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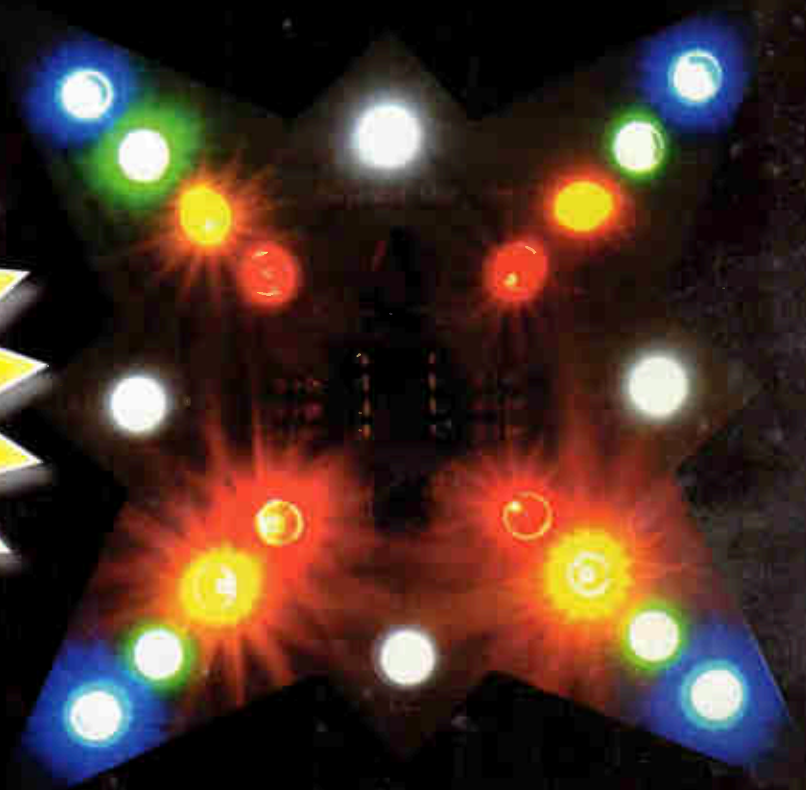

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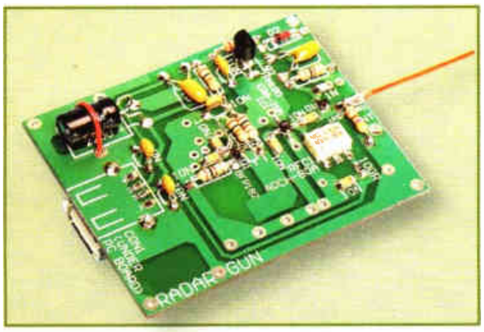

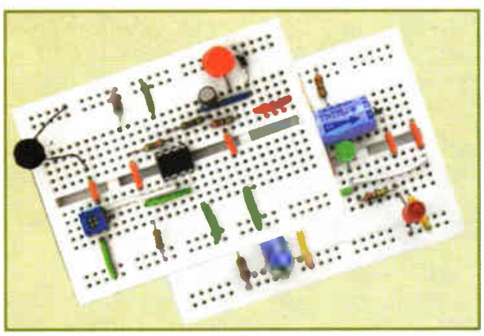

Projects and Circuits

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Our January 2009 issue will be published on Thursday 11 December 2008, see page 72 for details.


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EVERYDAY PRACTICAL ELECTRONICS
FEATURED KITS

December '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

STARSHIP ENTERPRISE DOOR SOUND EMULATOR

KC-5423 £11.75 plus postage & packing

This easy to build kit emulates the unique noise made when the cabin doors on the Starship Enterprise open & close. The 'shut' noise is also duplicated. The sound emulator can be triggered by switch contacts (normally open) which means you can use a reed magnet switch, IR beam or PIR detector to trigger the unit. Kit includes PCB with overlay, case & all electronic components with clear English instructions.

- Requires 9-12VDC power

* As published in EPE Magazine June 2008

IR REMOTE EXTENDER MKII KIT

KC-5432 £7.25 plus postage & packing

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

* As published in EPE Magazine August 2008

VOLTAGE MONITOR KIT

KC-5424 £6.00 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features a 10 LED bar graph that lights the LEDS in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges complete with a fast response time, high input impedance & auto dimming for night time driving.

- Kit includes PCB with overlay, LED bar graph & all electronic components.
- Requires 12VDC power
- Recommended box: UB5 HB-6015

* As published in EPE Magazine June 2008

AC/DC CURRENT CLAMP METER KIT FOR DMM'S

KC-5368 £8.75 plus postage & packing

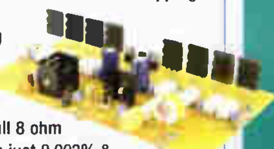
It uses a simple hall effect sensor & iron ring core set up, & connects to your digital multimeter. It will measure AC & DC current & has a calibration dial to allow for any magnetising of the core. Much cheaper than pre-built units.

- Kit supplied with PCB, clamp, case with silk screened front panel & all electronic components.

* As published in EPE Magazine January 2006

STUDIO 350 HIGH POWER AMPLIFIER KIT

KC-5372 £55.95 plus postage & packing



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

* As published in EPE October 2006

RADAR SPEED GUN MK2

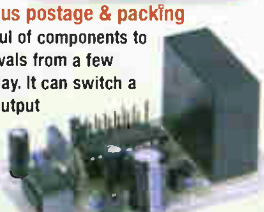
KC-5441 £29.00 plus postage & packing

If you're into any kind of racing like cars, bikes, boats or even the horses, this kit is for you! It reads speed in km/h or mph up to 250 km/h or 155 mph. The electronics are mounted in the supplied Jiffy box & the radar gun assembly can be made simply with two coffee tins fitted end-to-end. The circuit needs 12VDC at only 130mA, so you can use a small SLA or rechargeable battery pack. Kit includes PCB & all specified components.

*As published in EPE Magazine December 2008

THE FLEXITIMER KIT

KA-1732 £5.95 plus postage & packing



This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices & can be powered by a battery or mains plug pack.

- The kit includes PCB & all components.

* As published in EPE Magazine September 2007

SOLAR ECO-HOUSE KIT

KJ-8924 £7.25 plus postage & packing

This instructive kit will help develop manual dexterity & teach the fundamentals of electric circuits & solar power. The house is fun to build & will introduce your child to the eco-friendly concepts in a deceptively entertaining way. The house has its own solar panel & a windmill to supply free power to the lighting & sound circuits, or it can run from ordinary batteries. Simple & safe for ages 8+. Requires 2 x AA batteries for non-solar operation.

* Approximately 160mm square

Deluxe Solar Educational Kit

KJ-6694 £7.95 plus postage & packing

A series of do-it-yourself experiments to acquire the basic knowledge of solar energy. Supplied with a solar panel which incorporates 3 x 1.5V cells for series or parallel connection.

The kit comes complete with:

- Solar cell module • Musical unit
- Small DC motor • Wire with motor clips
- 4 jumper wires • Nuts & plastic spanner
- Colour spinner discs • Plastic lamp
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VOL. 37 No. 12 DECEMBER 2008

Congratulations to the ingenious

One of the most pleasant aspects of working on *EPE* is receiving elegant solutions to circuit and system problems in our regular slot *Ingenuity Unlimited*. It is a constant reminder that one of the core pleasures of electronics is the opportunity for creativity and originality.

So, it is no surprise to learn through correspondence in letters, the online *EPE Chatzone* and *Ingenuity Unlimited* that *EPE* readers are an inquisitive, creative and ingenious community. I am sure that most of what we receive would land on our desks without the encouragement of prizes. After all, part of the enjoyment of creativity and that 'Eureka moment' when a design comes together is sharing one's achievements with like-minded enthusiasts. Nevertheless, we do feel that excellence should be acknowledged and we offer two fantastic prizes, courtesy of our friends at Pico Technology. First prize is a Pico 3206 PC-based oscilloscope worth £799, plus there is a Pico 2105 handheld oscilloscope for the runner up.

This year's winner is Ian Hill from Plymouth, whose Mobile Phone Switch circuit elegantly combined digital and analogue design to produce a simple, but effective circuit enabling virtually any mobile phone to remotely control a relay (Jun 07). Many congratulations Ian, I'm sure your 'scope will encourage you to greater things. Second prize goes to *Ingenuity Unlimited* stalwart – Rev Thomas Scarborough from South Africa. His original idea for an Atmospheric Charge Monitor struck just the right balance between originality, interest and ease of implementation (Aug 07). I would also like to award an honorable mention to Stephen Stopford for his Temperature Drift Monitor (Jul 08) – well done Stephen, keep the designs flowing and maybe this coming year will be a prizewinning one for you.

Remember, not only do we pay for all printed *Ingenuity Unlimited* ideas, but also we aim to award prizes every 20 or so published entries. So, you have a one-in-ten chance of winning a fantastic piece of professional test equipment. Not bad odds, so what are you waiting for – send us your ideas!

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READERS' TECHNICAL ENQUIRIES

Email: techdept@epemag.wimborne.co.uk
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PROJECTS AND CIRCUITS

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

COMPONENT SUPPLIES

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

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The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment, as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; readers should check local laws.

Zoombak and Slingcatcher

The cleverest gadgets are the ones that do something very difficult, but make it look easy. Barry Fox reports

THE Zoombak Personal Locator – launched earlier this year in the USA and now adapted for use in the UK ahead of mainland Europe – uses a built-in GPS chip to check where it is, and an integrated Vodafone cellphone chip and SIM to transmit its location. So anyone worried about losing a car, bike, laptop, dog, child, wife or husband can attach a pager-sized pod, and keep track of where it is.

The Zoombak pod costs £99.99 outright, but needs a £9.99 monthly subscription to make it work and keep it working. After purchase, the owner hides the pod in a car or hangs it round the dog's neck, and goes on-line to activate. The pod then sends its location to Zoombak's control centre. To check the location, the owner goes to Zoombak's website, enters a password and uses Microsoft's Virtual Earth to display a map or satellite view which marks the pod's position.

The owner can also set a personal 'Geofence' or safety zone. This could be the back garden for a dog, and the front drive or company carpark for a car. The Geofence also has time windows, eg all day for the back garden, all night for the front drive and 9 to 5 for an office carpark.

If the Geofence is breached, Zoombak automatically sends the owner an email or phone text message. If the breach is a worry, the owner then has three choices: use a PC to follow the pod's progress live, using Virtual Earth mapping; ask for regular text messages with location details; or phone Zoombak customer service.

The battery lasts around five days, but if the device is permanently fitted to a car it can be kept charged. Zoombak's senior VP Craig Woodward describes the way the device works as 'bread-crumbing' – laying the electronic equivalent of a trail of crumbs through a forest. He sees Zoomback as 'a new product category for the trade' which 'will make a great alternative gift for Christmas'.

The system can also alert when the pod returns to its safety zone. So other uses include checking that a teenage daughter has safely arrived home after borrowing the family car. Because the device is clearly visible on a dog, it is good for lost dogs only. Dog thieves will just remove the pod.

So far the system only works in the UK where there is Vodafone cover; there is no roaming across the Channel. Browse **www.zoombak.co.uk** for more details.

Slingcatcher

Sling Media is best known for the Slingbox, a device which takes TV signals from a receiver – such as a Sky box – and sends it over a secure Internet link for display on a PC anywhere in the world. So a traveller can use a receiver in London to watch British TV on a laptop in a hotel room in Hong Kong – and even change channels back home by remote control.

Sling's new Slingcatcher (cost £200) takes video from the screen of a PC and sends it to a TV set across the room, or across the world. As a bonus, Slingcatcher punches holes through the recording and viewing restrictions on Catchup TV systems such as the BBC iPlayer or SkyPlayer.

Slingcatcher works in two ways; as a standalone box, or in conjunction with an existing Slingbox. When used with a Slingbox, Slingcatcher grabs the Slingbox network signal and converts it into a conventional TV signal for display on any TV set. The network can be in a home or over the Internet.

So, Slingcatcher can take TV signals from the living room and show them on a bedroom TV, or capture the living room signals anywhere in the world and show them on a local TV. Slingcatcher comes with a remote, which sends control signals back through the network, to switch or pause the source TV.

When software called Sling Projector is installed on a networked PC, Slingcatcher works on its own to grab video as it is displayed on the PC screen and stream it to a TV screen. The software can format the signal coming from the PC so that only the video window is shown on the TV screen, with playback buttons and tool bars removed. So iPlayer or SkyPlayer, and social sites like YouTube, can now be watched full screen on TV, instead of in a window on a PC screen.

Pre-launch demonstrations in London of the BBC motoring programme *Top Gear* from iPlayer, upscaled to 720p, filled a 42-inch screen with slightly soft but otherwise very acceptable pictures. Sling's Stuart Collingwood confirms that 'in essence' there is nothing to stop someone connecting Slingcatcher's AV outputs to a DVD or other recorder, and capturing the video signal that is coming from the PC. This lets the user record Catchup TV programmes, even though they are protected by Digital Rights Management, which prevents permanent capture on a PC and limits viewing life, eg to seven days after transmission. "We are not breaking DRM" says Collingwood. "And we don't re-broadcast. It's a point-to-point service". Browse **www.slingmedia.com/uk**.

Which lead is which?

Faced with a spaghetti jungle of audio, video, phone, data and aerial cables, with no reliable colour coding and no way to find out which ones end where? Clipping tester probes to the cores and screens usually ends in tears of frustration.

British company Vision Products has a simple, neat answer. The DC Tester Pro is a DC transmitter, like a small torch, with a socket which takes a couple of dozen plug-in connectors that fit most common cable plugs and sockets. A separate small bleeper-buzzer has a similar socket. Put the transmitter at one end of a cable and the buzzer at the other, and a high pitched sound (loud enough to hear from a distance) confirms a straight though connection. An LED on the transmitter warns if there is a short circuit on the line.

For the £40 that the kit costs, it would be hard to buy all the neatly matching back-to-back F-type, BNC, IEC, RH45, RJ11 and RCA connectors – assuming you can find somewhere that sells them.

The instructions could be better though. It's counter-intuitive to do as the flimsy booklet fails to advise, and push screw-threaded connectors into non-threaded sockets.

For more info contact Vision Products (Europe) Ltd, Dept EPE, Unit 1 Redbourne Park, Liliput Road, Northampton NN4 7DT. Tel: 0845 017 1010. Web: **www.vision-products.co.uk**

WaveAce Oscilloscopes

The LeCroy Corporation has introduced the WaveAce series of digital oscilloscopes that expands its line of portable, affordable and easy-to-use oscilloscopes in the 60MHz to 300MHz range. The WaveAce is said to improve troubleshooting and shorten debug time by providing unique features such as long memory, colour display, extensive measurement capabilities and advanced triggering. A streamlined, time-saving user interface provides quick access to all important controls.

With its USB host and device ports, the WaveAce easily connects to a memory stick, PC or printer. The variety of standard acquisition modes and advanced triggers simplifies capturing even the most complex waveforms, making the WaveAce a valuable tool for designing, debuging and troubleshooting.

With a maximum sample rate of 2GS/s and up to 18kpts memory, the WaveAce is claimed to be a performance leader in this class of portable oscilloscopes. The long memory allows users to capture full sample rate acquisitions that are four to six times longer than the main competition, improving how a user can understand and analyse waveforms.

The high performance and large feature set of the WaveAce is controlled by an intuitive user interface with 11 different languages and streamlined front panel. All important controls and menus are accessed from the front panel with a single button press. All positions and offsets can be reset by simply pressing the knob; pressing the V/Div knob will switch between fixed and variable gain; and pressing the T/div knob will toggle between zoom modes. Buttons on the front panel that open and close menus or switch modes are backlit to let the user know exactly in what mode the WaveAce is operating.

Documenting results and saving screenshots, waveforms and setups is easy. Internal storage can hold up to 20 waveforms and 20 setups. Mass storage can be done by connecting a USB memory device directly to the front panel of the oscilloscope.

The rear panel USB port allows for direct printer connection or connection to a PC for control with a software utility called *EasyScope*. This enables remote control through a virtual front panel and also provides an easy method for saving waveforms and screenshots directly to a PC.

For more information browse **www.lecroy.co.uk**.

OPPORTUNITY FOR LUCKY SCHOOLCHILDREN

Lucky primary school children in Warwickshire will belong to one of only four schools throughout the world who will be able to talk live to astronauts based on the International Space Station. Children from Budbrooke School near Warwick will have a ten-minute slot to be able to put their questions by radio link to an astronaut who is orbiting more than 200 miles above the earth.

The idea for the link-up with space came from the school's Imagineering Club – a National Grid-sponsored project to get young children interested in science and engineering. National Grid employee Ciaran Morgan, whose son is a pupil at the school, will be using his amateur radio expertise to help set up the link.

The children will be talking to Richard Garriott who is only the sixth private citizen to conduct a mission on the space station. Richard, who is the son of Owen Garriott, a NASA astronaut in the 1970s, wants to inspire interest in space and space exploration. His father, who was a keen radio amateur, began the first-ever conversations between astronauts and radio amateurs on earth. Jeremy Curtis from the British National Space Centre, which was responsible for setting up activities for Richard Garriott's UK education programme, said: "We were delighted to recommend Budbrooke School as the ideal school for this exciting link-up."

For further information about Richard Garriott, his mission on the International Space Station and photographs, see his website at ***www.richardinspace.com****. For further information about the Imagineering Foundation and the clubs that are run in schools by volunteer engineers please visit* ***www.imagineeringweb.co.uk.***

The British National Space Centre (BNSC) is at the heart of UK efforts to explore and exploit space. BNSC is a partnership of seven government departments, two research councils, the Met Office and the Technology Strategy Board. It coordinates UK civil space activities and represents the UK at the European Space Agency. For more information, visit ***www.bnsc.gov.uk****.*

Bletchley Park Winter Lectures

Bletchley Park Trust announced a fascinating series of lectures for the winter season through to April 2009. All the lectures will be held in Bletchley Park Mansion, which is steeped in history and provides an atmospheric setting.

Thursday, 8 January 2009 – *Code and Cypher Machines* by John Alexander. A well known collector of code and cypher machines, John will be talking about some of the machines he has come across.

Thursday, 12 February 2009 – *Personality Clashes and Power Struggles in the Early History of Radar* by Phil Judkin. Philip is a leading member of the Defence Electronics Group and is an authority on World War Two electronic warfare. His lecture will present a human aspect of radar use.

Thursday, 12 March 2009 – *General Anders and Demobilisation of the Polish 2nd Corps* by Michael Hope. Michael has a passionate interest in World War Two Polish military matters and has researched and written about many aspects of Polish Second World War history.

Thursday, 9 April 2009 – *Bletchley Park and the Double Cross Agents of World War Two* by Peter Wescombe. Peter is a founder member of the Bletchley Park Trust who has researched many aspects of the Bletchley Park story.

Lectures start at 7.30pm and the mansion is open from 6.30pm. The ticket price includes a glass of wine, orange juice or coffee after the lecture. Admission charges: single lecture – £10.00. Advance booking is strongly advised, please contact Victoria Pettier on 01908 640404 or email **info@bletchleypark.org.uk**.

Build Your Own Radar Speed Gun –

If you're into any kind of racing – cars, bikes, boats or even horses – then this project is for you. It's a microwave Doppler speed radar system, similar to the expensive gear used by traffic police, only much cheaper. It can read directly in km/h or mph for speeds up to 250km/h.

MOST OF US ARE familiar with the radar speed guns used by traffic police to detect speeding motorists. If you've been caught speeding yourself and have had to pay a hefty fine, you probably don't want to know any more about them. But if you're a car or bike racing enthusiast, you may well have wanted one of them yourself, so you could measure the speed of cars or bikes.

In these two articles (part two, next month) we're going to show you how to build a Radar Speed Gun of your own – for much less than the cost of a professional unit. It can measure the speed of cars, bikes, horses, runners or even boats with a bit of ingenuity. It's compact and lightweight, can read directly in either km/h (kilometres/hour) or mph (miles per hour), and operates from 12V DC. There's also a hold switch to enable you to freeze the reading.

The system is in two parts. There is a microwave head unit, which is in a small shielded box. It is mounted on the underside of a cylindrical antenna housing made from two 500g coffee cans joined end-to-end, to form the radar gun barrel assembly. This is linked by a cable to a counter/display unit housed in a UB1 type/size plastic box.

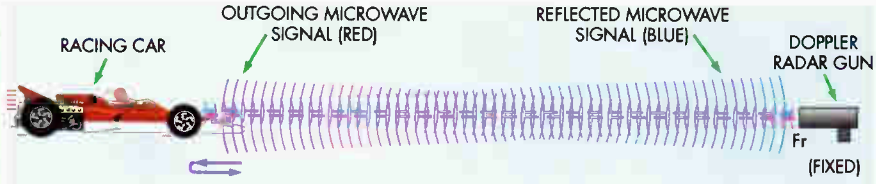
Part 1

By JIM ROWE

How it works

First of all, to get a good understanding of the basic principles of Doppler speed radar, please read the explanation and look at the diagram

How Doppler Speed Radar Works



Speed = v (metres/sec) c = speed of EM radiation, 2.9979246×10^8 m/s $Fo = 2.45 \times 10^9$ Hz

When $v << c$: Returning Frequency $Fr = Fo + (2 . v . Fo/c)$

Doppler Frequency $Fd = Fr - Fo = Fo - (Fo + (2 . v . Fo)/c)$

$= (2 . v . Fo)/c$

$= v . (2 . Fo)/c$

$= (v . 16.34)$ Hz

Note: This assumes vehicle is moving directly towards (or away from) Radar Gun – i.e., on axis.

If vehicle is instead moving at an angle of φ to the Radar Gun's axis, then the Doppler Frequency is given by $Fd = (v. 16.34 . \cos\varphi)$ Hz

Fig.1: the basic principle behind a Doppler radar speed gun.

When an ambulance, fire engine or police car is speeding towards you with its siren going, the frequency (or pitch) of the siren sounds higher than its actual frequency. That's because as the vehicle is moving towards you, it tends to 'catch up' with the sound waves – effectively compressing them. Then, when the vehicle is speeding away from you, the frequency of the siren sounds lower than its actual frequency, because the movement of the vehicle is now effectively stretching the sound waves.

This is the 'Doppler effect', named after Austrian physicist Christian Doppler, who first explained it around 1842.

This principle is used to measure the speed of cars, bikes, boats and other vehicles with Doppler speed radars, such as those used by traffic police.

The basic idea is shown in the diagram of Fig.1. The radar gun is fixed in position and transmits a narrow beam of microwave radiation (with frequency F_O) towards the moving vehicle. This outgoing radiation propagates towards the vehicle at the normal speed of electromagnetic (EM) radiation in air – at 299,792,458m/s (metres per second); ie, the same as the speed of light (c).

Because the vehicle is moving towards the radar gun, the effective frequency of the microwave beam it 'sees' is a little higher than F_O. In fact, it's actually $F_O + (F_O . v)/c$ where 'v' is the vehicle speed. This is the frequency of the microwave signal reflected from the vehicle, back towards the radar gun.

When this reflected signal is detected by the microwave gun, its frequency is higher again by the same amount (because it is being effectively transmitted by the moving vehicle). As a result, the frequency of the reflected microwave signal returning to the radar gun is given by:

$$F_r = F_O + 2(F_O . v)/c$$

In the radar gun, the reflected signal is heterodyned with the outgoing microwave signal, which generates the difference frequency between the two. This difference frequency is given by:

$$\begin{aligned} F_d &= F_O - [F_O + 2(F_O . v)/c] \\ &= 2(F_O . v) / c \\ &= v(2F_O / c) \end{aligned}$$

This is the Doppler frequency, and it is directly proportional to the vehicle speed. For example, if we use a microwave frequency of 2.45GHz, the Doppler frequency turns out to be 16.34 times the vehicle speed in metres/second. So, if the vehicle is travelling at 60km/h, which is 16.6m/s, the Doppler frequency will be close to 271Hz.

If the vehicle is moving away from the radar gun instead of towards it, the reflected microwave signal returning to the radar gun has a frequency which is lower than the outgoing frequency by exactly the same amount. So when the two are heterodyned together in the radar gun as before, the Doppler frequency is exactly the same.

The radar gun is therefore able to measure the speed of the vehicle quite accurately by feeding the Doppler frequency to a counter. This counter can be made to indicate the speed directly in km/h (or mph) by adjusting its timebase or gating time to allow for the scaling factor of $2F_O / c$.

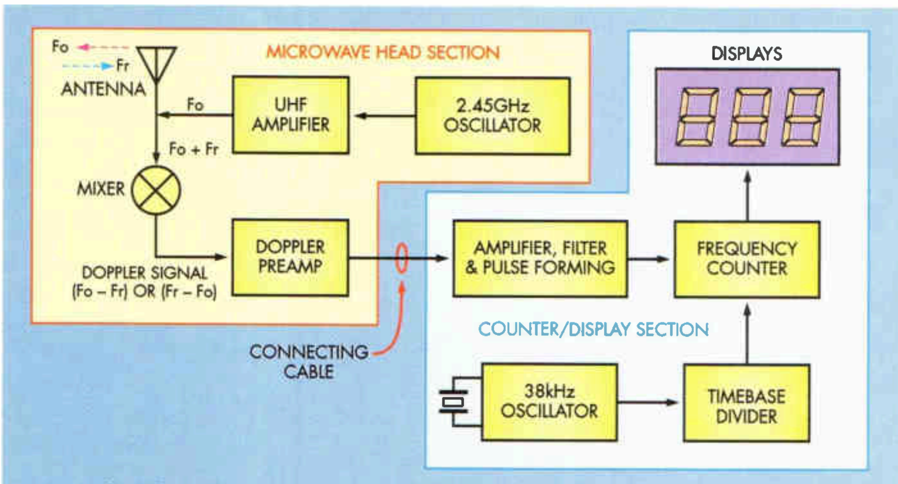


Fig.2: this diagram shows the circuit blocks used in the Radar Speed Gun. It consists of two main sections: a microwave head section and a counter/display section.

in the accompanying panel. Once you have that under your belt, you will be ready to follow the block diagram of the project itself, shown in Fig.2.

As you can see, the microwave head section has a small UHF oscillator to generate a low-power continuous microwave signal with a frequency of 2.45GHz (2450MHz). This signal is then passed through a UHF amplifier, to achieve a power level which although low, is sufficient to give the unit a good Doppler range and sensitivity.

The amplified 2.45GHz signal (F_o) is then fed to the microwave antenna, which is just a small 1/4-wave 'whip' inside the coffee-can gun barrel.

The 2.45GHz energy radiated from the antenna is then directed out of the open end of the barrel, towards the subject we wish to measure. Microwave energy reflected back from the 'target' returns down the barrel to the antenna and is received as a signal with a frequency F_r, which will be higher or lower than the outgoing 2.45GHz signal, depending on whether the vehicle is moving towards the radar gun or away from it.

This received signal F_r is then fed into a mixer along with the original signal F_o. As a result, the mixer's output contains the difference between F_r and F_o (ie, either $F_o - F_r$ or $F_r - F_o$). This is the Doppler signal, which is quite low in amplitude, but its frequency is directly proportional to the vehicle's speed. It is then passed through a simple audio amplifier stage (the Doppler preamp) to boost its level before sending it down the cable to the counter/display section.

Counter display

In the counter/display section, the Doppler signal is amplified and passed through an LP (low-pass) filter and then converted into a train of narrow pulses to give it a digital waveform. Its frequency is then measured and displayed on the 3-digit LED readout.

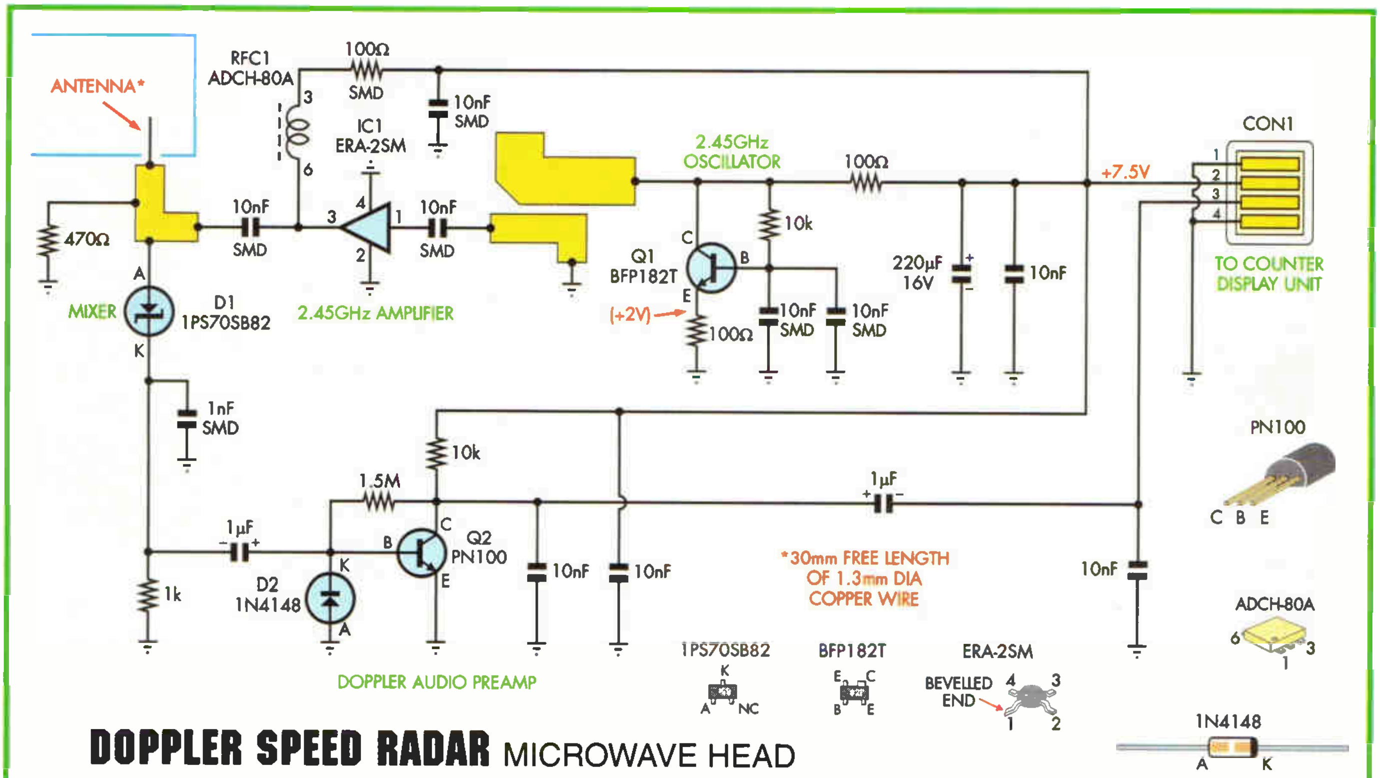


Fig.3: the microwave head section uses a 2.45GHz oscillator based on transistor Q1. This drives a microstrip line, after which the signal is amplified by IC1 and fed to the antenna. The reflected signal is first fed to mixer stage D1 to produce the Doppler signal and this is amplified by transistor Q2 and fed to pin 3 of CON1.

Parts List – Radar Speed Gun

Microwave Head

1 double-sided PC board, code 694 (Head), available from the *EPE PCB Service*, size 51 × 64mm
1 piece of 0.3mm brass sheet, 89 × 76mm, for shield box
2 500g instant coffee tins, 129mm diameter × 173mm long (with one plastic cap, see text)
1 35mm length of 1.25mm diameter copper wire
1 ADCH-80A broadband RF choke (RFC1)
1 PC-mount type-A USB connector, (CON1)

Semiconductors
1 ERA-2SM wideband UHF amplifier (IC1)
1 BFP182T UHF *NPN* transistor, SOT-143 package (Q1)
1 PN100 *NPN* transistor (Q2)
1 1PS70SB82 UHF Schottky diode, SOT-323 package (D1)
1 1N4148 signal diode (D2)

Capacitors
1 220μF 16V radial electrolytic
2 1μF 25V tantalum
4 10nF multilayer monolithic ceramic
5 10nF X7R ceramic, 1206 SMD package
1 1nF COG ceramic, 1206 SMD package

Resistors
(0.25W 1% carbon, unless specified)

1 1.5MΩ	1 470Ω
2 10kΩ	2 100Ω
1 1kΩ	

1 100Ω 0805 SMD package

Counter/Display Unit

1 PC board, code 695 (Display), available from the *EPE PCB Service*, size 84 × 148mm
1 UB1 plastic box (158 × 95 × 53mm)
1 mini rocker switch
1 35 x 53mm piece of red Perspex sheet
4 25mm long M3 tapped spacers
4 6mm long M3 countersink head machine screws
4 6mm long M3 round head machine screws
1 38kHz mini quartz crystal (X1)
1 PC-mount type A USB connector (CON1)
1 PC-mount 3.5mm stereo socket (CON2)
1 PC-mount 2.5mm concentric DC connector (CON3)
4 14-pin DIL IC sockets
4 16-pin DIL IC sockets
1 USB type-A to type-A cable
8 PC pins

Semiconductors
3 FND500 common cathode LED displays (DISP1,DISP2,DISP3)
1 LM324 quad op amp (IC1)
1 4093B quad Schmitt NAND gate (IC2)
1 4027B dual JK flipflop (IC3)
1 4553B 3-decade counter (IC4)
1 4511B BCD to 7-segment decoder (IC5)
1 4069 hex inverter (IC6)
1 4020B 14-stage binary counter (IC7)
1 4073B triple 3-input AND gate (IC8)
3 PN200 *PNP* transistors (Q1,Q2,Q3)
1 PN100 *NPN* transistor (Q4)
1 1N4004 rect. diode (D1)
1 1N4148 signal diode (D2)

Capacitors
1 2200μF 16V radial electrolytic
1 220μF 16V radial electrolytic
2 100μF 16V radial electrolytic
2 47μF 16V radial electrolytic
3 10μF 16V radial electrolytic
6 100nF multilayer monolithic ceramic
1 100nF MKT metallised polyester
2 47nF MKT metallised polyester
1 22nF metallised polyester
1 10nF metallised polyester
1 4.7nF metallised polyester
1 3.3nF metallised polyester
1 2.2nF metallised polyester
2 1nF metallised polyester
1 330pF disc ceramic
2 27pF NPO disc ceramic

Resistors
(0.25W 1% carbon, unless specified)
1 2.2MΩ 0.5W carbon film

1 1MΩ	2 4.7kΩ
1 330kΩ	3 1kΩ
6 100kΩ	7 680Ω
4 47kΩ	1 470Ω
2 22kΩ	1 100Ω
4 10kΩ	2 47Ω
1 6.8kΩ	

1 2kΩ horizontal trimpot (VR1)

Where To Buy A Kit

This project was sponsored by Jaycar Electronics and they own the design copyright. Kits are available from Jaycar (see ad), less, of course, the coffee cans.

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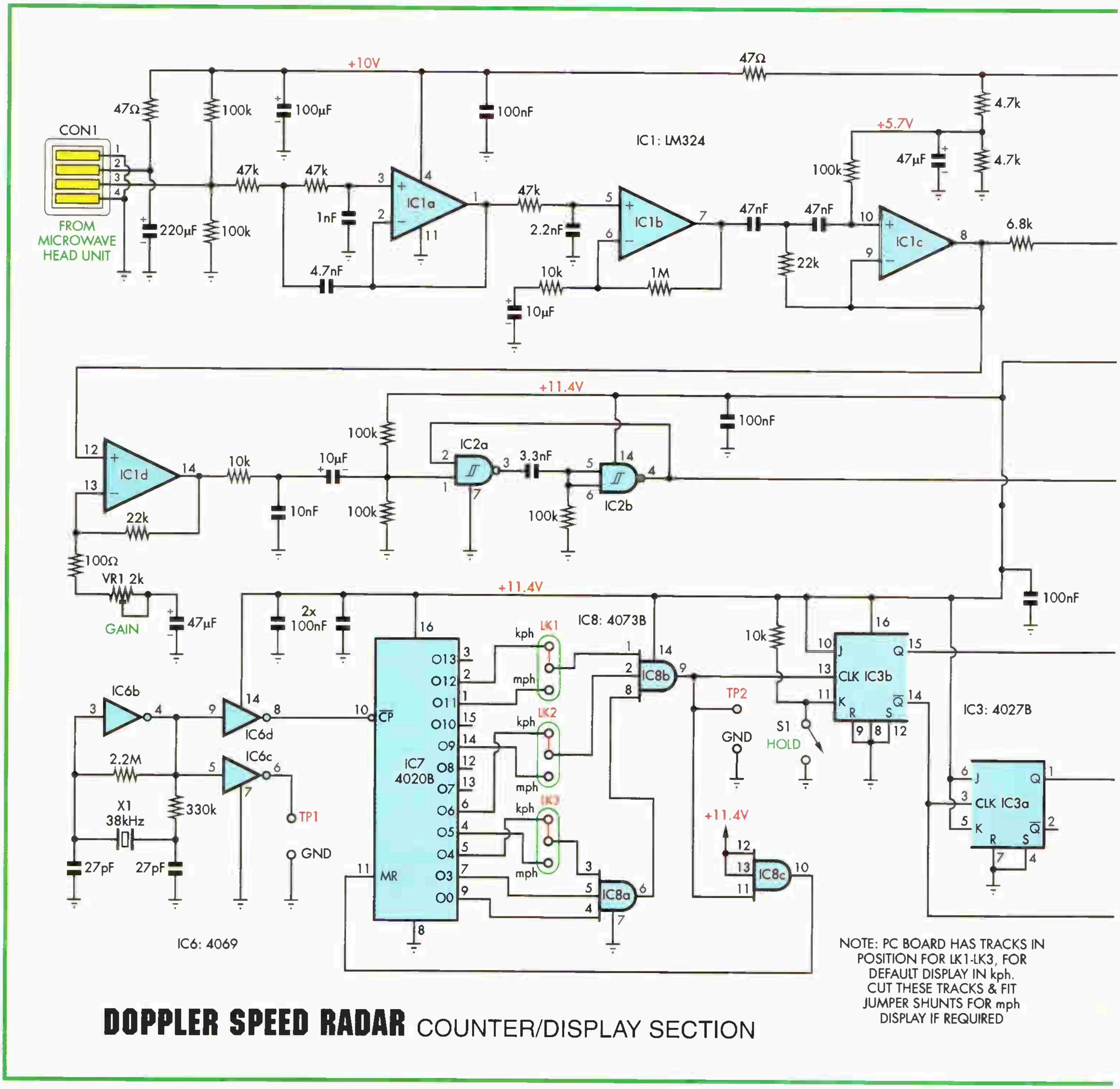
The counter's gating signal is derived from a 38kHz crystal oscillator via a frequency divider chain, programmed to produce the correct gating time to compensate for the Doppler frequency/speed scaling factor – and thus give a readout directly in km/h or mph.

The divider programming is normally set for a gating time of 220ms, which gives a readout in *km/h*. If a readout in *mph* is needed instead, then three short tracks on the display PC board can be cut and three alternative links fitted to change the divider programming for a gating time of 137ms.

Features and Specification

- **A compact handheld Doppler speed radar system operating on a frequency close to 2.45GHz. Range is 200+ metres for a family car**
- **Can be set to read directly in kilometres per hour (km/h) or miles per hour (mph), to over 250km/h**
- **Resolution is 1km/h or 1mph, with an accuracy of around 1%**
- **2.2 measurements/sec for km/h, or 3.6 measurements/sec for mph**
- **Measured speed is displayed on a 3-digit LED display**
- **Hold switch lets you freeze the reading**
- **Operates from 12V DC, current drain around 130mA.**



DOPPLER SPEED RADAR COUNTER/DISPLAY SECTION

Microwave head circuit

Now that you have an overall view of what happens inside the Radar Speed Gun, let's work through the circuit diagrams to give you a more detailed insight. First, we'll look at the circuit of the Microwave Head section – see Fig.3.

The 2.45GHz oscillator is formed by the circuitry around Q1, a BFP182T *NPN* planar UHF transistor. This comes in a very small SOT-143 surface-mount package and has a transition frequency (f_t) of over 5GHz, making it suitable for an oscillator operating at 2.45GHz. Here we use it in what is essentially a Colpitts circuit, with the oscillation frequency determined by the microstrip line connected to the collector.

A small amount of 2.45GHz energy from the oscillator is coupled into a second microstrip line running close by and parallel to the collector line. This coupled energy is then fed to the input of IC1, which is a Mini Circuits ERA-2SM wideband UHF amplifier in a very small 'pill' SMD package with four leads (two of which are grounded).

Boosting the signal

IC1 provides a gain of about 12dB, boosting the 2.45GHz signal to the right level for feeding to the antenna. Pin 3 of IC1 is both its output pin and its power supply pin. DC power is fed to it via a

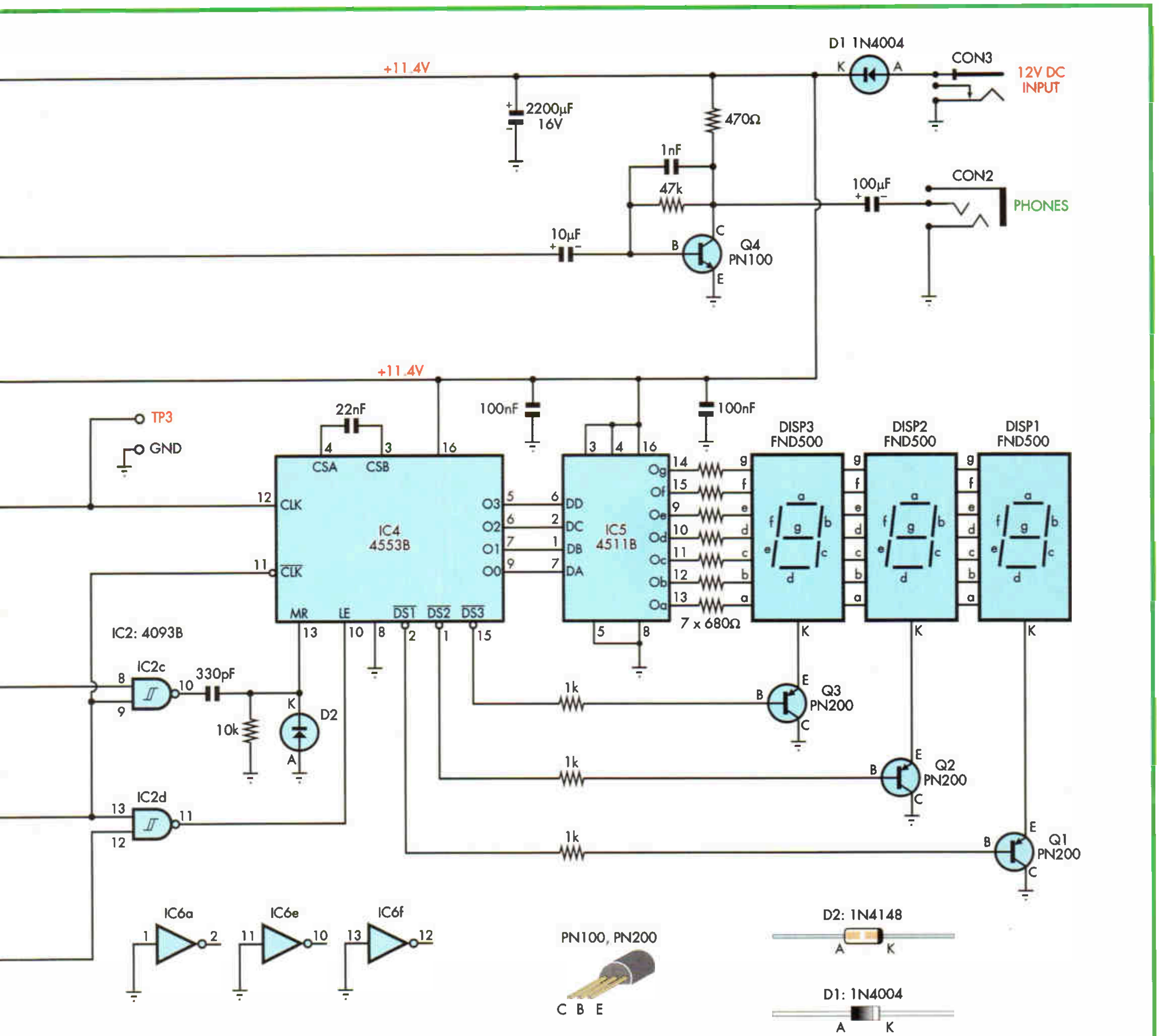


Fig.4: the counter and display circuit. The incoming signal from the head unit is amplified and filtered using op amps IC1a to IC1d and the resulting signals are then used to drive the frequency counter section (IC4, IC5 and the three 7-segment displays). IC6b, crystal X1, IC7, IC8 and IC3 form the 38kHz oscillator and timebase divider circuit for the counter.

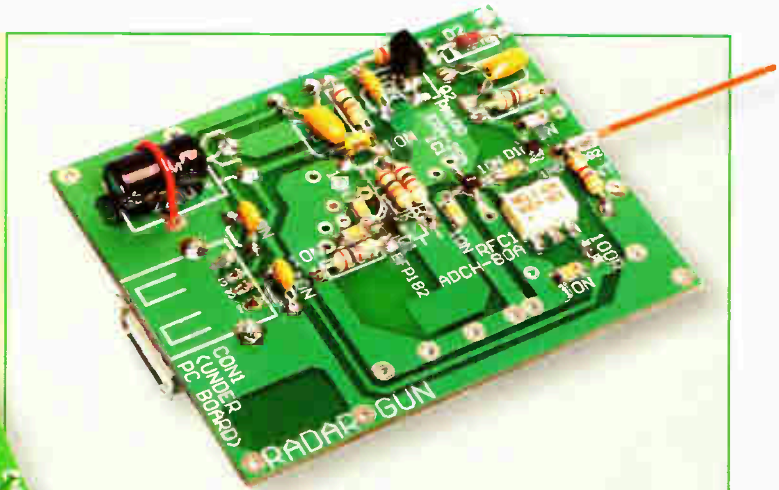
100Ω bias resistor and RFC1, a special UHF choke. The amplified RF energy is coupled out (via a 10nF capacitor) to a third and quite short microstrip line, which takes it to the antenna.

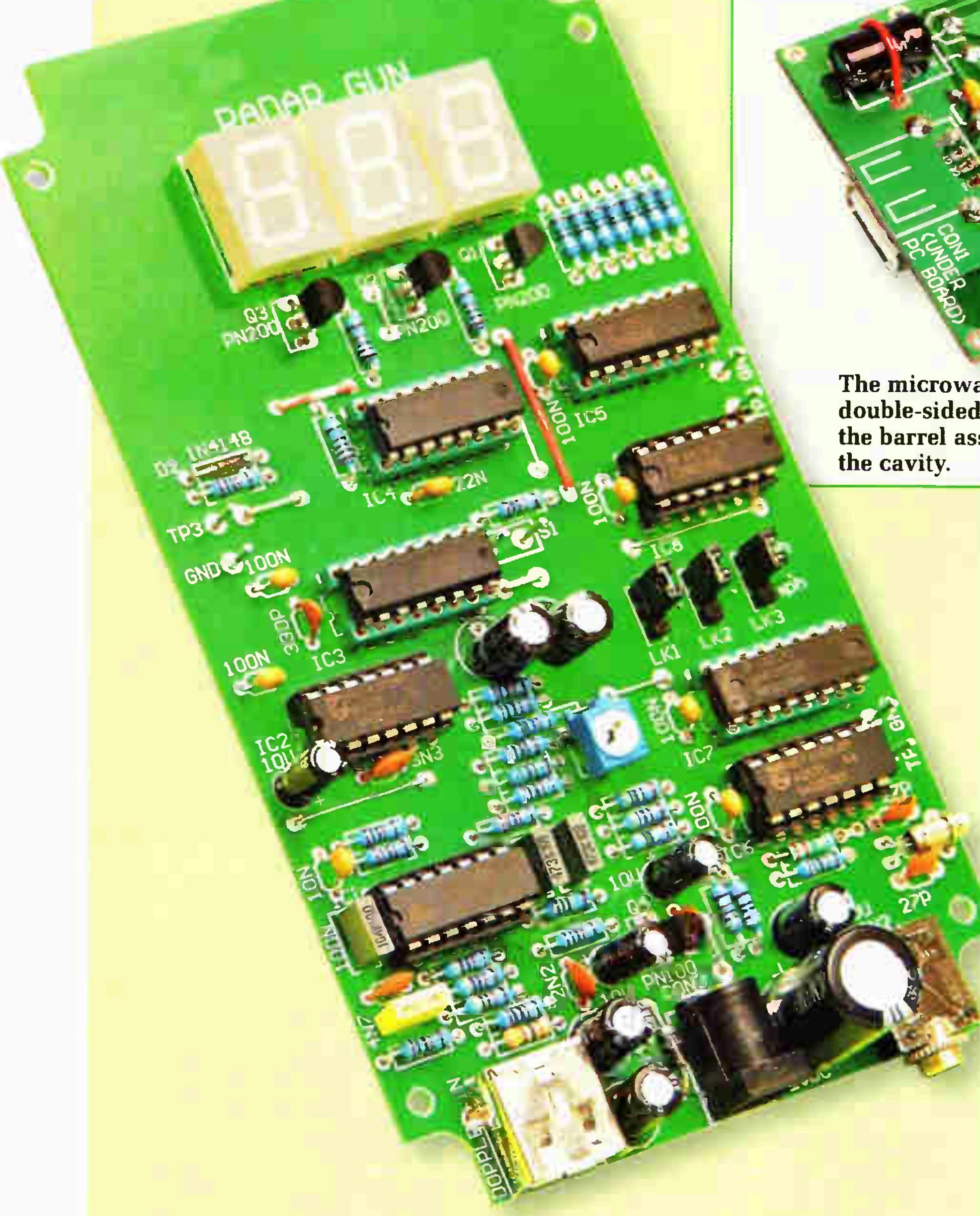
The antenna is a 30mm length of 1.3mm copper wire attached to the end of this third microstrip line, positioned at the correct point inside the Radar Gun's coffee-can barrel to ensure that the 2.45GHz energy is radiated away in a reasonably narrow beam.

The microwave energy reflected from the moving vehicle re-enters the barrel and reaches the antenna, which now acts as a receiving antenna. So a small amount of this reflected energy passes back down the antenna feed microstrip line, where it enters mixer diode D1, together with some of the original 2.45GHz energy from IC1.

D1 is a 1PS70SB82 Schottky diode in a very small SOT-323 SMD package and with very low capacitance, making it suitable for use in UHF mixers. Here its mixing action results in the Doppler difference frequency appearing across its 1kΩ load resistor, with all of the UHF signals and mixing products conducted to earth via a 1nF bypass capacitor. The Doppler audio signal from the mixer is then coupled via a 1µF capacitor to the base of transistor Q2, a common emitter amplifier stage.

The amplified Doppler signal appears at the collector of Q2 and is





The microwave head section is built onto a small double-sided PC board. This mounts vertically under the barrel assembly with its antenna protruding into the cavity.

This is the prototype counter and display board. The full constructional details will be covered in Part 2, next month

coupled via a second 1μF capacitor to pin 3 of CON1, a USB Type A connector used to mate with the cable linking the microwave head with the counter/display section. The same cable is used to provide the microwave head with +7.5V DC from pin 2 of CON1.

Counter/display circuit

Fig.4 shows the Counter/Display circuit. As shown, the Doppler signal from pin 3 of CON1 is first fed to a low-pass filter stage based on op amp IC1a. It then passes to IC1b, which is a non-inverting amplifier stage with a fixed gain of ×101, as set by the 1MΩ and 10kΩ feedback divider resistors. The amplified Doppler signal from IC1b then passes through a high-pass filter stage based on IC1c, which filters out any low-frequency noise that may still be present.

The output of IC1c is basically an amplified and cleaned-up version of the Doppler signal, which is now sent in two directions. One is via the 6.8kΩ resistor to a headphone driver stage using transistor Q4, which allows you to monitor the Doppler signals with a pair of headphones. This can help in aiming the radar gun at the particular vehicle or object whose speed you want to measure.

The second and main path of the Doppler signal from IC1c is to the input of IC1d, which provides further gain. IC1d's gain can be adjusted from about ×20 to ×220 using trimpot VR1. This allows you to adjust the sensitivity of the Radar Speed Gun, depending on whether the object being measured is close or further away.

From IC1d, the boosted Doppler signal is passed through a passive low-pass filter formed by a 10kΩ resistor and 10nF capacitor, and is then fed into a pulse-forming circuit based on Schmitt NAND gates IC2a and IC2b. The signal emerges from pin 4 of IC2b as a train of narrow (300μs) negative-going pulses of the same frequency, but with an amplitude of about 11.4V peak-to-peak.

This 'digital' version of the Doppler signal becomes the input for the frequency counter section and can also be monitored using an oscilloscope at test point TP3.

The frequency counter is based on IC4, a 4553B 3-decade BCD counter with built-in output latches and display multiplexing. It is coupled to three 7-segment LED displays via IC5, a 4511B BCD-to-7-segment decoder, which drives the displays.

The digit select outputs from IC4 (pins 2, 1 and 15) are used to turn on each display digit at the correct time via driver transistors Q1, Q2 and Q3.

Timebase signals

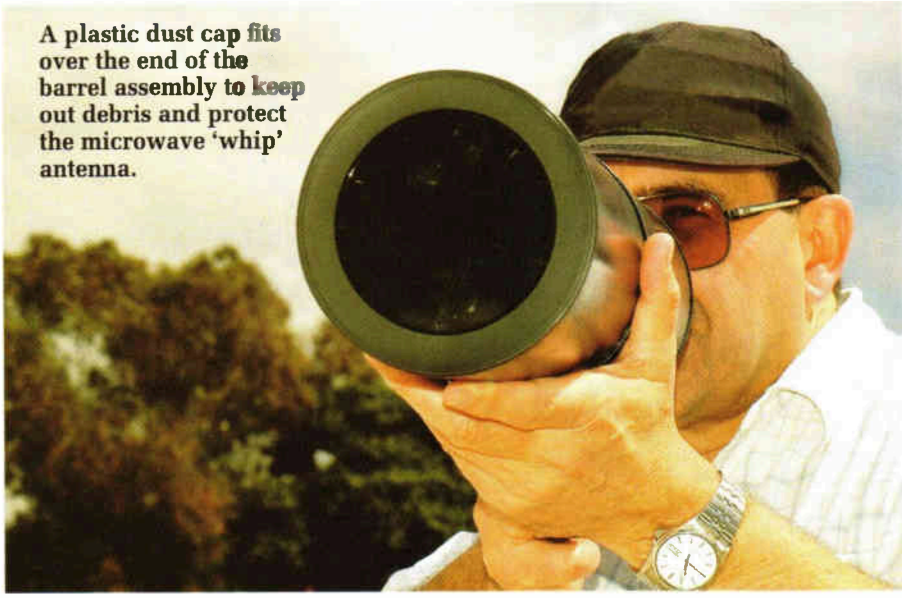
As noted earlier, the counter's timebase signals are derived from a 38kHz crystal oscillator. The oscillator uses IC6b, part of a 4069 unbuffered hex inverter. Two sections of the same IC (IC6d and IC6c) are used as buffers for the 38kHz clock signal, one to drive the programmable timebase divider and the other to drive test point TP1.

The timebase divider is IC7, a 4020B 14-stage binary counter, together with triple AND gate IC8 (a 4073B), used for reset gating to achieve the desired division ratios. Links LK1 to LK3 can be used to change the division ratio between 4185:1 (for readings in km/h) and 2601:1 (for mph). The three links are short tracks on the PC board for default readings in km/h. To change the divisor settings over for readings in mph, simply cut the tracks under the PC board and fit jumper shunts or wire links in the three 'mph' link positions instead.

Whichever setting has been selected, the timebase pulses from the divider can be monitored at test point TP2. For the default km/h setting, the pulses at TP2 will have a frequency of 9.0778Hz, while for the mph setting, they'll be at 14.6103Hz.

The timebase pulses are used to toggle the two flipflops in IC3, a 4027B dual JK flipflop. The two flipflops are cascaded and, along with gates IC2c and IC2d, run as a simple sequencer for controlling the counter.

The output of IC3a is used directly to control the clock input of IC4 (pin 11) and also to gate the $\overline{Q}$ output of IC3b via IC2d to produce the latch enable signal for IC4 (pin 10). The LE signal transfers each count into IC4's output latches at the end of each gating period. The output of IC3a is also used to gate the Q output of IC3b via IC2c, to produce (after differentiation) a reset pulse for IC4's counters (pin 13).



A plastic dust cap fits over the end of the barrel assembly to keep out debris and protect the microwave 'whip' antenna.

The frequency counter therefore runs continuously in a count/latch enable/reset cycle at a rate of 2.2 measurements per second for km/h readings, or 3.6 measurements per second for mph readings.

The Hold switch (S1), to freeze the reading, grounds the 'K' input (pin 11) of IC3b to disable the flipflop and hold the present reading in the counter.

Power supply

The complete circuit operates from 12V DC and this is applied to the counter/display unit via connector CON3. The total current drain is about 130mA. You can use a pack of eight series-connected C-size alkaline cells, or a small 12V sealed lead-acid (SLA) battery, like the compact 1.3Ah unit sold by Jaycar as SB-2480. The latter will run the Radar Speed Gun for about 10 hours on a single charge.

Construction

The construction details will be explained in Part 2. Incidentally, the Jaycar kit **will not** include the two coffee cans that are used to make the Radar's antenna barrel. So you might want to visit your local supermarket to buy a couple of cans of budget instant coffee. If possible, get one can with a push-on plastic cap, because this comes in handy as a dust cap for the open front end of the antenna barrel.

Alternatively, the plastic top of a bulk CD container can be used as a dust cap, although it won't be as tight a fit as a cap designed for a can. ***EPE***

Vero-ly the hole-y truth

TechnoTalk

Mark Nelson

How do you convert a sketched circuit diagram to a working Veroboard layout? If you want to see the power of collaboration, just look in on how an online chat group works. Mark Nelson provides the background.

This month our topic is decidedly *practical* electronics, the proper hands-on variety and the sort you develop and build on the bench. This kind of electronics construction revolves entirely around components and instantly there's a quandary – for hobbyists at least.

Imagine you are developing a design for publication in a magazine, or for a club or user group. Do you make it as compact and elegant as possible, with surface-mount technology (SMT) components and plated-through holes (PTHs) connecting tracks on either side of the board? Or do you opt for good old discrete components (the sort we probably have boxes of in stock) and a straightforward single-sided printed circuit board (PCB)? Or maybe the circuit is simple enough to knock up on Veroboard. Decisions, decisions...or perhaps no decision at all.

I note that many magazine project designs still rely on proper-sized components, which are easy to see and handle (unlike SMTs, which one of my chums describes as trying to solder mouse droppings, except that 'droppings' is not the word he uses).

Knife and fork

All of this is too technical for one of my friends. He's been in the hobby for some time; he started pulling radios to bits over 60 years ago, and is a firm believer in what he calls 'knife and fork' electronics. This, I assume, refers to the kind of implements in his tool kit and certainly his preferred mode of constructing electronics designs is on tag strips, using valves and condensers of course.

This is a little extreme, perhaps, but it might be worth taking a moment to recall how people built one-off projects 50 years ago. Perfboard was the norm, and if you didn't have the pleasure of playing with this stuff then Google Images will provide several photos of it. In essence, it was a printed circuit board without the printed circuit. It did, however, have the holes; in fact the whole surface of the board was covered in a grid of holes spaced a tenth of an inch apart.

The idea was that you poked component leads through the holes, pulled them tight, then soldered them to the lead of an adjacent component. Properly designed and tightly 'woven', your project could end up quite neat and professional-looking. What's more, there was a bonus of the rather jolly 'carbolic' smell you got if your soldering iron dwelt too long, the board itself being made of SRBP (synthetic resin bonded paper). The heat melted the resin, but no harm was done apart from charred marks.

Innovations

Three innovations to make our life easier appeared in the 1960s (I'm pretty certain all were children of the sixties). They were solderable perfboard, instant PCBs and Veroboard (the main subject of this article).

Solderable perfboard (look up 'perf-board' on Wikipedia) was like traditional perfboard but with the helpful addition of small copper solder pads on one side. This was a significant improvement, as you could now solder component leads to the copper 'islands' and avoid the 'rat's-nest' clutter of longer leads beneath the board. Unfortunately, the glue fixing the islands soon parted company from the SRBP layer. Not very clever (or perhaps my soldering was too heavy-handed).

The instant PCB or 'Printed Circuit Panel', to give it its official name, was an inspired idea from Radiospares (RS Components these days). These were ready-made 'universal' PCBs measuring 6in by 2in (152mm × 51mm), on which you could build a simple amplifier or switching circuit with the minimum of additional wiring.

The solid-state version had holes and pads for eight transistors, while the thermionic one was designed for two valves. Both had room for plenty of passive components as well, plus an 8-way edge connector. At 6s 6d for a packet of three (the cost of three monthly hobby magazines, or £10 in today's money) they were not cheap and perhaps not such an inspired idea after all.

Veroboard at last!

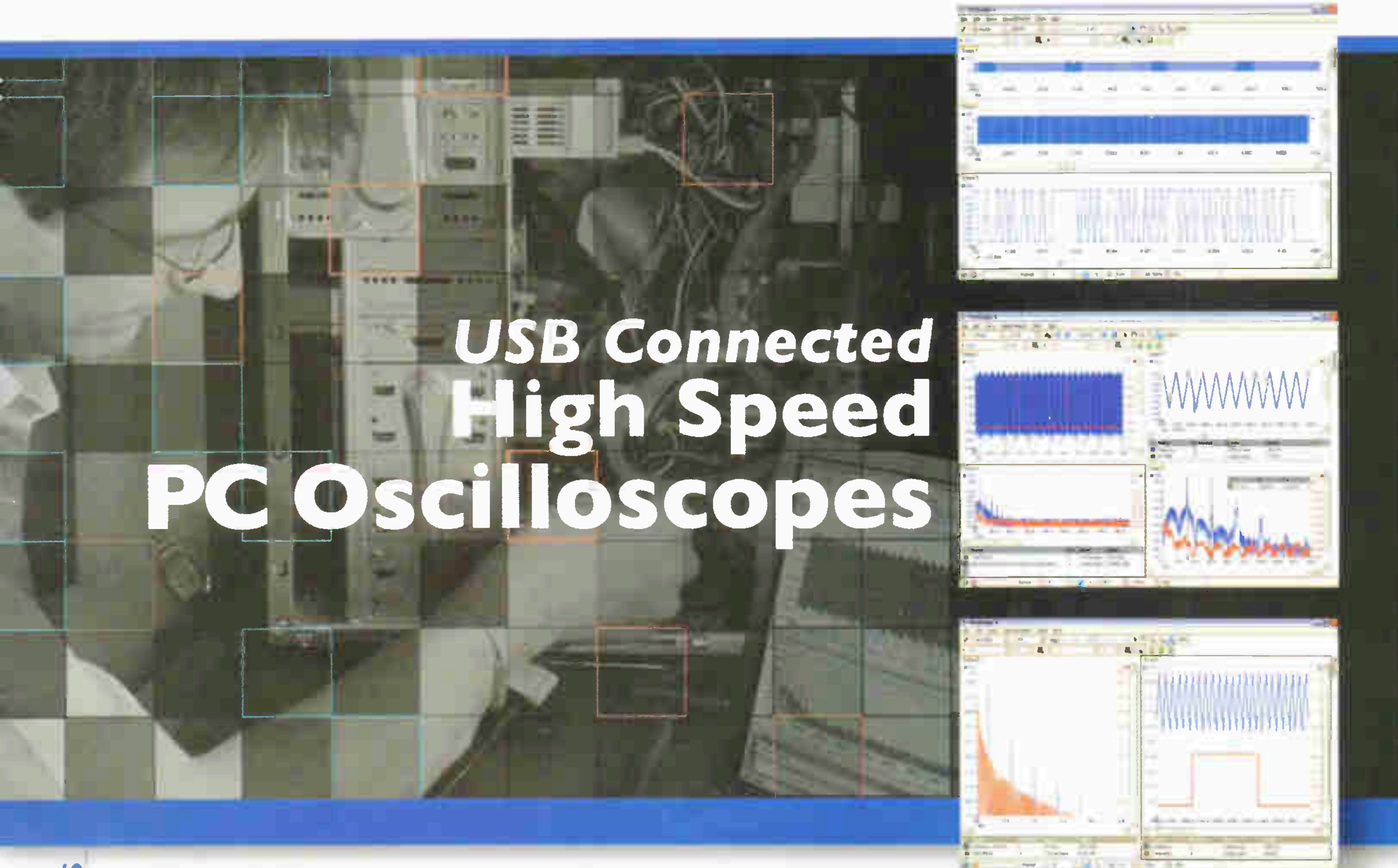
By far the most significant innovation of the 1960s was Veroboard (its trade name in the UK, known as Vectorboard in the USA and stripboard (the generic term). Veroboard is too well known to require description here, but you'll find an excellent article on Wikpedia if you search for stripboard. The Vero website is also very useful (**www.verotl.com/node/7**).

If I have one gripe against Veroboard, it's simply that I seldom get the design right the first time and resent having to unpick a design and start again. This happens even if I design the circuit first with pencil and paper; I guess I'm not very good at visualising circuits in my mind. Evidently, I'm not the only one, as Alfredo Sola asked in the MERG e-group, "Can anyone recommend a software package (preferably freeware or shareware, failing that any software) which converts schematics to pin layouts on Vero/stripboard?"

Responses came aplenty and here is a selection, as recommended by helpful MERGers (all programs are for Windows):

- *Stripboard Designer* (**www.geocities.com/stripboarddesigner/**). This program was highlighted in the March 2002 issue of this magazine, and makes it easy to break strips, jump wires and place components on stripboards. You can even draw your own components and save them in a library for reuse – or just use the standard component library.

  Some of the features include zooming in, zooming out, panning, rotating and flipping the design. You can view and also print the board from the component side or the solder side. There are older versions available for download, with an enhanced version promised for release at some time in the future. No charge for downloads, but saving the file you have designed will be delayed for 15 minutes.
- *Veecad* (**http://veecad.com/**). A true CAD program, this one takes a schematic-generated netlist and assists you in building a layout on stripboard. Priced at US $26.26, it's not expensive, but a less feature-rich free version is also available. You need another program that produces schematics of several specified formats such as Protel (available free on the MERG website **www.merg.org.uk**).
- *Stripboard Magic* (**www.marlwifi.org.nz/other/stripboard-magic**). This is 'abandonware' and some users consider it under-featured ('left to its own artificial intelligence it wastes a lot of board.'). One report says that it needs additional run-time software.
- *Verodes124* (**www.heyrick.co.uk/software/verodes/index.html**). A feature of this free program lets you print an overlay of either side of the board. This can then be stuck to the board to guide you in placing components and cutting tracks.
- *Lochmaster* (**www.abacom-online.de/uk/html/lochmaster.html**). Commercial program with a free demo version that does not allow you to save, print or export. Loch is German for 'hole', by the way.



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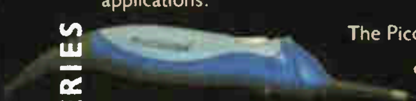

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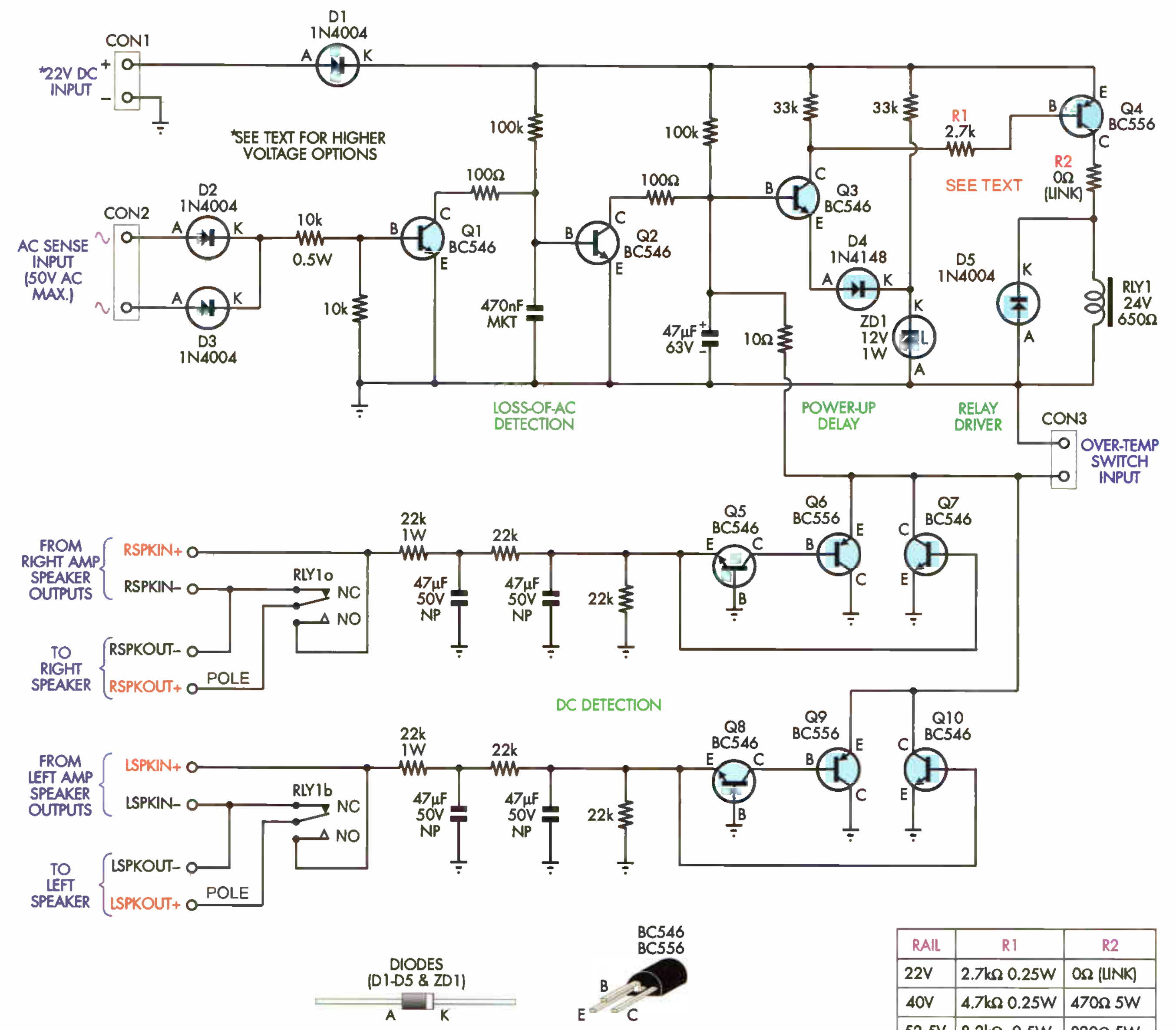
20W Class-A Amplifier Pt.3

Universal Speaker Protection and Muting Module

Designed for use in our Class-A Stereo Amplifier, this Speaker Protection and Muting Module is really a universal unit. It can be used with other amplifier modules and commercial stereo amplifiers and protects the loudspeakers in the event of a catastrophic amplifier failure. The module also mutes the loudspeakers at switch-on and switch-off to prevent those scary thumps.

By Greg Swain and Peter Smith



RAIL	R1	R2
22V	2.7kΩ 0.25W	0Ω (LINK)
40V	4.7kΩ 0.25W	470Ω 5W
52.5V	8.2kΩ 0.5W	820Ω 5W
57V	8.2kΩ 0.5W	1kΩ 5W
70V	12kΩ 1W	1.2kΩ 10W

SPEAKER PROTECTION & MUTING

Fig.1: each channel of the amplifier is monitored for DC faults by three transistors – Q5, Q6 and Q7 for the right channel and Q8, Q9 and Q10 for the left channel. If a DC signal is detected, Q3's base is pulled low, turning it off along with Q4 and the relay. Transistors Q1 and Q2 provide the switch-off muting feature. If the 'AC Sense' input voltage ceases, Q1 turns off, and Q2 turns on, which again pulls Q3's base low and turns off Q4 and the relay.

ALTHOUGH DESIGNED specifically for our Class-A Stereo Amplifier, this unit can actually be used with any audio amplifier with supply rails up to about 70V DC, simply by selecting two resistor values to suit.

Basically, the unit provides the following features:

1) It protects the loudspeakers against catastrophic failure in the amplifier – eg, if an output transistor goes short circuit

2) It provides muting at switch-on and switch-off, to prevent thumps from the loudspeakers

3) It provides an input for an over-temperature switch to disconnect the loudspeakers if the output stage heatsink temperature rises above a certain level.

Note, however, that this last feature is not used in the Class-A Stereo Amplifier. This is because its heatsinks run hot all the time (about 30°C above ambient) and disconnecting the loudspeakers does nothing to cool them down, since the output stage in each amplifier module draws a constant 1.12A – equivalent to a power dissipation of just under 50W.

By contrast, disconnecting the loudspeaker from a class-B amplifier will immediately reduces the current through the output stage to the quiescent current setting – typically around 50mA (assuming that there's no fault

This view shows how the unit is mounted in the rear lefthand corner of the Class-A Stereo Amplifier metal cabinet.

in the amplifier). So, for a class-B amplifier, it makes sense to use over-temperature sensing. If the heatsink to which the output transistors are attached gets too hot, disconnecting the loudspeakers immediately reduces the dissipation to just a few watts, which allows the heatsink to cool.

Note that the loudspeakers are connected (and disconnected) using a heavy-duty double-pole relay. We'll have more to say about that later.

Protecting the loudspeakers

By far the biggest reason for incorporating speaker protection into an amplifier is to prevent further damage in the case of a serious amplifier fault. For example, if the main supply rails are ±70V DC. This means that if one of the output transistors fails and there's no loudspeaker protection, more than 70V DC would be applied to the speaker's voice coil.

In a nominal 8Ω speaker, the voice coil has a DC resistance of around 6Ω and so the power dissipation would be around 800W, until the supply fuse blew. In the meantime, this amount of applied DC power is likely to push the voice coil out of its gap, damaging the voice coil and suspension in the process. And if the on-board supply fuse didn't blow fairly quickly, the voice coil would quickly become red-hot and could set fire to the speaker cone material.

This risk applies to any audio power amplifier of more than about 40W per channel. So a loudspeaker protection circuit is a very good idea.

The risk of setting fire to the loudspeaker is nowhere near as great with the Class-A Stereo Amplifier because the supply rails are just ±22V. In this case, a shorted output transistor would result in a dissipation of about 80W in the speaker's voice coil. It might not be enough to cause a fire, but it's certainly high enough to damage the loudspeaker by burning out the voice coil.

Muting the thumps

Muting switch-on and switch-off thumps is another important function of this unit.

Switch-on thumps are eliminated by using a simple circuit to delay the relay from turning on when power is first applied. This way, the amplifier modules are able to power up and settle down before the relay switches on (after about five seconds) to connect the speakers.

By contrast, switch-off thumps are eliminated by using an 'AC Sense' input to monitor the secondary AC voltage from the transformer (up to 50V AC max). When this AC voltage disappears (ie, at switch-off), the circuit switches the relay off in less than 100ms.

This is much faster than simply relying on the collapsing DC supply rail to turn the relay off. In practice, this could take half a second or more, as the main filter capacitors discharge – more than long enough for a any switch-off thumps to be audible.

Circuit details

Refer now to Fig.1 for the full Speaker Protection and Muting Module circuit details. As shown, each channel of the amplifier is connected to the NC and NO (normally closed and normally open) contacts of a relay. The relay wipers (poles) and NC contacts then each respectively connect to the positive and negative loudspeaker terminals.

Each channel of the amplifier is monitored for DC faults by a triplet of transistors – Q5, Q6 and Q7 for the right channel and Q8, Q9 and Q10 for the left channel. We'll describe the operation of the right channel only, as the circuit for the left channel is identical.

As shown, the active signal from the amplifier's right channel is fed to a low-pass filter consisting of three 22kΩ resistors and two 47μF 50V bipolar (BP or NP) electrolytic capacitors. This network removes any audio frequencies and just leaves DC (if present under fault conditions) to be monitored by the three transistors,

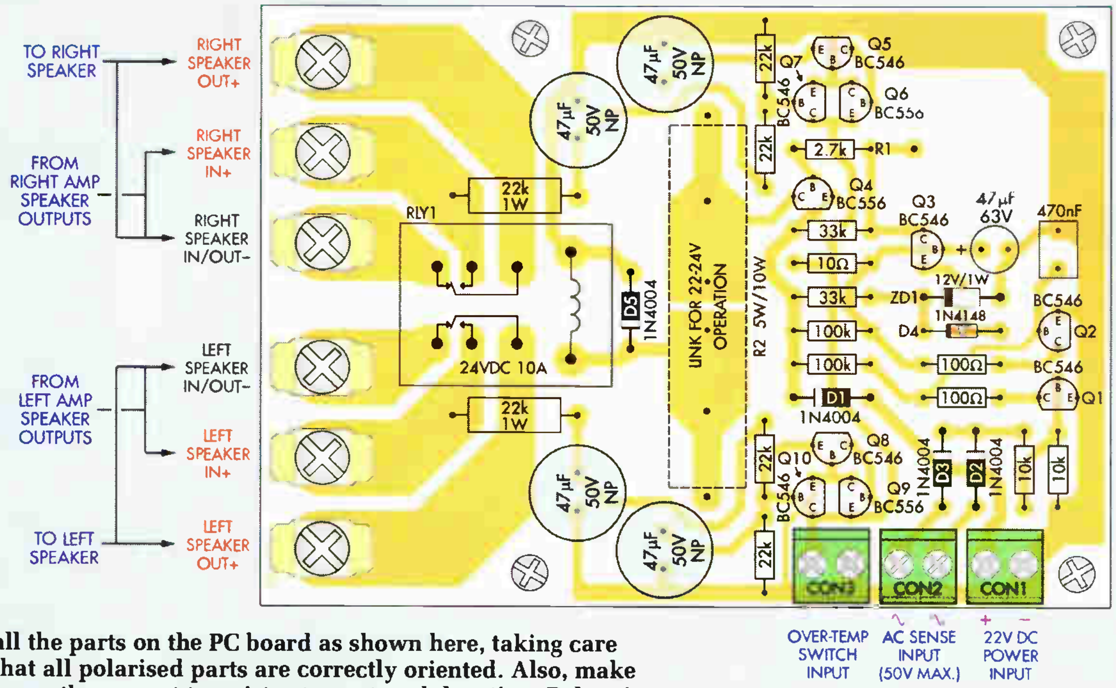
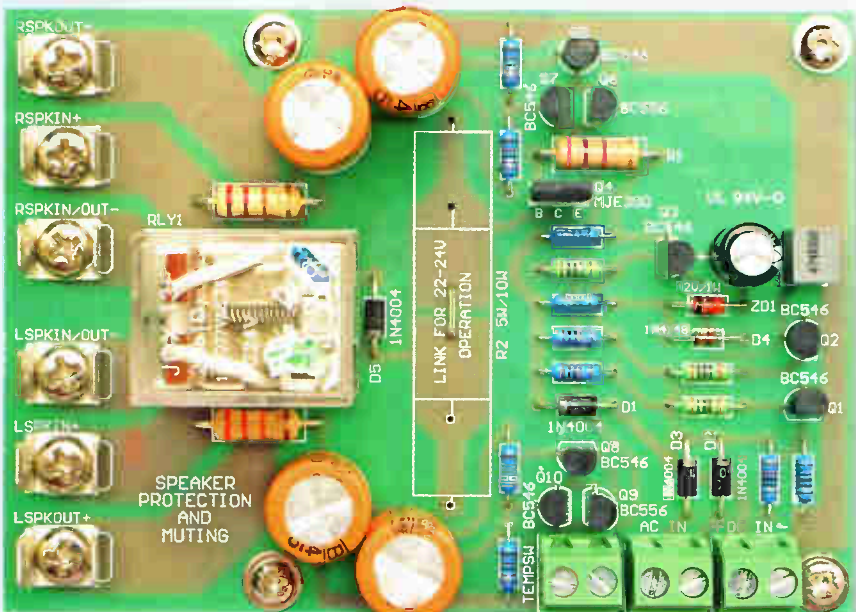


Fig.2: install the parts on the PC board as shown here, taking care to ensure that all polarised parts are correctly oriented. Also, make certain you use the correct transistor type at each location. Below is the completed PC board.



Q5, Q6 and Q7. This is because we don't want audio signals to trip the protection circuit.

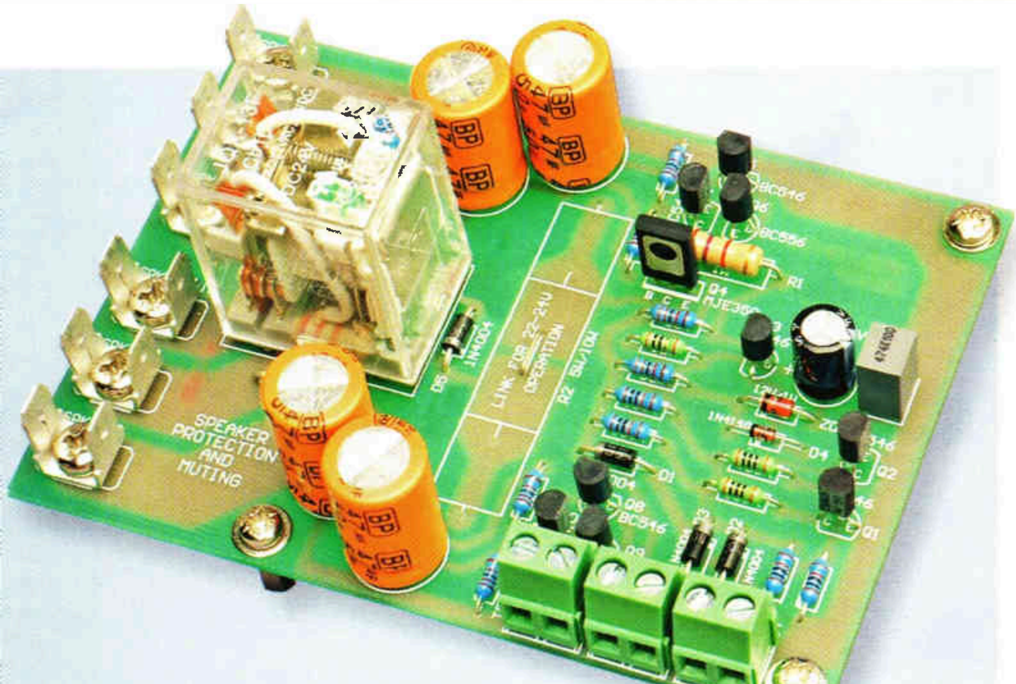
The low-pass filter output is connected to the emitter of Q5 and to the base of Q7. Transistor Q5 monitors the amplifier output for negative DC signals, while Q7 monitors for positive DC signals.

In operation, transistor Q7 turns on if a DC signal of more than +0.6V is present on its base. Similarly, Q5 turns on if a DC signal of more than –0.6V is present on its emitter. This in turn pulls transistor Q6's base low and so Q6 also turns on.

Normally, in the absence of amplifier faults, transistors Q5-Q7 are all *off* and Q3 is biased *on* via the 100kΩ resistor connected between its base and the positive supply rail (ignore Q1

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	4	22kΩ	red red orange brown	red red black red brown
❑	2	22kΩ 1W, 5%	red red orange gold	not applicable
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.7kΩ	red violet red brown	red violet black brown brown
❑	2	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown



This prototype board (also shown in the other photos) used an MJE350 transistor for Q4, but this has now been changed to a BC556.

and Q2 for the time being). As a result, Q3 pulls Q4's base down (via resistor R1) to just over 12.6V, as set by diode D4 and Zener diode ZD1, and so Q4 and relay RLY1 are also on.

Now let's consider what happens if an amplifier fault condition results in DC being present at its output. In this case, either Q6 or Q7 turns on and pulls Q3's base low via a 10Ω resistor. When that happens, Q3, Q4 and the relay all immediately turn off, disconnecting the speakers.

Diode D5 protects Q4 by quenching any back-EMF spikes that are generated when the relay is switched off.

Transistors Q8, Q9 and Q10 monitor the left channel of the amplifier and they switch Q3, Q4 and the relay in exactly the same manner.

Relay specifications

The relay selected for the job is a 24V DPDT (double-pole, double-throw) type, with contacts rated at 10A. There are two reasons for this high contact rating. First, we want the contact resistance in the relay to be as low as possible so that it has negligible effect on the amplifier's performance, as regards to distortion, damping factor and so on.

Second, the relay contacts have to pass and break the heavy DC current which would otherwise flow through the loudspeaker if a fault occurs in the amplifier. However, we don't merely use the relay to disconnect the amplifier's output from the speakers. If we simply did this, it's possible that the contacts would just arc across and so the heavy DC current would continue to flow through the loudspeaker.

That might seem unlikely, but when you have a heavy DC current and a high DC voltage pushing it along, it can be quite hard to break the circuit. This problem is solved by shorting the moving (pole) relay contacts to the loudspeaker ground lines (via the otherwise unused NC contacts) when the relays turn off. This diverts the arc current to chassis and ensures that the fuses blow on the amplifier.

By the way, the relay specified in the parts list (Altronics S-4313 – **www.altronics.com**) has an in-built green LED that lights when the relay turns on. It's a nice feature that lets you quickly check the status of the relay during testing, but it is not really necessary.

Muting delay at switch-on

Muting at switch-on is achieved using a delay circuit. This consists of the 100kΩ resistor and the 47µF capacitor connected to Q3's base, along with diode D4 and Zener diode ZD1.

When power is first applied, the 47µF capacitor is discharged and Q3's base is held low. As a result, Q3, Q4 and the relay all remain off. The 47µF capacitor then charges via the 100kΩ resistor until, after about five seconds, it reaches 13.2V. This now forward biases Q3, which then turns on Q4 and the relay to connect the loudspeakers. This is more than sufficient time for the amplifier modules to settle down and achieve stable operating conditions.

Why 13.2V on Q3's base? Well, that's the sum of the voltages across ZD1, diode D4 and Q3's base-emitter junction when the transistor is on.

Switch-off muting

Transistors Q1 and Q2, together with diodes D2 and D3, provide the switch-off muting function.

Diodes D2 and D3 rectify the AC voltage that's fed to the AC Sense input (at connector CON2) from a transformer secondary winding (up to 50V AC max). Provided this AC input voltage is present, the rectified output forward biases transistor Q1 and so keeps it turned on. This in turn holds Q2's base low and so Q2 is off and Q3 functions normally.

The 100kΩ resistor and the 470nF capacitor, at Q2's base, form a time constant that's long enough to ensure the Q2 remains off when Q1 very briefly turns off during the AC zero crossing points.

However, if the AC signal ceases (ie, at switch off), Q1 immediately turns off and Q2 turns on and quickly discharges (within a millisecond or so) the 47µF timing capacitor via a 100Ω resistor. As a result, Q3, Q4 and the relay all turn off and the loudspeakers are disconnected, effectively eliminating any switch-off thumps.

Over-temperature input

Connector CON3 is the temperature sensor input. It relies on the use of a normally-open (NO) thermal switch that's normally bolted to the heatsink used for the amplifier's output power transistors.

Basically, this input is wired in parallel with transistors Q6 and Q7 (and Q9 and Q10) and it controls transistor Q3 in exactly the same manner.

When the temperature reaches a preset level (set by the switch itself), the contacts inside the thermal switch close and pull Q3's base low via the associated 10Ω resistor. As a result, Q3 turns off and this switches off Q4 and the relay.

Parts List – Speaker Protection Module

1 PC board, code 693, available from the *EPE PCB Service*, size 112.5mm × 80mm
1 10A 24V DPDT PC-mount relay (Altronics S-4313)
3 2-way 5mm or 5.08mm pitch terminal blocks (CON1 to CON3)
4 M3 × 10mm tapped spacers
4 M3 × 6mm pan head screws
6 M4 × 10mm pan head screws
6 M4 flat washers
6 M4 shakeproof washers
6 M4 nuts
6 6.3mm double-ended 45° or 90° chassis-mount spade lugs
0.7mm diameter tinned copper wire for link

Semiconductors
7 BC546 *NPN* transistors (Q1-Q3, Q5, Q7,Q8 and Q10)
3 BC556 *PNP* transistors (Q4, Q6 and Q9)
4 1N4004 diodes (D1 to D3, D5)
1 1N4148 diode (D4)
1 12V 1W Zener diode (ZD1)

Capacitors
1 47µF 63V PC electrolytic
4 47µF 50V non-polarised (bipolar) electrolytics
1 470nF 50V metallised polyester (MKT)

Resistors (0.25W 1% carbon film)

2 100kΩ	1 10kΩ 0.5W
2 33kΩ	1 2.7kΩ (R1)
4 22kΩ	2 100Ω
1 10kΩ	1 10Ω
2 22kΩ 1W 5%	R2 See Text

Attaching The Spade Connectors

It's important that the double-ended spade lugs are fitted correctly to the PC board.

Fig.3 (right) shows how they are mounted. Each lug is secured using an M4 x 10mm screw, a flat washer (which goes against the PC board pad), an M4 star lockwasher and an M4 nut.

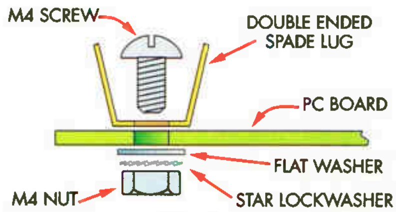


Fig.3

The trick to installing them is to first do the nut up finger-tight, then rotate the assembly so that it is at a right-angle to the PC board. A screwdriver is then used to hold the M4 screw and the spade lug stationary while the nut is tightened from below using an M4 socket and ratchet.

Do the nut up nice and tight to ensure a good connection and to ensure that the assembly does not rotate. Don't be too heavy-handed though, otherwise you could crack the PC board.

The exact same mounting method should also be used for the spade lug terminals attached to the power amplifier modules and to the power supply board described last month.

When the heatsink subsequently cools down, the thermal cutout opens again and Q3, Q4 and the relay turn on again to reconnect the loudspeakers.

As previously stated, the over-temperature sense feature is not used with the Class-A Stereo Amplifier because the heatsinks run hot all the time and disconnecting the loudspeakers does nothing to cool them.

Power supply

Power for the Loudspeaker Protection circuit is derived from a suitable DC rail within the amplifier. This can range anywhere from about 20V DC up to 70V DC.

In the case of the Class-A Stereo Amplifier, we use the +22V and 0V rails from the power supply board. The 'AC Sense' signal is picked up directly from the AC terminals on the bridge rectifier (more on this in a future issue).

Note that the values shown for R1 and R2 on Figs 1 and 2 assume a 22V to 24V supply rail. If the available DC supply rail is higher than this, then resistors R1 and R2 must be changed accordingly to ensure a base current of about 3 to 5mA for Q4 (as set by R1) and to ensure that no more than about 24V DC is applied to the relay coil (R2). In the latter case, it's just a matter of selecting R2 so that the relay current is about 37mA (assuming that the relay has a coil resistance of about 650Ω).

The inset table included with Fig.1 shows resistor values to suit differing supply rails.

Construction

The parts for the Speaker Protection and Muting Module are all mounted on a PC board, coded 693. This board is available from the *EPE PCB Service*. Fig.2 shows the component layout and assembly details.

Mount the resistors and diodes first, taking care to ensure that the diodes are all oriented correctly. Table 1 shows the resistor colour codes, but you should also check each resistor using a digital multimeter before installing it, just to be sure.

Install a 2.7kΩ 0.25W resistor for R1 and a link for R2 if you are building the unit for the Stereo Class-A Amplifier. Alternatively, select these resistors from the inset table shown in Fig.1 if you intend using a supply rail greater than 24V.

If the supply rail is between the values shown in the table, then simply scale the resistor values accordingly and use the nearest preferred value.

The six double-ended spade lugs for the speaker input and output terminals are next on the list. These are attached using M4 × 10mm screws, flat washers, star washers and nuts – see Fig.3.

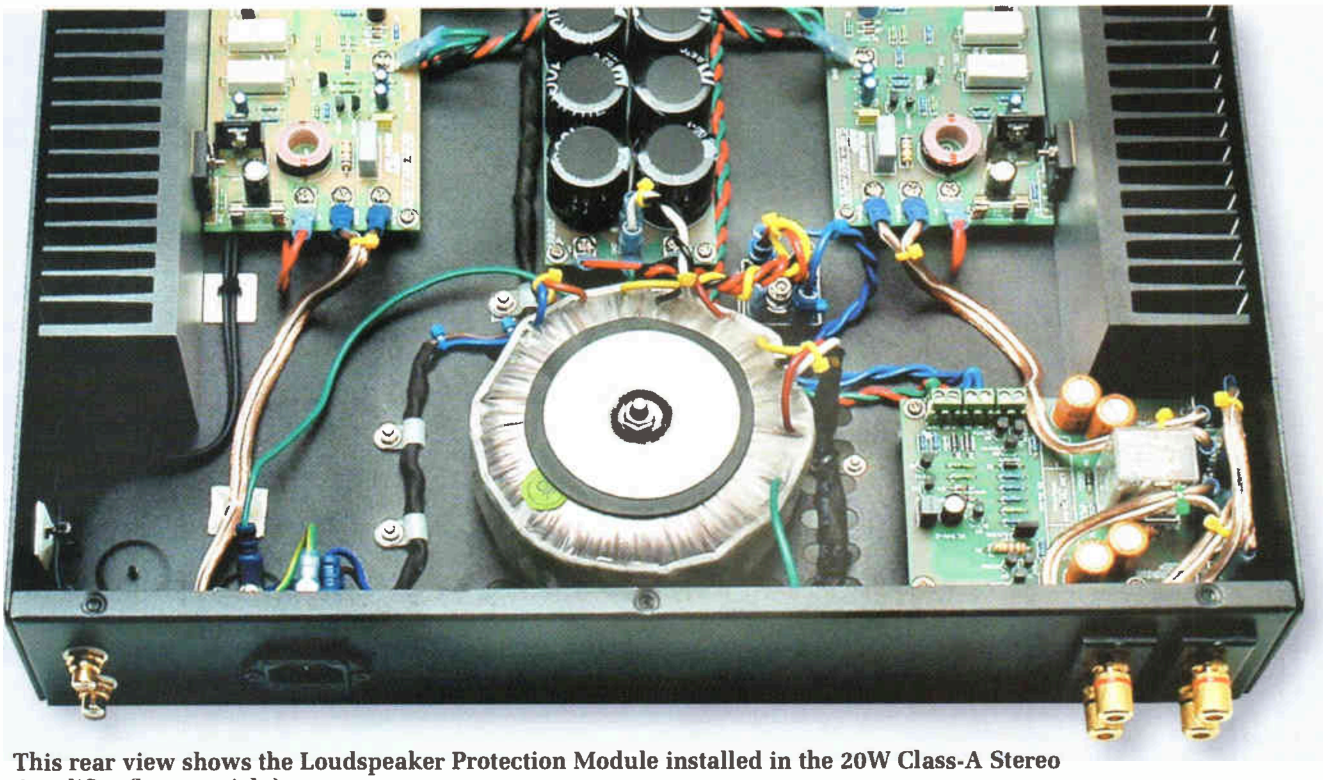
Note that, ideally, the double-ended spade lugs supplied should be 90° types. However, if you are supplied with 45° types, just bend the lugs to 90° before installing them on the board.

The transistors, the electrolytic capacitor and the bipolar capacitors can now be installed, taking care to ensure that the correct transistor type is fitted to each location. The four 47µF bipolar capacitors can go in either way around, but do watch the orientation of the polarised 47µF 63V electrolytic capacitor.

Finally, you can complete the board assembly by fitting the three 2-way terminal blocks and the DPDT relay.

Testing

If you have a suitable DC supply you can test the unit prior to installing it. To do this, first connect the supply to screw terminal block CON1 and install a wire link between one of the CON2 AC Sense input terminals and the positive supply rail (this is done to ensure transistor Q1 turns on). Do *not* connect anything to



This rear view shows the Loudspeaker Protection Module installed in the 20W Class-A Stereo Amplifier (bottom right).

the temperature switch input or to the speaker terminals at this stage.

Next, apply power and check that the relay turns on after about five seconds. If it does, temporarily short the temperature switch input – the relay should immediately switch off.

Similarly, the relay should immediately switch off if you disconnect the link to the AC Sense input.

The next step is to check that the relay switches off if a DC voltage is applied to the loudspeaker terminals (this simulates an amplifier fault condition). To do this, apply power, wait until the relay switches on, then connect a 3V (2 × 1.5V cells in series) or 9V battery (either way around) between the ground terminal of CON1 and the LSPKIN+ terminal. The relay should immediately switch off.

Repeat this test for the RSPKIN+ terminal, now reverse the battery polarity and perform the above two tests again. The relay should switch off each time the battery is connected.

Note that we don't connect to the LSPKIN– or RSPKIN– terminal for this test because these two inputs are fully floating at this stage. That changes when the module is installed in a chassis and the loudspeaker leads are connected, because the negative loudspeaker terminals on the amplifier are connected to chassis (via the power supply).

Troubleshooting

If the relay doesn't activate when power is first applied, switch off immediately and check for wiring errors – eg, incorrect supply polarity, or a transistor in the wrong location. If this doesn't locate the fault, switch on and check the supply voltage, then check the voltages around the transistors. Q3's emitter should be at about 12.6V and its collector at 12.8V, while both Q3 and Q4 should have base-emitter voltages of 0.6V.

Similarly, Q1 should have a base-emitter voltage of 0.6V (provided the link between the AC Sense input and the positive supply terminal is in place) but the other transistors (Q2 and Q5 to Q10) should all be off – ie, they should have base-emitter voltages of 0.2V or less.

If Q3's base voltage is low (around 0.2V), then it could mean that Q2 is on and Q1 is off, possibly due to no voltage being applied to Q1's base. Alternatively, one of the transistors in the speaker input monitoring circuits (ie, Q5 to Q10) could be faulty (short circuit). You can quickly isolate which circuit section is at fault by disconnecting the 10Ω and 100Ω resistors to Q3's base.

Just remember that all transistors that are turned on will have a base-emitter voltage of about 0.6V. This should enable you to quickly locate where the trouble lies.

That's all for now. Next month, we'll describe the low-noise Preamplifier and Remote Volume Control Module. ***EPE***

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Temperature Sensors

Temperature sensors are variously called 'thermostat switches', 'thermal cutouts' and 'thermal circuit breakers' and are available in a range of trip temperatures from 50 to 100°C. Note that the temperature sensor used with this unit must be a normally open (NO) type.

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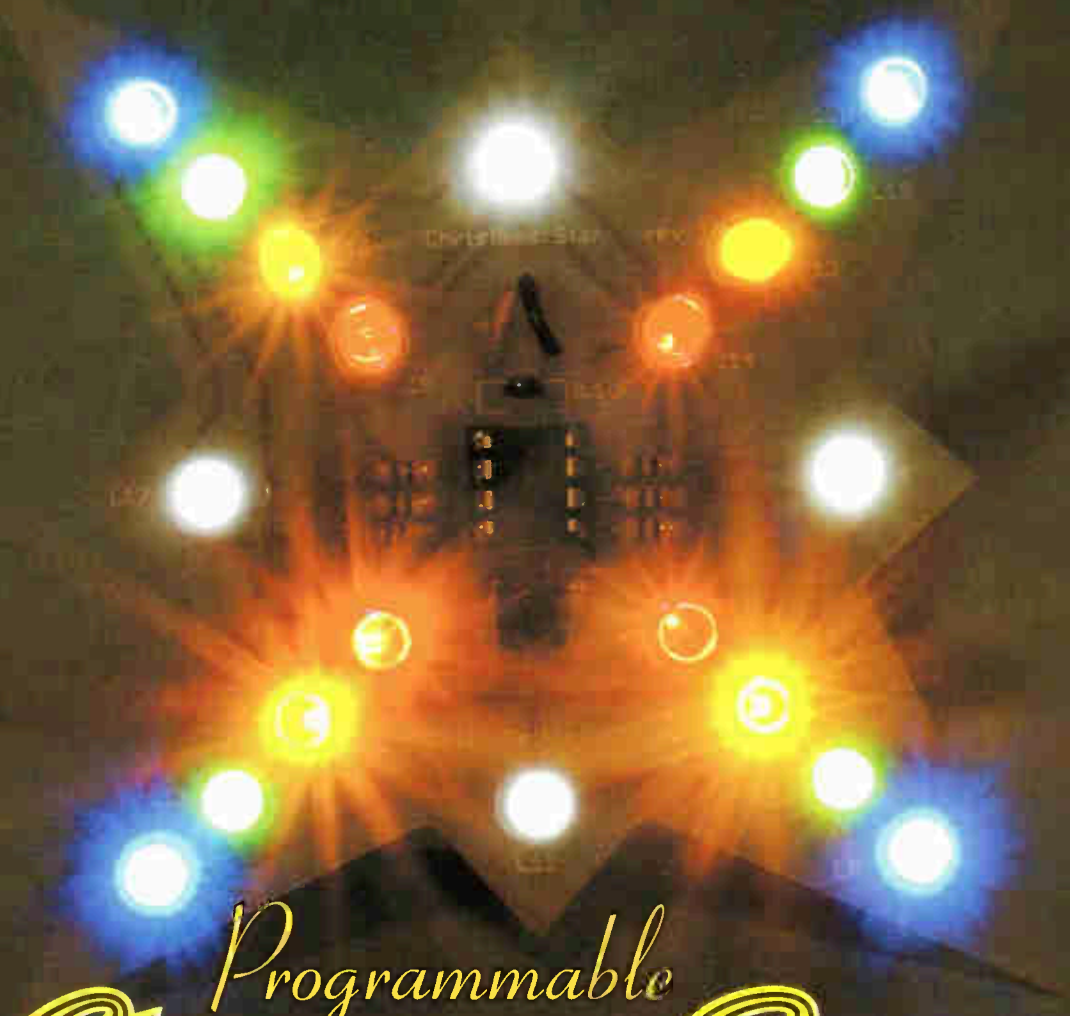
M12/08

Star of wonder, star of night!
Star of royal beauty bright;
Westward leading, still proceeding,
Guide us to thy perfect light.



Programmable Christmas Star

Features

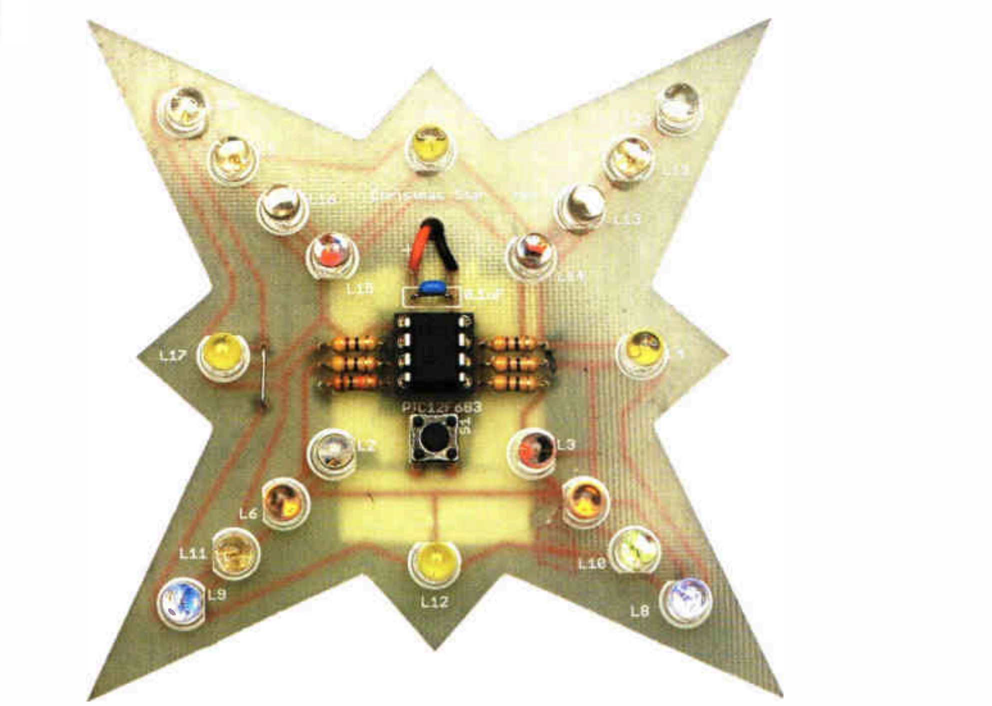
- ★ *Light enough to hang on the Christmas tree or in a window*
- ★ *Cycles through hundreds of pre-programmed patterns*
- ★ *User programmable (with optional PIC programmer)*
- ★ *Programmable display rate*
- ★ *Patterns can be looped*
- ★ *Twinkle effects*
- ★ *Battery powered*
- ★ *Turns itself off after three hours*
- ★ *Low component count*

by David Meiklejohn

RECENT advances in microcontroller technology mean that our latest festive offering, based on a single 8-pin PIC micro, has very few components and can be run from a pair of 1.5V batteries.

As it is also extremly easy to build, and you can reprogram it if you want different patterns, we believe this new Christmas Star will be even more popular than previous projects.

It runs through a programmed pattern sequence, held in EEPROM on the PIC. With a suitable PIC programmer, such as Microchip's low-cost PICkit 2, it is possible to load a new sequence into the EEPROM without affecting the underlying code. *There's no need to understand PIC programming to create your own display sequence.*



Here's the Christmas Star, actual size, from the front. Each 'arm' has the same colour run of LEDs – blue, green, yellow and red, with single white LEDs between.This shot was taken with the LEDs flashing, hence some colour shown. It's not quite as dramatic as the photo earlier, taken in near darkness

How it works

Fig.1 shows the complete circuit, such as it is! It consists of little more than the pre-programmed PIC12F683-I/P microcontroller, 20 LEDs and a few resistors.

Typically, to control a large number of LEDs using a small number of output lines, the LEDs are arranged in a matrix, say 5×4 for 20 LEDs, with transistors driving each row and/or column.

That was the common approach taken for most previous Christmas Star projects, but not this time! So how *do* we drive 20 LEDs with an 8-pin PIC and five resistors?

It's made possible through a technique known as 'Complementary LED Drive'. It relies on two factors:

1) LEDs will only conduct (and therefore produce light) when a high-enough forward voltage is applied. If the voltage is too low, or reversed, they simply won't light up.

2) The PIC12F683 has tri-state outputs. That is, they can be set high (nearly 3V in this circuit), low (close to 0V), or placed into a high-impedance input state, effectively disconnecting them from the circuit ('off'). Further, the outputs can either source or sink current, up to 25mA.

As an example, consider what happens when the PIC is configured with pin GP5 high, pin GP0 low, and pins GP1, GP2 and GP4 tri-stated (disconnected). Current will flow from GP5 through resistor R1, then LED19, returning through R5 to GP0. So LED19 will light up. Since LEDs are one-way devices, current cannot flow through LED20, so it stays off.

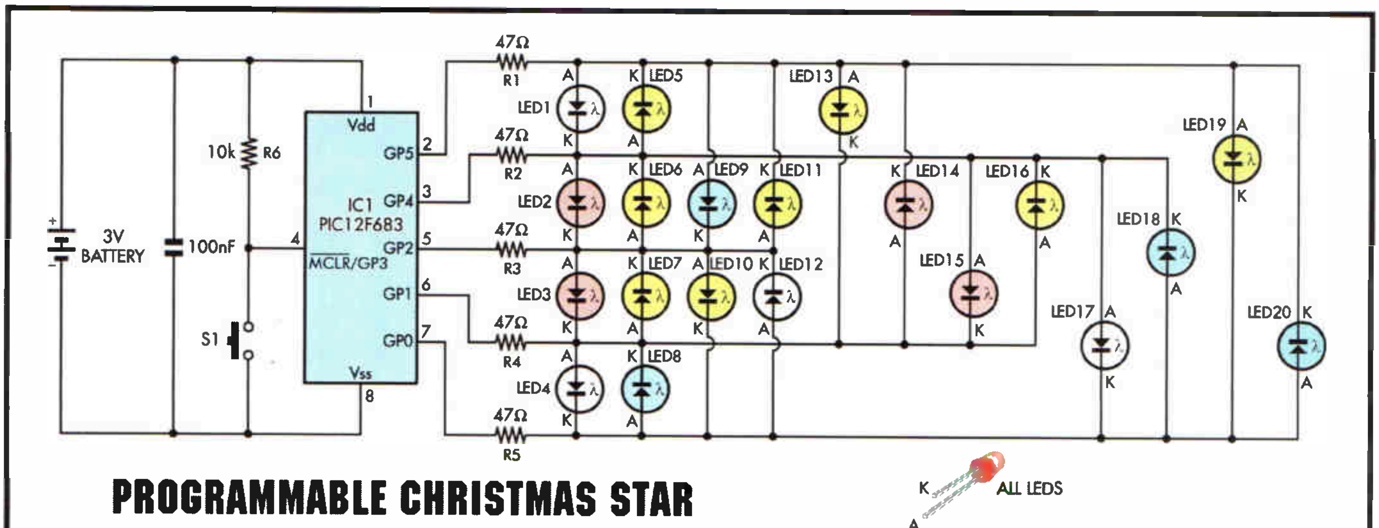


Fig.1: Because the PIC chip takes care of timing, sequencing and lighting the LEDs, the circuit is extremely simple. You don't have to follow the LED colours used in the prototype, but the patterns will obviously be different.

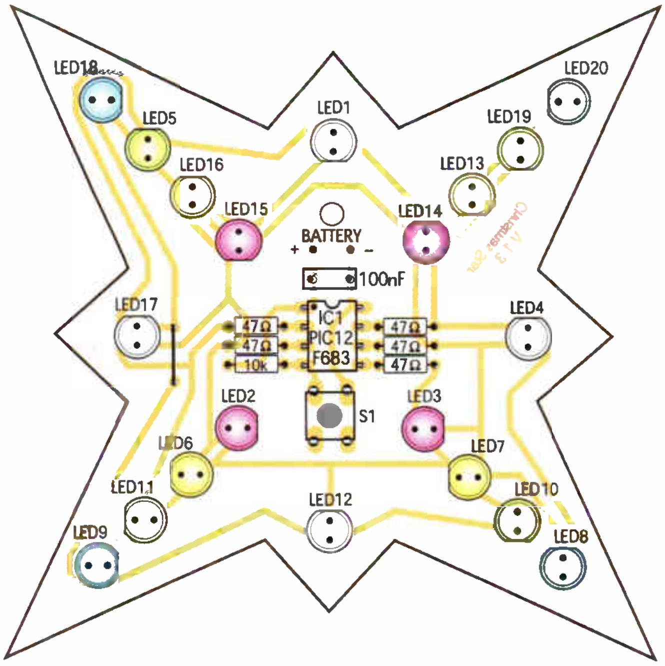


Fig.2: About the only thing that can go wrong when assembling the Christmas Star is to put an LED (or the PIC chip) in the wrong way, or to have a bad solder joint underneath. Otherwise it should be pretty much plain sailing, even for a complete novice!

Light matters

But there are other paths for current to flow from GP5 to GP0. For example, via LEDs 9 and 10 in series. But these two series LEDs are also in parallel with LED19, which is conducting.

Here's where factor 1 (which we mentioned earlier) comes into play. The forward voltage across a conducting LED is roughly constant; for a red LED it is around 2V.

The voltage drop across the series combination of LED9 and LED10 must be the same as that across LED19. So each of LED9 and LED10 will have a forward voltage of only a half that of LED19. If LED19 is turned on with a 2V drop, there will be a drop of only 1V across each of L9 and L10 – not enough to make them conduct. So they won't light up.

You'll find many other possible paths for forward conduction; a particularly obvious one is the series combination of LED1, LED2, LED3 and LED4. Similar reasoning shows that the voltage across each is only a quarter of that across the conducting LED19; not enough for them to turn on. Similarly, for other paths, such as the non-obvious LED13, LED16, LED17 combination. In fact, with GP5 high, GP0 low, and the other outputs 'disconnected', only LED19 will have enough forward voltage to light up.

Using this technique, it is possible for five outputs to uniquely address up to twenty LEDs, with the limitation that they can only be turned on one at a time.

Multiplexing

To overcome this limitation, the software uses multiplexing to make it appear as though more than one LED is lit at the same time. The software displays patterns on up to four LEDs, which are turned on in sequence, each for 200µs, at nearly 1250Hz, creating the illusion that the four LEDs are all on together.

The remainder of the circuit is very straightforward. Resistors R1 to R5 limit current to the LEDs. The current path to a given LED will always flow through two of these resistors, so the effective resistance in series with each LED is 94Ω.

Assuming a 3V power supply, and a red LED with a forward voltage drop of 2V, LED current will be 10mA – well within the supply capability of the PIC.

Switch S1 is used as an on/off switch. Resistor R6 holds PIC pin $\overline{\text{MCLR}}$/GP3 high until S1 is pressed, pulling the input low. The software polls for this at the end of each display cycle and if S1 is pressed, it puts the PIC into a low-power sleep mode. The PIC is then set to automatically wake up if the switch is pressed again.

Switch debouncing is done in software, so there is no need for external debounce circuitry.

Power is supplied direct from two 1.5V batteries. N-cells were chosen because their size makes them easy to mount unobtrusively on the back of the board. But cheaper AAA cells will also fit, albeit a little less neatly. They'll also last longer.

Alkaline batteries will provide more than 50 hours continuous operation, and should last up to two years with the circuit in sleep mode ('off').

Finally, a 100nF bypass capacitor is used to smooth the power supply to the microcontroller. It helps to keep the PIC stable, particularly as the batteries discharge toward the PIC's minimum operating supply voltage of around 2V.

Software

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

Software and kits are also available from the author see **www.gooligum.com.au/kits/xmaster/xmaster.html**. The site also has a video to download of the complete display sequence.

Construction

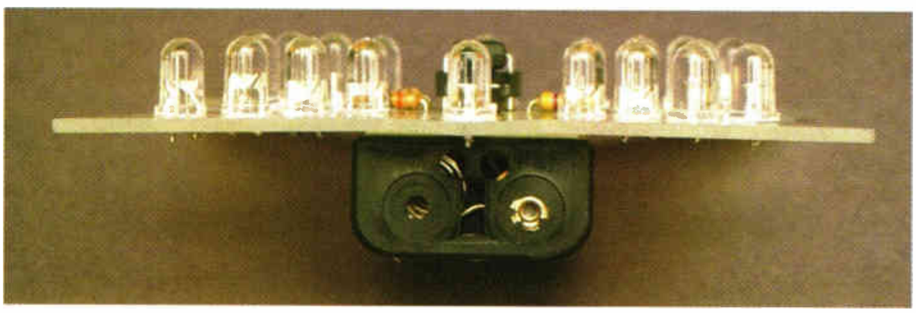
The Christmas Star is built on a single-sided PC board, cut in the shape of an eight-pointed star. All components are mounted on this PC board (see Fig.2), so construction is very straightforward. This board is available from the *EPE PCB Service*, code 692.

First, you'll need to choose your LEDs. In the prototype, all the LEDs are clear, high-intensity types.

Five colours were used: red, green, yellow, blue and white; arranged with four red LEDs forming an inner ring, then yellow, green and finally blue at the outermost of the big points. White LEDs are used on the four small star points.

Of course, you can arrange the colours any way you want; after all, it's your star! And the choice of high intensity or diffused types with a wider viewing angle is entirely up to you.

These two shots show how the dual N-cell battery holder fits on the back of the PC board, secured in place with double-sided foam adhesive tape or pads. Note that an 'AAA' holder will also (just) fit on the PC board and will give longer battery life than the N-cells used in the prototype. Even so, you should expect about 50 hours of display from a pair of N-cells. Don't mistake the 1.5V N-cells for 12V remote control batteries. They are not too dissimlar in size and 24V would create a whole different display... briefly!



Parts List – Programmable Christmas Star

1 star-shaped PC board, code 692, available from the *EPE PCB Service*
1 pre-programmed PIC12F683-I/P microcontroller (IC1)
20 5mm LEDs (see text for colours and types)
1 100nF monolithic capacitor
1 10kΩ 0.25W resistor
5 47Ω 0.25W resistors
1 6mm PCB mounting tactile or click-effect pushswitch, 5mm pin spacing (S1)
1 N-cell battery holder with fly leads (or AAA – see text)
2 N-cell alkaline batteries (or AAA – see text)
Double-sided foam tape (to mount battery holder)

Not so intense

About now, you may be wondering how it is possible to use blue, or indeed most high-intensity types, when they have a forward voltage higher than the supply voltage of 3V.

In practice, they do run at voltages down to 2.5V or so; they're just not as bright as they would otherwise be. At low voltages, they're still about as bright as a 'normal' LED; quite bright enough to light up nicely at night time!

An IC socket for the PIC is strongly recommended. Besides reducing the risk of damaging the chip, it means that later, if you acquire a PIC programmer, you have the possibility of creating your own display pattern.

Begin construction by soldering in the resistors, then use one of the discarded resistor off-cut leads for the single wire link. Next comes the IC socket, the capacitor, the pushbutton switch and the LEDs.

Take special care of the correct orientation of each LED. If you put any in backwards, the star will still operate, but the patterns will be wrong.

Testing

At this point, you can test the circuit, with the IC socket empty, by putting the two batteries into the (not yet installed) battery holder, then putting the battery holder leads (ie 3V) across various combinations of pins 2, 3, 5, 6 and 7 on the IC socket.

For each different combination, a single LED, specific to that combination, should light strongly. Note that it is possible, if you have used a range of LED colours, that you will see other LEDs light very dimly in addition to the single strong light. If so, don't worry, you won't notice that effect when the display is operating.

If no combinations produce any light, use a multimeter to check that you're getting 3V from the battery pack. If you see more than one LED light up strongly at once, you probably have one of them in backwards, or perhaps a solder 'bridge' on the board. If one combination doesn't produce any light, while others do, you probably have either a dead resistor or LED, or a soldering problem such as a 'dry' joint.

If all the LEDs check out OK, remove the batteries from the battery pack, cut the leads suitably short (15mm or so), thread them from the back of the board to the front through the hole above the capacitor. Solder the wires back

Capacitor Codes

Value	(µF value)	IEC Code	EIA Code
100nF	0.1µF	100n	104

The wires from the battery holder come up through the board from underneath, then solder back through the board in the normal way. This helps take the strain off the cables and pads.

through the board in the normal way to the copper pads marked '+' and '–', being careful of polarity!

If you now reinsert the batteries, nothing should light up; if it does, you have a 'short circuit' somewhere. Next, remove the batteries again and use double-sided foam tape to stick the battery holder to the bottom of the board (see photos at left).

Finally, you're ready to insert the microcontroller. Taking antistatic precautions (touch an earthed case first), carefully insert the PIC into the IC socket, with the notch on the IC toward the capacitor. Make sure that none of the PIC leads are bent or skewed in the process.

Now insert the batteries again and you're finished! At this point, the display may start by itself, but normally, the star will do nothing until you momentarily press the button of S1. The display sequence should now start.

Operation

Operation of the Star is very simple – push the button of switch S1 to start, and press it again to stop. If you forget and leave the display running, the star will shut itself off after around three hours. If this happens, just press the button again to restart.

Creating your own patterns

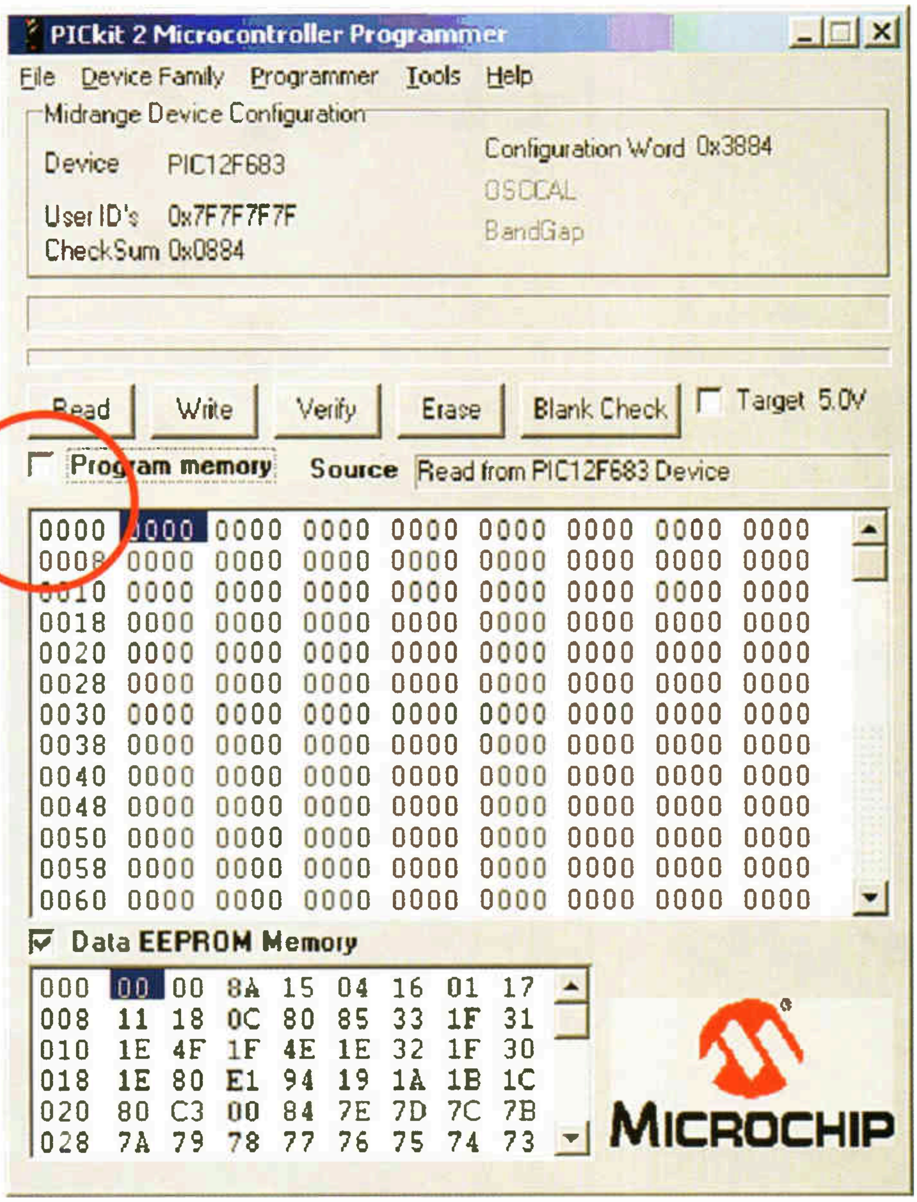
The command codes that define the display patterns are held in unprotected EEPROM, which you can update, independently of the source code held in flash memory, with a suitable programmer. You'll find the information you need to reprogram overleaf.

PIC programmer

An excellent low-cost programmer is Microchip's PICkit 2. It comes with software that allows the PIC's EEPROM to be updated without affecting the program code in flash memory.

The new command codes can be typed directly into the PICkit 2 EEPROM window and loaded to the microcontroller.

It's very important to uncheck 'Program memory', so that the program code itself is not overwritten. See the screenshot below.



If you don't uncheck this box (ringed in red above) when reprogramming your Christmas Star, you will overwrite the program itself, rendering the star useless!

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown

OVERLEAF:
Pattern Sequence Command Codes and Pattern Definitions for those who want to reprogramme the patterns.

Pattern sequence command codes

Code	Command	Description
0	Pause	All LEDs off Use for a short pause between pattern sequences
1 - 91	Pattern	Display a pre-defined pattern of up to four LEDs which are on 'at once'. For a list of, and details of each pattern, refer to the next page. LEDs are lit, one at a time, in pseudo-random order, in quick succession to create an overall 'twinkling' effect.
92 - 126	Twinkle	Twinkle rate = (code-91)ms between changes. If the code value = 92, a different LED is lit every 1ms – you may think too fast for the eye to see. But due to imperfections in the 'random' number generation, you'll still see a shimmer at this maximum twinkle rate. For code = 126, the twinkling is at its slowest, around 29Hz.
127	End of sequence	Marks the end of the programmed sequence. Not necessary if your display codes fill the whole EEPROM, as the interpreter will restart at the beginning if the end of the EEPROM is reached.
128	End loop	Go back to first pattern in current loop – see below. Use this to create loops, to avoid having to fill the EEPROM with repeated sequences of codes to create a repeating effect. Instead, place a 'start loop' instruction at the start of the sequence, and an 'end loop' (128) instruction at the end.
129 - 191	Start loop	Repeat count = code-128 EG. to repeat a sequence of patterns four times, you would place a code of 132 (= 128+4) before the first pattern code, and a code of 128 after the last. Note that nested loops are not supported. An 'end loop' code will always return to the most recent 'start loop'. Sets the display rate, ie the time spent displaying each pattern before moving to the next in sequence. It allows you to vary the speed of the display in different parts of the presentation.
192 - 255	Set Speed	Freq = 1000000/[8192(256-pattern)] Hz Max freq (code = 255) is 122Hz. Min freq (code = 192) is 1.9Hz. The default display rate, if you don't set your own speed, is 6.8Hz

As an example of how to put it all together, here's some code to twinkle at a moderate rate for 10s, then turn off (pause) for 1s, then repeat:

Code	Comment
195	display speed = 2.0Hz
148	repeat following patterns 20 times (128+20=148)
101	twinkle at 101-91=10ms per change (100Hz)
128	end loop
0	pause (all off)
0	pause again – at 2Hz we need 2 pauses to make 1 second
127	end sequence (repeat from beginning)

Christmas Star Pattern Definitions

Code	Description	LED 1	LED 2	LED 3	LED 4
0	All off				
Individual LEDs					
1	1 only	1			
2	2 only	2			
3	3 only	3			
4	4 only	4			
5	5 only	5			
6	6 only	6			
7	7 only	7			
8	8 only	8			
9	9 only	9			
10	10 only	10			
11	11 only	11			
12	12 only	12			
13	13 only	13			
14	14 only	14			
15	15 only	15			
16	16 only	16			
17	17 only	17			
18	18 only	18			
19	19 only	19			
20	20 only	20			
Arms					
21	SE arm	8	10	7	3
22	NE arm	14	13	19	20
23	NW arm	15	16	5	18
24	SW arm	2	6	11	9
Rings					
25	ring 1 - inner	3	14	15	2
26	ring 2 - inner mid	7	13	16	6
27	ring 3 - outer mid	10	19	5	11
28	ring 4 - outer	8	20	18	9
29	Small points	12	4	1	17
Complimentary pairs					
30	N S	1	12		
31	E W	4	17		
32	SE1 NW1	3	15		
33	SE2 NW2	7	16		
34	SE3 NW3	10	5		
35	SE4 NW4	8	18		
36	SW1 NE1	2	14		
37	SW2 NE2	6	13		
38	SW3 NE3	11	19		
39	SW4 NE4	9	20		
Half arms					
40	SE inner	3	7		
41	SE outer	10	8		
42	NE inner	14	13		
43	NE outer	19	20		
44	NW inner	15	16		
45	NW outer	5	18		
46	SW inner	2	6		
47	SW outer	11	9		
Complimentary halves					
48	SE NW inner	3	7	15	16
49	SE NW outer	10	8	5	18
50	SW NE inner	2	6	14	13
51	SW NE outer	11	9	19	20
Alternate LEDs – 2 per arm					
52	SE 1 3	3	10		
53	SE 2 4	7	8		
54	NE 1 3	14	19		
55	NE 2 4	13	20		
56	NW 1 3	15	5		
57	NW 2 4	16	18		
58	SW 1 3	2	11		
59	SW 2 4	6	9		
Alternate LEDS – 4 per diagonal					
60	SE 1 3 NW 1 3	3	10	15	5
61	SE 2 4 NW 2 4	7	8	16	18
62	NE 1 3 SW 1 3	14	19	2	11
63	NE 2 4 SW 2 4	13	20	6	9
64	SE 1 3 NW 2 4	3	10	16	18
65	SE 2 4 NW 1 3	7	8	15	5
66	NE 1 3 SW 2 4	14	19	6	9
67	NE 2 4 SW 1 3	13	20	2	11
Inner and outer – 2 per arm					
68	SE arm	3	8		
69	NE arm	14	20		
70	NW arm	15	18		
71	SW arm	2	9		
Inner and outer – 4 per diagonal					
72	SE NW	3	8	15	18
73	NE SW	14	20	2	9
Middle LEDS – 2 per arm					
74	SE arm	7	10		
75	NE arm	13	19		
76	NW arm	16	5		
77	SW arm	6	11		
Middle LEDS – 4 per diagonal					
78	SE NW	7	10	16	5
79	NE SW	13	19	6	11
Inner and outer half arms – opposites on diagonal					
80	SE inner NW outer	3	7	5	18
81	SE outer NW inner	10	8	15	16
82	NE inner SW outer	14	13	11	9
83	NE outer SW inner	19	20	2	6
Inner and outer half arms – perpendicular opposites					
84	SE inner NE outer	3	7	19	20
85	SE inner SW outer	3	7	11	9
86	NE inner SE outer	14	13	10	8
87	NE inner NW outer	14	13	5	18
88	NW inner NE outer	15	16	19	20
89	NW inner SW outer	15	16	11	9
90	SW inner SE outer	2	6	10	8
91	SW inner NW outer	2	6	5	18

Commands

92-126	Twinkle Rate:	(code-91)ms between changes
127	End of sequence	
128	End of loop	Go back to first pattern in current loop
129-191	Start loop	Start of loop: repeat count = code-128 times
192-255	Set Speed	Freq = 1000000/[8192(256-code)] Hz

EPE

Recycle It!

BY JULIAN EDGAR

A £5 variable voltage power supply

Want to be able to dim lights in, say, a model rail layout? Or what about varying the speed of a low-powered motor or regulating the voltage going to a bike headlight, so that its brightness stays the same as the battery voltage falls? It's all possible for less than £5.

THIS DESIGN uses a slightly modified car phone charger. Most car phone chargers use a DC-DC switching power supply to reduce the voltage from the car's 13.8V to whatever the phone requires. However, it's easy to modify the PC board to give an adjustable voltage output.

Apart from the car phone charger (the electronics are normally built into the cigarette lighter plug), all you need is a 10kΩ multiturn potentiometer. Car phone chargers are available in secondhand shops, at the tip and in the junk rooms out the back of phone retailers, while a 10kΩ pot can be scrounged from some old gear or purchased from your local electronics parts retailer.

Building it

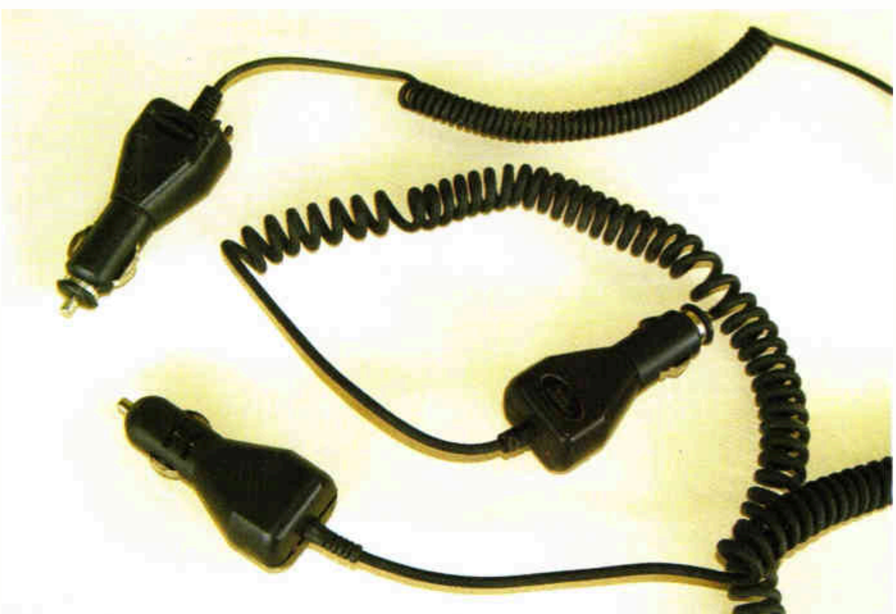
Fig.1 shows a typical circuit for a car phone charger. The IC controls the output voltage, using voltage feedback provided by resistors R1 and R2. So, if you change the values of R1 and R2, the voltage output will also change.

However, rather than have a fixed output, we can vary the output at will by installing a potentiometer in place of the two resistors. Then it's just a case of measuring the output voltage and adjusting the pot until the required voltage is obtained.

If you want the voltage to be set and then forgotten, use a trimpot. Alternatively, if you want to be able to vary the voltage at any time, wire a full-size pot to the board with flying leads.

The most difficult part is finding the correct resistors to change. Individual chargers vary quite a lot, so the component designations marked on the board (eg R1, R2) will probably not coincide with Fig.1. Hmmm.

So how do you find the right resistors? The answer is to closely look at



Inside each of these car phone chargers is a sophisticated DC/DC converter that can be easily modified to provide a variable output power supply.

Rat it before you chuck it!

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

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

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

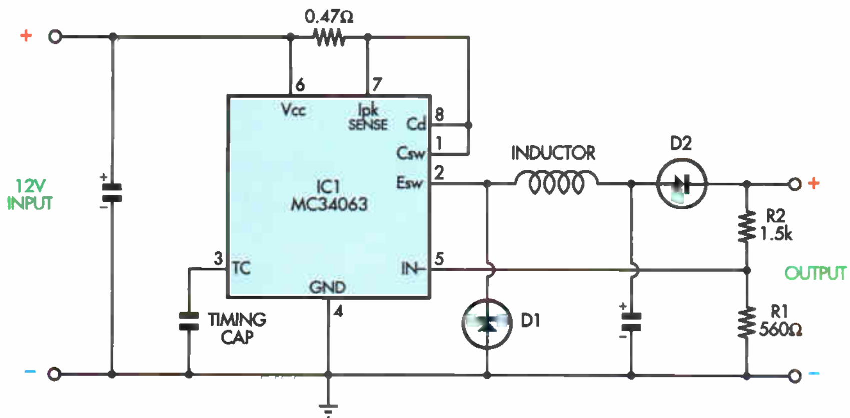
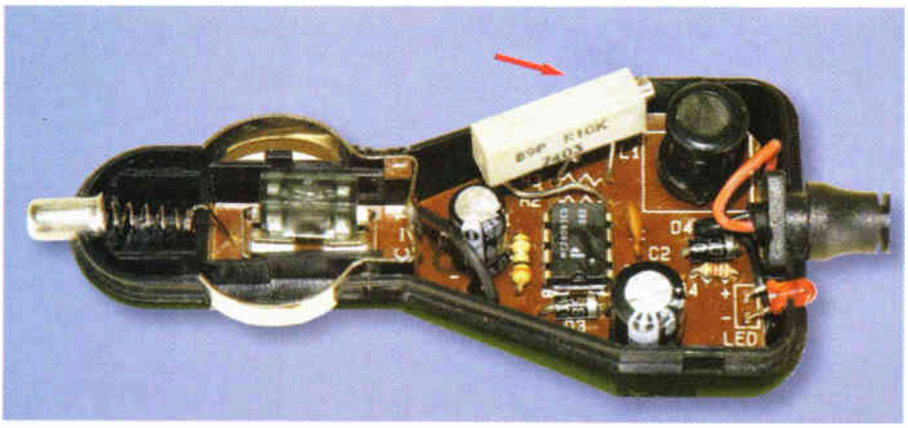


Fig.1: the circuit of a typical car phone charger. The output voltage is set by R1 and R2. If these are replaced with a 10kΩ pot, the output voltage can be adjusted over a wide range.



The charger is modified to produce a variable output by substituting a pot (arrowed) for two resistors. If external adjustment is needed, a full-size pot can be wired to the board with flying leads. In this case, a multiturn pot has been used, which allows for very accurate setting of the output voltage.

the top and bottom side of the board. Somewhere, there will be two resistors that join to a common track at one end, but go to different tracks at their other ends. The track that both resistors join to will also connect to pin 5 of the IC. Given that there will only be three or (at most) four resistors on the board, it shouldn't be all that hard to find the resistor pair in question.

The next step is even easier – remove these two resistors and solder the pot to the board in their place. The centre terminal (moving contact) of the pot goes to the track where the two resistors were originally joined together, while the outer pot terminals connect to the remaining two vacant pads.

Note that in some cases it's easier to make the connections by soldering the pot to the track side of the board.

Each of these bike headlights is run from a modified phone charger. The chargers are used to drop the voltage from the available 12V (provided by sealed lead-acid batteries that also power the electric-assist bike) to a regulated 6V.

Using it

To test the modified power supply, you'll need a source of 12V power and a multimeter.

First, connect the power supply to the 12V source (eg, a plugpack), making sure that you get the polarity the right way around (the tip of the cigarette lighter plug is positive). That done, connect the multimeter to the output leads of the adaptor and measure the voltage as the pot is adjusted – the output voltage should vary.

Finally, place a load on the output (eg, a small 12V bulb) and check that you can alter the brightness of the lamp over a wide range. Typically, you can draw about 0.5A from the unit (depending on the plugpack). If the output voltage is critical, the pot should be set with the typical load attached. *EPE*

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Using the Microchip PICkit 2 Debug Express to build a Capacitive Switch

By Marcel Flipse

A few passive components produce a capacitive switch

THE PICkit 2 Debug Express is a small kit with a development target board and a debugger. It has everything you need to develop a small project from scratch.

It was reviewed in the June '07 issue of *EPE*, showing the development environment (MPLAB) and the features of the debugger. The design presented in this issue is a Capacitive Switch, built with just a few passive components. The switch is implemented with Microchip's mTouch™ technology.

Microchip currently offers a number of different hardware solutions to suit the demands of any application, from the most basic single-button design using the small PIC10F, to the peripheral-rich mid-range and PIC24FJ MCU families. The design presented here is built with the PIC16F887 that is on the development board.

mTouch

Microchip's mTouch Sensing Solution is a touch-sensing design based on changes in capacitance. Many modern applications implement capacitive sensing to provide a sleek, aesthetic, and professional look to their product.

The basics of capacitive sensing are illustrated in Fig.1. As a user brings their finger close to the sensing pad, additional capacitance is introduced to the system. This capacitance is detected through a PIC microcontroller, additional circuitry and software that detects a 'button press'.

The PIC16F887 features a comparator peripheral with SR Latch. Capacitive mTouch Solution implements the capacitance of the touch sensor as a frequency-determining element in a relaxation oscillator. The frequency of the oscillator is then measured, and any shift due to a user's touch is detected and validated in software. Fig. 1 shows the schematic for the oscillator/timer circuit used, along with the sensor capacitance.

The relaxation oscillator is a free-running RC oscillator using the two comparators with an SR latch to change the charge direction of the sensing capacitor's voltage, up or down.

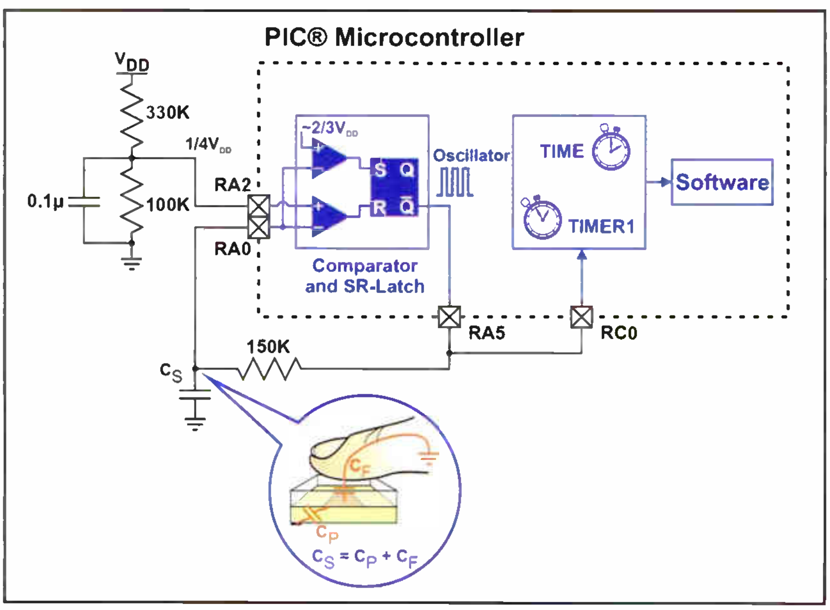


Fig.1: Basic mTouch oscillator schematic

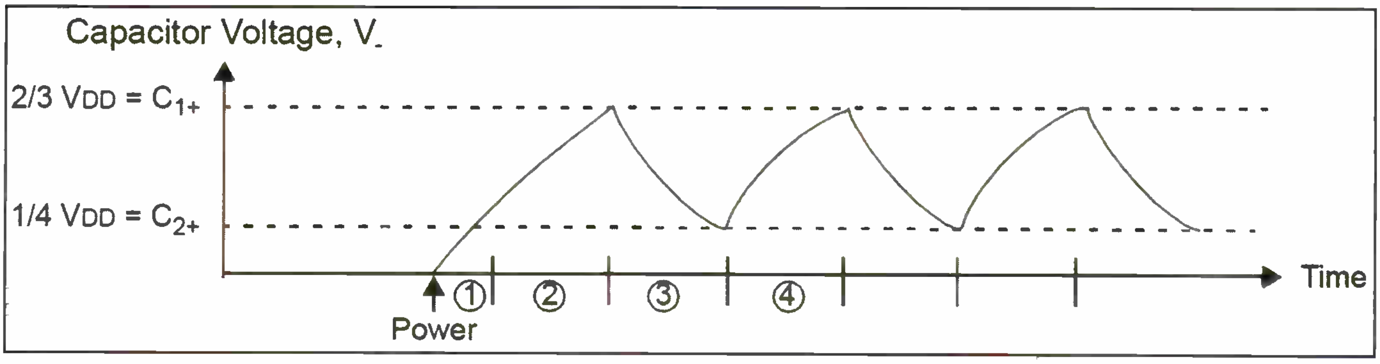


Fig.2: Charge and discharge cycles

It will charge and discharge the capacitor at a rate determined by the RC time constant, and it will charge between upper and lower limits set by the positive inputs to the comparators. The upper limit is internal, but the lower limit must be supplied externally. A simple resistor divider with a 100nF decoupling capacitor will do the job. The 100nF capacitor is in place to reject high-frequency noise from the power supply and ensure a stable lower limit.

The voltage across the sensing capacitor will charge and discharge between these limits, and is driven by logic level signals at $C2_{OUT}$. Comparator 2's output, $C2_{OUT}$, is configured for Q in order to get the appropriate charging and discharging behaviour. The feedback resistor forms the RC circuit with the sensor plate denoted as C_S. When the voltage across capacitor C_s is below the lower limit, $C2_{OUT}$ goes high, and the system will begin charging.

In between the limits, the system will retain the last state (charging or discharging). When the voltage above upper limit $C2_{OUT}$ goes low the system will begin discharging and continue to discharge through the middle region. An illustration of the charge and discharge cycling is shown in Fig. 2. The output, Q, and the charging or discharging state it represents is determined by the relative values of the negative input to the positive input of each comparator and the SR latch.

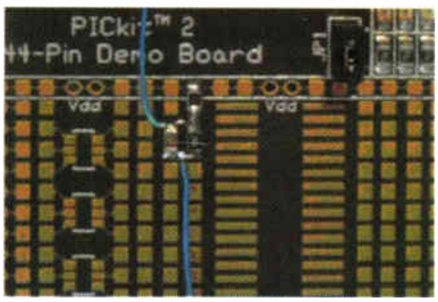


Fig.3: External lower voltage limit components

Building the circuit

The circuit can be built in minutes. The author used two surface mount resistors and a capacitor to construct the voltage divider for the lower voltage limit. The components were soldered on the prototyping area, see Fig.3. Wirewrap wire was used to make the connections.

When designing a capacitive button, the shape of the pad is not very important. The area of the pad is what is important. A larger pad area will allow better detection and sensitivity.

The author used a 20 pence coin, but any metal area will work, see Fig.4. A 150kΩ resistor was used for charging and discharging. The value of the resistor and the sensing capacitor determine the oscillator frequency. Any frequency in the 100kHz to 400kHz range will work. The exact frequency is not important, but having a high frequency yields more counts in the measuring process and a better resolution than a low frequency.

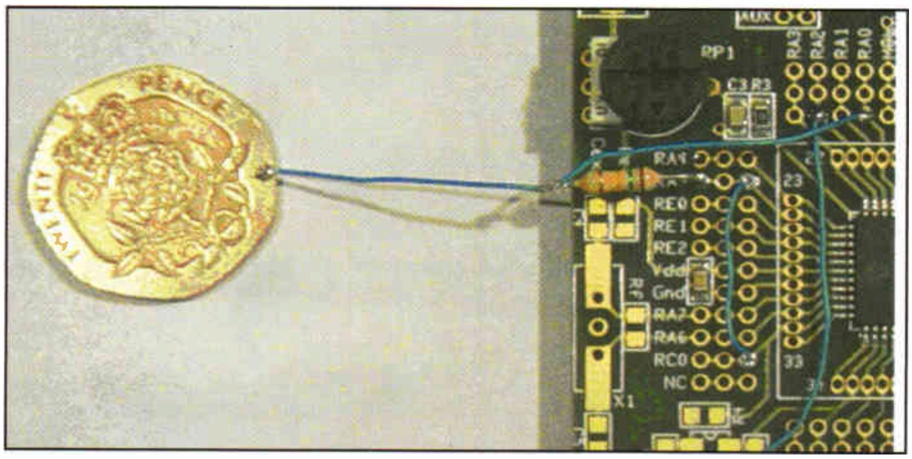


Fig.4: A 20 pence mTouch sensor pad

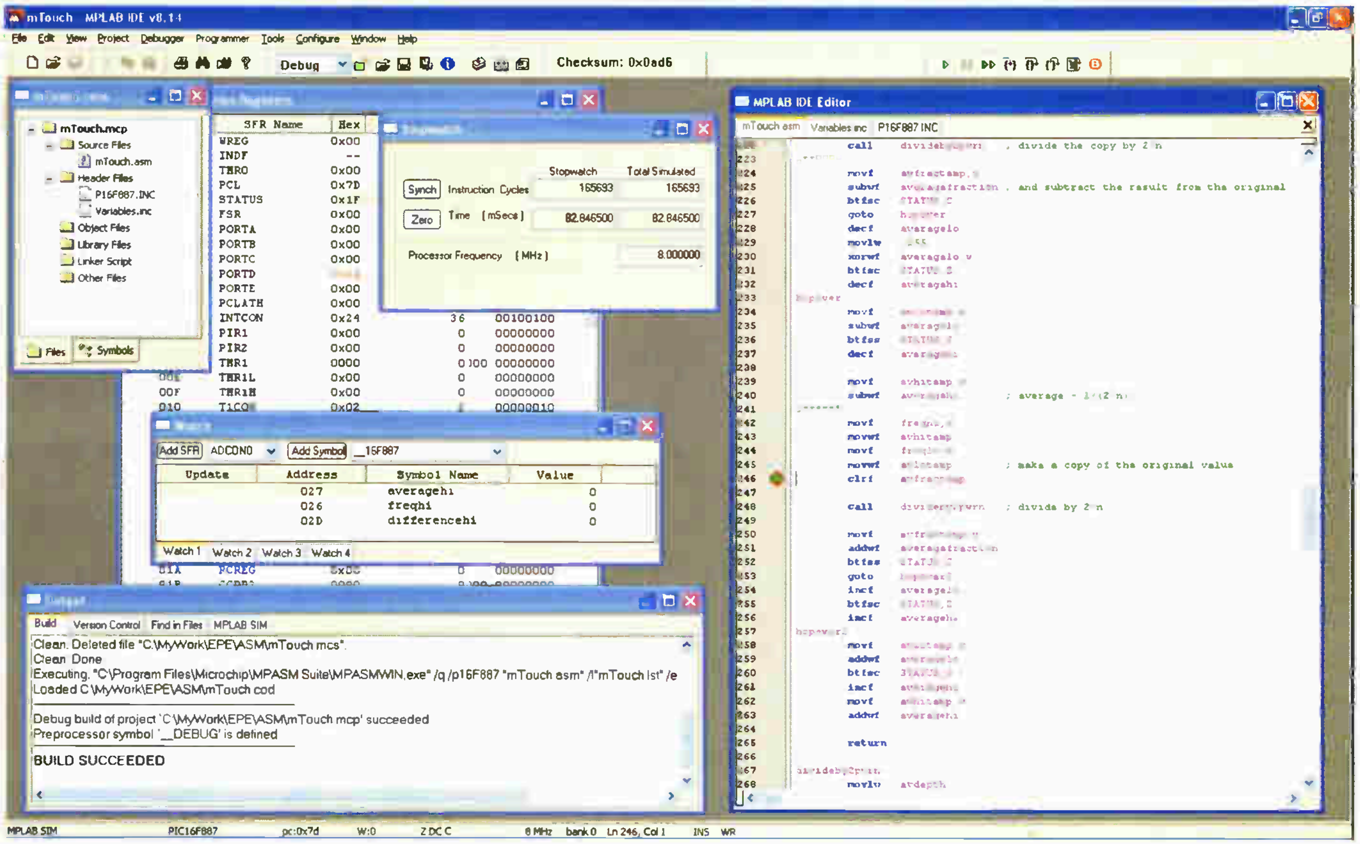
The next task is to connect the output of the oscillator to Timer1, so the software can measure the frequency. Another piece of wire was used to connect RA5/$C2_{OUT}$ to the RC0/T1CKI pin of the PICmicro. The last wire that needs to be soldered runs from the junction of the RC to the comparator module (RA0/C12IN0-). Remove R3 from the board, as this will disable the onboard pot. See Fig.4.

Software

The last step is to implement the code. The code was written in assembly language and can be compiled using MPLAB, which can be downloaded free of charge from the Microchip website.

The first step is to initialise the comparator peripheral. The appropriate registers are set in the Init subroutine. Once the oscillator is running, its frequency must be monitored to detect the drop in frequency caused by a finger 'press'. Each time $C2_{OUT}$ changes from '0' to '1' Timer1 will increment.

A fixed timebase is used to measure the frequency over a defined period. Timer0 provides this fixed period timebase. At the start of a measurement, Timer0 is



cleared and it will count up to 255 and then overflow. On overflow, the Timer0 interrupt, T0IF, causes the program to vector to the Interrupt Service Routine.

The value of TMR1 is then read and compared to previous readings.

If the current value of TMR1 is significantly lower, the capacitance has increased and a 'button press' is detected. The LEDs connected to PORTE will light up. The new value is averaged into a running average, which is the base value for comparison. At the end of the Interrupt Service Routine, once all tasks determining a 'button press' are finished, both Timer1 and Timer0 are cleared and restarted for the next reading.

Additional information

The software for this project can be found at the *EPE* website:

www.epemag.com

Additional information on mTouch can be found on the Microchip website at:

www.microchip.com/mtouch

Special offer

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

By Robert Penfold

INTERFACE

SERIAL PORT COMPATIBILITY ISSUES

THE BASICS of using the MSCOMM ActiveX component with Visual BASIC 6.0 were covered in an earlier *Interface* article. While there are advantages in using this combination to produce software for use with USB/RS232C add-ons, there is the major drawback of the software having less than total compatibility with modern versions of Windows. This should not really be the case, since the software is being produced using a Microsoft product that does things 'by the book' and does not take any shortcuts.

In most respects, the compatibility with current versions of Windows is quite good, but as explained in previous *Interface* articles, it can be difficult to get programs to run for the first time. This does not seem to be due to any major flaw in the programs, but would appear to be a result of Vista's somewhat overcautious approach to running programs. It is secure to a degree that can make it difficult to run some perfectly legitimate programs.

Express relief

Compatibility issues can be avoided using a more modern version of Visual BASIC, such as Visual BASIC 2008 Express Edition, which has a different means of handling serial ports. It is supplied complete with a component called SerialPort, which has many of the features provided by MSCOMM, but is not a direct equivalent to it. Like MSCOMM, it is not available by default, and it must be loaded onto a form before its facilities can be used.

Note that it will not appear on the form when the finished program is run, and it will not even appear as an icon on the form when the program is being written. Instead, its icon will appear in the lower section of the main window. It can be selected here, and its properties will then appear in the Properties window (Fig.1). Most of the SerialPort parameters can be controlled via the program, but the Properties window provides an easy means of setting the initial parameters.

The normal word format for interfacing to user add-ons is one start bit, eight data bits, and one stop bit with no parity. This word format is usually set by default, but it is as well to check these settings in the Properties window if you will not be setting them using program code.

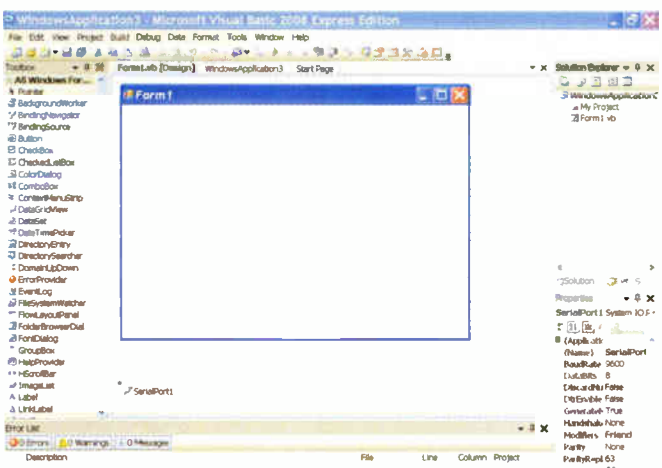


Fig.1. The serialPort component is loaded onto the form, but it does not appear on the form. Instead, it appears in the panel beneath the form

Listing 1

```
Public Class Form1

   Private Sub Form1_Load(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles MyBase.Load
       SerialPort1.Open()

       HScrollBar1.SmallChange = 1
       HScrollBar1.LargeChange = 5
       HScrollBar1.Minimum = 0
       HScrollBar1.Maximum = 255
       HScrollBar1.Value = 0

   End Sub

   Private Sub HScrollBar1_Scroll(ByVal sender As System.Object,
ByVal e As System.Windows.Forms.ScrollEventArgs) Handles
HScrollBar1.Scroll
       SerialPort1.Write(Chr(HScrollBar1.Value))
       Label1.Text = Chr(HScrollBar1.Value)
       Label2.Text = HScrollBar1.Value
   End Sub
End Class
```

Incidentally, there is no way of setting the number of start bits, since there is always just one of them. The baud rate will probably default to 9600 baud, which is good enough when making some initial experiments, but a higher rate is needed in some real-world applications.

Make sure that the Handshake parameter is set to 'None'. Handshaking should be unnecessary with a user add-on, and there can be difficulties when sending data if it is accidentally enabled.

It is essential that the PortName parameter specifies the correct COM port. Standard serial ports built into a PC will usually be fixed as COM1 and COM2, but the port number assigned to a virtual serial port, such as a USB adapter, will not necessarily remain unchanged. In particular, the port number assigned to a USB adaptor is quite likely to change if the adaptor is unplugged and reconnected later.

This is almost certain to happen if it is reconnected to a different USB port, since the adaptor will be regarded as a totally new port by the operating system. Anyway, with real-world software that uses a serial port it is normally necessary to provide some means for the user to select the correct port.

Stringing along

The normal problem when using a serial port with a user add-on is that the built-in routines for handling serial communication are aimed more at sending files or strings than at sending simple bytes of data. In some applications this is not a problem, but in most cases it is just individual bytes of numeric data that must be handled, or perhaps small groups of bytes. This was more problematic in the days when the user add-on was likely to be based on a UART and some logic devices, or just standard logic devices throughout. String conversions in either direction with this type of circuitry would be very difficult.

The same is not true when the add-on circuit is based on a PIC chip or some other microcontroller. String conversion in either direction should not prove difficult, and should really be quite easy if the characters in the strings will only be digits from 0 to 9. Handling the flow of data is also relatively easy when using a gadget based on a microcontroller, since everything is handled by software routines, with no extra hardware being required.

Consequently, in a modern context there is usually no absolute necessity to find a way of persuading the software in the PC to deal with data exchanges on a byte-by-byte basis. On the other hand, there is usually some string conversion required at some stage of the proceedings, and the PC is probably the easiest place to deal with it. Anyway, here we will only be concerned with the exchange of data in the form of bytes rather than in the form of text strings.

Sending data

Sending data is somewhat simpler than receiving it, so we will start with this aspect of serial communications. Sending data can actually get quite involved, but Listing 1 strips the process down to the bare necessities.

This was written using Visual BASIC 2008 Express Edition, which is still available as a free download from the Microsoft site (as is a new Service Pack). It might also work with the 2005 version of this program, but it will definitely not work with any earlier edition.

A scrollbar is used to provide a variable value from 0 to 255, and each new value set on the scrollbar is sent via the serial port. Each value and its corresponding ASCII character are displayed by the program. In order to work properly, this program requires a form with a horizontal scrollbar and two label components. Of course, it must also have a SerialPort component with suitable parameters set. To keep things straightforward, the default names are used for all four components. The existing code is either modified to match Listing 1, or it is erased and replaced with the new code.

The first subroutine opens the serial port and sets suitable parameters for the scrollbar. If preferred, the parameters for the scrollbar can be set by way of its Properties window rather than using program code, but either way it is essential that the generated values are restricted to integers from 0 to 255. In other words, they must be valid values for a byte so that they can be sent via the serial port. The SmallChange value should be set to one, so that any integer from 0 to 255 can be generated.

The second subroutine sends each newly generated byte of data using the 'SerialPort1.Write()' method. The value from the scrollbar is stored in Hscrollbar1.Value, and it is converted into the corresponding ASCII character using a Chr() instruction. This character is then converted back into the corresponding byte value by the system and it is then sent via the serial port. The ASCII character and the unconverted byte value are used as the Text parameters for the Label1 and Label2 components respectively. Fig.2 shows the program in action. The only two pins of the serial port used when sending data are TXD (pin 3) and Gnd (pin 5). Full connection details for a 9-pin PC serial port are provided in Fig.3.

Listing 2

```
Public Class Form1
    Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As System.
EventArgs) Handles MyBase.Load
        SerialPort1.Open()
    End Sub
    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As System.
EventArgs) Handles Button1.Click
        SerialPort1.DtrEnable = True
    End Sub
    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As System.
EventArgs) Handles Button2.Click
        SerialPort1.DtrEnable = False
    End Sub
    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As System.
EventArgs) Handles Button3.Click
        SerialPort1.RtsEnable = True
    End Sub
    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As System.
EventArgs) Handles Button4.Click
        SerialPort1.RtsEnable = False
    End Sub
End Class
```

Highs and lows

There are two handshake outputs on the serial port that are not normally needed with user add-ons due to the lack of any hardware handshaking. These can be used as general purpose logic outputs, but it must be remembered that these operate at normal RS232C levels of about $\pm$12V, and not at normal logic levels. Like RS232C data outputs, they must be used with line receivers in order to provide ordinary logic compatible voltages.

The two handshake outputs are the DTR and RTS lines, which are respectively at pins 4 and 7 of the serial port. These can be set as True (+12V) or False (–12V) via the DtrEnable and RtsEnable parameters. Listing 2 can be used to test these outputs, and it requires a form equipped with four control buttons and the SerialPort component. The text of each button is altered to indicate its function (Fig.4). Operating one of the buttons places either the DtrEnable or RtsEnable parameter at the appropriate setting, and the output level on the line should change accordingly.

A digital test meter set to a suitable voltage range is all that is needed in order to confirm that the two output lines are providing the appropriate responses.

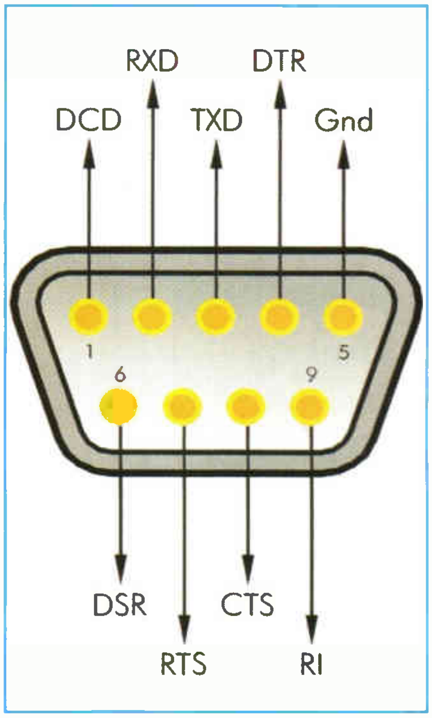


Fig.3. Connection details for a standard port. Only the TXD and Gnd terminals are required when sending data

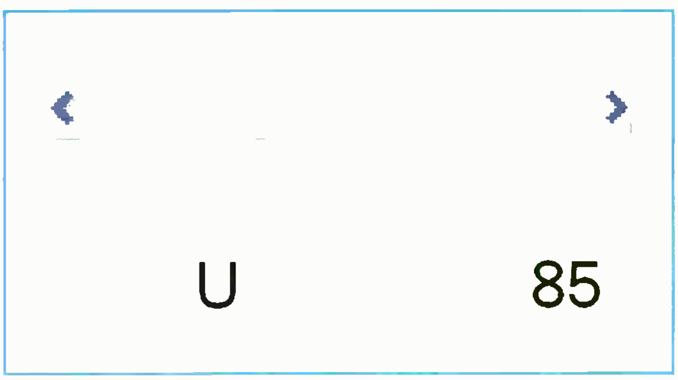
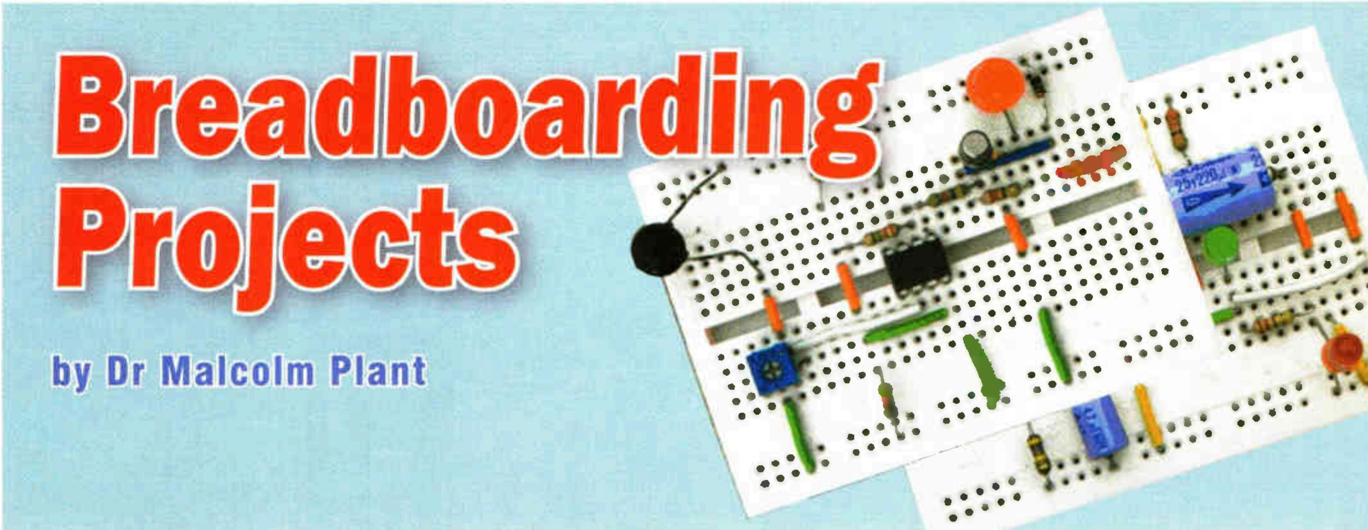


Fig.2. The simple serial port transmission program in operation. The last value transmitted is displayed, together with its corresponding ASCII character

Fig.4. Four buttons are required for the program that demonstrates control of the two handshake outputs (DTR and RTS). These outputs operate at RS232C signal levels and not at standard logic voltages



A beginner's guide to simple, solder-free circuit prototyping
Part 3: Thermostat and Games Timer

In this third part of our series we present constructional designs for a Thermostat and a Games Timer, both built on a plug-in breadboard.

Project 5:
Thermostat

Have you ever wanted to keep something at a constant temperature? That's certainly what a thermos flask does, but what about an electronic solution?

Fig.3.1 shows one way of doing this electronically. The circuit is designed to maintain an environment, such as a small aquarium or a small enclosure containing insects, at a steady temperature.

How it works

A thermistor, TH1, is the sensing component, having a resistance that increases as its temperature falls – it is called a *negative temperature coefficient (NTC)* thermistor. The heating element is a low voltage filament lamp.

The circuit comprises three building blocks – see Fig.3.1. In sensing building block 1, a voltage divider is made up of the thermistor and a potentiometer, VR1, which is used as a variable resistor, both connected in series. The voltage at point *X* rises and falls as the thermistor warms up and cools, respectively.

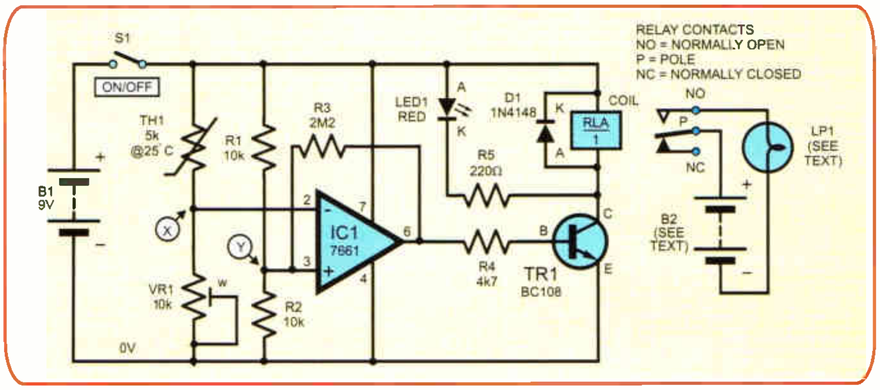


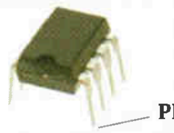
Fig.3.1: Circuit diagram for the Thermostat

In building block 2, a switching circuit based on an integrated circuit operational amplifier (op amp), IC1, senses the difference in the voltage between its two inputs, at pins 2 and 3. Pin 2 responds to the varying voltage from the sensing circuit by comparing it with the fixed voltage set on pin 3,

Components needed...

Integrated circuit, IC1: type 7661 CMOS operational amplifier (op amp)
Transistor, TR1: type BC108 or similar general purpose type in a TO18 style package
Thermistor, TH1: NTC (negative temperature coefficient) disc type with a resistance of 5kΩ at 25°C. For example, type TTC502A,
Light emitting diode, LED1: suggest red
Diode, D1: type 1N4148 signal diode
Relay, RLA: low voltage 6V type, single-pole changeover contacts
Potentiometer, VR1: 10kΩ miniature preset type
Resistors, R1 to R5: 10kΩ (R1,R2). 2.2MΩ (R3), 4.7kΩ (R4) and 220Ω (R5), all 0.25W carbon film
Switch, S1 (On/Off): single-pole, single-throw (SPST) (optional)
Battery, B1: 9V and connecting leads
Protobloc and wire links
Plus: Heating lamp (LP1) and appropriate low voltage power supply (ie, battery) – see Fig.3.1

Component Info

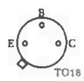


IC1, type 7661 op amp (operational amplifier).

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

TR1, type BC108 *NPN* transistor

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



TH1, disc thermistor (5kΩ resistance at 25°C). Example, type TTC502A

Has long leads and can be connected either way round in the circuit

D1, type 1N4148 signal diode

Needs to be connected as shown on the circuit diagram, with the cathode (K) terminal, marked with a black band, connected to the positive supply

marked by point *Y*. Depending on the setting of VR1, there will be a point when the temperature of the thermistor cools sufficiently to cause the voltage at

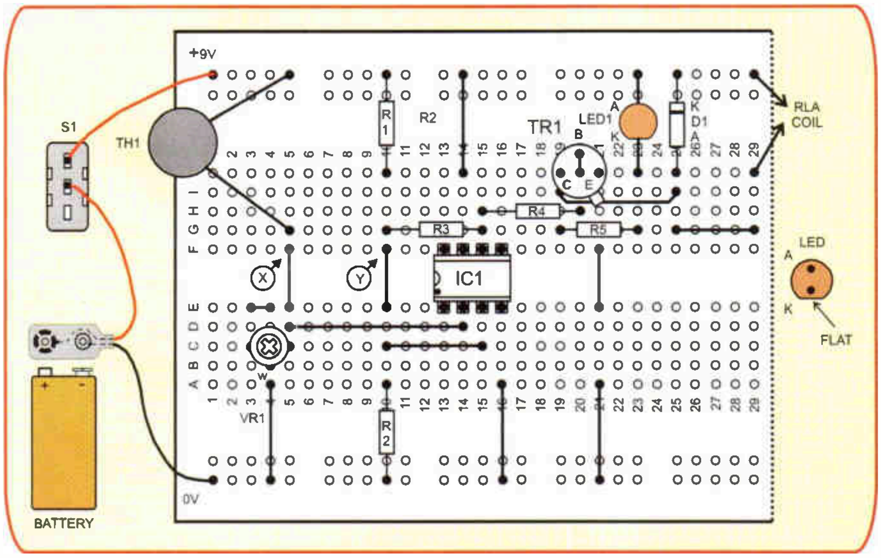


Fig.3.2: Assembly of the Thermostat on Protobloc

point *X* (pin 2) to fall below that at point *Y* (pin 3). When this happens, the output voltage at pin 6 of the op amp rises sharply and switches on transistor TR1 and energizes relay RLA.

The relay driver circuit is the third building block. The relay then switches on the filament lamp, LP1, which acts as a heater. Thus this heater only switches on when the temperature has fallen below the preset temperature set by VR1. Resistor R3 is essential for the snap-action (Schmitt trigger) switching of the op amp. Note that the reference voltage at point *Y* is set at half the supply voltage by resistors R1 and R2 through voltage divider action.

Notes

- **Do not use the relay to control power from the mains supply. If you want to control mains-operated devices you should seek the help of a qualified electrician.**
- Use the *Circuit Tester* (from Part 1) to identify the base lead of TR1 and to confirm that it is not damaged
- Note that switch S1 will not be needed for a Protobloc assembly, but will be for a permanent assembly
- You need a screwdriver to adjust VR1 and a thermometer to check that the relay is energized when the thermistor senses that the temperature of the enclosure has fallen below the preset temperature.
- A 741 type of op amp will not work in this circuit. Its output voltage does not fall to zero and therefore it will not switch off the transistor. That is why a CMOS op amp is used, its output voltage ranges between 9V and 0V, thereby firmly switching the relay on and off.

Construction brief

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

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

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

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

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

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

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

Project 6:
Games Timer

THE complete circuit diagram for the simple Games Timer is shown in Fig.3.3.

Essentially, it comprises one building block based on a single 555 timer IC (integrated circuit), wired as a monostable. The circuit produces an audio alarm after a preset time delay.

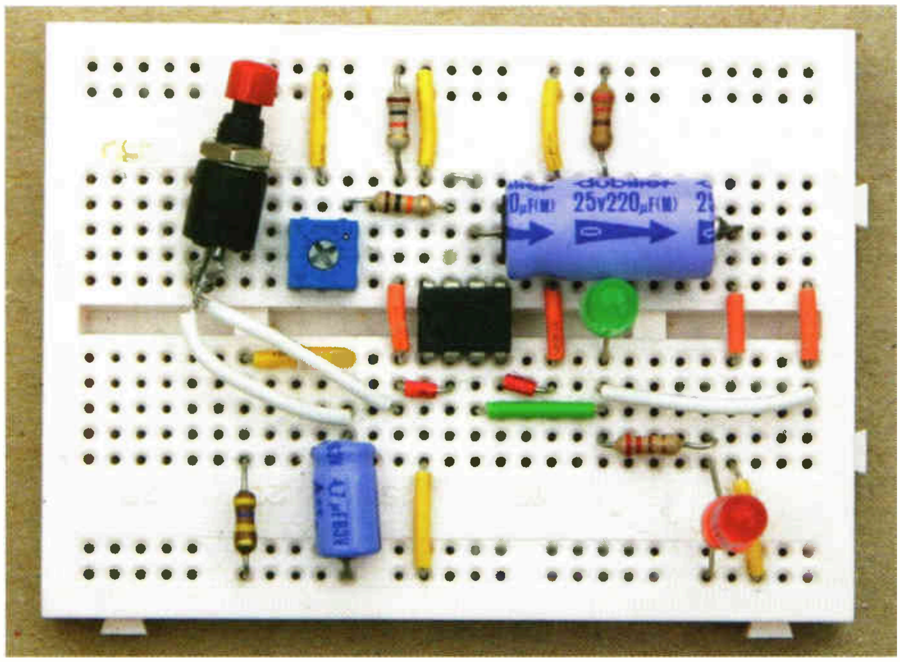
How it works

Pushswitch S2 is pressed momentarily to start the timing. Preset potentiometer VR1 (wired as a variable resistor) and capacitor C2 determine the time delay, which is between about ten seconds and three minutes using the component values shown. At the end of the timing period, the voltage at pin 3 of IC1 falls and the buzzer sounds.

When the circuit is switched on by means of S1, the buzzer sounds at first, but stops once the circuit is triggered to come on again after the time delay. When LED1 is lit, it shows the circuit is ready to be triggered or the timing has ended, while LED2 lights during the timing period.

Time out

You can increase the values of VR1 and C2 to provide longer time delays. Capacitor C1 offers a short circuit when S2 is pressed, momentarily causing trigger pin 2 of IC1 to be connected to 0V to start the timing. Resistor R4 connected across capacitor C1 ensures that the capacitor discharges once it becomes momentarily charged by pressing S2.



Games Timer assembled on Protobloc (buzzer and battery not shown)

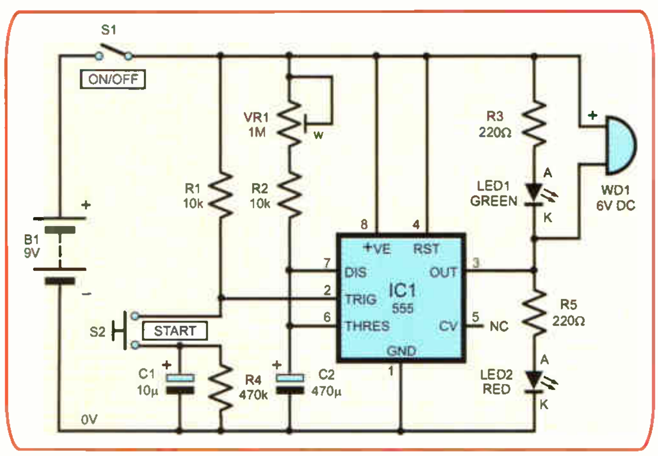


Fig.3.3: Games Timer circuit diagram

You will need...

Three basic tools for assembling Protobloc projects: screwdriver, snipe-nose pliers and wire cutter/strippers

Components needed...

Integrated circuit, IC1: type 555 timer
Light emitting diodes, LED1, LED2: suggest one green (LED1) and one red (LED2)
Buzzer, WD1: miniature 6V DC type
Potentiometer, VR1: 1MΩ, miniature preset type
Resistors, R1 to R5: 10kΩ (R1, R2), 220Ω (R3, R5) and 470kΩ (R4)
Capacitors, C1 and C2: both axial electrolytic types, values 10µF (C1) and 470µF (C2), 16V or higher working voltage. For C2 use values between 100µF and 1000µF
Switch, S1 (On/Off): single-pole, single-throw (SPST) (optional)
Pushswitch, S2: push-to-make, release-to-break
Battery, B1: 9V and connecting leads
Protobloc and wire links

Component Info

IC1, type 555 timer IC

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

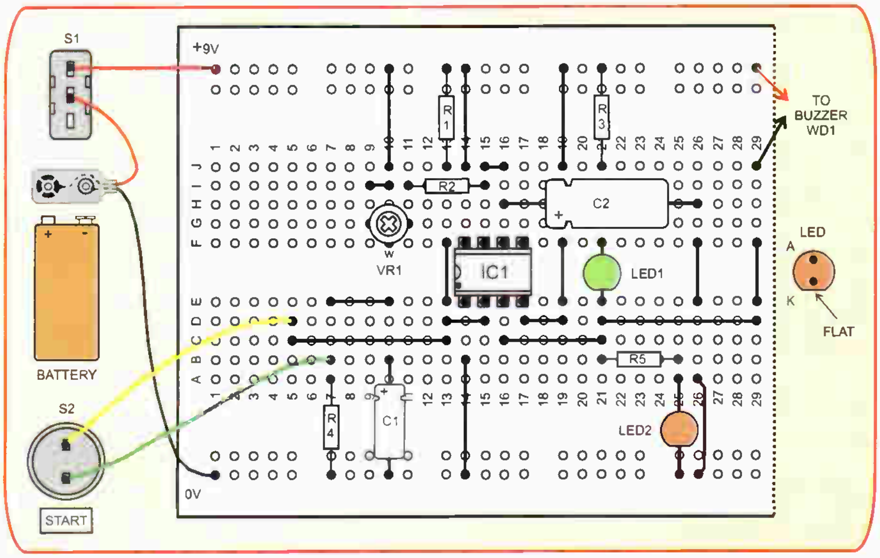
Electrolytic capacitors

C1 (10μF) and C2 (470μF) 16VW

These are polarised; usually indicated by a + or – symbol on their body. The axial variety is shown on the Protobloc, but radial or PCB types could be accommodated

Pushswitch, S2

push-to-make, release-to-break



3.4: Assembly of the Games Timer on the Protobloc

Resistor, R1, ensures that the voltage on the trigger pin is normally at the positive supply voltage.

Breadboard

The Protobloc component layout for the Games Timer is shown in Fig.3.4. If the preset is replaced by a rotary pot, a dial attached to VR1 may be calibrated in seconds and minutes as required

Notes

- Capacitors C1 and C2 are polarized and require connecting as shown
- The time delay is given approximately by the product of the values of C2 and (VR1 + R2)
- If unsure, use the Circuit Tester from Part 1 to distinguish between the anode and cathode leads of each LED
- Switch S1 will not be needed for a Protobloc assembly, but will be for a permanent assembly

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A Clap Switch and a simple Intercom

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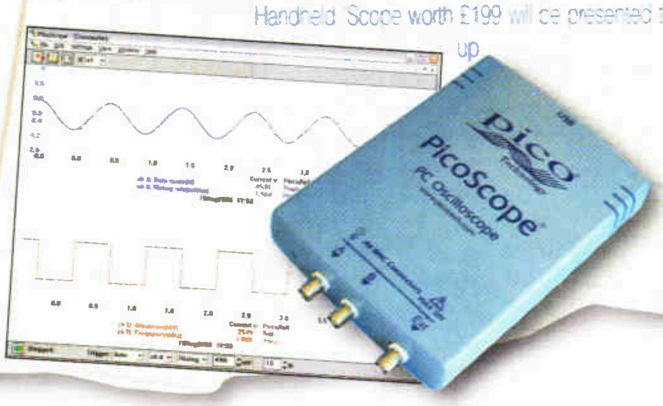

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VROOM – *Top Gear Effects*

Motorboat, vaccum cleaner, turbo-prop aircraft – you name it, this circuit will emulate it. It mixes three oscillators to produce a remarkably realistic simulation of various motor sounds.

The Vroom sound effects circuit diagram is shown in Fig.1. In order to create a convincing motor sound, one requires at least three oscillators to run in parallel. Further, each of these oscillators needs to be buffered, and finally mixed. With this in mind, the CMOS 40106 Schmitt hex inverter IC would seem ideal. Having six Schmitt NOT (inverter) gates, it lends itself to creating three clock generators (RC oscillators, or relaxation oscillators) with three buffers. Capacitors C4 to C6 then mix the three outputs, and further serve to block DC. While the CD40106BE was used here, all makes of this IC should give good performance.

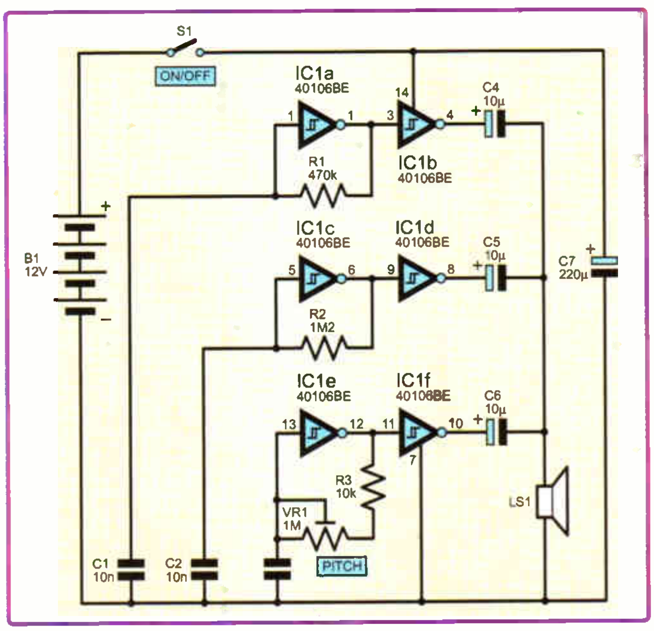

Fig.1. Vroom sound effects circuit

LS1 should ideally be a moving coil loudspeaker (a miniature loudspeaker is acceptable). A piezo device is less likely to give a realistic sound. Volume is modest, so that an amplifier is advised for increased output. Capacitor C7 serves to smooth the supply voltage and reduce the possibility of any frequency lock between the oscillators. The supply voltage may be varied between 3V and 15V, with loss of volume at lower voltages.

Preset potentiometer VR1 serves to alter the pitch of the engine sound. As it is, the circuit's pitch is a little on the high side – more like a vacuum cleaner or a racing motorcycle. Pitch may be reduced by increasing the values of C1 to C3, perhaps to 22nF. Preset VR1 could be replaced with two fixed resistors, one of which is switched in and out of circuit – this would provide a different motor sound, eg when reversing a motorised model. For the more ambitious hobbyist, one could add an automated volume control, eg to create a V6 doorbell when a bell-press is pushed – or automated pitch.

Thomas Scarborough, Cape Town

PICO PRIZE WINNERS

Once more it's time to decide the lucky winners of superb PC-based Oscilloscopes, generously donated by Pico Technology, to whom we extend our appreciation for sponsoring the column again. For more information about Pico's range of test equipment visit their web site at **www.picotech.com**, or see their advertisement elsewhere in this issue. Matt Pulzer and John Becker considered 20 published *Ingenuity Unlimited* entries; the results are:

Winner–receives a superb PicoScope 3206 Digital Storage Oscilloscope worth £799: *Mobile Phone Switch (June '07)* by Ian Hill – **Runner-Up** – a PicoScope 2105 Handheld 'Scope worth £199: *Atmospheric Charge Monitor (Aug '07)* by Thomas Scarborough

Logic device families

A FREQUENT contributor to the *EPE Chat Zone* on-line forum (via **www.epemag.co.uk**) **steerpike** posted a question about logic families:

When buying components, on my list I usually just write things like 'CD4094B' and often they hand over something like an HCF4094 or an HEF; I never think about the difference – they just work. Last week, they told me they've stopped selling the 'CD' series, and what did I want instead?

So what are the usual, trendy, substitutes for the old 'CD' series that is intractably embedded in my concept of digital electronics? Some web pages say HCF and HEF devices are restricted to 5V, but then the HEF4016 is good up to 15V, as with the old CD4016.

More recently **big_nige** asked a related question:

Many years ago I had a book called The TTL Data Book, *published by TI. It had pin-outs of the entire 74xx family at the time, as well as timing details. Is a similar thing available for the modern equivalent, which I assume is 74HC? Or do I have to download individual data sheets?*

So this month's topic is logic devices – the meaning of their code numbers and where to look for data on them.

Logic families

There is a bewildering number of 'logic families', ie types of circuitry and manufacturing process technologies for implementing discrete digital devices. The first commercially available logic family was Resistor-Transistor Logic (RTL), introduced in 1962. This was followed by Diode-Transistor Logic (DTL) and then the Transistor-Transistor Logic (TTL) of the classic 7400 series.

All these are based on the bipolar junction transistor (BJT), with TTL using a 'multiple emitter' transistor at logic gate inputs. New versions of TTL were introduced over the years to provide higher operating speed and/or lower power dissipation, for example Advanced Schottky TTL (ASTTL).

The majority of modern logic families are now based on MOSFETs (Metal-Oxide-Semiconductor Field Effect Transistors). MOS logic may be implemented using *N*-type or *P*-type MOS transistors alone (NMOS and PMOS), or both together (Complementary MOS – CMOS).

Table 1: Logic Families from Texas Instruments

Code	Logic Family	Technology
ABT	Advanced BiCMOS Technology	BiCMOS
ABTE	Advanced BiCMOS Technology / Enhanced Transceiver Logic	BiCMOS
AC	Advanced CMOS Logic	CMOS
ACT	Advanced CMOS Logic	CMOS
AHC	Advanced High-Speed CMOS	CMOS
AHCT	Advanced High-Speed CMOS	CMOS
ALB	Advanced Low-Voltage BiCMOS	BiCMOS
ALS	Advanced Low-Power Schottky Logic	BiPolar
ALVC	Advanced Low-Voltage CMOS Technology	CMOS
ALVT	Advanced Low-Voltage CMOS Technology	BiCMOS
AS	Advanced Schottky Logic	BiPolar
AUC	Advanced Ultra-Low-Voltage CMOS Logic	CMOS
AUP	Advanced Ultra-Low-Power CMOS Logic	CMOS
AVC	Advanced Very-Low-Voltage CMOS Logic	CMOS
BCT	BiCMOS Technology	BiCMOS
CB3Q	Low-Voltage, High-Bandwidth Bus Switch Technology	CMOS
CB3T	Low-Voltage, Translator Bus Switch Technology	CMOS
CBT	Crossbar Technology	CMOS
CBT-C	CBT with Undershoot Protection	CMOS
CBTLV	Low-Voltage Crossbar Technology	CMOS
CD4000	CMOS Logic	CMOS
F	Fast Logic	BiPolar
FB	Backplane Transceiver Logic	BiCMOS
FCT	Fast CMOS Technology	CMOS
GTL	Gunning Transceiver Logic	BiCMOS
GTLP	Gunning Transceiver Logic Plus	CMOS
HC	High-Speed CMOS Logic	CMOS
HCT	High-Speed CMOS Logic	CMOS
HSTL	High-Speed Transceiver Logic	BiCMOS
JTAG	JTAG Boundary Scan Support	BiCMOS
LS	Low-Power Schottky Logic	BiPolar
LV-A	Low-Voltage CMOS Technology	CMOS
LV-AT	Low-Voltage CMOS Technology	CMOS
LVC	Low-Voltage CMOS Technology	CMOS
LVT	Low-Voltage BiCMOS Technology	BiCMOS
PCA	Inter Integrated Circuit	CMOS
PCF	Inter Integrated Circuit	CMOS
S	Schottky Logic	BiPolar
SSTL	Stub Series Terminated Logic	BiCMOS
SSTV	Stub Series Terminated Low-Voltage Logic	CMOS
TCA	Inter Integrated Circuit	CMOS
TS	TI Switch	CMOS
TTL	Transistor-Transistor Logic	BiPolar
TVC	Translation Voltage Clamp	CMOS
VME	VME Bus Products	CMOS

Almost all MOS logic is now implemented in CMOS. The classic CMOS logic family is the 4000 series, but CMOS versions of the 7400 series are also available (eg 74HC00 and many other more modern families). MOS and bipolar transistors can be used together to exploit the advantages of both, in Bi-CMOS, the 74ABTC series for instance.

Table 1 lists the range of logic families currently available from Texas Instruments (**www.ti.com**), showing the family code, the name and technology type. This list ranges from effectively obsolete families

Table 2: Example device code prefixes

Prefix	Manufacturer
SN	Texas Instruments
CD	Texas Instruments, National Semiconductor, Harris, Fairchild, RCA
HEF	NXP, Philips, Motorola, Texas Instruments, STMicroelectronics, SGS-Thompson
HCF	SGS-Thompson, STMicroelectronics,
MC	Motorola, STMicroelectronics, SGS-Thompson

to the most recent logic low voltage high speed logic technologies. Other manufacturers produce similar lists of their logic families.

The device code prefixes such as CD and HEF mentioned by Steerpike are manufacturer designation codes – they indicate who made the chip, they may also indicate the device family, but this is not always the case. These are rarely unique to a single manufacturer, although some prefixes are strongly associated with one (such as SN for Texas Instruments). Semiconductor companies change names and are bought and sold by other companies, so the prefixes change allegiance too. Also, compatible devices are and were often made by multiple manufacturers, with the same prefixes.

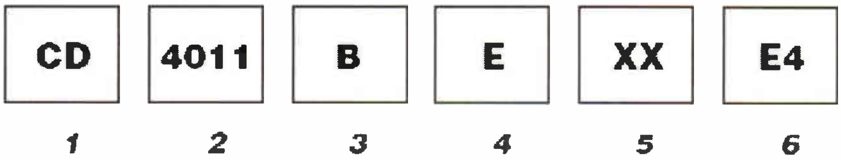

Fig. 1. Example anatomy of an IC's code name (from Texas Instruments)

Table 3: The various parts of the IC code from Fig.1

Part	Description	Examples
1	Prefix - Designates the manufacturer	CD
2	Type - The logic function, up to five digits	4016 4049
3	Supply Voltage	A – 12 V Maximum B – 18 V Maximum UB – 18 V Maximum, Unbuffered
4	Package format	E – Plastic Dual-In-Line Package (DIP) F – Ceramic DIP M – Plastic Surface-Mount Small-Outline Integrated Circuit (SOIC) *There are many more of these.*
5	High-Reliability Screening. This code indicates compliance with MIL standards for military products only.	
6	RoHS and Green Status	*Codes to indicate conformance to Lead-Fee and other environmental standards*

A few common prefixes and associated manufactures for logic devices old and new are listed in Table 2. The list is not exhaustive either in terms of logic device manufacturers or which companies have used the prefixes. Some of the companies listed no longer exist.

The complete anatomy of an IC's full code name can be quite complex. For example, Texas Instruments have a 12-part code for some of their SN74 logic devices. The kind of information the device codes may include is things such as temperature range, special features, bit width, options, revision version, speed grade, packaging type and RoHS (Restriction of Hazardous Substances)/green status. Fig.1 shows one example of how an IC's code number is formed. This is for CD4000 logic devices from Texas Instruments, which were originally from Harris Semiconductor.

Table 3 shows what each part of the code means.

In Fig.2 is shown an example of the 12-part code number for Texas Instruments SN74 devices mentioned above. We will not provide a complete breakdown here, but note that Part 3 is the device family – many, but not all, of the codes in Table 1 can appear here. The device function code is Part 7, eg 00 for a quad 2-input NAND gate). Some parts of the code may be blank for some devices. Not all functions are available in all families and manufacturers usually publish large 'selection guide' tables indicating what functions are available in which family.

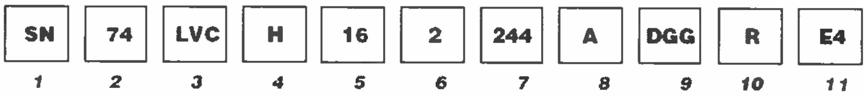

Fig.2. Structure of example SN74 device code from Texas Instruments

Logic selection

If you want all the serious details on the various logic families, take a look at the Texas Instruments *Logic Selection Guide*. The document version at the time of writing is 2007 Rev. Z, which is available as a 101-page, 4.5MB PDF download. The document URL is:

focus.ti.com/lit/ml/sdyu001z/sdyu001z.pdf

Other manufacturers also produce logic selection guides, for example the *Standard Logic ICs Selection Guide* from STMicroelectronics. This document is at:

www.st.com/stonline/products/promlit/pdf/sgstandig-1204.pdf

We do not know what websites Steerpike has seen which stated that the HCF and HEF devices are limited to 5V; however, the best place to look for device data is on the latest version of a manufacturer's datasheet. The manufacturers' websites and/or datasheets also state the current production status, so you can tell if the device is obsolete, about to be discontinued or still in production.

Datasheets for the HEF4016, CD4016, and HCF4016 are available on NXP's (formerly Philips'), Texas Instruments' and STMicroelectronics' websites respectively. The relevant URLs are:

NXP: **www.standardics.nxp.comproducts/hef/datasheet/hef4016b.pdf**

TI: **focus.ti.com/lit/ds/symlink/cd4016b.pdf**

ST: **www.st.com/stonline/products/literature/ds/2027.pdf**

From NXP, the Philips 1995 Datasheet for the HEF4016 refers you to the HE4000B family specification datasheet, which states that the maximum supply voltage is 18V, but recommends an upper limit of 15V (unless further limited by power dissipation constraints). The family datasheet refers to HEC and HEF devices, the difference between HEF4000 and HEC4000 devices being the operating temperature range. However, only HEF devices seem to be listed on NXP's website. The HEF4016BP plastic DIP version is listed as being in production.

The Texas Instruments 2003 Datasheet for the CD4016B (which it acquired from Harris Semiconductor) states the maximum supply voltage for reliable operation is 18V and the absolute maximum is 20V. Characteristics are quoted up to 15V, again presumably a recommended maximum. A Package Option Addendum to Texas Instrument's datasheet, dated 18 Sep 2008, states that the plastic DIP version (CD4016BE) is in active production.

The STMicroelectronics 2001 datasheet for the HCF4016B states that the absolute maximum supply voltage is 22V, but the recommended maximum is 20V. On the page with the link to the datasheet there is a section titled *Related Information,* under which there is a link titled *5V Logic Product Page*. This may have caused Steerpike or others to assume the HCF4016 is a 5V device, whereas the datasheet clearly states that it is not.

The CD, HEF and HCF 4000 series devices from different manufactures should be more or less the same in terms of their basic characteristics, such as maximum supply voltage. The information from these three datasheets seems to indicate some variation in absolute maximum supply voltage, and possibly recommended supply voltage.

In most cases, minor differences between different manufacturers' versions of the same logic device should not cause any problems; as Steerpike says "I never think about the difference – they just work". So, when choosing a chip from a supplier it probably does not matter which one you go for, but if in doubt check the datasheet using the internet.

Wrongness

Occasionally, things do go wrong of course – if the circuit depends critically on a parameter which changes between device versions. This can cause problems even with ICs from the same manufacturer, particularly in products manufactured over many years. For example, if the IC manufacturers change the production line, keeping the devices in specification, but possibly making them better (eg faster) than older versions, product using the chips may then fail due to a timing problem caused by the faster devices being 'out of step' with the rest of the circuit. Such problems are unlikely to affect electronics hobbyists, but have occurred in long running commercial designs.

The situation with different logic families is different. Devices with the same function (NAND gate, JK-type flipflop etc), with the same function code (eg 7408, 7474) in different logic families are not equivalent. Different logic families may have completely different supply voltages, and even if they can share the same supply their logic levels and drive capabilities may not be fully compatible.

Full characteristics of their logic families are, of course, published by the IC manufacturers.

Data sources

Mention of manufacturers' documentation leads us to Big_nige's question about *The TTL Data Book* from Texas Instruments. As was pointed out by **istedman** in a reply on the forum, the modern equivalent is the *Digital Logic Pocket Data Book*. The current version of this document is Rev. B, Jan 2007, which is a 794-page, 6MB PDF download. The URL is: **focus.ti.com/lit/ug/scyd013b/scyd013b.pd**.

This document has device pinouts and basic information on a large number of logic families (many of those in Table 1) and includes all of the well known basic 4000 and 7400 series devices that Texas Instruments still manufacture. The *Digital Logic Pocket Data Book* does not contain full datasheets. These have to be downloaded separately from Texas Instrument's website (or other manufacturers where appropriate).

A number of document URLs have been listed in this article and were correct at the time of writing. However, please note that semiconductor manufacturers, like many other businesses, occasionally restructure their websites. The documents should still be there, but you will need to navigate from the home page following links such as Products<Logic>Standard Logic. Look for documents or pages titled *Logic Selection Guide* or similar.

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PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

OLED Graphics Displays

When we build projects that include a microprocessor, more often than not the reason for including one is to provide some control over, or receive feedback from the circuit. To provide the user with access to this control or feedback, a display is frequently included. Simpler circuits may use LEDs or a small buzzer to provide feedback, but a display adds enormous flexibility into a project; and it looks good too!

LCD characteristics

Over the last decade, the display of choice has been the monochrome character liquid crystal display (or LCD display as it is commonly referred to, despite the grammatical error). The format of two lines of sixteen characters has become the norm, despite many other variants.

This format has become so popular that in most cases smaller LCD displays are actually more expensive, simply due to the economics of supply – LCDs in the 2 × 16 format are manufactured in such large quantities that the manufacturing cost is much lower than those for simpler displays. This lower manufacturing cost is reflected in the price we pay for the component, even when purchasing just one.

The popularity of the 2 × 16 character LCD is such that many manufacturers produce their own displays with a compatible interface. In many cases, displays from different manufacturers are indistinguishable from each other and this makes the designer's life much easier. There is nothing worse than writing a constructional article using some specialist component, only to find the sole manufacturer has stopped making it by the time your article is published!

These LCD displays all bear the same characteristics. The display area is arranged as 32-character cells. Each cell is a uniform array of 35 small dots, arranged in a grid five wide by seven tall.

The LCD display is mounted on a small PCB that contains one or two ICs which provide the interface (control) between the display itself and your microcontroller. A small read only memory (ROM) within the control IC simplifies the means by which you write information onto the display – you specify an ASCII character code, and the controller will draw the corresponding dots in a character cell.

The controller IC has a small amount of RAM too, which can be used to display user-generated graphical symbols within a character cell. This is useful for creating icons (a battery symbol for example) but as the display is arranged as a collection of character cells, it is not possible to write in the gaps between characters, and so a full display sized graphical image cannot be produced.

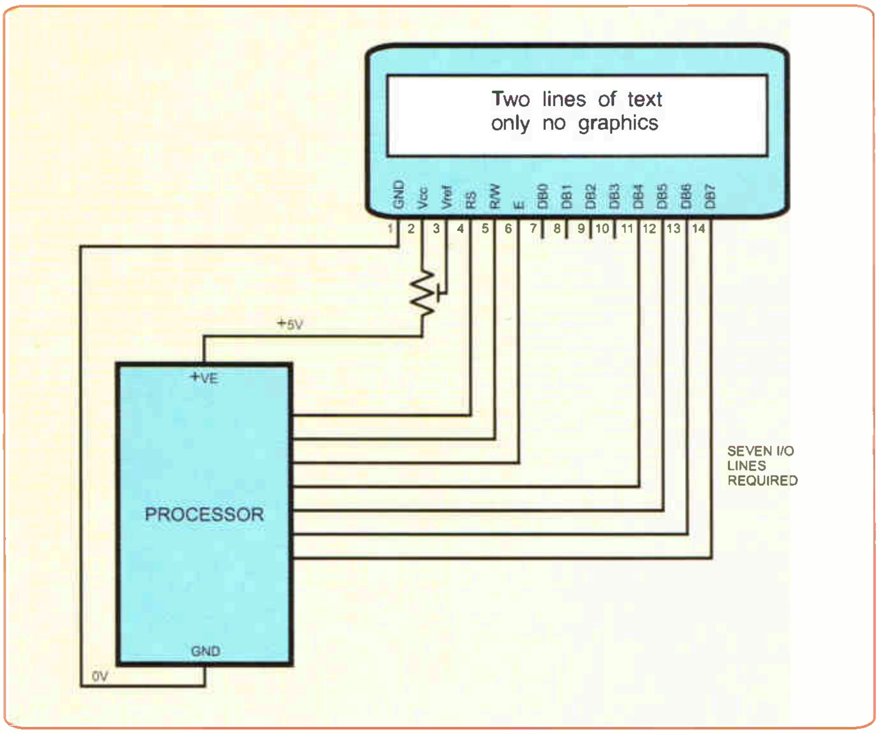

Fig.1. Simplest interface to a 2 × 16 LCD. It requires seven I/O lines and a variable resistor that must be manually 'tuned' to get an acceptable display. Display legibility varies greatly with temperature and voltage

These displays have other drawbacks too. They have a limited viewing angle, which means you have to adjust the orientation of the display to be able to view it properly. They also require a backlight if they are to be viewed in dim or dark lighting conditions, which can significantly increase the power consumption. On the plus side, they are now quite cheap, can run at the same voltage as the microprocessor, and draw little power, although this is too high for a truly portable device if the display is left on continuously.

Because this style of LCD has been around for such a long time and they are used in a wide range of products, a standard has emerged for the physical and programming interface to them. A minimal interface circuit, as drawn in Fig.1, shows that only seven I/O lines are required to drive it, or eight if you intend to switch the backlight on and off under control of your microcontroller.

Four lines are used as data signals (an 8-bit byte, specifying commands or character data, is split into two 4-bit nibbles and sent one after the other) and the remaining three are used to control the display. The software required to write data to the display can be as compact as a few tens of instructions.

Alternatives

These displays have been perfectly acceptable for hobbyist designs for years, but with the prominence of cheap mobile phones sporting full colour displays, hobbyists have begun to yearn for more, as a colour graphics display can mean showing images, cartoons, maps and more. The monochrome, character-only display has begun to appear rather dull.

Monochrome graphic LCD displays are available, although somewhat harder to obtain. They are more expensive, typically costing upwards of £20 for a small panel offering 100 by 60 dots. As the dots are uniformly spaced these displays are suitable for showing images, albeit in a single colour, typically grey, blue or green. These displays are not going to show your family album in a good light!

Laptop and PDA LCD displays are an appealing choice, but unfortunately they are unsuitable for direct connection to a small microcontroller. These larger displays contain no on-board RAM, but instead rely on data being transferred directly from the host processor's main memory at high speed – requiring data transfer at much higher rates than any PIC processor can support. Controller ICs are available that can provide the necessary interface, but these chips are difficult to obtain and even more difficult to solder.

Mobile telephone displays, on the other hand, are a possibility. Cheap replacement displays can be purchased on eBay, and some suppliers (Sparkfun being one example) even provide links to source code and datasheets on the Internet. However, you are at the mercy of the manufacturers, as these displays are only produced while a particular mobile phone is in fashion – in a year's time it may disappear. That's not a problem if you are only producing a single unit, but if you intend to make many or would like to re-use your work in the future, that could be an issue.

Finding a small, low power, easy-to-use and easily obtainable colour display has been something of a mission for the author. It appears that the search may now be over. And oddly enough, it isn't based on liquid crystal technology, but an exotic, organic LED technology.

OLED

Organic LED (OLED) displays rely on a polymer molecule that emits light when a voltage is applied to it. Over the years a number of different molecules have been developed that emit different coloured light, to the extent that companies can now produce 'full colour' displays, where each dot on the display can be set to one of 262, 144 colours. Despite being relatively new and rather exotic, the manufacturing process is relatively simple, and displays based on OLED technology can be purchased at a reasonable cost.

The key discovery behind today's OLED displays is the discovery in the 1950s of electroluminesce in organic materials by researchers in the University of Nancy, France. Further improvements and discoveries in the 1970s resulted in a Nobel prize for chemistry being awarded in 2000. OLEDs have a prestigious past! OLEDs as we know them today were first created in the 1980s, with products appearing in the late 1990s.

Despite their clear advantages in certain areas, OLEDs have only occupied niche markets and the availability of display devices for hobbyists has been non-existent until quite recently. Small display panels from companies such as Densitron are, however, now available through hobbyist-friendly suppliers such as Farnell at very affordable prices. For this article, we look at the DD-160128FC-1A display from Densitron, a 160 × 128 pixel full-colour display, with a viewing area of 31mm × 25mm. The display is available from Farnell for around £17.

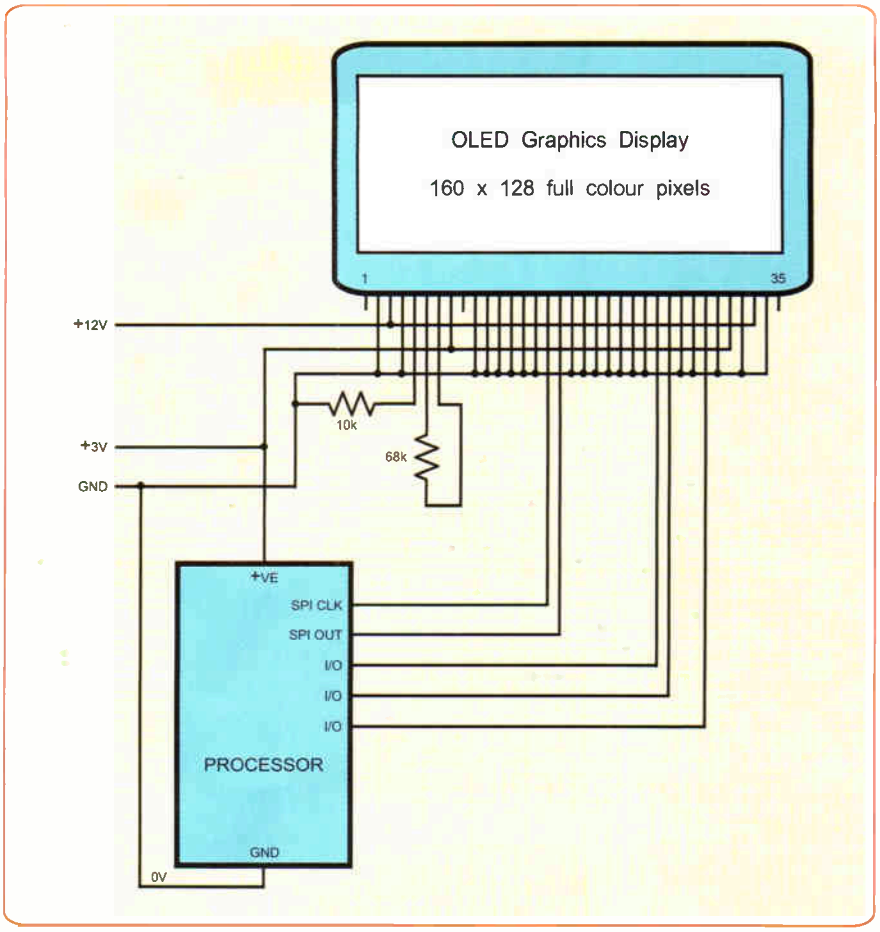

Fig.2. Simplest interface to an OLED display. Although two resistors are required, these are small, fixed value resistors

OLED interface

The basic circuit required to connect an OLED display to a microcontroller is shown in Fig.2. This is actually simpler than the interface to the classic LCD display, as the interface uses an SPI bus rather than a 4-bit parallel bus. The display does support the use of a parallel bus, which gives a much faster update rate at the expense of an extra five I/O pins, but this was not found necessary for simple applications. The SPI bus enables the display to be written to quickly enough so that the update is not visible.

You will notice from the circuit diagram that a separate, higher voltage supply is required. There are two power supplies required: 3V for the controller IC that drives the panel, and 12V for the OLED panel itself. Current consumption at 12V is in the order of 10 to 15mA. No variable resistor is required in this design; the display has an excellent viewing angle, very good contrast

Fig.3. LCD and OLED side-by-side; which do you prefer?

and the brightness can be varied through commands from the processor.

As the display technology is emissive (ie, the molecules in the display give off light) there is no need for a backlight. This has the added benefit that the displays are very thin – just a few millimeters. Ideal for a small portable device!

Software

So, what about the software? The processor communicates with the display using the SPI protocol, an interface that we have covered in previous *Pic n' Mix* articles. The SPI interface is so common – it's used to communicate with ICs such as EEPROM memory – that many PICs have special hardware built-in to simplify its use. Microchip provide full source code to use the SPI interface in C, and various examples of suitable source code for assembly programming can be found on the web. Many BASIC language compilers support it too, so there are lots of options for getting started. There is even source code for 'bit-bashed' SPI communication if your processor does not have dedicated SPI peripheral hardware.

Besides the usual SPI bus pins, the display requires two additional signals for communication. The first pin provides a RESET signal, which should be driven low for 200ms and then high for 200ms before any communication is made with the display. The second pin, RS, determines whether the next sequence of SPI messages are commands or data for the display. With this information, and the list of commands from the datasheet, it's easy to put together some low level routines that initialise and write pixel data to the display.

Some example source code, written in C, can be found in the downloads section of the magazine's website.

The only drawback with this display is that you are only able to write pixel data – there are no high level routines for writing text or graphics primitives such as lines, circles or boxes. That's not a problem if you intend to use the display primarily for images; you simply transfer the bitmap data to the display, as shown in the supplied source code. For those higher level routines, you are going to have to write them yourself. But then, isn't that all part of the fun of it?

Needless to say, Microchip do come to the rescue, again, with a fully equipped software library for addressing graphics displays. See the reference at the end of the article for details.

If there is sufficient interest in this display technology we may create a simpler library of software routines to do basic shapes and text.

The only drawback with this display is that connecting to it requires a special 35-pin connector. The good news is that a suitable connector is available from Farnell (part number 1112561) The bad news is that the connector is a surface mount style part, and has a very fine pitch for soldering connections – 0.5mm between pads.

This makes it an enormous challenge if you are not an expert with the soldering iron! A small development PCB is available from Farnell (part number 1500758) that brings the required connections out to a 0.1in pitch header – much more acceptable for the hobbyist soldering iron.

In Fig.3 is shown an example of the OLED display in use beside a standard 2 × 16 LCD. While each will continue to have their own niche uses, it's quite clear which is the more attractive!

Next month, we return to the subject of using PIC processors to connect to the Internet, building on the circuit introduced last month to provide a much more interesting embedded website.

Reference

Microchip Graphics Library:
www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=2608&param=en532067

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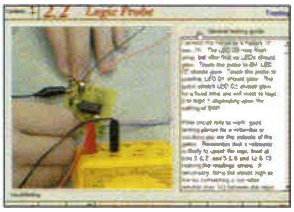


Logic Probe testing

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

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

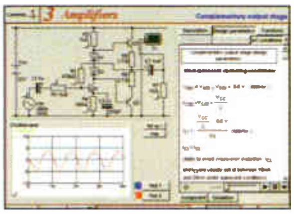
ELECTRONIC CIRCUITS & COMPONENTS V2.0

Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits***. ***Active Circuits***. *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS



Complimentary output stage

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

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

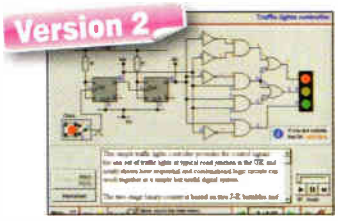
ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

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

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

DIGITAL ELECTRONICS V2.0

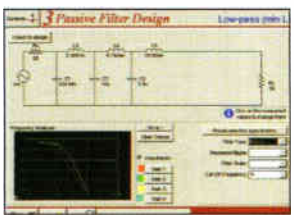


Virtual laboratory - Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

ANALOGUE FILTERS



Filter synthesis

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

PRICES

Prices for each of the CD-ROMs above are:
(Order form on third page)

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

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PICmicro TUTORIALS AND PROGRAMMING

HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

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

- Makes it easier to develop PICmicro projects
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- Supports PICmicro microcontrollers with A/D converters
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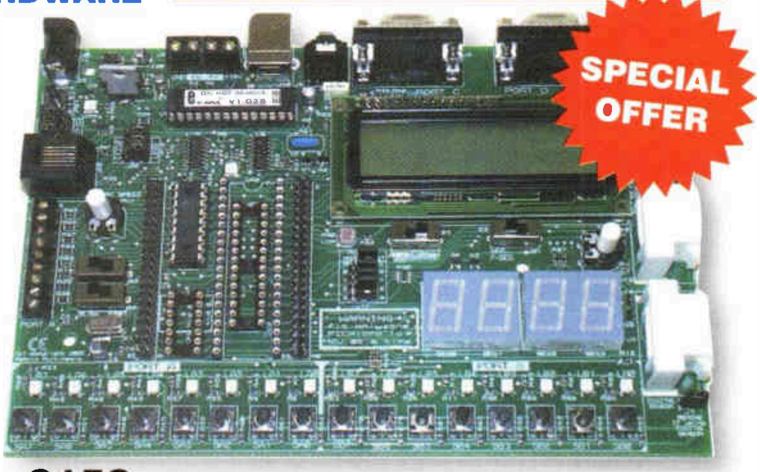
- Can be powered by USB (no power supply required)



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

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

SOFTWARE

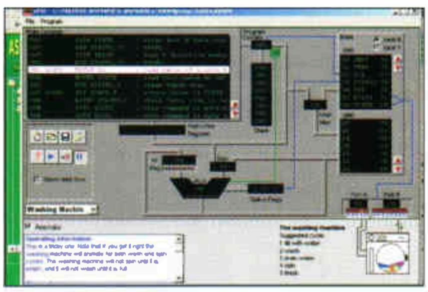
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

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

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

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

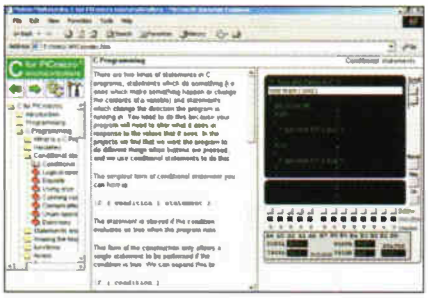


'C' FOR 16 Series PICmicro Version 4

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

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

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



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

FLOWCODE FOR PICmicro V3

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

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

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

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

PRICES

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

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

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

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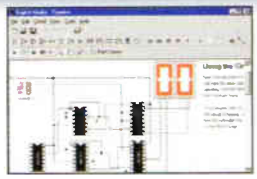
DIGITAL WORKS 3.0



Counter project

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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 ☆

Web connections

Dear EPE,

My dialup connection, which I find adequate for my needs, started slowing down about two years ago. I put it down to the age of my laptop running W98, and decided to wait for Vista to get established before buying a new machine.

Outlook Express stopped working in early June of this year, but otherwise my PC can still do everything else at its own speed. The shiny new Dell Vostro 1000 – with you guessed it, Vista and IE – was hooked up to my dialup connection. I sent and received my first email and then tried for a web page of a newspaper. It was slow, much slower than my old computer, and stopped/redialled several times before coming up with a fault code: 'your server has terminated the POP3 connection wait 300 seconds', or something like that.

I checked and rechecked the settings in IE7, and reduced the safety and security setting to the lowest they can go. Sometimes I get lucky and manage to view a page before the thing drops out. My last month's bill contained eight pages of dialup attempts – it used to be less than two pages. Large junk mail files, especially one that keeps being misdirected to me from someone in charge of a social club and to all members, take so long that it stops working.

I now use webmail on my old machine and delete all the junk to free up my mail box, then I download any mail I want to read and store. My ISP (Cable and amp, Wireless) refuses to admit that they have throttled back the speed, but instead offered broadband!

I am reluctant to go on broadband as I don't really need it. I know from my experience of working with a large British telecom company up to the end of 2000 that it is easer to have lunch at Buckingham Palace than to get anything except a rotary dial phone working properly at three cable miles from the local exchange, which is my situation.

I also know the damage that lightning storms can do to networks and the bits connected to them out in the sticks.

Assuming that I have got everything in IE7 set correctly, I would like to try a speed accelerator like Onspeed, which you mentioned in the October 2007 issue. I would be very grateful if you have any feedback from anyone using this service and please keep Vista in *Net Work*.

By the way, the old 'copper wires' you keep referring to are not all copper. Unfortunately, a large amount of aluminum was used when the price of copper went through the roof in late 1960 through to early 1970 – joints crumble easily and can go 'high resistance'.

Phil Foster, via email

Alan replied to Phil:

Thanks for the mail, which I'm digesting. I'm also asking some contacts about any experiences with Onspeed. It is highly frustrating when systems seem to 'choke' before the line drops altogether. I can't imagine that an ISP would throttle narrowband traffic in this way though. I partly suspect IE7 (is the built-in anti-phishing filter turned off?) or an antivirus program/antimalware/antispyware program that is set to its most aggressive setting.

One area I would look at though, is the modem – I have seen this sort of thing before on machines using an internal Winmodem, and all problems disappeared when I installed an external US Robotics Sportster (my favourite modem). It's still going strong to this day. A Winmodem or 'soft modem' depends on Windows software for data processing, then Windows drivers become more critical. An external unit handles everything with its own silicon-based DAC. I never had any further problems after switching to a US Robotics type, and I still recommend them to this day.

I understand the point about broadband, but I'm in the sticks of Lincolnshire as well, about as far as I can be from the exchange (sited in a wooden hut in the next village, near the duck pond...) and I believe BT were being conservative in their early estimates of the quality of service available at the extreme distances. I manage 3 to 4 Mbps thanks to an unthrottled business tariff (but it is £30 per month) and I am approximately four miles away.

Broadband does allow access to other services, including online banking, that are truly onerous with dialup. The possibility of Skype and holding web cam sessions with distant relatives also opens up, and it becomes a flat-rate cost that can be budgeted for. Overall, I do believe that broadband's higher costs vs dialup yield much greater rewards and is likely to be money well spent. But I accept that some users have modest needs, for which the pay as you go package is sufficient.

I'll be trying to handle Vista in more depth in the future, now that the OS is settling down. Thank you for your interest.

Alan Winstanley,
***EPE* Online Editor**

Intelligent car air-conditioning controller

Dear EPE,

I liked the aircon project in Oct 08's *EPE*, but the author's analysis of the way car aircons work is too simplistic. Maybe in Australia their cars work as described, but in Europe there are further variations, which may limit the type of cars the project can be used on. My knowledge on this is not great, but I have repaired a couple of car aircons, so I had to research the subject.

On many non-climate controlled cars, the thermostat shown in the article regulates the air to say 15°C by cutting the compressor in and out. It does not, as implied in the article, set the cabin temperature. If the driver wants his car hotter than 15°C, the fascia 'temperature' control blends hot air from the normal car heater with the 15°C air to get a higher temperature. The blending is not thermostatically controlled, so the driver needs to regularly adjust the knob for comfort.

The advantage of this system is that you get low humidity and it's cheap to build. The disadvantage is that it's wasteful of fuel and not temperature controlled.

I suggest a more fuel-efficient way to use this project is to insert a simple cabin thermostat (electromechanical or electronic type) in series between the existing thermostat and the compressor flag input. Then the outlet air will be regulated to whatever the cabin thermostat is set to – and the fascia knob should be left on its coldest setting when the aircon is used. I can't guarantee there won't be side effects, such as excessive humidity and conceivably icing up of the evaporator. Also, will this circuit upset the way the PIC logs the flag signal?

Some cars, like older Skoda Fabias and no doubt others from the Volkswagen Audi Group, use a variable swashplate compressor. Superficially, the wiring diagram looks the same as in the article, but a 0V to 5V analogue signal is applied to this, instead of the 12V one, which varies the swashplate angle and hence the flowrate/pressure. The temperature sensor in the evaporator air outlet is a thermistor that inputs into a processor, which then controls the swashplate angle to achieve the steady 15°C air temperature. The compressor is always rotating, even when the aircon is off, and so there is no electromechanical clutch between the engine and compressor for this project to operate on. Thus, the project would need some modification to work on this sort of system and trying to use the project's 12V output on the compressor's 0V to 5V input may damage it.

One way of telling the type of compressor is to listen under the bonnet when the aircon is turned on. If there is loud click and a drop in revs it's the electromechanical clutch cutting in. Swashplate ones change from small output to max with no real change in noise. Last, many modern clutch ones are now quite quiet and the revs very stable, so they may not be distinguishable from swashplate ones. Measuring the voltage on the input to see if it's analogue is the best way to tell them apart.

Edward Chase, via email

Thanks Edward. Comments anyone?

Linux and more

Dear EPE,

It upsets me that I seemed to be the only person in the UK that can happily download the Linux programme Ubuntu, but cannot get it to run. I have tried using Vista computers, XP computers and even laptop computers, but the nearest I got was for the system to ask for a username and password and then ask again, followed by a refusal to accept it. I wonder if anybody has counted up the number of hours they waste per day downloading updates? I seem to have spent at least two hours a day fighting updates while trying to get things to work as well as they did the day before.

Does anybody know, through your *Readout* column, of a battery-powered unit which can pick up the output from handheld theatre radio MICs and convert it to headphone output? The reason I ask is I am rather deaf and have had to give up going to our local pensioners club because my stereo NHS hearing aid cannot cope with the combined onslaught of the announcer plus 60 women who just will not stop rabbiting! I have tried Maplins and the RNID, but they have nothing to offer.

Of course, the basic problem is I don't know whether the equipment is just a bog standard FM transmitter, or if it uses the special set of frequencies allocated for it. Perhaps somebody knows of an article for one of these things, because despite extensive searches I cannot find any reference to anybody using one anywhere. I have even found that inductive loops in theatres just don't work for me, and gradually I find myself withdrawing into a world of silence where people talk about me, but not to me.

An interesting exercise might be to ask your readers to jot down how much they have spent on electronic equipment over say the last 30 years that is now totally obsolete. I think with the money I have spent I could afford to go on a world cruise on a luxury liner for 10 years. Certainly cheaper than living in an old peoples home these days.

BTW, round here the local plod seem to be giving the disabled buggy riders a hard time pretending that you need tax, insurance and an MOT. Also, if they were designed with shopping in mind I wonder why they all have such tiny shopping baskets built in? A friend of mine has had two buggies stolen, so perhaps a fancy burglar alarm circuit with a tracker system built in could be a very useful future project for *EPE*. My son has an ancient 'cheepo' mobile phone concealed in his huge caravan as a backup to the expensive tracker system that all of the pro thieves look out for.

George Chatley, via email

Can anyone offer helpful comments for friend George, a long-term EPE *reader?*

MIDI Drum Kit

Dear EPE,

I'm building the *MIDI Drum Kit* featured in *EPE* over several issues from December '07. I'd like some advice on how the holes for the inputs/outputs of the DB9 box are cut. In the text it doesn't really explain this at all, it just states 'make sure the holes are correct'. I've tried lining up the circuit boards on top of the box, then ruling lines downwards, however, it's near impossible because the circuit boards go in upside down, so they move a lot when I'm ruling the lines.

So, in short, how do I measure/cut out the holes on the DB9 box for the MIDI drum kit? Any help would be appreciated.

Vince Casals, via email

We suggest you use paper templates – mark the position of all the holes on sheets of paper by drawing around the sockets etc, and then use these templates to mark out the case. Check everything before cutting the box by measuring the position of the holes on the PCB and the case, allowing for the thickness of the case wall.

Rat It

Dear EPE,

I see you have a new column, *Recycle It* or 'Rat it before you chuck it'. My sister recently got rid of Sky TV and gave me the Sky + box, from which I was able to salvage a 160GB hard drive which is now in my computer as a slave drive. It was already formatted to NTFS, so all that remained to do was configure the jumpers and delete countless episodes of *Coronation Street* and *Eastenders*!

Craig Patterson, via email

Well done Craig, that's a worthwhile bit of ratting!

Praiseworthy editorship

Dear EPE,

It seemed, when Mike Kenward retreated to the role of publisher earlier this year, that he had merely changed rooms, rather than having left the building. He very much deserves, however, acknowledgement for his extraordinary contribution as electronics editor.

Mike served as editor from 1984 until 2008, during which time he acquired and united several major electronics titles, building them into the world's No. 1 electronics magazine. He successfully pioneered Internet publishing, too, producing the first-ever printed magazine that could also be bought and downloaded from the Internet. He promoted electronics education in various fields, *inter alia* through the acclaimed biannual *Teach-In* series. He promoted many major British companies and products, some of which became household names, such as Maplin and Sinclair.

He had an extraordinary eye for innovation, and many ground-breaking designs appeared in the magazine, with no small number going into production. He undoubtedly had the finest author policy of all, which surely was in large part responsible both for the innovative material that he published, and for the expansion of the magazine worldwide. He promoted several people who became major electronics writers in time, such as Barry Fox, Andy Flind, and John Becker. Finally, he forged an association with *Silicon Chip* magazine of Australia, thus widening the horizons both of electronics readers and advertisers.

During Mike's editorship, we had the privilege of being part of a fascinating and inspiring era of hobby electronics.

Thomas Scarborough, Cape Town, via email

Thanks Thomas. I too, and many others I'm sure, would echo your comments regarding what Mike has achieved, and wish him well.

Net Work

Alan Winstanley

This month, we look at some recent developments, starting with what's new in the web browser world.

Some of the more niggling features of an increasingly bloated Internet Explorer 7 include its slow startup time and the irritating behaviour of the IE7 search box. By default, its search dialogue box utilises Microsoft Live Search (**www.live.com**), though this can be changed via the nearby dropdown menu to, for example, Google, or follow the guidelines at **http://tinyurl.com/2v9sk2**

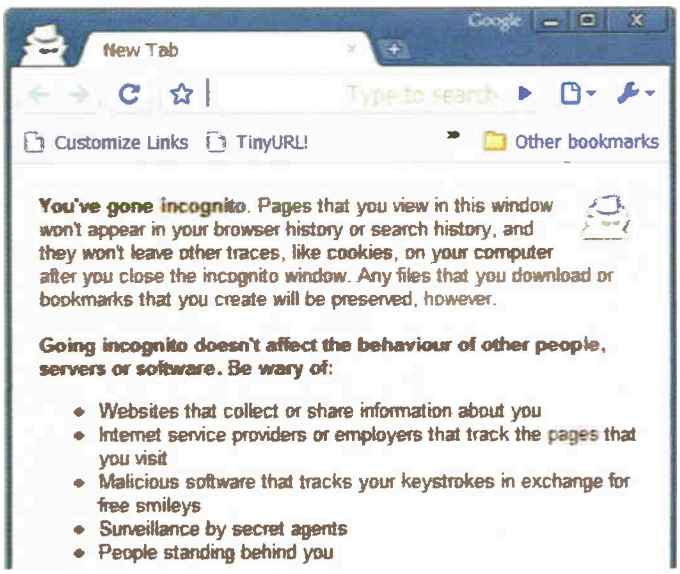
After opening IE7, clicking on the Search box and starting to type a search phrase, the leviathan browser completes its boot-up process and sometimes switches 'focus' to its main address box instead. So, a user searching for 'everyday practical electronics' gets as far as typing 'eve…' before discovering that the browser has entered '…ryday practical…' into the main address bar. The entire search phrase has to be deleted and retyped in the Search box, which is infuriating and timewasting for busy Internet workers eager to press ahead.

The latest incarnation of Internet Explorer Version 8 is in Beta 2 mode, available at **www.microsoft.com/windows/internet-explorer/beta/default.aspx**. However, at this stage the update is probably best left to computer enthusiasts. For many web surfers, Firefox is a far more viable and usable alternative, originally based on Netscape Navigator, the grandfather of all web browsers. It can be installed free via **www.firefox.com**. More alternatives include the uninspiring Safari from **http://www.apple.com/safari/** and the innovative Opera browser from **www.opera.com**.

Chrome plated

Google recently unwrapped its own web browser with barely a whimper. Google Chrome is a free browser and, like the ubiquitous Google search engine, it is based on a minimalist design that is fast and slick to use. Perhaps Chrome lacks some of the bloated add-ons of IE7, but it is sprightly and has some intuitive features that makes surfing more productive and rewarding. Being open-source, Chrome holds out the promise of many interesting plug-ins being created in the future.

Usefully, the Search dialogue and address bars are rolled into 'one box for everything', so when you open Google Chrome, the dialogue box is there in milliseconds, literally, enabling users to start typing a URL or search phrase straight away. This is a fabulous timesaver. Google Chrome displays your most visited websites on the start-up page in the form of snapshot thumbnails, and within a second of launching you can click one and be on your way. As the human mind identifies best with images, not words, the thumbnail gallery is a brilliant way of helping you to recall and locate recently visited sites.



Google Chrome's 'Incognito' mode helps preserve your privacy when surfing online, with plain-English explanations to boost your confidence

Additionally, if any website is 'misbehaving' or locking up, the user can shut down individual processes in Google Chrome without needing to close the whole program. This protects the rest of your work in progress, another valuable feature for busy people checking out multiple sites.

Many IE7 users find Internet Explorer's paranoid security settings and error messages all but unfathomable. Chrome offers an altogether more user-friendly warning about insecure websites, showing green secure addresses or URLs crossed through in red if they are potentially insecure.

Chrome's new 'Incognito' mode (CTRL + Shift + N) temporarily disables cookies and histories from being stored on your computer, helping you to protect your privacy online.

Even though the browser is still in Beta, the whole look and feel of Google Chrome is of a refined and highly usable browser that is grown-up and designed for today's Internet user. Download Chrome for XP or Vista free from **www.google.com/chrome** and see what you think.

No more malware?

PC Tools, the home of Spyware Doctor software, was acquired by Symantec earlier this year. PC Tools is a robust subscription-based program that detects spyware and adware and has been recommended in previous years, but in the author's experience it has become too resource-intensive to permit full-time operation on many 'production' machines. The writer soon turned off its full-time scanning and resolved to scan his hard disks periodically instead, which half-defeated the object of buying it. It also has to be renewed annually to receive updates (approx $50 for a three PC yearly licence).

All of this was brought into sharp focus when a colleague's laptop became infected with some very nasty malware, which choked off all Internet activity and brought the laptop to its knees. In fact, I had previously installed Spyware Doctor to deal with a previous problem on the same machine.

The infection was soon identified as AntiSpyKit malware. It symptomatically alerted that legitimate programs were 'viruses' and the only solution was, of course, to purchase the full AntiSpyKit program. It was impossible to uninstall, and by Googling for 'antispykit' it was seen that many users suffered the same headache.

A personal favourite and trusted website, **www.bleepingcomputer.com** pointed the way to Malwarebytes' Anti-Malware, a free download from **www.malwarebytes.org**. Sure enough, after running Anti-Malware on the infected laptop, the problematic malware was removed and the laptop was returned to service.

You can email Alan at **alan@epemag.demon.co.uk**

DIRECT BOOK SERVICE

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

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF *EPE*

All prices include UK postage

Electronics Teach-In + FREE CD-ROM

Mike Tooley

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

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

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

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

ROBOTICS

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. Then explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

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

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.

198 pages **Order code BP902** **£14.99**

ANDROIDS, ROBOTS AND ANIMATRONS
Second Edition – John Iovine

Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.

The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.

224 pages **Order code MGH1** **£16.99**

RADIO

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£20.00**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£4.45**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the last century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£5.49**

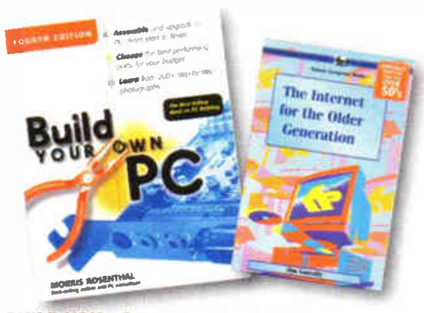
COMPUTERS AND COMPUTING

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages **Order code BP600** **£8.99**



BUILD YOUR OWN PC – Fourth Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. The author goes 'under the hood' and shows step-by-step how to create a Pentium 4 computer or an Athlon 64 or Athlon 64FX, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows XP. The few existing books on this subject, although outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are looking for.

224 pages - large format **Order code MGH2** **£16.99**

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**

PROGRAMMING 16-BIT PIC MICROCONTROLLERS IN C – LEARNING TO FLY THE PIC24
Lucio Di Jasio (Application Segments Manager, Microchip, USA)

FREE CD-ROM

A Microchip insider tells all. Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists to help readers perform the most common programming and debugging tasks. FREE CD-ROM includes source code in C, the Microchip C30 compiler, and MPLAB SIM software, so that readers gain practical, hands-on programming experience.

Until recently, PICs didn't have the speed and memory necessary for use in designs such as video- and audio-enabled devices. All that changed with the introduction of the 16-bit PIC family, the PIC24. This new guide teaches readers everything they need to know about the architecture of these chips, how to program them, how to test them and how to debug them. Lucio's common-sense, practical, hands-on approach starts out with basic functions and guides the reader step-by-step through even the most sophisticated programming scenarios.

Experienced PIC users and newcomers alike will benefit from the text's many thorough examples, which demonstrate how to nimbly side-step common obstacles and take full advantage of all the 16-bit features.

496 pages +CD-ROM **Order code NE45** **£32.99**

THEORY AND REFERENCE

ELECTRONIC CIRCUITS – FUNDAMENTALS & APPLICATIONS
Third Edition
Mike Tooley

A comprehensive reference text and practical electronics handbook in one volume – at an affordable price!

New chapter on PIC microcontrollers – the most popular chip family for use in project work by hobbyists and in colleges and universities.

New companion website: spreadsheet design tools to simplify circuit calculations; circuit models and templates to enable virtual simulation; a bank of on-line questions for lecturers to set as assignments, and on-line self-test multiple choice questions for each chapter with automatic marking, to enable students to continually monitor their progress and understanding.

The book's content is matched to the latest pre-degree level courses, making this an invaluable reference for all study levels, and its broad coverage is combined with practical case studies, based in real-world engineering contexts throughout the text.

The unique combination of a comprehensive reference text, incorporating a primary focus on practical applications, ensures this text will prove a vital guide for students and also for industry-based engineers, who are either new to the field of electronics, or who wish to refresh their knowledge.

400 pages **Order code NE43** **£23.99**

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (Max) Maxfield

BOOK + CD-ROM

This book gives the "big picture" of digital electronics. This indepth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

500 pages **Order code BEB1** **£35.99**

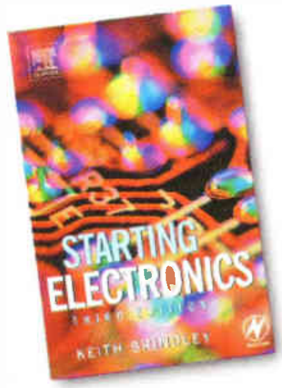
BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

CD-ROM

This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

Over 800 pages in Adobe Acrobat format

CD-ROM **Order code BEB2 CD-ROM** **£21.95**



FUNDAMENTAL ELECTRICAL AND ELECTRONIC PRINCIPLES
Third Edition
C. R. Robertson

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There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

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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.

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Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

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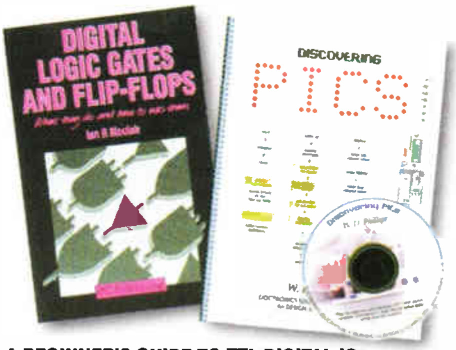

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Mike James

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For details see the shop on our UK web site at www.epemag.com or contact us for a list of *Radio Bygones* books.

PROJECT BUILDING AND TESTING

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** £5.49

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

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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

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.

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Is your frequency meter running out of range? In this clever project, a high speed prescaler can extend the range of virtually any frequency counter to over 2.8GHz. It divides frequencies by exactly 1000, so gigahertz can be read directly in megahertz.

STEREO CLASS-A AMPLIFIER – PART 4

For next month's section on our high performance amp, we'll build an appropriately sophisticated Stereo Preamplifier & Remote Volume Control module. Naturally, it's a low-noise, low-distortion design, specifically engineered to match our very classy Class-A amplifier, but it can also be used with other stereo power amps.

BUILD YOUR OWN RADAR SPEED GUN – PART 2

In part 1, we unveiled our new low-cost microwave Doppler Radar Speed Gun, designed for measuring the speed of cars, bikes, boats, horses and even human sprinters. Next month, we'll show you how to build it, use it and have fun with it!

AN AUTOMATIC STOPWATCH TIMER

Our popular recycling series continues with a look at discarded electronic watches. Do you need to automatically record equipment running time? The stopwatch timer project described starts when power is applied to a low-voltage (12V) circuit and automatically stops when the power is switched off. Very handy – and as usual, it costs next to nothing!

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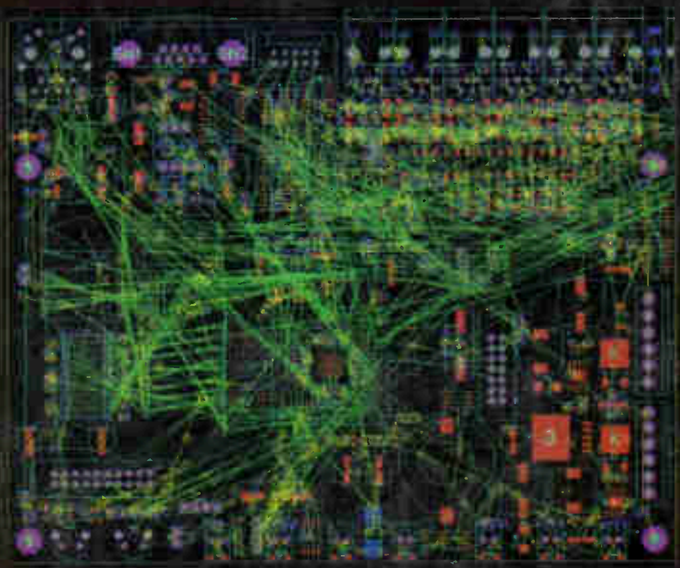

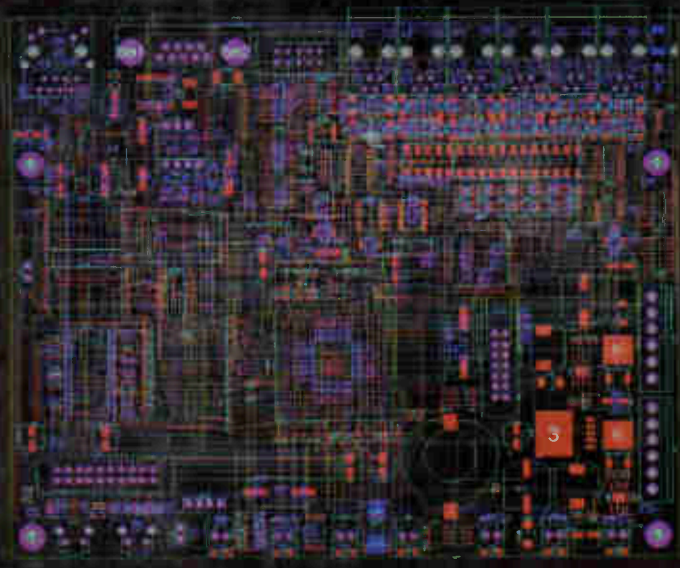

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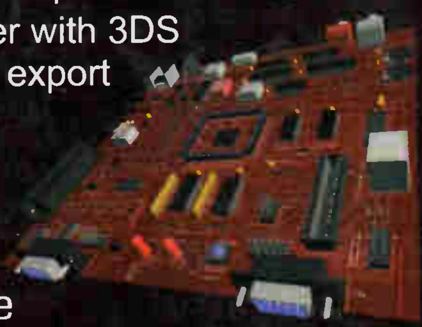

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