is the wrong way round to act as a freewheeling diode. However, as stated in the previous article, there are circuits in which this diode can be used as a freewheeling diode.

The previous article did not give any details of what these circuits are, but we will have a brief look at a couple now. In all cases these circuits involve multiple transistors, usually in push-pull, bridge, or similar switching configurations.

The first example is the power stage of a typical 3-phase brushless DC motor control, the schematic for which is shown in Fig.6. Typically such systems will use six-step control of the motor and so have quite complex switching arrangements. We will not describe the complete operation, but one example of how freewheeling occurs is as follows.

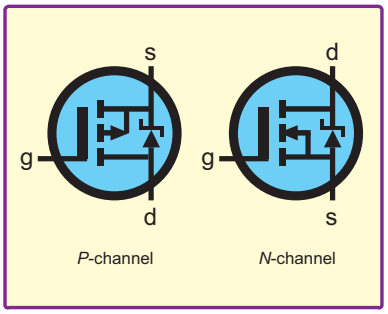

Fig.5. Power MOSFET symbols showing body-drain diode

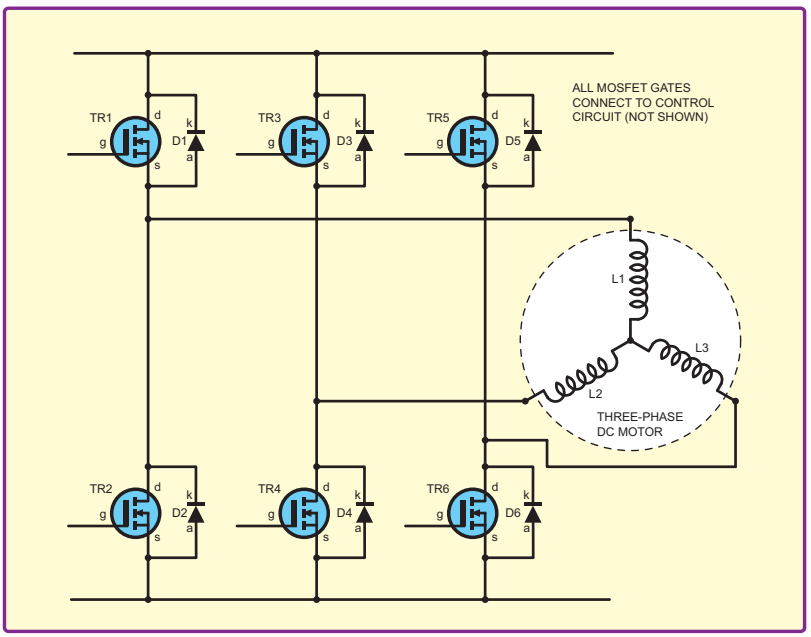

Fig.6. Three-phase brushless DC motor control power stage. This circuit can use MOSFET body diodes as freewheeling diodes

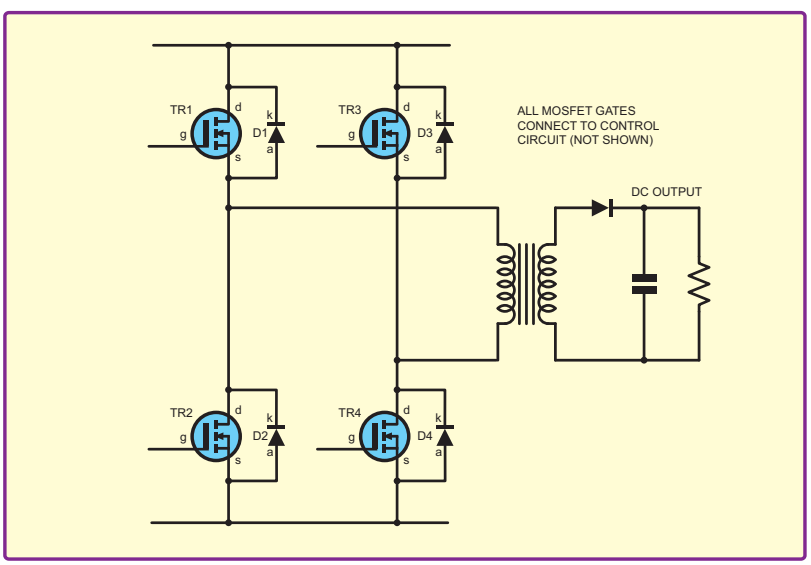

Fig.7. Simplified power stage of a zero-voltage-switching full bridge converter. This circuit can use MOSFET body diodes as freewheeling diodes

Suppose initially that windings L1 and L2 are on and L3 is not. So, MOSFETs TR1 and TR4 are on, the other MOSFETs are off, and the current flows through TR1, L1, L2 and TR4. Then suppose TR1 is turned off. The inductance produces a back-EMF which switches on the body diode of MOSFET TR2 (D2) causing a freewheeling current to flow through the path D2, L1, L2 and TR4. Further details of this circuit can be found in an article by Finocchiaro and Gaito [2].

The article goes on to explain that in applications where power MOSFET body diodes are used as freewheeling diodes, devices which have specifically designed high-speed diodes should be used, such as, in this case the STD5NK53ZD from ST Microelectronics (**st.com**). The devices are trademarked as 'SuperFREDmesh' in which FRED stands for Fast-Recovery Epitaxial Diode. This brings us back to the earlier point that diode speed is important where freewheeling occurs in high performance circuits.

The second example is the power stage of a zero-voltage-switching full bridge DC to DC converter. A simplified schematic for this shown in Fig.7 and it can be seen that this is similar in basic structure to the previous circuit. The reliability of circuits of this type is discussed in the paper by Saro et al [3]. Although this paper is quite old it is relevant because is explicitly mentions freewheeling body diodes. The authors conducted a failure analysis on a statistically significant population of mass produced circuits which showed that the lower body-diode reverse recovery results in lowering the failure rate. Again this supports the argument that diode switching characteristics are important for freewheeling diodes.

The previous article on switching inductive loads was quite brief and mainly concerned with power MOSFET avalanche ruggedness, which sometimes enables freewheeling diodes to be avoided. Steve's email highlighted the need for a more detailed look at this topic and hopefully we have now addressed his concerns.

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[1] STMicroelectronics, *New High Voltage Ultra-Fast Diodes: The Turboswitcht A and B Series,* Application Note AN601, 2004. Available online at **www.st.com/stonline/books/pdf/docs/3604.pdf**

[2] Finocchiaro S., Gaito, A. (STMicroelectronics, Power MOSFET Division), *Fast-diode MOSFETs in current commutation*, EE Times-Asia, June 1-15, 2007. Available online at **www.eetasia.com/ARTICLES/2007JUN/PDF/EEOL_2007JUN01_POW_TA.pdf**. We could not find a datasheet for the STD5NK53ZD mentioned here, but the STD5NK52ZD is probably similar **www.st.com/stonline/products/literature/ds/11465/std5nk52zd.pdf**

[3] Saro, L., Dierberger, K., Redl, R., *High-voltage MOSFET behavior in soft-switching converters: analysis and reliability improvements*, Proceedings of the Twentieth International Telecommunications Energy Conference (INTELEC), 1998, pp. 30-40. Available from **ieeexplore.ieee.org**.

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PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Interfacing PICs to the Internet via Ethernet – Part 3

Last month, we described the nuts and bolts of Microchip's Ethernet offering, the ENC28J60 IC. This month, we take a look at the support software provided free of charge by Microchip and a minimal PIC processor circuit to drive the interface.

Stack software

The Stack software is downloaded as a single 4.5MB .zip file. Inside this file is a Windows Installation program and a text file describing the release. The installation program will, by default, copy all the PIC C source and MPLAB project files to the location **C:\Microchip Solutions**, unless you specify an alternate location. The listing of installed files can be seen in Fig.1.

Besides copying the TCP/IP source code across, the installation program also copies some complete example projects which you can 'build out of the box' and run immediately if you want – assuming that you have suitable hardware of course. We will discuss the hardware configuration issues later.

You should note that to use the MPLAB project files you should have a recent version of MPLAB installed, at least version 8.10. Upgrading will be quite a challenge for those of you on a slow Internet connection because the MPLAB installation has grown to 80MB in size. If you are on a slow connection, it is probably best if you ask a friend with broadband to download the file for you! Once you have the installation program, run it, and accept all the defaults to install it onto your PC.

What gets installed?

Over 12MB worth of data files get installed. That sounds quite intimidating, but most of this data is pre-compiled program files. Only 1.5MB is actual source code for the TCP/IP software. That can sound intimidating too, as many of us are more used to working with files of only a few KB. Fortunately, Microchip have created the software in such a way that most of it can be completely ignored. This code lives in the **Microchip\Include** and **Microchip\TCPIP Stack** sub-directories underneath the main **Microchip Solutions** directory, should you be interested in taking a look.

There are several other directories installed underneath the Microchip Solutions directory, all ending with the word 'App'. These are complete, example applications that can be run 'as is' or used as a basis for your own project. Each folder contains 'C' language source code and project files for use with MPLab. Both the Hi-Tech and Microchip C compilers are supported, although we will be concentrating on the Microchip compiler.

All of these projects reference the single TCP/IP Stack directory for their communications functionality, demonstrating how the stack code is quite generic and can be used without modification by a number of different projects. Microchip have clearly put some effort into making the code as generic and user friendly as possible.

Stack customisation

Although these example applications can be used as supplied, they are designed to be used with specific hardware produced by Microchip – such as the PicDemNet2 board. The programs rely on specific processor I/O pins being used for buttons, LEDs, LCD etc. These boards can be purchased from the likes of Farnell or RS for £50 to £80, but Microchip also provide the full circuit details in application notes on their website, so you can build your own.

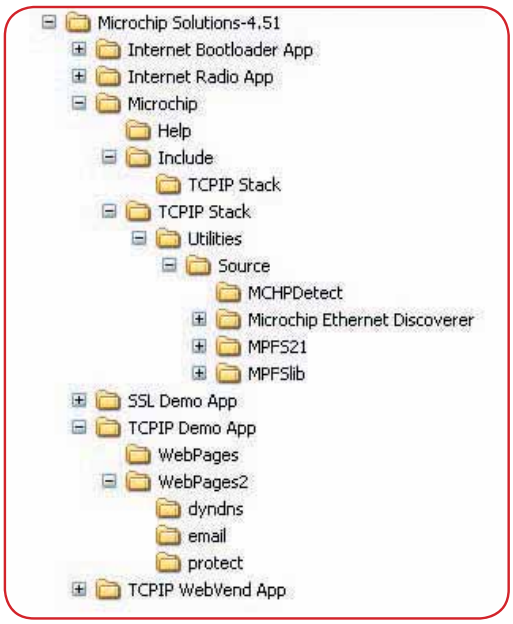

Fig. 1. Installed files

We are going to use a very simple processor circuit based on the Microchip PICDEM Z board, chosen because it is a simple circuit and uses a processor similar to the one we would like to use, the PIC18F2620 (one of the author's favorite processors.)

Control circuit

Our control circuit is shown in Fig.2. As the title of the circuit suggests, we will be using this, in conjunction with the circuit presented last month, to provide a simple, yet complete web server.

Although very simple, there are a few points worth mentioning about the PIC circuit. A 3.3V regulator is employed to provide power to last month's Ethernet interface, as the ENC28J60 cannot work at 5V.

We could, of course, have used one of the low voltage processors (the PIC18LF2620 would have been a drop-in replacement), but these parts are often difficult to obtain from the usual suppliers. It is also useful to demonstrate how it is possible to interface between a 5V processor and the 3V Ethernet chip, since many non-Microchip processors operate at only 5V.

Supply voltage

In fact, very little is required to interface the Ethernet chip to a 5V processor system because the ENC28J60's input pins are tolerant to voltages up to 5V. The only signals that require some attention are the output pins from the ENC28J80 that connect to the microprocessor (the serial data output line and the interrupt pin). When set to a logic '1' these pins are only driven to a voltage of 3.3V, a voltage level that is insufficient to cause a logic '1' to be detected by the processor. So we need some means of converting the signal up to 5V.

The simplest method is to use a 74LS family logic IC. These ICs have inputs that will trigger a logic '1' when the signal on the input reaches about half rail – approximately 2.5V when the chip has a 5V power supply. You can use virtually any non-inverting logic gate; the author used one gate from a 74LS245 octal bus transceiver, simply because that was the first 74LS device that came to hand in the workshop. You could use an AND gate with the two inputs wired together.

Avoid using any home-grown voltage level shifters in this circuit as the serial data line can be very fast, and the ICs will not tolerate any signal degradation. Best to stick with a 74LS IC.

Things can get a lot simpler, of course, if you are able to use a processor that can operate at 3V. Any PIC 'LF' type processor will do, as the 'L' in the name stands for

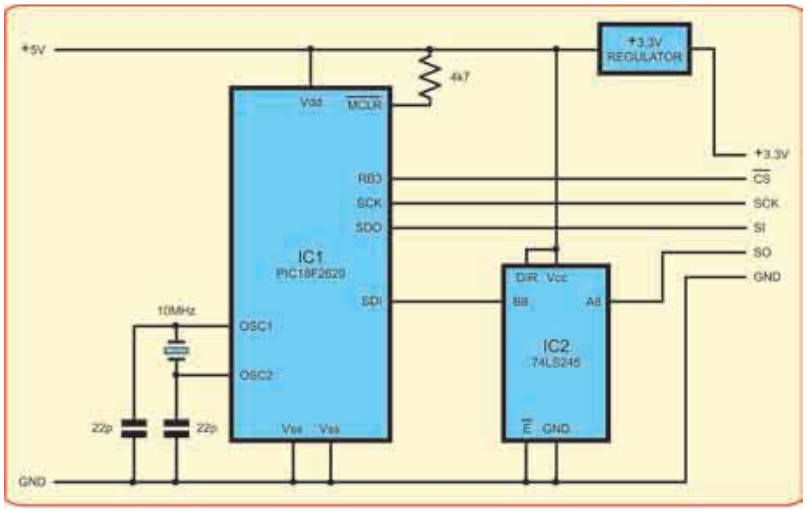

Fig. 2. PIC web server control circuit

low voltage operation, and many of the larger 16F and 18F parts are made with a low voltage option. If you do use an LF part, then you can remove IC2 and wire the SO signal from the Ethernet circuit directly into the processor's SPI input.

Using a 3V processor can have another benefit too. The Microchip stack software supports the use of large external memory ICs such as the SST25VF016B 2M byte flash memory chip, which can provide additional storage space for web pages without you having to write any extra software. These memory chips tend to run at around 3V, so it simplifies the electronics if all the ICs are running at that voltage.

Memory use and customisation

This month we will be using the Flash memory internal to the PIC processor for data storage, but in a later article we will explore the use of additional memory and dig a bit further under the hood of the stack code.

We are using the 'TCPIP Demo' application as the basis of our demonstration project, so if you are looking through the list of installed files you can ignore all the other 'App' subdirectories.

Customisation of the application starts with matching your specific hardware setup to the code. The code has been carefully written so that the changes required are localised to a single file – **hardwareprofile.h**, which you will find in the 'TCPIP Demo App' directory. A single #define at the top of the file:

#define PICDEMZ

causes the software to configure itself for the hardware setup of the PICDEMZ PCB, which our circuit is loosely based on. If you are designing your own circuit you can locate the section that deals with hardware mapping in this file and simply change it to match your design. The PICDEMZ layout is, however, a fairly sensible setup.

The various features of the TCP/IP stack code can also be configured from a single file, called **TCPIPConfig.h** located in the same directory. While you can modify it by hand, Microchip have supplied a Windows program called 'TCPIP Configuration Wizard' to help you. It allows you to step through the various options, and supplies some explanation on what each option does. For the hardware we are using here, which has very limited memory, we have had to cut out many of the stack features to get the code to fit within the PIC18F2620.

Also located in the 'TCPIP Demo App' directory are two sub-directories, **Webpages** and **Webpages2**. These hold the web pages that you create and that will be displayed when someone logs onto your embedded web server. Once created, the web pages must be converted into 'C' source files by running the batch file **Convert WebPages to MPFS.bat**. There is no file storage system on the PIC hardware, so web pages are converted into raw data held as character arrays in 'C' source files. It's rather basic, but then so is our hardware, and the tools created by Microchip make the process very easy to use, so this isn't a big problem.

The final part of configuration is to select your hardware's MAC address and IP address. Typically, the IP address should be one that can exist on your local network; that's quite a complex issue, so we will cover that in detail in the next article. For now, we have specified an IP address of 192.168.62.69 in the **TCPIPConfig.h** file. Feel free to change it to suit your local setup.

Trying it

Having set-up the stack code and made a few tentative modifications to the existing web pages, it's time to try things out. The software is built by double-clicking on the **TCPIP Demo App-C18.mcw** file and selecting **Project/Build All** from the main menu of MPLab. Once built, load the resulting .hex file onto your PIC using your favorite programmer.

The process of selecting the MAC and IP address, and then actually getting the hardware connected to the Internet is quite an involved process if you are not familiar with networking systems, so we will leave that for the next article. For now, you can look at an example embedded web server based on the described hardware at the Internet address: **http://mikehibbett.dyndns.org**

The web page includes a simple feedback comment area, so feel free to leave a message.

The complete source code for this project can be found in the *PicNMix* directory on the Downloads section of the *EPE* website.

Next month, by way of a change, we look at exciting developments in the area of low cost colour graphic displays based on organic LED technology, and how this technology may offer the next step beyond the classic 2 ×16 LCD panel. We will return to the Ethernet project the following month. Until then, enjoy trying to crash the author's embedded PIC web server!

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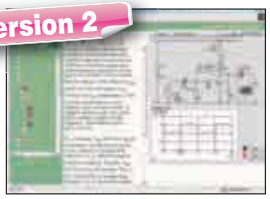

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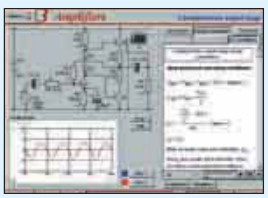

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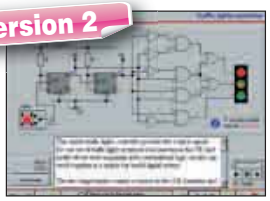

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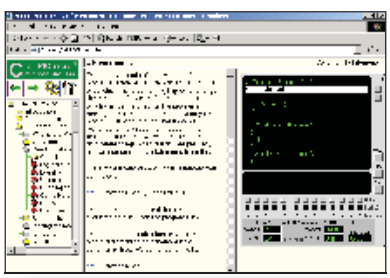

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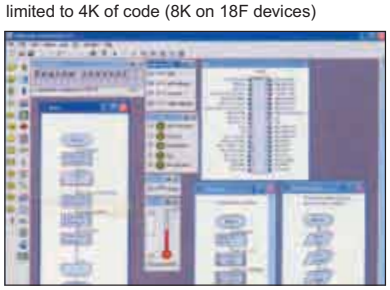

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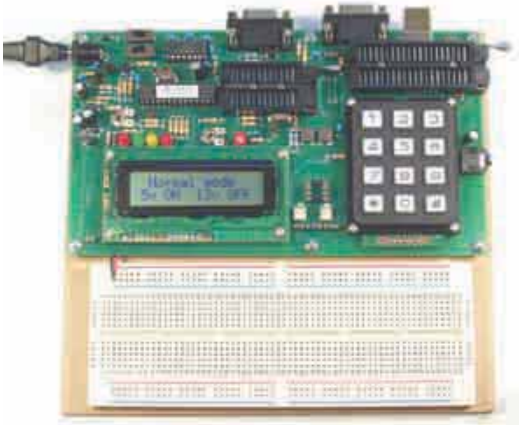

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Web site:- www.brunningsoftware.co.uk

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The first two books and the programmer module are the same as the P928. The third book starts with very simple PC to PIC experiments. We use PC assembler to flash the LEDs on the programmer module and write text to the LCD. Then we learn to use Visual C# on the PC. Flash the LEDs, write text to the LCD, gradually creating more complex routines until a full digital storage oscilloscope is created. (Postage & ins UK £10, Europe £20, rest of world £34).

Mini Training Course £64

This course is based on the Brunning Software PIC slave which connects to a USB socket on your PC. The BSPslave has a programmable PIC which connects to LEDs, a push button, a sounder, a 16 character by 2 line display, and a 12 way i/o socket. We start with a simple programme to flash the LEDs. We pause the programme at critical points while it is running in the PIC, and view the PICs registers, a brilliant way to learn about PICs. We learn to generate sounds, study the timer and interrupts, and write text to the display. We study simple serial communication by sending text between the PIC and the PC. We use the analogue to digital converter and finish with a fully worked project to measure temperatures. Price includes a BSPslave,180 page book, PIC assembler on CD, USB lead and project components (2 thermistors, resistors, capacitors, leads and connector). A perfect course for students and absolute beginners. (Postage & ins UK £5, Europe £10, rest of world £15).

Ordering Information

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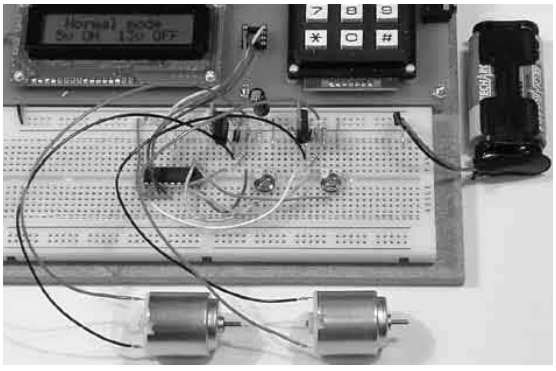

White LED and Motors

Our PIC training system uses a very practical approach. Towards the end of the second book circuits need to be built on the plugboard. The 5 volt supply which is already wired to the plugboard has a current limit setting which ensures that even the most severe wiring errors will not be a fire hazard and are very unlikely to damage PICs or other ICs.

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READOUT

Email: editorial@wimborne.co.uk

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

All letters quoted here have previously been replied to directly

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★ LETTER OF THE MONTH ★

WUBI Linux, and more

Dear EPE,

I followed the recent *Readout* advice of Graham Hardy and installed the WUBI version of Linux and, like James Bickerton, I found problems installing my Epson CX3650 (which is a printer, scanner, copier combo). The Ubuntu OS sometimes finds the printer, but most of the time not. I also had problems installing the scanner. Although I found some sites that show how to install the CX3650, for some reason or another, I was unable to install it.

I also had problems installing Mathworks Matlab 7.1 and MPLAB as well. I did install WINE, as suggested by Graham before trying to install these programs. I managed to install MPLAB, but some parts of PIC-LITECC were not installed. As regards MATLAB, there is software that works like MATLAB that is designed for Linux, but I would like to work with MATLAB as it is an industry standard.

Also, I tried to install XILINX 10.1 to program my Spartan 3 Card, but it did not install. This, though, may be due to having an earlier version installed in Windows!

Like James Bickerton, I immediately fell in love with Ubuntu, especially when I managed to make my PC work like a Macbook with all those extra visual effects and still having the speed expected from a Core2Duo. Although Windows Vista is trying to have the same visual effects, the processing speed is much slower than Ubuntu!

I'd also like to comment on your recent *Super Speed Corrector*. I immediately interested myself in this project as I am trying to build an ECU for an engine for my final year B.Eng degree. I cannot understand how the crank sensor input which might be a square wave (if the pickup sensor is a Hall effect type, or a sinusoidal wave if the pickup sensor is a magnetic type) is going to be detected.

The crank sensor I am using is a magnetic type, so I had to change the sinewave output to a square wave by injecting the sensor's output signal into a high gain op amp circuit that would work between saturation points, thus obtaining the square wave.

I then fed this into a 40106 to obtain better switching. The micro (P18F4455) detects the square wave input and by counting the pulses (I used PIC input RA4 as a counter), the micro then knows when to inject fuel and to spark.

If there are any suggestions about this, especially what type of driver transistors to drive the high-tension coil to use (I am using the IRFZ48N – these are becoming very hot!), I am all ears!

Last but not least, I would like to thank *EPE*. It has been my mentor for many years (I have subscribed since 1995), it has helped me gain practical hands-on experience which is invaluable. At the moment I am strengthening my theory while I study for a degree, but having a degree without practical experience would not make much of a top-notch electronics engineer!

Joseph Attard, via email

Thank you for this, Joseph. We are not able to offer advice on the driver transistors but hope readers can help.

Four-channel AV Selector

Dear EPE,

Referring to the first paragraph on page 15 of the *Four-channel AV Selector* in the August '08 issue, sticking a label on a front panel and covering with clear packaging tape will not give a long-lasting result. This tape denatures, becoming brittle, less transparent and losing adhesion.

I prefer to stick such a label directly to the panel with 3M Spray Mount, the one in the blue aerosol tin. Then a further layer of transparent film (such as for overhead projection) can be applied, or self-adhesive weatherproof (therefore UV-stable) tape.

The trick with the spray adhesive is to allow a short time for slight drying before actually sticking the label or transparency to the substrate, or else the adhesive will itself be non-transparent, might bleed through or not stick properly. Experience determines the correct hold-over time between spraying and sticking, possibly around 30 seconds on a warm day.

When finished, hold the aerosol upside-down out of the window, point downwind and give a short squirt until the sound of the spray changes. This clears adhesive from the nozzle, finishing with just propellant, thus preserving the tin for future use. Although expensive, only small amounts are needed and a tin should last for ages if looked after in this way.

Godfrey Manning G4GLM, Edgware, Middx, by email

Thanks for another useful piece of advice Godfrey.

MSDOS on XP and Vista

Dear EPE,

A few months ago I saw complaints on the *Chat Zone* from the magazine's gurus that MSDOS was unhappily missing from XP and Vista. As I have MSDOS prompts on both my XP laptop and my Vista desktop computers I do not believe it. In both versions click <Start>, then <All programs>, then <Accessories> and there you'll find MSDOS masquerading as 'Command Prompt'. It has also happily been upgraded to cope with long file names.

Alan S. Raistrick, via email

Many thanks for that Alan, I'm sure many will be pleased to know the info.

Unobtainable Components

Dear EPE,

I'm glad you are including articles from *Silicon Chip* magazine – as the electronics industry in the UK appears to be on its knees, I guess there wouldn't be many articles otherwise – but have you considered how we source components?

Jim Rowe has two favourite components for his video articles – the MAX4451ESA and the LM1881 – which are quite hard to find. 'hobbyist' retailer Maplin, for example, has not very much in the way of components. All others seem to charge the earth for postage. Even Aussie Jaycar doesn't appear to stock the kits for Jim Rowe's projects, which I find surprising.

Remember why you have the word 'Everyday' in your title? From the beginner's mag *Everyday Electronics*? Up until a few years ago, the best bit of that magazine still appeared in your magazine – *Shop Talk*. That was there to tell us how to find the parts we need. All we get now is a blithe injunction to see the advertisers. And how many of them are there? Jaycar is about the only one that isn't totally PIC orientated – and they don't stock the parts. So it's all very well importing the articles from Oz, but how about telling us where to get the bits?

Incidentally, when are you going to run Jim Rowe's article on *Component Video to RGB*? There is at least one media player on the market (Emprex EM1) that produces high quality component or composite.

Brian Williams (reader since a schoolboy in the '60s), via email

Publisher Mike Kenward replies:

With the advent of the Internet we have found that it is generally possible to source parts. There is also a Shop Talk *section on the* EPE Chat Zone *which, incidentally, is hardly ever used! The MAX4451 can be obtained direct from Maxim via their website and the LM1881 from Cricklewood Electronics or RS Components. It is sad that there are now so few companies serving the hobbyist with components.*

We did not feel that there was still a demand for the Composite Video to RGB *project – unless readers tell us otherwise.*

Simple Serial Interfacing

Dear EPE,

I thought I would pass on to readers a simple method of PC interfacing that I have found useful using a PC's serial port. The serial port contains a number of lines other than those used for serial communications and very basic I/O can be achieved with these. In my case, I wanted to connect two buttons for 'start' and 'stop' and an LED to indicate the state controlled by software.

I connected two momentary action push-buttons, via current limiting resistors (10k), to the CTS (clear to send) and Ring Indicator lines from a 9V battery. I also connected an LED from the DTR (data terminal ready) line to ground via a current limiting resistor (1.2kΩ). I put a reverse-connected diode across the LED to protect it from reverse bias voltages as the serial port produces plus and minus potentials relative to ground. I then wrote some software in Visual Basic V6 Professional (the version with the MSCom control) to respond to the 'OnComm' events generated by the control.

The code is:

```
Private Sub MSComm1_OnComm()
    Select Case MSComm1.CommEvent
        Case comEvCTS    ' Change in the
CTS line.
            'Turn on external LED
            MSComm1.DTREnable = True
            'put your code in here
        Case comEvRing   ' Change in the
Ring Indicator.
            'Turn off external LED
            MSComm1.DTREnable = False
            'put your code in here
    End Select
End Sub
```

You will need to set and open the correct COM port. You should also be aware that the events are triggered on both button press and release, including any switch bounce. Hope this is useful.

Mark Jiggins MSc MIOA, via email

Thanks Mark, readers who have PCs that still have serial ports could well find your suggestion useful, and also amend the program to get round the switch bounce.

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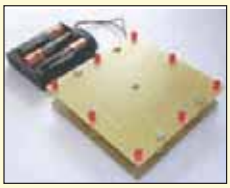

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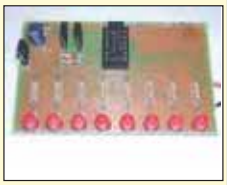

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Net Work

Alan Winstanley

Diagnosing Internet problems is similar to troubleshooting a faulty circuit board, with some simple detective work helping to narrow down the likely cause. By eliminating some obvious factors you can gradually drill down to the root cause of the problem. In fact, I have just used Tracert myself, to help sort out a typical problem with a nearby PC that connects to the Internet via Wi-Fi.

Fishing with Wireshark

On another occasion, I was curious as to why my Belkin router was working overtime, judging by the constantly flickering LEDs (it's always worth keeping half an eye on them), when my network should in theory have been dormant. Checking the router, network activity was going through the roof. The question was how to figure out what the router was doing.

At this point, I started the Wireshark Protocol Analyser, a free download from **www.wireshark.org**. Windows, Linux, Solaris, Mac and other versions are available. It is beyond the scope of *Net Work* to explain this software in any depth, but the following pointers will help get readers started.

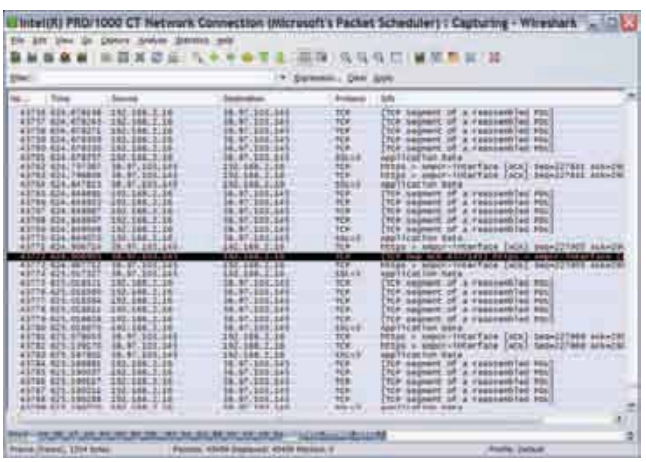
Wireshark is a packet sniffer that helps unravel network traffic and analyse what is happening. It will capture, record and save details for future inspection. You can also copy individual events to the clipboard, such as your router reaching out to a particular IP address.

After starting Wireshark, choose your network adaptor by going Capture/ Interfaces and click the Start button of your network card (in my case, Intel Pro 10/ 100 connection was listed, so click Start there). Prepare for your screen to fill up with data as Wireshark gives you the lowdown on your network activity!

Two columns of IP data are especially useful – *Source* and *Destination*. It is here that you see (maybe for the first time!) a shark's eye view of network traffic. By default, the software analyses raw traffic, resulting in long arrays of source and destination IP addresses being captured.

Recall that your own Windows PC's IP address is usually in the form of 192.168.xx.xx . This will appear in the Wireshark window as a source or destination, depending on direction.

In my own case, I saw that a particular IP address (which I have disguised for privacy reasons) was constantly communicating with my network and was responsible for the traffic. Having grabbed the IP address from Wireshark, a Traceroute revealed the path, actually to a user at Cambridge University. Had someone hacked into my network?



```
C:\Documents and Settings\ARW>tracert 131.xxx.yy.zzz

Tracing route to xxx.yy.phy.cam.ac.uk [131.xxx.yy.zzz]
over a maximum of 30 hops:

  1    <1ms     <1ms     <1ms  192.168.2.1
  2    41ms     41ms     42ms  x.dsl.enta.net
                                [78.12.34.56]
  3    42ms     40ms     40ms  gi4-2.telehouse-
                                east3.dsl.enta.
                                net [78.12.34.56]

[…]
  9    47ms     46ms     48ms  cambridge.site.
                                ja.net[193.60.0.154]
 10    48ms     47ms     47ms  route-cent-3.cam.
                                ac.uk [192.153.213.194]
 11    51ms     48ms     46ms  route-west-3.cam.
                                ac.uk[131.aaa.bb.ccc]
 12    47ms     48ms     47ms  xxx.yy.phy.cam.
                                ac.uk[131.xxx.yy.zzz]

Trace complete.
```

Eye2Eye

I was none the wiser, but Wireshark provided another clue:

```
64248  201.958029   131.xxx.yy.zzz  192.168.2.1  UDP
Source port: eye2eye  Destination port: eye2eye
```

The 'Eye2Eye' took some googling to find the answer, but a forum user said that when a BBC iPlayer is stopped from downloading and then closed, Eye2Eye still transmits data to other computers even though the process is not visible in the Windows Processes tab. So my machine was working in a peer-to-peer link, with my stored BBC TV programmes being shared with a user at Cambridge University.

A little more help is available deep within Wireshark – by going Capture/Options before starting the session, tick the box 'Enable Network Name Resolution' which is unchecked by default. Then click Start.

Having enabled the lookup (or resolution) of IP addresses in this way, Wireshark soon reports something more human-recognisable than an IP:

```
950287    1868.624124          rm12.rbsov.bbc.co.uk
192.168.2.3  UDP Source port: 18040  Destination port: 6970
```

My local network IP address is 192.168.2.3 and the source/ destination address alternates with **rm12.rbsov.bbc.co.uk** – in other words it's my network using Real Player to listen to *BBC* radio over the web.

Wireshark can be used to filter out particular types of traffic and draw graphs of activity (use the Filter dialogue boxes). You can also copy and paste parts of a log or save entire logs for later analysis. Check out the Statistic menu too.

Next month, we'll have a roundup of the latest browser and anti-mailware software. You can email Alan at **alan@epemag.demon.co.uk**.

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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.

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2

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**

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**

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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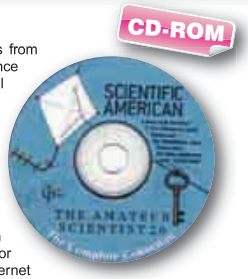

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BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

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**

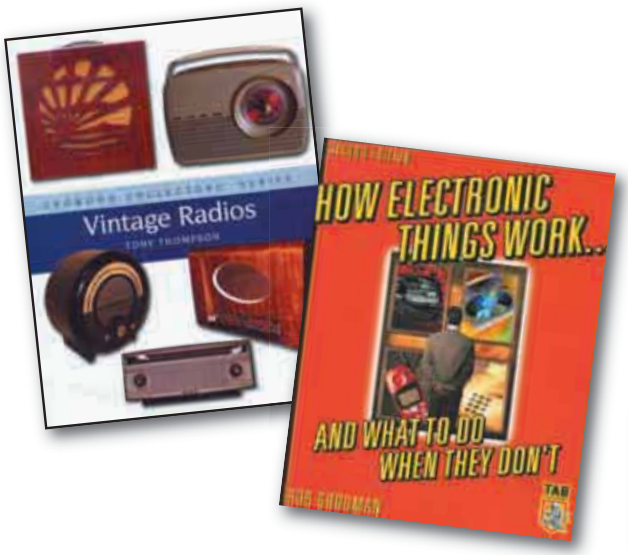
OSCILLOSCOPES – FIFTH EDITION
Ian Hickman

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**

VINTAGE RADIOS
Tony Thompson

Since the 1920s the radio set has been an important part of most people's lives. In the thirties and forties the wireless was an important piece of furniture and a potent symbol of status; beautifully made floor-standing and table-top sets in veneered wood and trendy Bakelite became the focal points of living rooms up and down the land. After the war the emphasis began to change towards portability, and the change from valves to transistors in the 1960s changed the radio into a more useful but far less interesting object.

The book tells the collector, and the armchair wireless enthusiast, everything he or she needs to know about classic radios from the 1920s to the end of the 1960s. All the important makes and models are discussed, and the author also covers buying and selling, care and restoration, and many other topics, including foreign radios and radio-related ephemera.

Illustrated with hundreds of colour photographs, this is the perfect collector's companion to the fascinating topic.

208 pages - hardback **Order code CVR** **£21.95**

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PROJECT BUILDING

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:
Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.
In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** **£5.49**

BUILDING VALVE AMPLIFIERS
Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.
A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.
Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£23.99**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

STARTING ELECTRONICS, THIRD EDITION
KEITH BRINDLEY

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.
A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits. Breadboarding layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£12.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.
There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.
Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£5.45**

THEORY AND REFERENCE

THE EMERGENCE OF BROADCASTING IN BRITAIN
Brian Hennessy

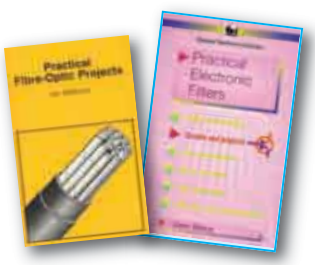
The beginning of any great enterprise should be recorded for posterity. Few knew that the Children's Hour "Uncles", Arthur, Jeff and Caractacus, were also the engineers who struggled by day to develop technical equipment – and would soon become Assistant Controller, Station Director and Organiser of Programmes for the BBC.

This is a very human account, from the dawn of radio to the attainment of a Royal Charter in the late 1920s. It tells of the struggles and frustrations of engineers in developing innovative equipment and of the great John Reith who battled with everyone to bring the BBC from a staff of four up to a Corporation of several hundred.

Brian Hennessy's book also describes the devlopment of broadcasting equipment, the search for premises and looming bankruptcy before ending with the emergence of a firmly established Chartered Corporation – the BBC.

Meticulous research over many years, over a hundred photographs, plans and diagrams as well as interviews with many of those who were there at the time, make this a valuable and original work for those involved in media studies, for radio enthusiasts or simply for those interested in radio and the fascinating story of the emergence of broadcasting.

436 pages **Order code EBB** **£26.00**



PRACTICAL ELECTRONIC FILTERS
Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

188 pages **Order code BP299** **£5.45**

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NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photocopies of articles are available if required – see the Back Issues page for details. WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.

Please check price and availability in the latest issue. A large number of older boards are listed on, and can be ordered from, our website.

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★ RFID Security Module	628	£7.14
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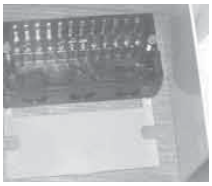

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Published on approximately the second Thursday of each month by Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Printed in England by Apple Web Offset Ltd., Warrington, WA1 4RW. Distributed by Seymour, 86 Newman St., London W1T 3EX. Subscriptions INLAND: £19.95 (6 months); £37.90 (12 months); £70.50 (2 years). OVERSEAS: standard air service, £23.00 (6 months); £44.00 (12 months); £83.00 (2 years). Express airmail, £32.00 (6 months); £62.00 (12 months); £119.00 (2 years). Payments payable to "Everyday Practical Electronics", Subs Dept, Wimborne Publishing Ltd. Email: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

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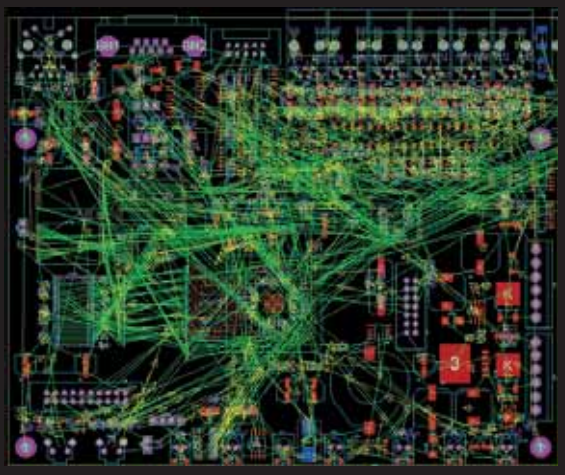

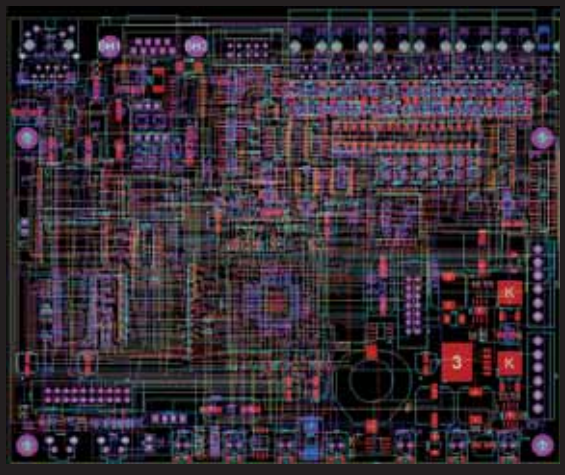

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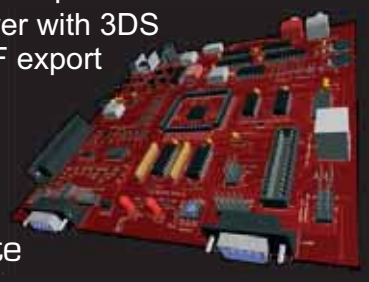

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