THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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NEW ELECTRONIC CONSTRUCTION KITS

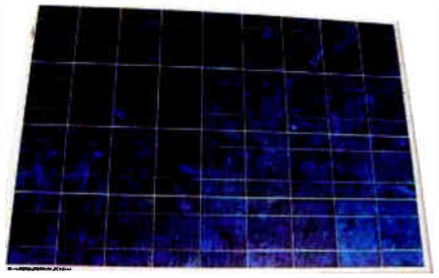
This 30 in 1 electronic kit includes an introduction to electrical and electronic technology. It provides conponents that can be used to make a variety of experiments including Timers and Burglar Alarms. Requires: 3 x AA batteries. £15.00 ref BET1803

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

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

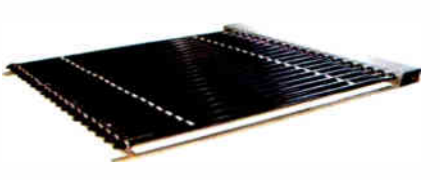
The 75 in 1 electronic kit includes an nintroduction to electrical and electronic technology. It provides conponents that can be used to make and test a wide variety of experiments including Water Sensors, Logic Circuits and Oscillators. The kit then progresses to the use of an intergrated circuit to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

SOLAR PANELS



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

EVACUATED TUBE SOLAR HOT WATER PANELS



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

2kW WIND TURBINE KIT

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

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

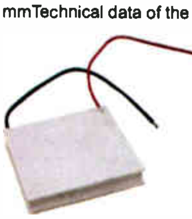
STEAM ENGINE KIT

The material in this pack enables you to build a fully functional model steam engine. The main material is brass and the finished machine demonstrates the principle of oscillation. The boiler, uses solid fuel tablets, and is quite safe. All critical parts (boiler, end caps, safety vent etc.) are ready finished to ensure success. The very detailed instruction booklet (25 pages) makes completion of this project possible in a step by step manner. Among the techniques experienced are silver soldering, folding, drilling, fitting and testing. Only £24.99 ref STEAMKIT Silver solder/flux pack £3.50 ref SSK

HOT AIR MOTOR (Stirling motor) This is an interesting metal based project for pupils aged 15 plus. The material pack will enable them to make a fully functional hot air motor. All the critical parts (piston, working cylinder, flywheel and coolers) have been pre-made and are ready for use. The detailed plans show all the important stages for the required metal working (Measuring with a vernier, sawing, silver soldering, drilling, marking out,thread making, silver soldering, sawing and filing, etc) At the same time the principles of the hot air motor are described in the wide ranging instructions. Technical data : Working cylinder stroke ø 12 x 10 mm Pressure cylinder stroke ø 13 x 11 mm Unloaded speed approx. 800 rpm Size: Flywheel dia. 55mm Base 130 x130 mm With sinter smooth bearings and ready shaped cooler. £29.70 ref STEAMKIT2 Silversolder pack £3.50 ref SSK

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

£14 ref TEL1



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

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STIRLING ENGINES

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HEAT PUMPS

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

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

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

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

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

This type of installation offers many advantages.

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

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

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

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

e) No regular maintenance required.

Some tips

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

5Kw (output) ground to air heat pump £1,099 ref HP5
9kw (output) ground to water heat pump £1,999 ref HP9.
Phone for delivery charges

ISSN 0262 3617

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

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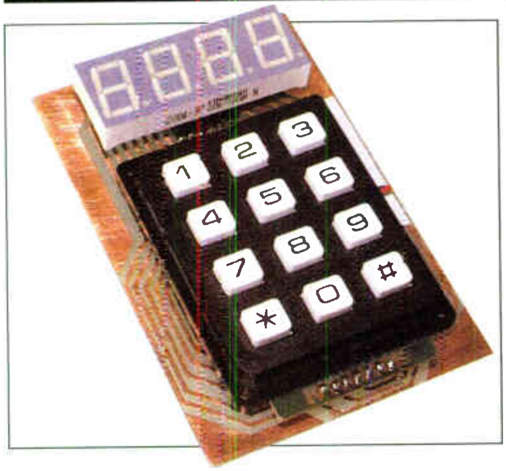

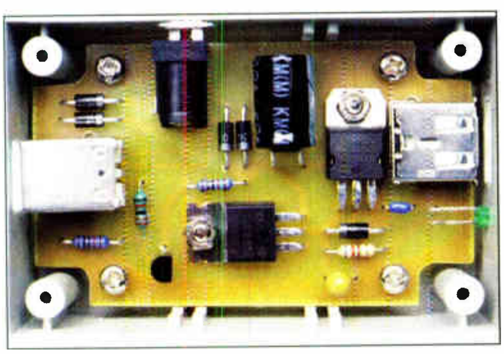

Projects and Circuits

Series and Features

Regulars and Services

Our January 2007 issue will be published on Thursday, 4 December 2006. See page 72 for details


Robot Kits
These educational electronic robot kits make a great introduction to the exciting world of robotics and require NO soldering. See website for details
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Are We On The Right Track?

A recent discovery made me wonder if we are going in the right direction when it comes to data storage. I personally still keep my 'address book' in the form of printed cards, which I find easier and quicker to use than a database – we also store article details for both *EPE* and *Radio Bygones* (our sister vintage radio magazine) on a card system Since the 'live' data is only consulted on a monthly basis and then stored for a number of years once articles have been published this system works well and has 'instant' access for everyone.

Recently I realised that our list of published PCBs – kept in an A5 book – dates back to May 1984, over 22 years ago now. The binding on the book had failed (they don't make them like they used to!) and I repaired it. It made me wonder if we had stored the data on computer how far back we would still be able to search it and how many times we would have needed to change the system/software/back-ups over those 22 years. There is a lot to be said for old fashioned pen and paper – although some of the early pencil entries in the book are a little faded they are all readable, so I know what articles requiring PCBs were published in every issue from May 1984 onwards, and it takes me about five seconds to find them. No waiting for a PC to boot up, or a database to open and then a search to be made. For 'static' data like this, that needs long-term storage, there is no better medium. (By the way we have yet to fill in half the pages in the book so it should last for more than 50 years, if the repaired binding holds out!)

Computers certainly have their place and many of our present projects could not be achieved without them. They also save us much time and trouble in the production cycle of the magazine. For instance, all the pages are uploaded to our printer's computer now – nothing goes by post or courier as it once did. Computers also save much time in the printing process where page layouts and printing plate making have all been computerised over the last few years.

The paperless office, much touted when PCs became a reality, certainly has not reached us at *EPE*. We still have bookcases full to bursting with back issues, data books, contracts, invoices etc. I doubt it will ever change and I doubt it will prove to be better if it does: knowing, as we now do, that computers do crash, do require backing up everyday and sometimes decide not to find the data you know is in there somewhere! But then maybe I'm just old fashioned rather than practical!

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite), from all UK newsagents (distributed by SEYMOUR) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just $15.99US (approx £9.00) per year available from **www.epemag.com**

SUBSCRIPTIONS

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Online subscriptions, for downloading the magazine via the Internet, $15.99US (approx £9.00) for one year available from **www.epemag.com**.

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BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £7.95 plus £3.50 p&p (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas.*

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READERS' TECHNICAL ENQUIRIES

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

PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

A number of projects and circuits published in *EPE* employ voltages than 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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Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.

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.

News . . .

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

DIGITAL TV'S CONFUSION

What's the difference between VCRs and PVRs? There are still mysteries to be solved before digital TV can take over, as Barry Fox reports

HOT on the heels of Ofcom and Digital UK's confusion over the difference between VCRs and PVRs, two more of the disparate bodies involved in switching the UK over from analogue to digital TV have admitted that VCR conversion is a serious obstacle. After a closed meeting with manufacturers and retailers, from which the press were excluded, the Digital Television Group and Freeview (DTV Services Ltd, owned by the BBC, National Grid Wireless, BSkyB, ITV and Channel 4) issued a telling press release.

Announcement

'With digital switchover planned to start in 2008, clear consumer understanding of digital TV recording is needed. Recent Freeview research has shown that there is little consumer awareness of digital TV recorders (PVRs or Personal Video Recorders), a finding supported by limited uptake of the devices already available for the DTT platform.'

The proposed solution is to create a new logo, Freeview Playback, which tells consumers that a device can record digital TV programmes off-air. After the event closed a DTG spokeswoman admitted: 'We don't have any figures for the number of VCRs in use. The public is confused over what they need to buy.'

At the time, the first Freeview Playback brand PVRs were not expected in the market before September 2006. The DTG's spokeswoman acknowledged that there may 'seem to be' a lot of different groups promoting digital TV and switchover, 'but they are trying to tie together.'

Far From Done

'The broadcasters think that once they have got the signal up to the top of the transmitter mast, it's job done', said a senior manager in a major Japanese manufacturer of TV and video equipment, who has been critical of the way switchover body Digital UK is run by broadcasters. 'The need to replace VCRs has been the big overlooked factor in the whole switchover plan. There is not even any agreement on what a PVR is. Is it a hard disc recorder or a DVD recorder or both?'

The DTG and Freeview have not yet addressed this question.

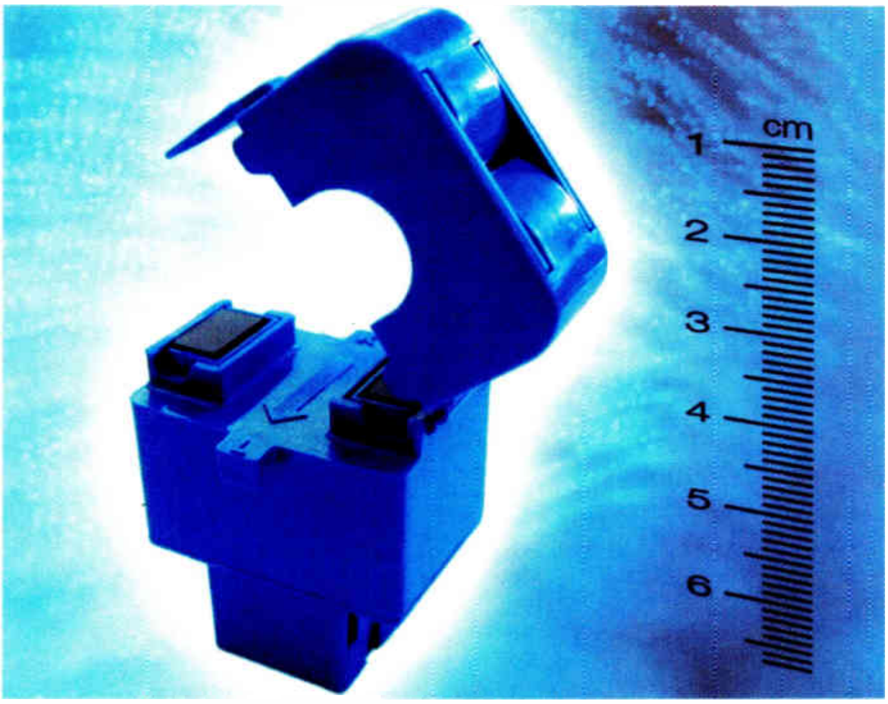
RAPID'S LATEST INFO

Rapid Electronics have sent their latest Secondary Focus A4 booklet – over 130 pages of products and info aimed at the Secondary Education sector. We've long known that they are heavily committed to that area and its curriculum requirements.

We won't try and highlight the contents of the booklet, but just say it has subject sections of Exercize Books; Graphics, Art & Design; Maths; Projects & Robotics; Design & Technology; Tools; Power Supplies & Test Equipment; Science; Audio Visual; Seasonal.

Rapid have also sent their New Products Focus publication, naturally highlighting what new product additions they have. Just in time to tell you that Rapid will be at the Design and Techology with ICT Education Show 2006 at NEC Birmingham, 16-18 November.

For more information on the publications or Rapid's products, contact Rapid Electronics Ltd., Dept EPE, *Severalls Lane, Colchester, Essex CO4 5JS. Tel: 01206 751188. Email: sales@rapidelec.co.uk. Web:* **www.rapidonline.com**.



AC Current Clamp

As though in timely answer to a question on our *Chatzone* recently, LEM have sent information about their cost-effective high quality compact split-core transducers for AC current measurement. As is common for similar products, this clamp enables currents flowing in cables to be measured without breaking into the cable, just clamping around them.

The LEM AT range allows AC current measurement from 5A to 50A RMS at 50/60Hz and has the current transformer and signal conditioning in a very compact split-core case, producing 0-5V DC, 0-10V DC or 4-20mA standard output. Self-powered or loop-powered versions are available.

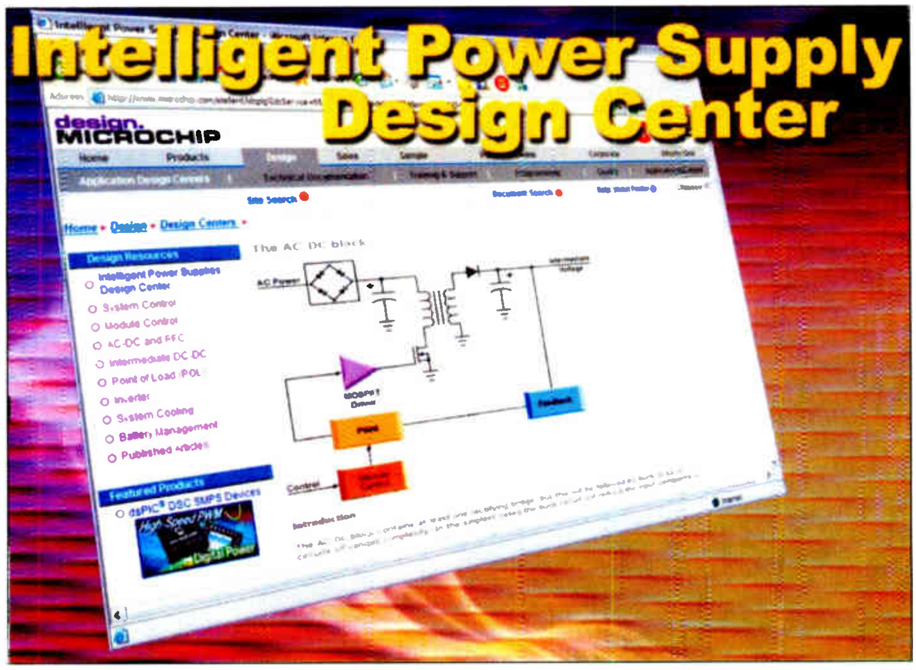
For more information contact: LEM UK Ltd., Dept EPE, West Lancashire Investment Centre, Maple View, White Moss Business Park, Skelmersdale, Lancs WN8 9TG. Tel: +44 1 695 712 560. Web: **www.lem.com**.

Microchip PSU Design

Microchip have announced an online Intelligent Power Supply Design Center (their spelling) at **www.microchip.com/power**. This comprehensive website provides the technical resources needed to design analogue power supplies, augment existing analogue PSU designs with inexpensive microcontrollers, or design switch-mode power supplies (SMPS) with full digital control of the power conversion feedback loop.

The site offers direct access to all Microchip's PSU application notes, reference designs and other technical documentation. Links to Microchip simulation tools (including the Mindi battery charger and PSU circuits) are also included.

Microchip has long provided cost-effective PIC microcontrollers and analogue products to the power supply market, and has recently announced a new family of dsPIC DSCs for full digital control of SMPSs. For additional information visit Microchip's Web site at **www.microchip.com/power.**



PORTABLE ELECTRONICS

Portable electronics needs a suitcase full of chargers to keep it working. British company Moixa Energy has the answer – a standard size rechargeable battery with a miniaturised charger and standard size USB power connector built-in.

Virtually all computer equipment and even modern hi-fi and videos now have a USB socket for connecting a keyboard, mouse or memory store. The sockets push out 5V to power whatever is plugged in.

Moixa's new AA NiMH (nickel metal hydride) USB cells contain intelligent circuitry that drops the USB supply to around 1.4V to charge the battery. A sensor detects the small heat rise and a voltage drop that signals a full charge, and switches off.

A safety timer shuts the full charge off after five hours anyway, and switches to trickle charge. A fully flat battery (with normal 1.2V reduced to 1V) fully charges in five hours, but 10 minutes is enough to deliver enough charge to keep a mouse running for the rest of the day.

The USB cells went on sale in the UK in mid October, and then will roll out through Europe, with a US launch later. A pair of AA cells will cost £13 but Design Director Chris Wright says he 'hopes to pull down the price through mass production'.

The cells charge from either old USB Version 1 sockets or the newer USB Version 2 standard, because both deliver 5V. The cell charger draws a current of around 250mA, so the cells need to plug direct into the sockets on a PC or powered hub socket which delivers 500mA. Unpowered sockets deliver only around 100mA so are not suitable – but these are increasingly uncommon.

Moixa's tests show that charging from a laptop reduces battery life by less than 10%. 'We have already built a prototype cellphone battery with USB charger', says Wright, 'so if you talk for an hour and need to charge your phone you just find the nearest USB socket and plug it in'.

Barry Fox

BlueControl

RF Solutions has introduced a Bluetooth remote controller that is designed for use with Bluetooth enabled devices such as PCs, PDAs and mobile phones. The BlueControl unit features four relays and is ideal for providing control in applications such as lighting, personal access and power switching.

BlueControl provides a secure and reliable telemetry link over distances up to 100 metres for Class I devices, or 10 metres for Class II. The control has an integral antenna and requires a 12V DC PSU.

For further information contact RF Solutions, Dept EPE, Unit 21, Cliffe Industrial Estate, South Street, Lewes, E.Sussex BN8 6JL. Tel: +44 0 1273 898000. Fax: +44 0 1273 480661. Email: sales@rfsolutions.co.uk. Web: **ww.rfsolutions.co.uk**

Churchill Opportunities

We have received information about the Winston Churchill Travelling Fellowships. These are unique and offer UK citizens from all walks of life and irrespective of background, education or professional qualifications the 'Chance of a Lifetime' to undertake study projects overseas related to their trade, craft or profession. Particpants return richer for the experience, to their benefit and that of the community.

Many people find it difficult to believe that they are elegible and the Trust has asked us to make this opportunity more widely known – we are pleased to do so.

Contact the Winston Churchill Memorial Trust, 15 Queen's Gate Terrace, London SW7 5PR. Tel: 020 7584 9315. Fax: 020 7581 0410. Email: office@wcmt.org.uk. Web: **www.wcmt.org.uk**.

MAPLIN'S LATEST

'Price Crash' is the heading on Maplin's latest info received – a multipage leaflet advising people of the bargain reductions they have on a number of product ranges, including computing and various accessories we all need from time to time – batteries, torches, shredders, fan heaters, etc. There are valuable money-off vouchers in this latest edition.

Maplin invite you to visit one of their 100 stores nationwide or log on to **www.maplin.co.uk**.

EOCS

We have received the latest issue of the *Electronic Organ Magazine* from the EOCS, the Electronic Organ Constructors Society – worth joining if you're into such interests. A lovely photo in the current issue, No 98, of a harmonium at the Saltire Museum having a notice saying that it has 53 intervals and 84 keys to each octave, to make playing easier! Musicians amongst you will appreciate the humour!

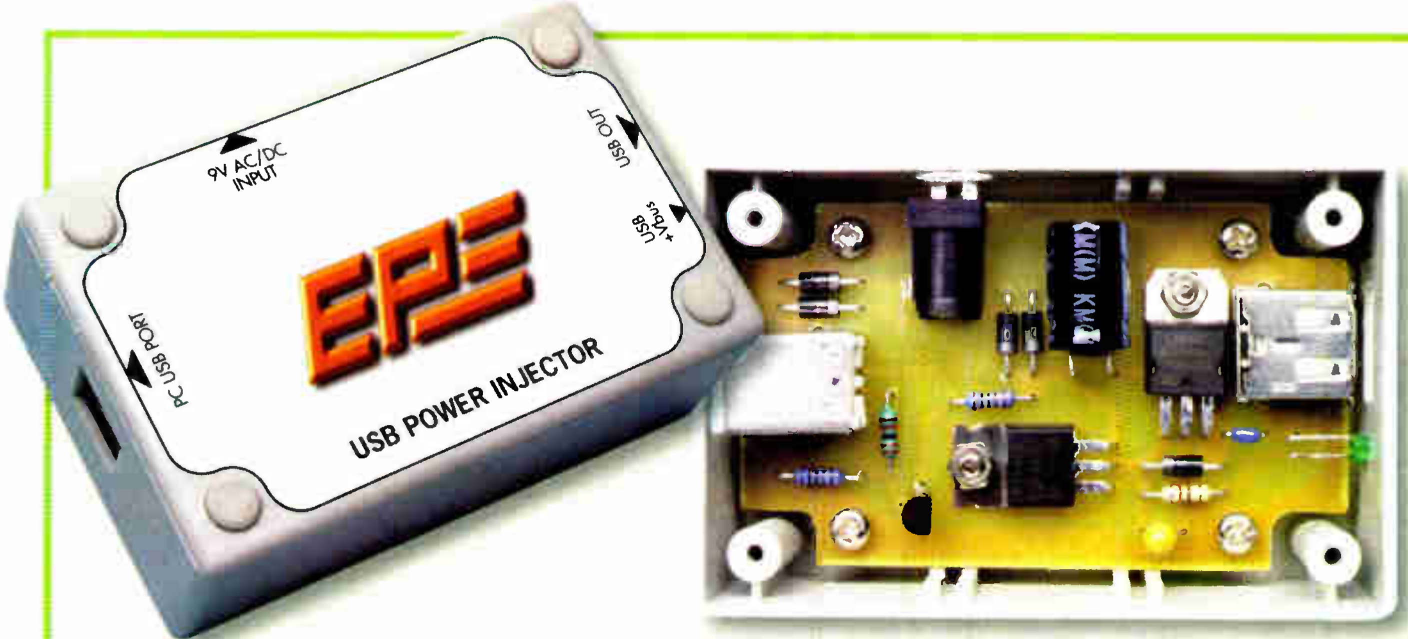
The EOCS can be contacted via Don Bray, 34 Etherton Way, Seaford, Sussex BN25 3QB, also via **editor@eocs.org.uk**.

New Gadgets Website

All The Best Gadgets have opened a new website in reponse to an increasing desire for gadgetry. With a wide range of appliances, ranging from plasma TVs to light sabers and iPod accessories, to professional poker chip sets, this website features 'all the best gadgets at all the best prices!'

In a world where the gadget is king, magazine racks are groaning with dedicated widget bibles and inboxes are flooded with online poker deals. The site stands out for a variety of reasons: a wide range of gadgets, gifts and accessories at 'ultra competitive prices', free delivery to anywhere in the mainland UK, fast despatch of goods.

So, contact All The Best Gadets Ltd., 9-10 Jew Street, Brighton, Sussex BN1 1UT. Tel: 01273 726489. Fax: 01273 746920. Email: info@allthebestgadgets.co.uk. Web: **www.allthebestgadgets.co.uk**.



USB Power Injector

By JIM ROWE

Do you have a new USB-powered peripheral, like a scanner, that needs more power than can be drawn from the socket on your PC or USB hub? Here's a little gadget that will solve your problem. It allows you to feed extra power into the USB line, controlled automatically by the PC – so your new peripheral will be turned on and off just as if it were being powered directly by the PC.

EACH USB SOCKET of a PC or self-powered USB (Universal Serial Bus) hub can supply up to 500mA at 5V DC, which can be used to power many USB peripherals directly. That's one of the advantages of USB and many of the newer peripherals are designed to be powered in this way.

Many low-cost USB hubs are also designed to take their own power from the PC, via their 'upstream' USB cable. That's fine in most cases, as the hub's internal circuitry only needs a few tens of milliamps to operate.

However, things start to get a little more complicated if you try to connect a number of bus-powered USB peripherals to your PC via such a hub, because the hub's 'downstream' output sockets can each only supply a maximum of 100mA. That's because all

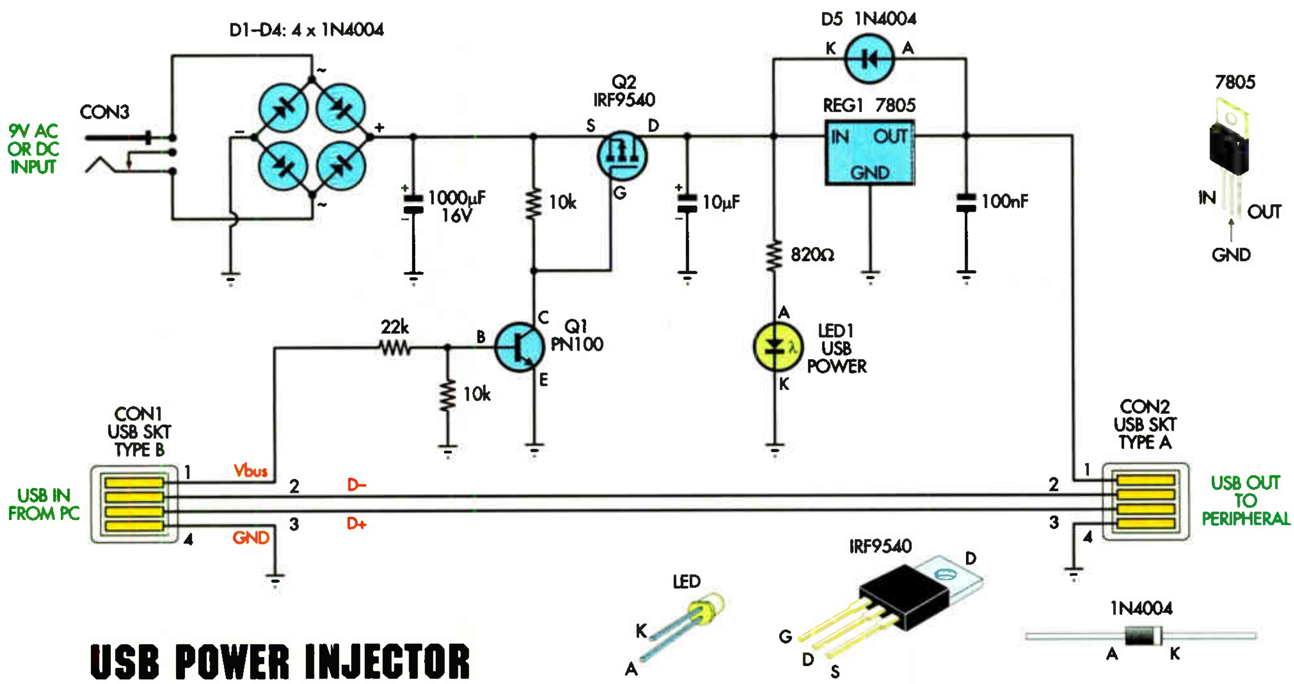


Fig.1: the USB Power Injector is essentially a switch and a 5V regulator. The Vbus supply from USB socket CON1 turns on transistor Q1 which then turns on MOSFET Q2. This then feeds unregulated DC to REG1 which in turn supplies 5V to the downstream USB socket CON2.

of their power must ultimately come from the PC itself, of course.

What happens if you have one of these hubs already powering say, three USB-powered peripherals and then you buy a USB-powered scanner or label printer that needs to draw more than 100mA? Ah, that is a problem. Luckily, it's easily solved; all you need is the USB Power Injector described here. It's designed to be connected in series with the USB cable to your new peripheral and also to a 9V AC or DC plugpack.

When it detects 5V DC coming from the PC and/or hub, it switches power from the plugpack through to a built-in 5V regulator, to provide your new peripheral with its own 5V power at up to 500mA.

All of the components used in the USB Power Injector are mounted directly on a very small PC board, which fits snugly inside a small plastic box.

How it works

Looking at the circuit diagram of Fig.1, power from the external plugpack comes in via socket CON3 and then passes through diodes D1-D4. These provide rectification for an AC plugpack or automatic polarity correction for a DC plugpack. Either way, a DC voltage of between 8V and 14V (or thereabouts) appears across the 1000µF reservoir capacitor.

CON1 is a USB 'Type B' socket, used as the Injector's 'upstream' or input port. It connects back to one of the USB output/downstream ports of your PC or hub, via a standard USB cable. Both of the data lines of CON1 are connected directly to the corresponding pins of CON2, a USB 'Type A' socket which is the Injector's output/downstream port. This connects to your new USB peripheral via another standard USB connecting cable, so the Injector is fully transparent in terms of USB data communication. USB data can pass straight through the Injector in either direction, between PC and peripheral and vice-versa.

When the PC is powered down though, power from the plugpack is not able to flow through to the peripheral because P-channel power MOSFET Q2 is connected in series and it is normally turned off. When the PC is turned on, +5V appears at pin 1 of CON1 and this switches on transistor Q1 via a 22kΩ base resistor. Q1 then switches on Q2, which becomes a very low resistance, about 0.1Ω.

This feeds the unregulated DC voltage across the 1000µF capacitor through to REG1, a 7805 +5V regulator which now provides +5V to pin 1 of CON2 and your peripheral device.

LED1 is used to provide 'power on' indication. LED1 is fed via the 820Ω series resistor from the switched DC at the input to REG1, so it's only illuminated when the Injector's power is switched on by Q2.

The 10µF and 100nF capacitors are included to ensure stable operation of REG1, while diode D5 is to protect it from reverse-voltage damage when the power is turned off.

Although REG1 has very little heatsinking, it should be able to power virtually any USB-powered peripheral which draws no more than the maximum drain of 500mA.

Construction

All the components used in the USB Power Injector (apart from the plugpack) are mounted directly on a small PC board. This measures 76 × 46mm and is available from the *EPE PCB Service*, code 597.

The artwork (Fig.3) for the PC board has rounded cutouts in each corner, allowing it to fit snugly in the small

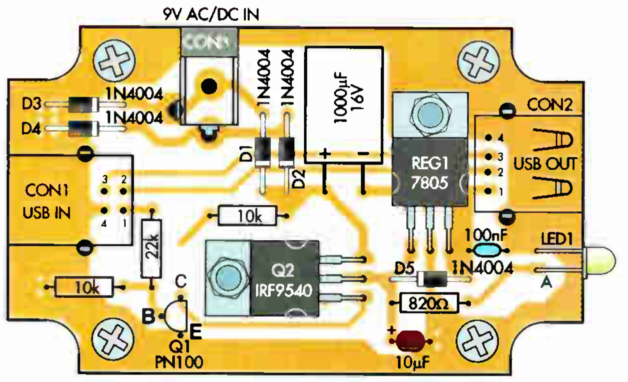


Fig.2: follow this component overlay to assemble the PC board. Don't get Q2 and REG1 mixed up – they look the same!

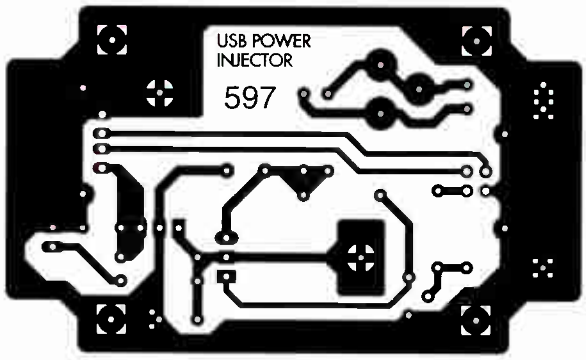


Fig.3: check your PC board carefully against this full-size etching pattern before installing any of the parts.

plastic box (83 × 54 × 31mm). It's supported inside the box by four 9mm long M3 tapped spacers, using four countersink 6mm × M3 screws through the bottom of the box and another four round-head 6mm × M3 screws through the PC board itself.

Rectangular holes are cut in the narrow ends of the box to provide access to the two USB connectors (CON1 and CON2), while a 3mm round hole is drilled in the end next to CON2, to allow LED1 to protrude through. Similarly, a 9mm hole is drilled in one of the longer sides of the box, to allow access to power input connector CON3. The locations of all box holes are shown in Fig.4.

The component overlay diagram for the PC is shown in Fig.2 and you can cross-check this with the internal photo below.

Fit the low-profile resistors and diodes first, taking care with the diode polarity as usual. Then fit the capacitors, taking care with the polarity of the 10µF and 1000µF capacitors. Note that the larger capacitor mounts over on its side, to make sure there is clearance between it and the box lid – see photograph below.

Next, fit the three connectors. The two USB connectors are different in terms of their pin layout, so make sure you fit them in their correct positions. You may need to elongate the holes for their attachment lugs slightly with a jeweller's file, before the connectors will fit down against the board.

The last components to fit are the TO-92 transistor Q1, LED1 and the two TO-220 devices Q2 and REG1. Make sure you don't swap the latter

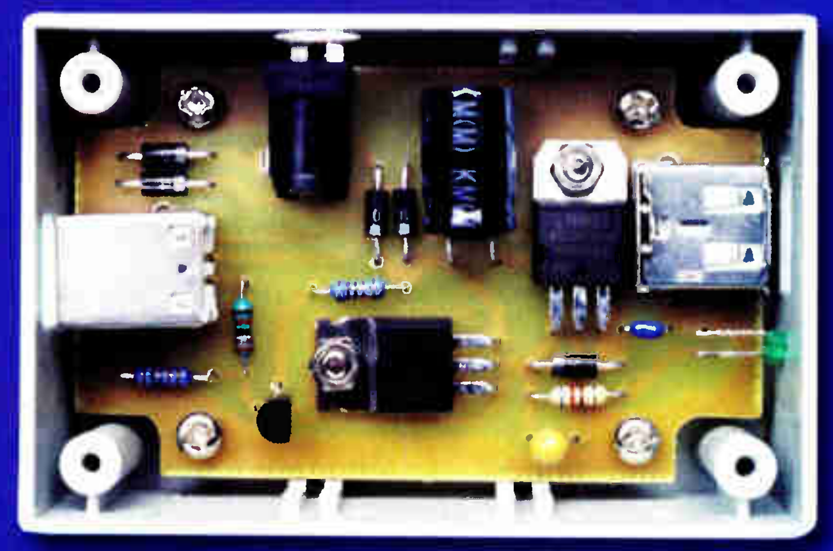
Parts List

1 PC board, code 597, available from the *EPE PCB Service*, 76 x 46mm
1 plastic utility box, UB-5 size (83 x 54 x 31mm)
1 USB socket type B, PC-mount (CON1)
1 USB socket type A, PC-mount (CON2)
1 2.5mm concentric LV power socket (CON3)
4 M3 tapped spacers, 9mm long
6 M3 x 6mm machine screws, round head
4 M3 x 6mm machine screws, countersink head

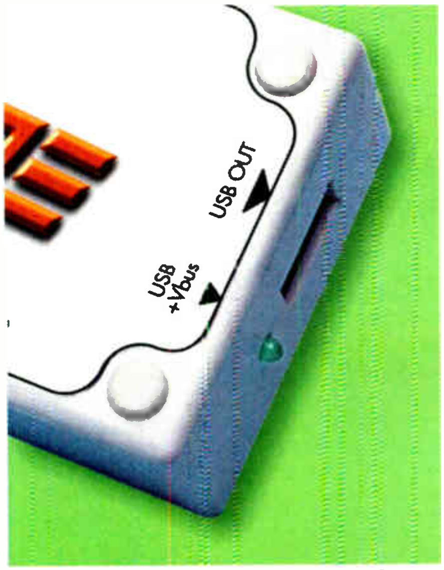
Semiconductors
1 7805 5V regulator (REG1)
1 PN100 NPN transistor (Q1)
1 IRF9540 P-channel MOSFET (Q2)
1 3mm green LED (LED1)
5 1N4004 diodes (D1-D5)

Capacitors
1 1000µF 16V PC electrolytic
1 10µF 25V tantalum
1 100nF (0.1µF) multilayer monolithic (code 104 or 100n)

Resistors (0.25W 1%)
1 22kΩ
2 10kΩ
1 820Ω



The PC board is mounted inside the case on four M3 x 9mm tapped spacers and secured using machine screws. Note how the 1000µF electrolytic capacitor is mounted.



The power indicator LED protrudes through a hole in the end of the case, adjacent to the USB output socket (CON2).

devices, as this may cause one or both of them to be damaged. Both devices mount flat down against the top of the board, with a 6mm × M3 machine screw and nut used to hold them down and also provide a small amount of heatsinking.

Make sure also that you fit LED1 with its "flat" side towards connector CON2 and its longer anode lead further away. The LED leads are soldered in place with the body about 11mm above the board and they are then bent down at right angles about 4mm above the board, so the body can protrude through the matching hole in the end of the box.

Once you have made the necessary holes in the UB-5 box (including the countersunk holes in the bottom, for the PC board mounting screws), the completed board assembly can be mounted in the box using the 9mm M3 tapped spacers.

Checkout time

There are no adjustments or setup needed on the completed USB Power Injector and very little in the way of testing. All you need do is connect the output of a 9V DC or AC plugpack to CON3 and confirm that indicator LED1 doesn't light until you also connect CON1 to a downstream USB port on your PC or USB hub.

If the LED then turns on and off when the PC is itself turned on and off, this confirms that it's working correctly. All that remains is to screw on the lid of the box and fit the cover plugs – although you might also want to stick on a dress label as well, to finish the job. The artwork for a suitable label is shown in Fig.5. ***EPE***

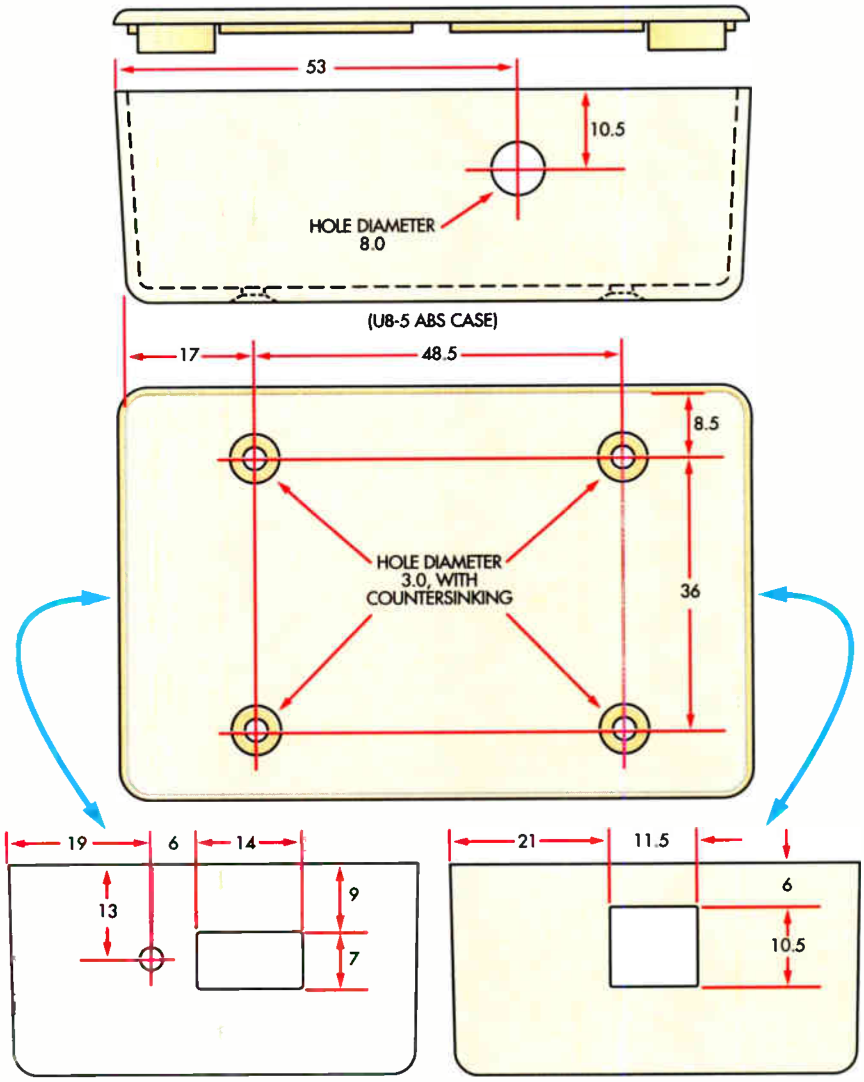


Fig.4: this diagram shows the drilling and cutout details for the plastic case that's used to house the board assembly.

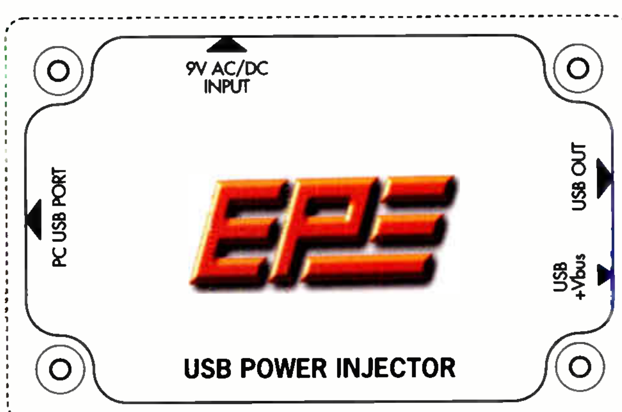


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Fig.5: this front panel label can be cut out or photocopied and attached to the lid of the case. It can be protected using wide strips of clear adhesive tape.

Banned Substances

Mark Nelson investigates why some commonplace products may soon acquire 'endangered species' status.

INCREASING legislation for consumer protection has got to be a good thing–at least in general. But it can be a real pain when it threatens user choice, particularly for hobbyists who know what they are doing.

In several hobby magazines a previously respected supplier of solder and soldering accessories ran advertisements urging readers to 'Stock up now on (soon to be) Banned Substances'. The words 'soon to be' were in much smaller print and the clear impression was that within a few months tin-lead solder could no longer be sold.

This of course is rubbish, a fact that a rival supplier soon spotted, running advertisements to the effect of 'Don't worry, it's still available from us' and adding that its use was restricted in certain applications. Which is entirely correct. Although since July of this year solder containing lead cannot be used for manufacturing new consumer products, its use is still permissible for repairing equipment already on the market, for making non-consumer items and for non-commercial (hobby) applications.

False Allegation

The allegation that tin/lead solder will cease to be available is totally false; it will still be made as there will remain many types of product that are not covered by the new rules. Of course, it may not be so easy to find in the shops and Maplin Electronics, probably Britain's biggest hobby electronics supplier, stopped stocking the stuff quite some time ago. The major online suppliers, such as Farnell, RS Components and Rapid Electronics continue to sell it and long may this last.

Whether the change of regulations will lead to prices plummeting or rising is not so certain. Some optimists imagine there will be a glut of the stuff as vendors dump large stocks, although any well-run business will have run down its stocks in advance of the cut-off date. It's more likely that the declining demand will cause prices to rise, although a shortage of the stuff is very unlikely. We shall see.

Battery Ban

Some scare stories are true, however, if the thought of not being able to buy rechargeable NiCad batteries fills you with dread. A pan-European effort to exclude poisonous heavy metals from landfill waste will result in a ban – the use of cadmium and mercury in portable batteries, with only a few exemptions. The applications for which NiCads will still be allowed include emergency lighting, power tools, certified medical equipment and the requirements of national security.

A major application that will cease is mobile radios and cordless telephones, in which NiCads have played the mainstay role for many years. These users will have to find compatible new batteries and chargers or else buy new appliances. Another effect of the legislation is the obligation on suppliers to collect and recycle all batteries, at no cost to the user.

There will be tough recycling targets too. Within four years of the directive coming into force, industry will be required to recover 25 per cent by weight of all batteries sold. The EU directive on this subject is expected to be published before the end of this year, with up to two years allowed after that for implementation.

'Worst Law Ever'

If you think these European directives are oppressive, then thank your lucky stars you don't live in Japan, where consumers only just escaped far more draconian legislation. It was in March of this year that the Japanese government did a U-turn and quashed the 'Electrical Appliance and Material Safety Law', which it had already passed in 2001. The legislation aimed to ban the sale of electrical consumer goods manufactured before the year 2001, unless they passed a safety test that would generally cost far more than the item's current value.

The aim of this directive was laudable, to protect users from buying unsafe goods at the same time as revitalising the economy by boosting the sale of new products. However, second-hand dealers were less cheerful; their market was stated to be worth around £500 million, although this was probably a significant underestimate.

What the do-gooders had failed to think through was the effect the legislation would have on the sale of classic hi-fi equipment, early home computers and gaming consoles, also electronic music apparatus and karaoke machines, all of which have passionate adherents in Japan. It also failed to foresee that the effective ban would lead to a flood of this equipment onto the export market at the same time as driving Japan's electronic heritage out of the country where it arguably belonged.

After stringent public criticism the government moved to a compromise position. For six months it would conduct the safety tests at its own expense (well, public expense really) and exempted 'vintage' musical instruments and certain other categories. Finally, the defining date for what was 'old' and therefore had to be tested was moved back from 2001 to 1989, enabling most second-hand products to escape testing. It was a near thing, though, with little wonder that Japanese citizens dubbed it their country's 'worst law ever'.

Grumpy?

Who's grumpy? Well, me for a start. People tell me I was already a Grumpy Old Man decades ago in my twenties, but at last that experience proves that we British are an adaptable race. We grumble for a while and then adjust to new rules and regulations.

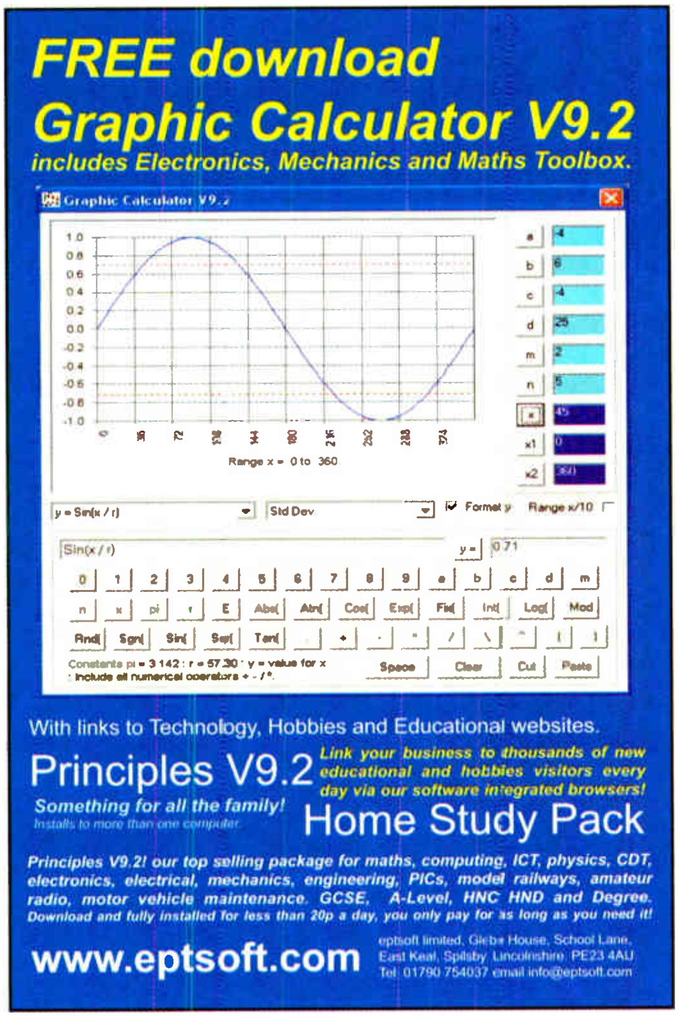
Look at workshop solvents for instance. When I was a kid my father had a tin of petrol in the garage, with an old paintbrush in it for degreasing materials. This was considered unsafe, so we changed over to Carbon Tetrachloride (CTC), also sold in every high street as Thawpit dry cleaning fluid (remember the wide-rimmed bottle with a cork applicator that took ages to saturate?).

Then CTC was declared taboo and we had to use 'trike' (Trichloroethylene) instead. Concerns about its toxicity meant it was banned in much of the world during the 1970s. No doubt there's an entirely safe substitute now and a quick Google search indicates Leksol (n-Propyl Bromide) is a direct substitute with no hazards at all (unless you know better). I'm afraid I stopped trying to keep up ages ago and just use Isopropyl Alcohol or Swan Vestas lighter fuel. I do have a Winchester of xylene under the sink as well, but there's so little left of this I'm saving it for later!

Filthy Phone Calls

While on the subject of cleanliness, I was shocked by another scare story recently, about a new hazard involving mobile phones – nasty bacteria! Under the headline 'Minging Mobiles' a newspaper informed me that keeping handhelds warm and cosy inside pockets makes an ideal breeding ground for nasty bacteria. 'Tens of thousands of microbes live on each square inch of mobile phones and hold more bacteria than a toilet seat,' thundered the article. 'Every time you use your phone to text or put it to your ear, thousands of bacterium [sic] are rubbing off on you to continue breeding', it continued.

Really? Surely these bugs are transferred onto the phone from your body, where they evidently do me no harm, so their advice to use anti-bacterial wipes sounds like a cynical excuse to sell more wipes!



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PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

More about using MultiMedia Cards with PICs

IN last month's *Pic n' Mix* we detailed the low level hardware and software interfacing to MultiMedia Cards (MMC), showing how simple they are to use. Reading and writing to them is surprisingly straightforward once you get over the hurdle of the various specification documents.

Accessing Data

Accessing the data outside of your project, however, is rather more difficult, especially if you intend to store the data in your own, non-standard way. If you are going to write or read large amounts of data – after all, that would be the reason for designing the media into your project in the first place – then you are likely to want to be able to access the data on a PC.

MMC readers for the PC are readily available and very cheap, as low as £5. These readers expect the media cards to have data organised on them in a structured way, typically either FAT12, FAT16 or FAT32 format.

Most Media cards are supplied pre-formatted to the FAT16 standard. What this means is that some of the memory locations on your card contain data that defines a FAT file system, just like a hard disk. And this can involve quite a lot of your precious memory; for example, on our MMC over 256KB of the total memory available is reserved for the FAT data. As this represents only 0.1% of total space, the loss is a small price to pay for the convenience.

FAT Tables

FAT16 stands for 'File Allocation Table, 16-bit'. It is an old disk file system designed by Microsoft that is capable of handling storage devices with capacities up to 2GB. It has been in common use on DOS and Windows based PCs for many years, but has now found its way onto removable media such as MMCs. The use of the FAT16 file system on removable media is a significant reason why transferring data from digital cameras, MP3 players etc to a PC is so simple.

A FAT is a collection of data structures that are placed onto the device that define how big the storage device is, how the memory is organised, and where the files are. Hard disks are quite complex devices with multiple platters, heads etc, but Media cards are, of course, just an array of bytes and so there is more information inside these data structures than we need. When we get on to describe the data structures we will skip over the unused parts, and concentrate on the fields of interest to us.

The specification of FAT16 is not trivial, but once we have gone through it you will find the software easy to use. Storing data in FAT format on a media card offers a world of opportunities not possible before – easily sharing data between your PIC-based project and a PC. Not only can you save text, images, sound files, binary files etc but you could (with a little thought and some further code) create PIC programs that you could 'run' by transferring from the Media card to the PIC's flash. You could create your own 'DOS' for the PIC!

WinHex

Before we start working through the FAT specification, you might want to download the program *WinHex* from the Internet (see the links under Reference at the end of this article). WinHex is one of a number of tools produced by X-Ways Software Technology AG designed for 'forensic analysis' of storage media.

In our case, it can be used to view the raw data on the card when attached to the PC via a cardreader. It's a small 1MB download that can be used free of charge in evaluation mode. Once downloaded, extract the files to a temporary directory, run the **setup.exe** and install to the default directory. Once installed, you can remove the temporary directory. When you run it for the first time a dialog, Fig.1, is shown.

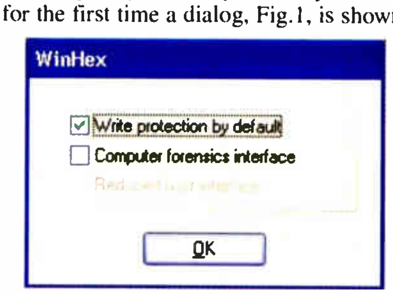


Fig.1. Initial dialog screen

Set the tick boxes as shown, then click on 'OK'. To view the contents of the MMC card click on 'Tools' followed by 'Open Disk'. In the dialog box that appears, select the entry 'Removable Medium' from under 'Physical Media'. The contents of your card will be displayed.

FAT16 Specification

Now, to the FAT16 specification. First, some terminology. As FAT was originally designed for hard drives which contained several disks and read heads, the means of identifying a particular byte within the unit is complicated. The original scheme was called CHS addressing – Cylinder, Head and Sector. This has been superseded by LBA, Logical Block Addressing, which uses a simple incrementing counter to identify the position of a byte; the drive takes care of where the byte is actually located.

For Media cards, implementing a simple linear array of bytes, CHS has no meaning and we consider data locations in terms of sectors. A *sector* is the smallest unit of data (i.e., size) managed by the file system, and typically consists of 512 bytes. A *cluster* is another unit of data, which can vary depending on the size of the card. The number of bytes per sector and number of sectors per cluster are defined within the FAT tables, which we read when we first power up the card.

So, why do we use sectors and clusters rather than bytes? It allows us to reduce the number of bits required when addressing, or indexing, into the card's data. If files are set to start at the beginning of a cluster, then you only need a 20-bit pointer rather than a 32-bit pointer (on a 2GB disk) to address the file. This saves space on the storage of file pointers. As we will see later, there can be a lot of them in the FAT, so reducing their size is a good idea.

Data Structures

There are several data structures that make up a FAT16 organised card, shown in Fig.2.

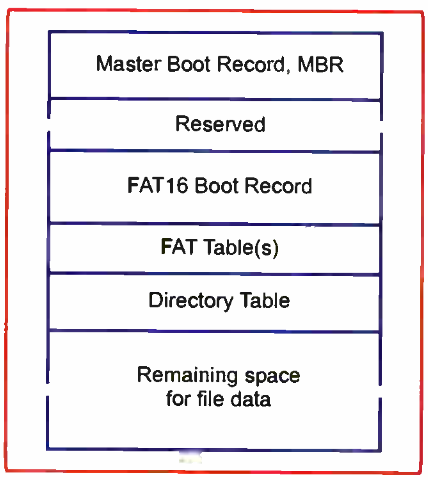


Fig.2. FAT16 Data structures

The size and locations of these vary, so we have to read each one in sequence and decode the information to find where the others are. The first one is the Master Boot Record, or MBR, conveniently located at sector 0, the first byte on the card. This record normally holds the initial software run by a computer (only 446 bytes) and the details of the locations of up to four partitions. A *partition* is an area of memory that

Master Boot Record - MBR		
Index, in hex	**Size, in decimal**	**Description**
0x000	446	Initial boot code
0x1BE	16	Partition 1 details
0x1CE	16	Partition 2 details
0x1DE	16	Partition 3 details
0x1EE	16	Partition 4 details
0x1FE	2	End marker (0xAA55)

Fig.3. MBR information

can be assigned to a logical disk; thus, you could have up to four logical drives. Each partition will hold a FAT16 boot record, FAT tables, a directory table and a large block of space for the actual file data itself. Fig.3 shows the information held in the MBR.

Note that in all the descriptions that follow, word and long word numbers (2-byte and 4-byte) are stored lowest value first, highest value last. So the number 0x1234 would appear in memory as 34 followed by 12. This is referred to as 'little endian' and is the format used by Intel processors when storing multi-byte values.

Partitions

Media cards are typically created with a single partition, so we look through the MBR's partition table details to find where this partition actually starts, as shown in Fig.4. We look for a value of 4, 6 or 14 in the partition type (which signifies a FAT16 file system) and then look to the offset field to find where the partition proper starts.

Partition – Directory Table		
Index, in hex	**Size, in decimal**	**Description**
0x00	8	File name, ASCII
0x08	3	File extension, ASCII
0x0B	1	File attributes
0x16	2	File creation time
0x18	2	File creation date
0x1A	2	File start cluster
0x1C	4	Size of file

Fig.4. MBR partitions

As you can see, there are a number of hoops that need to be jumped through, but this only needs to be done once when you power up the card. We are getting close to finding the data!

Another quick note: Most Media cards are supplied pre-formatted with these data structures, but in some cases when the card is reformatted by Windows the MBR is discarded, and location 0 holds the start of the partition. On a Media card the only use for the MBR is to locate the active partition so this does not cause us a problem, we just need to check to find out if the MBR is present or not.

FAT records

The FAT16 boot record, which you can see in Fig.5, appears at the beginning of the partition. Lots of key information in here helps us locate the remaining data on the card. It also tells us how many sectors are used for each cluster; a detail that will be important later on.

The first FAT table follows after the 'Number of reserved sectors'. The FAT table contains the list of clusters that make up your files. It's a type of linked list, enabling the file to be stored in chunks, filling up unused holes left by previously deleted files. It is obviously extremely important that the FAT table does not become corrupted, so there are typically two or more copies of the FAT table. When we write to a file, we must update all copies of the FAT.

The FAT table consists of a simple list of words (16 bits), one for each data cluster in the partition. The first two words are reserved and the next word holds the 'next in chain' pointer for cluster number two. By convention, cluster number two is the first data cluster, and it follows immediately after the directory table.

As an example of how the FAT table is organised, let's say you create a big file that needs three clusters to hold it. If this is the first file on the partition, it will occupy clusters 2, 3 and 4. The third entry in the FAT table, which is the marker for cluster number 2, will hold the value 3. The next word entry in the FAT table, for cluster number 3, will hold the value 4. The starting cluster for the file (2 in this case) is found by looking in the directory entry for that file.

Cluster Attributes

There are special values to indicate when the file ends, unused clusters etc. These are:

0x0000 : Cluster is unused

0x0003 : 0xFFEF : Next cluster in the file

0xFFF7 : Cluster contains a bad sector (do not use)

0xFFF8 – 0xFFFF : Last cluster in the file

As you can see, media that has a large cluster size will not be efficient at storing large numbers of files. If your cluster size is 4KB and you store a 4.1KB file, the file will occupy 8KB. This is the nature of FAT file systems; it is a trade off between storage efficiency and speed of access to files. The size of the cluster is not under your control, so you have to live with it.

The names, creation date and attributes of each file are not held with the file data but instead in the directory table that follows immediately after the FAT tables. The content of this data structure can been seen in Fig.6. The specification for the bit fields is detailed in the source code that accompanies this article, in the file **FAT16.inc**.

Partition – FAT16 Boot Record		
Index, in hex	**Size, in decimal**	**Description**
0x000	3	Reserved
0x003	8	OEM Name, ASCII
0x00B	2	Number of bytes / sector
0x00D	1	Number of sectors / cluster
0x00E	2	Number of reserved sectors
0x010	1	Number of FAT copies
0x011	2	Maximum root entries
0x16	2	Number of sectors / FAT
0x20	4	Number of sectors in the partition
0x26	1	Magic number (0x29)
0x2B	11	Volume name, ASCII
0x36	8	FAT type, ASCII (FAT16)
0x1FE	2	End marker, 0xAA55

Fig.5. FAT16 Boot Record partitions

Partition – Directory Table		
Index, in hex	**Size, in decimal**	**Description**
0x00	8	File name, ASCII
0x08	3	File extension, ASCII
0x0B	1	File attributes
0x16	2	File creation time
0x18	2	File creation date
0x1A	2	File start cluster
0x1C	4	Size of file

Fig.6. Partitions Directory Table

The filename and extension should be padded with spaces if not eight and three characters respectively. The first byte of the filename has a special meaning; a value of 0xE5 means 'This entry is free', and is the value you write in when the file is deleted. A value of 0x00 means 'No more files in the directory' and is used to signal to software that it does not need to continue looking for filenames.

The creation time and date fields are not mandatory, so you can leave them empty if you wish, or set them to a default value.

Sub-directories and File Names

In order to simplify matters we have left off an explanation of sub-directory and long filename handling; they are not necessary for basic file handling.

In the implementation we have also made a simplification to the way files are written; when we open the file we find the last cluster used on the disk, then we write data to consecutive clusters without trying to 'fill in' unused clusters elsewhere in memory. This enables the software to support high speed writing to the media, which is likely to be important for many embedded projects.

Example Software

The example software for this article (available from the Downloads section of the *EPE* website – **www.epemag.co.uk**) builds on last month's low level code. We have also added some new commands to the RS232 debug user interface to display a directory listing, the contents of a file etc. All the high level access functions are listed in **FAT16.inc**.

The nice thing about implementing a FAT interface is that the underlying software need implement only two functions; *readBlock* and *writeBlock*. We did just that last month, so this month's code focuses on the higher level FAT interfacing and ignores almost completely the underlying complexities of the card interface. This is a typical design practice; implement the software in 'layers', with each subsequent layer providing a greater level of abstraction from the preceding layers. No need to worry about SPI commands and bit twiddling this month!

Finally

This has been quite a length and complex discussion, but we hope that you can see the potential benefits are enormous, and quite good fun to experiment with.

Reference

WinHex: **http://www.x-ways.net/**

This unit is easy to build, with all parts installed on a double-sided PC board to eliminate internal wiring. It simply connects between the video source (eg, a set-top box) and your TV set or video projector.

By JIM ROWE

RGB to Component Video Converter

OK, YOU'VE JUST arrived home with your new widescreen TV set and tried to hook it up. But there's a problem – your new set has Y/Cb/Cr component video inputs while your digital set-top box only provides high-quality signals in RGB format. You've got three choices – throw a wobbly, use the composite video output (but at the expense of picture quality) or build this low-cost RGB to Component Video Converter.

IF YOU LIVE in an area where digital FTA (free-to-air) TV signals are available, it's well worth investing in the service because of their better picture and sound quality. However, to achieve the best possible picture quality, you have to use the component video signals from the DTV set-top box and feed these into the matching inputs of your TV set or video projector.

The big catch here is that some set-top boxes only provide RGB video signals, with separated red, blue and green outputs. In most cases, these signals are made available via one of the large 20-pin SCART sockets or Euroconnectors.

This doesn't suit some of the latest large-screen (and wide-screen) TVs and video projectors. These are usually designed to accept Y/Cb/Cr (or Y/B-Y/R-Y) component video, the same format as provided by the latest DVD players.

Unfortunately, you can't feed RGB signals directly into these sets or projectors. But you can convert the RGB signals into Y/B-Y/R-Y form, using the simple converter unit described here. It simply connects between your set-top box and your TV set or projector.

As shown in the photographs, the complete converter fits in a small instrument box. It runs from a 9V AC plugpack supply, drawing less than 50mA – ie, less than half a watt of power.

How it works

The operation of the converter is quite straightforward, because it simply duplicates the kind of matrixing used to produce the luminance (Y) and colour difference (R-Y and B-Y) signals from the original colour camera signals. To do this, it first creates the Y signal by combining the R, G and B signals in the correct proportions; ie:

$Y = 0.3R + 0.59G + 0.11B$

That done, it subtracts this Y signal from the R and B signals, to create the colour difference signals.

Fig.1 shows how this is done. The Y signal is produced by the mixer/adder stage based on IC1a which (like all of the other op amps used) is one half of a MAX4451ESA dual wideband amplifier. This stage is used to combine the three input signals in the right proportions, as determined by the three input resistor values.

Because IC1a is connected as an inverting amplifier, the signal at its output is an inverted version of the Y signal (ie, – Y). This – Y signal is then added to the R signal in IC1b to derive the R-Y colour difference signal.

In fact, IC1b operates with a gain of two (as set by the R1 resistor values), so its output signal corresponds to 2(R-Y). This is done to compensate for the voltage division that occurs when the converter's R-Y output is connected to the R-Y input of a TV set or video projector – ie, due to the effect of the converter's 75Ω 'back termination' output resistor and the set's 75Ω input impedance.

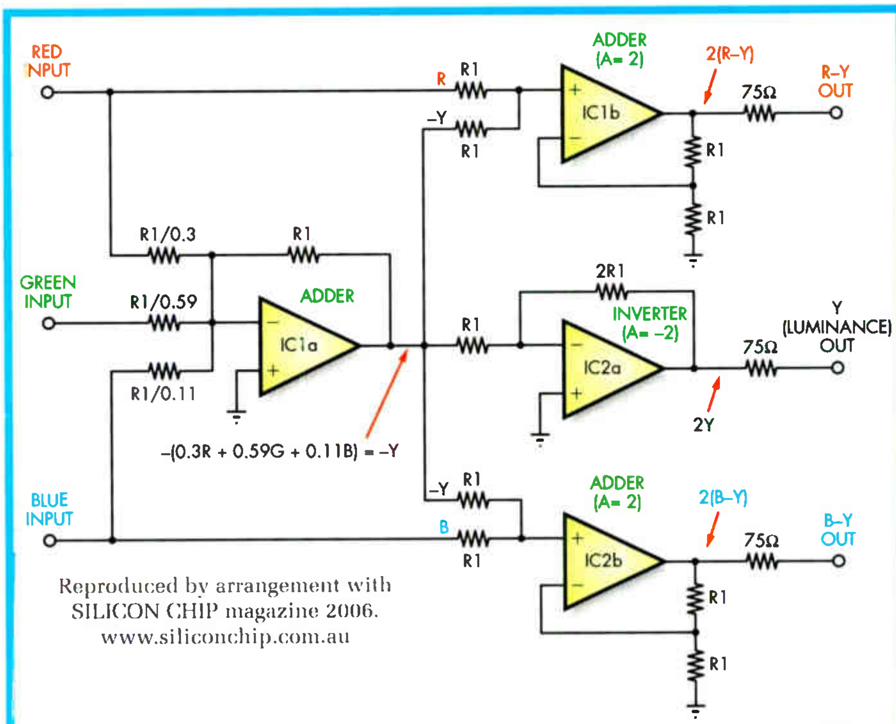
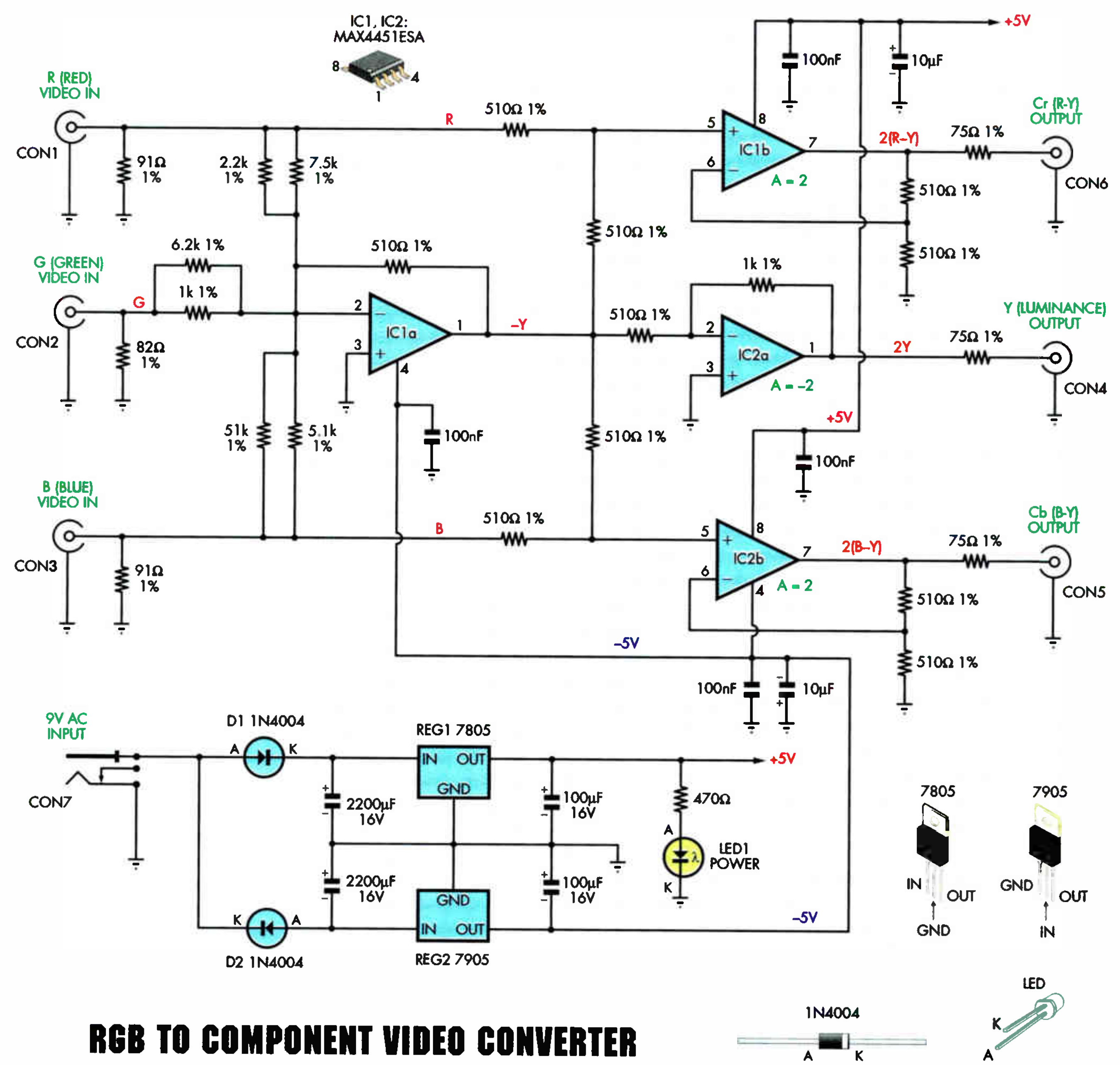


Fig.1: the RGB signals are added in the correct proportions in op amp IC1a to produce a – Y (inverted luminance) signal. This is then fed to IC1b & IC2b to produce the R-Y and B-Y colour difference signals, while inverter IC2a produces the Y luminance signal.

Above: the rear panel provides access to the three component video RCA output sockets and the power socket.



RGB TO COMPONENT VIDEO CONVERTER

Fig.2: the complete circuit for the RGB To Component Video Converter. Op amps IC1a, IC2a & IC2b all operate with a gain of two, to compensate for the signal losses that occur due to the 75Ω "back termination" output resistors and the set's 75Ω input impedance.

Exactly the same arrangement is used to produce a 2(B-Y) colour difference signal, using adder stage IC2b. In this case, we simply add the – Y signal to the B signal and again amplify their sum by two.

The centre output buffer stage using IC2a operates as an inverting amplifier with a gain of two and converts the -Y (luminance) signal from IC1a into an output signal of 2Y. As before, this stage operates with a gain of two to compensate for the inevitable voltage division due to the 75Ω back termination and input resistors.

Now take a look at Fig.2 which shows the full circuit details. As shown, all the resistors shown as R1 in Fig.1 actually have a value of 510Ω. These resistors are in the feedback networks and at the inputs to IC1b, IC2a & IC2b. By contrast, the various parallel resistor combinations between the three video inputs and IC1a's inverting input (pin 2) are chosen to give the correct mixing proportions.

For example, the 2.2kΩ and 7.5kΩ resistors from CON1 give a value of 1701Ω, which is very close to the correct figure for the R component (ie, 510/0.3 = 1700Ω) Similarly, the 1kΩ and 6.2kΩ resistors give a value of 861.1Ω, which is very close to the correct figure for the G component (510/0.59 = 864.4Ω). And finally, the 5.1kΩ and 51kΩ resistors give 4636Ω, exactly the right figure for the B component (510/0.11 = 4636Ω).

The 91Ω and 82Ω resistors across the three video inputs ensure that each has the correct 75Ω input resistance. Note that these resistors are all somewhat higher than 75Ω, to compensate for the effects of the various mixing resistors connected to them. This impedance matching is necessary to ensure that the input cables from your set-top box or other RGB video source are correctly terminated, to prevent ringing.

Power supply

The converter's power supply is simple, as the MAX4451 devices operate from ±5V supply rails and draw quite low current.

Power is derived from a 9VAC plugpack and this feeds half-wave rectifiers D1 and D2. These produce +13V and −13V rails which are filtered using two 2200µF electrolytic capacitors and fed to 3-terminal voltage regulators, REG1 and REG2. The +5V and −5V regulator outputs are then filtered using 100µF capacitors and fed to the op amps supply pins (4 & 8).

LED1 provides power-on indication. It is simply connected across the +5V rail in series with a 470Ω current-limiting resistor.

Construction

All of the converter circuitry is built on a double-sided PC board, coded 596, measuring 117 × 102mm. This in turn is housed in a standard instrument case measuring 140 × 110 × 35mm, to produce a very compact and neat unit.

There's no off-board wiring at all – all the RCA input and output connectors are mounted directly on the PC board along the front and rear edges. These are all accessed through holes in the front and rear panels when the case is assembled.

It is necessary to solder some component leads on both sides of the board. You'll also need to solder a short length of tinned copper wire (such as a resistor lead offcut) through one 'via' hole, to make the connection between top and bottom tracks. To make it easy, these points are all indicated on the PC board overlay diagram (Fig.3) with red dots. The full-size top and bottom copper-foil masters are given in Fig.6.

Most of the components fit on the top of the board in the usual way. The only exceptions are the two MAX4451ESA

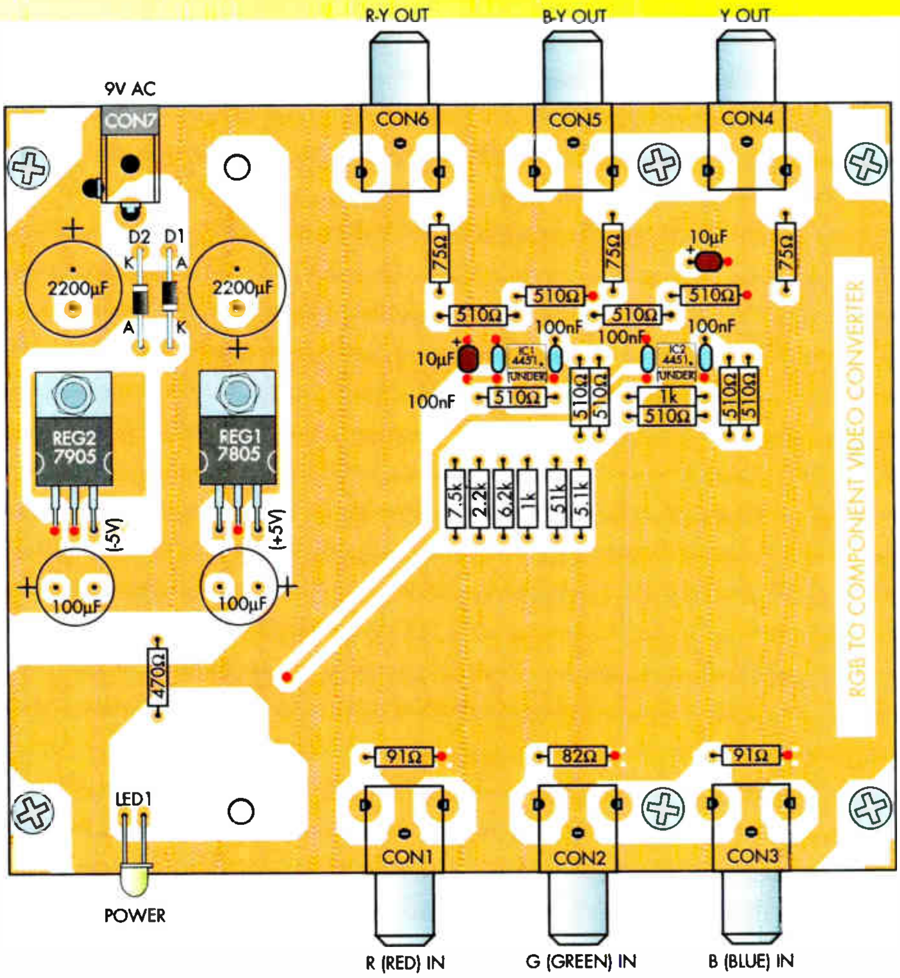
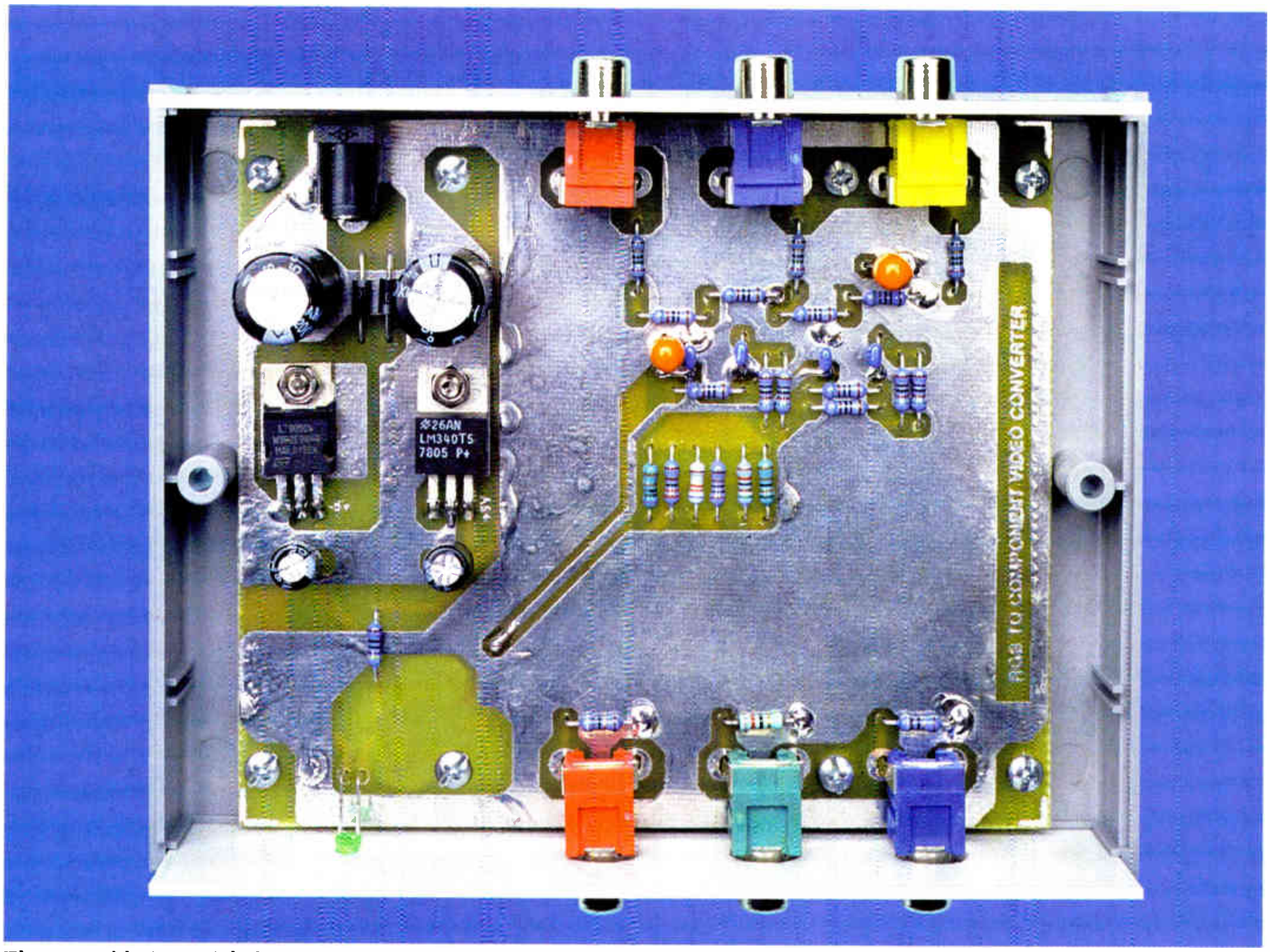


Fig.3: install the parts on the top of the PC board as shown here. The red dots indicate where component leads (and the single 'via' above left from CON1) are soldered to both sides. The two MAX4451 dual op amps are mounted on the underside – see Fig.5.

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	51kΩ	green brown orange brown	green brown black red brown
❑	1	7.5kΩ	violet green red brown	violet green black brown brown
❑	1	6.2kΩ	blue red red brown	blue red black brown brown
❑	1	5.1kΩ	green brown red brown	green brown black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	1.5kΩ	brown green red brown	brown green black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	10	510Ω	green brown brown brown	green brown black black brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	2	91Ω	white brown black brown	white brown black gold brown
❑	1	82Ω	grey red black brown	grey red black gold brown
❑	3	75Ω	violet green black brown	violet green black gold brown



The assembly is straightforward but be sure to install all polarised parts with the correct orientation. These include the diodes, 3-terminal voltage regulators, the LED and the two 'surface-mount' op amps.

surface-mount SOIC packages, which are mounted on the bottom of the PC board (more on this later).

Begin the board assembly by fitting the short wire link which forms a 'via' between the top and bottom copper tracks of the −5V supply rail. It's located near the front of the board, about 17mm to the right of the 470Ω resistor just behind LED1. Fitting this link first will make sure you don't forget it.

Next fit the resistors, making sure you solder their 'earthy' leads to both sides of the board where indicated. Table 1 shows the resistor colour codes but we advise checking each value on a multimeter before it is fitted, just to make sure. That done, install the RCA sockets and the 9V AC power socket, using a small drill to enlarge their mounting holes if necessary.

The three small 100nF monolithic capacitors can be fitted next, again taking care to solder their leads to both sides of the board where indicated. That done, fit the two 10µF tantalum capacitors and the larger electrolytics, making sure each of these polarised components is orientated correctly. The earthy lead of both tantalum capacitors is soldered to the top copper as well, as shown in Fig.3.

Next fit the two diodes (D1 & D2) in the power supply,

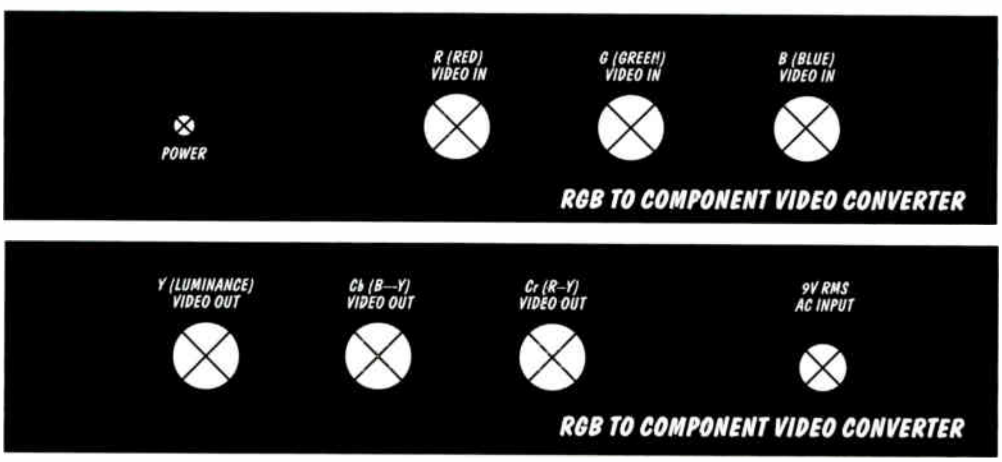


Fig.4: these full-size artworks can be used as drilling templates for the front and rear panels.

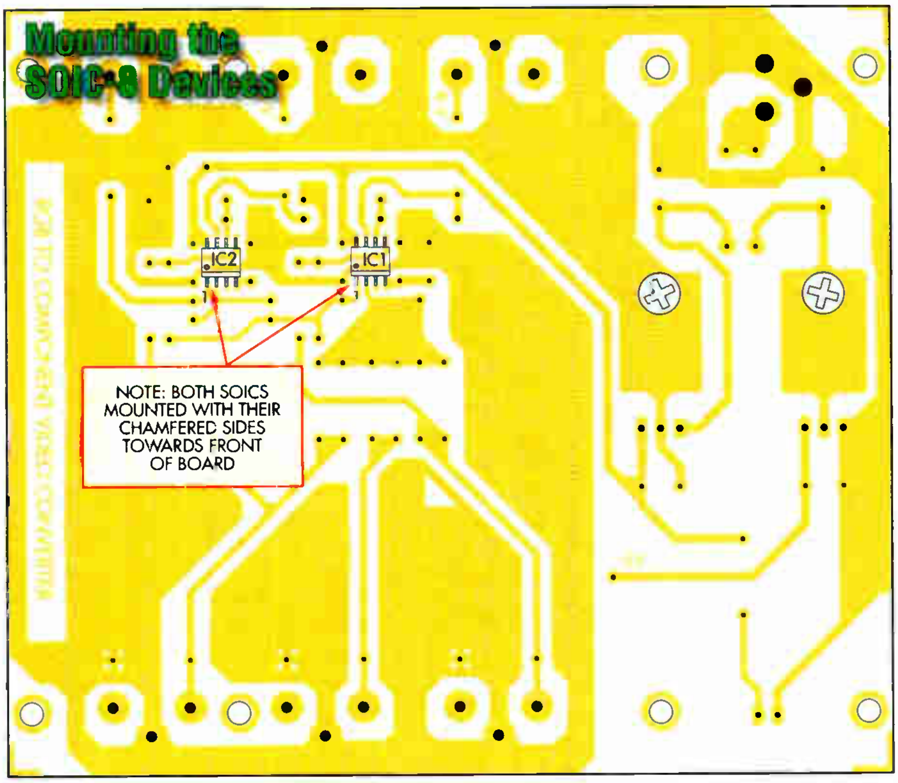


Fig.5: the two MAX4451ESA dual op amps are mounted on the underside of the PC board, as shown here. Be sure to install them the right way around.

Parts List

1 PC board, code 596, available from the *EPE PCB Service*, 117 x 102mm (double-sided)
1 plastic instrument case, 140 x 110 x 35mm
6 RCA phono sockets, PC-mount (2 x red, 2 x blue, 1 x green, 1 x yellow)
1 2.5mm concentric LV power connector (CON7)
2 M3 x 6mm machine screws with M3 nuts
6 4G x 6mm self-tapping screws, pan head

Semiconductors
2 MAX4451ESA dual wideband op amps (IC1,IC2)
1 7805 +5V regulator (REG1)
1 7905 -5V regulator (REG2)
1 3mm green LED (LED1)
2 1N4004 1A diode (D1,D2)

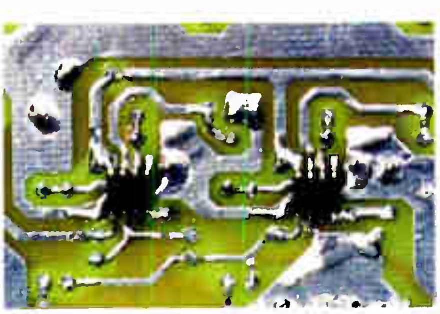
Capacitors
2 2200µF 16V RB electrolytic
2 100µF 16V RB electrolytic
2 10µF 25V tantalum
4 100nF multilayer monolithic (code 100n or 104)

Resistors (0.25W 1%)

1 51kΩ	2 1kΩ
1 7.5kΩ	10 510Ω
1 6.2kΩ	1 470Ω
1 5.1kΩ	2 91Ω
1 2.2kΩ	1 82Ω
3 75Ω	

again watching their polarity. Follow with the two regulators, making sure that you fit each one in the correct position. REG2 (the 7905) goes on the lefthand side, while REG1 (the 7805) mounts to the right of REG2. Don't get them mixed up!

Each regulator is mounted horizontally, with its three leads bent downwards 5mm from the device body so that they pass through the holes in the PC board. They are both secured using 6mm × M3 machine screws and nuts and this should be done before soldering their leads. Note that REG1's centre lead is soldered on both sides of the board, as are two leads for REG2.



You will need a fine-tipped solderi iron to install IC1 & IC2. Make sure that you don't overheat them or leave solder bridges between their pins.

Surface mount ICs

Once the regulators are in, you are ready to fit the two surface-mount ICs (IC1 & IC2). These are 8-lead SOIC packages and mount on the underside of the board – see Fig.5. They have a 1.25mm lead spacing, so they're not too small for manual handling and soldering, providing you're careful and use a soldering iron with a fine-tipped bit.

To fit these ICs, invert the board and locate their mounting positions – you'll find the two sets of four small rectangular pads in each position. That done, remove the devices from their packaging and examine each one with a magnifying glass to identify the small chamfer along one side (ie, adjacent to pins 1-4 of the device).

Both devices are mounted on the board with this chamfered side towards the front – ie, downwards in Fig.5. Be sure to use a fine-tipped soldering iron for this job and be careful not to overheat them or leave solder bridges between their pins.

The best way to install them is to hold each device in place with a toothpick while you press down gently on one of its leads with the tip of the soldering iron. This will usually make a weak solder joint between the lead and the tinning on the board copper – enough to hold the device in place while you solder the remaining leads to their pads. That done, you can then go back and solder the first lead properly, to complete the job.

The final component to fit is LED1 (the power LED). This in installed on the top of the board, with its longer anode lead towards the right (ie, towards CON1). It should be mounted with its body about 17mm above the top of the board (a strip of cardboard between the leads makes a handy spacer).

After mounting, bend its leads down together at right angles at a point 9mm above the board. This ensures that it will later protrude through its matching hole in the front panel when the board is installed in its case.

Drilling the panels

The next step in the construction is to prepare the front and rear panels

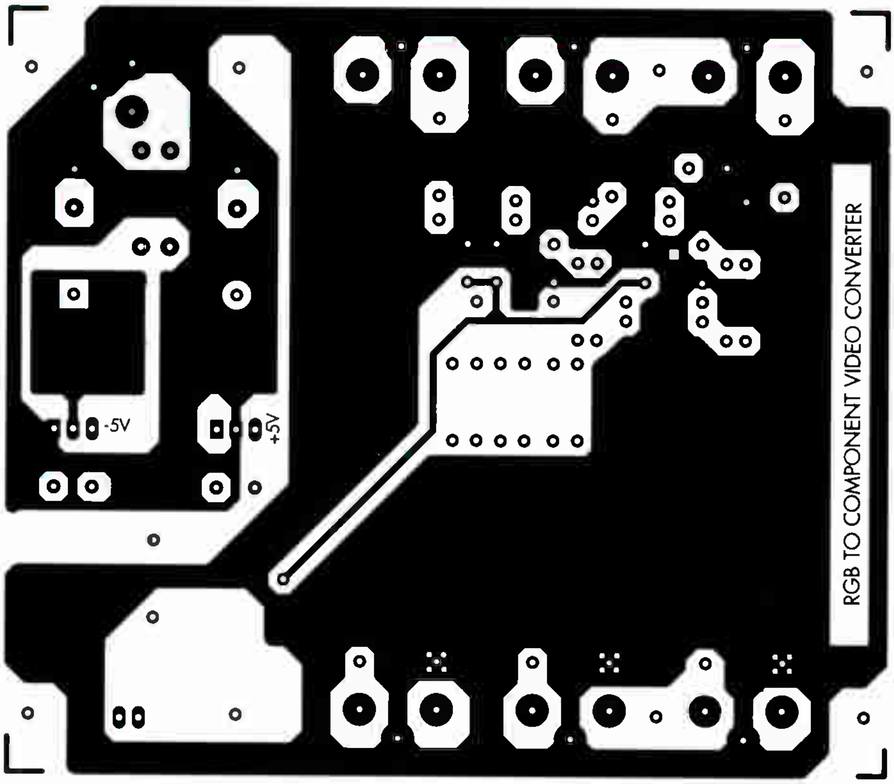


Fig.6a: Full-size top etching pattern for the PC board.

of the case. This involves drilling and reaming a small number of holes for the various connectors and the power indicator LED, using photocopies of the panel artworks as templates see Fig.4.

Once that's done, additional photocopies of the artworks can attached to the outside of each panel for a professional finish. The way to do this is to first make a copy of each artwork on adhesive-backed A4 label sheet paper. The labels are then trimmed, peeled off the backing and attached to the panels. That done, a length of clear packaging tape (ie, wide adhesive tape) is applied over each panel to protect it from dirt and finger grease.

Finally, any excess tape is trimmed off and the holes cut out using a sharp hobby knife.

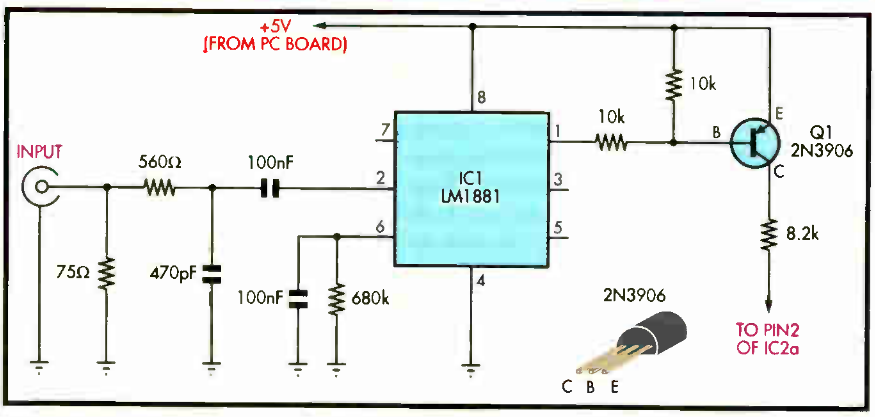
Final assembly

Now for the final assembly. This is done by first fitting the panels over the connectors on each side of the board (and also over the LED in the case of the front panel). That done, lower the assembly into the bottom half of the case, sliding each panel into its mating slot. It's then simply a matter of fitting eight 6mm-long self-tapping screws (four along the front and four along the rear) to hold the PC board in place.

Finally, the top half of the case can be fitted and secured from the bottom using the two long countersink-head self-tappers provided.

Your RGB to Component Video Converter is now complete and ready for use. There are no adjustments to make – all that's needed is to connect a suitable 9V AC plugpack and it should spring to life.

SYNC FIX



Unfortunately, some set-top boxes do not output a 'sync-on-green', which in the converter circuit would propagate through to the Y (luminance) output for use in the TV. However, they do have composite video outputs. This little add-on circuit extracts the sync pulses from the composite signal and adds them to the Y output to correct this deficiency. (If the sync-on-green is not present the set will probably display a blank screen).

A fourth RCA input socket can be added to the front panel of the converter to accept the composite signal from the set-top box (or other appliance). The appliance may have a composite output in the form of a separate RCA phono socket or as part of the SCART connector. Alternatively, the 'Y' channel of a Y/C output can be used as the source.

The composite video signal is first terminated with a 75Ω resistor (see diagram) and excessive chroma or noise is attenuated with a simple low-pass RC filter, formed by the 560Ω resistor and the 470pF capacitor. The signal is then AC-coupled to the input of an LM1881 sync separator IC.

The separated sync pulses appear on pin 1 of the LM1881, after which they're inverted by transistor Q1. The result is injected into the Y signal path by feeding it into the input (pin 2) of op amp IC2a on the converter PC board. An 8.2kΩ series resistor effectively sets the sync level at about 0.3V.

The circuit can be built on a small piece of stripboard (approx. 20 × 40mm) and attached to a vacant area of the PC board with double-sided tape. **Graham Bowman**

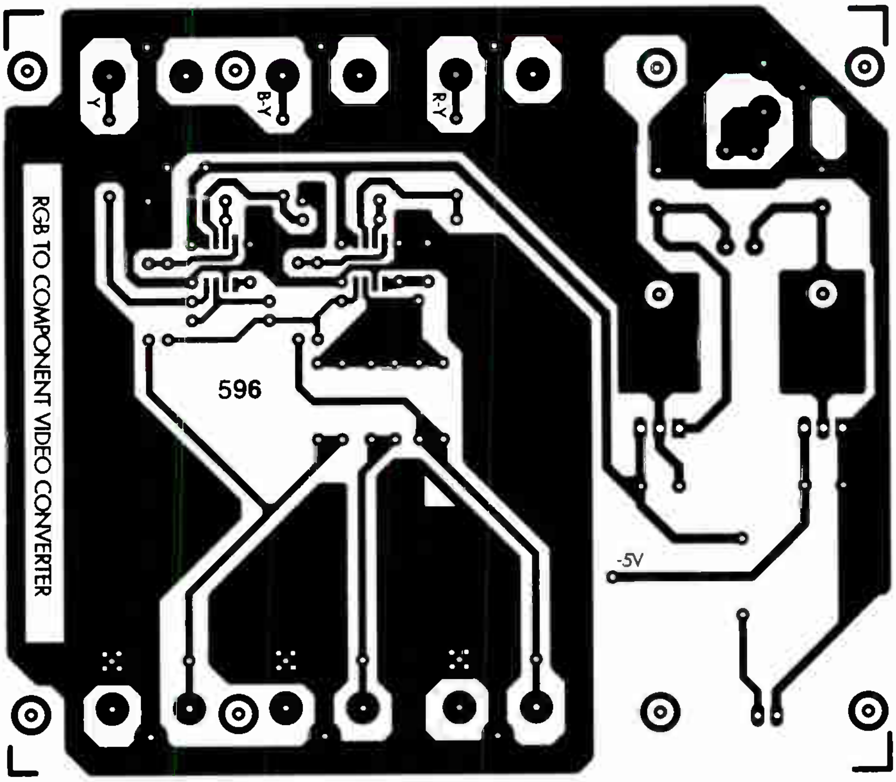


Fig.6b: Full-size bottom etching pattern for the PC board.

Troubleshooting

In the unlikely event that it doesn't work, the first step is to go back over your work and carefully check that all components are correctly positioned and orientated. Check also for missed solder joints, especially where leads have to be soldered on both sides of the PC board.

Next, check the power supply rails with your multimeter. There should be +5V at the output of REG1 and −5V at the output of REG2. If you don't get these voltages, check the two regulators and diodes D1 and D2, plus the polarity of all electrolytic capacitors.

You should also be able to measure +5V (with respect to board earth) on pin 8 of each of the two surface-mount ICs. Similarly, pin 4 of each device should be at −5V, but be careful not to short out adjacent pins with the meter probe when making these measurements.

Finally, if LED1 fails to light even though the +5V rail is correct, check that the LED has been installed correctly. Check also that its 470Ω resistor is correct. *EPE*

INTERFACE

Robert Penfold

EXPLORING THE GRAPHICS CAPABILITY OF VISUAL BASIC 2005 EXPRESS

Microsoft's Visual BASIC Express 2005 has been mentioned in previous *Interface* articles, and it created a significant amount of interest from *EPE* readers. This is not surprising, as it is a reasonably competent version of Visual BASIC that is available as a free download from the Microsoft web site.

Although the original intention was for this program to be available as normal commercial software after November 7 2006, it will now remain as a free download for its lifetime. Thus, it should still be available as a free download when this magazine appears in the newsagents, and for some time thereafter.

There is no way of knowing how long Microsoft will continue to support this program, so it is probably advisable to download it sooner rather than later if it is something that might be of use to you.

The Microsoft web site has a great deal of useful information about Visual BASIC 2005 Express, and the other programs in the Visual Studio 2005 Express range. These are all available as free downloads incidentally. This is the best place to start for information on Visual BASIC 2005 Express, and there is also a link to the download on this page:

http://msdn.microsoft.com/vstudio/express/vb/

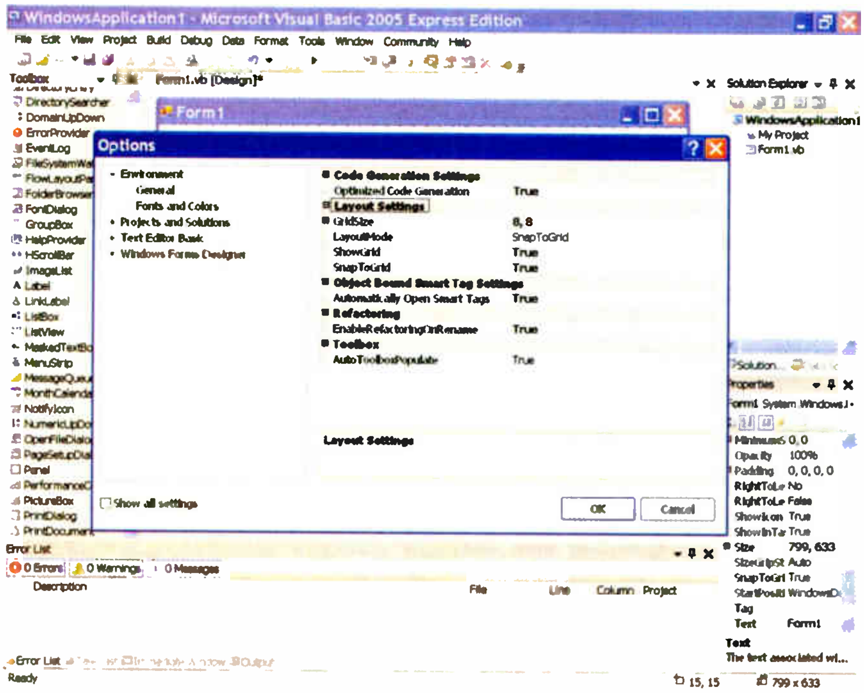


Fig.1. The Options window enables the screen and snap grid facilities to be switched on and off. The horizontal and vertical grid sizes are individually adjustable

Graphics Capability?

Although Visual BASIC 2005 Express is in many ways a very capable piece of software, it would be naïve to expect it to be the equal of the full-price versions of Visual BASIC. It is inevitable that some aspects of the program are limited or absent. Some readers have queried the lack of any graphics capability, but it is a case of the graphics tools being limited rather than completely absent.

The most obvious omissions are the Shape and Line components, which enable such things as rectangles, circles, ellipses, and lines of various widths to be drawn on the screen. These are not supplied as part of Visual BASIC 2005 Express, and there are no cut-down versions of them either. However, it is possible to produce some simple graphics using conventional programming and the Graphics.Drawline instruction.

Unfortunately, the graphics capabilities seem to be a substantially cut down version of those found in Visual BASIC.Net. Consequently, trying to produce simple animated graphics for such things as virtual controls and panel meters is probably not a worthwhile proposition.

This is not to say that the graphics of Visual BASIC 2005 Express are of no use when writing software for electronic projects. It does mean that any graphics will mainly be used to give a smarter and more functional appearance, rather than providing things such as virtual controls.

Fortunately, Visual BASIC 2005 Express does include the usual range of controls such as scrollbars and buttons, and it can produce big digital readouts via Label components and suitably large text sizes. Something like the numeric keypad featured in the previous *Interface* article should be equally easy to produce using Visual BASIC 2005 Express.

One slight problem when you first start using the program is that the form lacks both visual and snap grids. This makes it very difficult to get buttons, labels, etc., accurately aligned on the form. Both visual and snap grids are available, and will almost certainly be required when producing any software for PC add-ons.

The window that controls the grids is obtained by going to the Tools menu and selecting Options. Then select General in the left-hand panel of the Options window. This has controls that enable the grids to be switched on or off, and the grid size to be set (Fig.1). The grid size is set in pixels, with the horizontal and vertical sizes being independently adjustable.

Drawing

Drawing lines is done in a rather roundabout fashion. The first step is to double-click a blank area of the form so that the code window appears. Next, select Paint from drop-down menu in the top right-hand corner of the code window. This produces a basic subroutine in the code window, into which the graphics program is added. For this example I used six lines of code to add some lines to the dummy control panel shown in Fig.2. Apart from decoration, the purpose of the lines is to group five buttons that will effectively operate as a bank of radio buttons.

```
Private Sub Form1_Paint(ByVal sender As Object, ByVal e As System.Windows.Forms.PaintEventArgs) Handles Me.Paint

e.Graphics.DrawLine(Pens.Black, 40, 350, 700, 350)

e.Graphics.DrawLine(Pens.Black, 40, 450, 700, 450)

e.Graphics.DrawLine(Pens.Black, 40, 350, 40, 450)

e.Graphics.DrawLine(Pens.Black, 700, 350, 700, 450)

e.Graphics.DrawLine(Pens.Black, 515, 350, 515, 450)

e.Graphics.DrawLine(Pens.Black, 578, 350, 578, 450)

End Sub
```

Each instruction has five parameters within the brackets, and the first of these is the colour of the line. When typing the instruction, the built-in tint system presents a list of the available colours at this point, so it is just a matter of selecting the required colour from the list. The other four parameters are pairs of co-ordinates. The Visual BASIC 2005 Express co-ordinate system is like the one used in other versions of Visual BASIC in that it has 0,0 in the top left-hand corner of the window.

It is different in that it operates using pixels rather than the more arbitrary system of other versions. The first line is therefore drawn from a point 40 pixels in from the left and 350 pixels from the top, to one 700 pixels from the left and 350 pixels from the top of the window.

There is a big drawback in using conventional programming rather than the visual approach. The lines never appear on the form, so it is necessary to press F5 and run the program in order to check whether the graphics code is having the desired effect. Working out designs on graph paper should provide initial results that are reasonably accurate. Even so, it will usually be necessary to do a little 'fine tuning' in order to get things just right.

Filled In

The lack of a width parameter is a major limitation of the DrawLine instruction, but there is a way of drawing thick lines. There is a DrawRectangle instruction, which draws the outline of a rectangle using a one-pixel wide line. This can be used to draw 'hollow' lines.

Perhaps of more use, there is a FillRectangle command that produces 'solid' rectangles. By drawing long and thin rectangles it is possible to produce thick lines. This subroutine uses filled rectangles to produce a 'thicker' version of the panel design (Fig.3):

```
Private Sub Form1_Paint(ByVal sender As Object, ByVal e As System.Windows.Forms.PaintEventArgs) Handles Me.Paint

e.Graphics.FillRectangle(Brushes.Black,
    40, 350, 660, 5)

e.Graphics.FillRectangle(Brushes.Black,
    40, 450, 660, 5)

e.Graphics.FillRectangle(Brushes.Black,
    40, 350, 5, 100)

e.Graphics.FillRectangle(Brushes.Black,
    700, 350, 5, 105)

e.Graphics.FillRectangle(Brushes.Black,
    515, 350, 5, 105)

e.Graphics.FillRectangle(Brushes.Black,
    578, 350, 5, 105)

End Sub
```

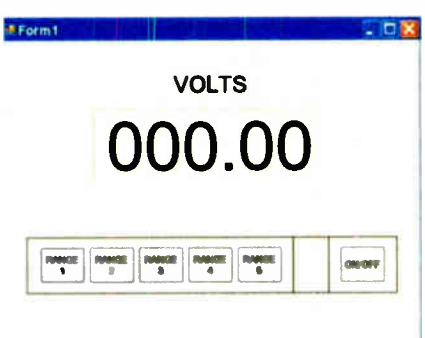


Fig.2. Lines are easily programmed, but with this method there is no way of adjusting the line width

Note that for filled shapes the colour is set using Brushes parameter rather than the Pens type. The four co-ordinates again work in pairs, but only the first two are true co-ordinates. These set the position of the top left-hand corner of the rectangle. The next two values respectively set the width and height of the rectangle. In the current context, they effectively set the length and the width of horizontal lines, or the width and length of vertical lines.

There are other shapes available, including ellipses. The co-ordinate parameter for ellipses operates in essentially the same way as for rectangles, and they specify the position and size of an imaginary rectangle that is just large enough to contain the ellipse.

By default, objects drawn on the form will go behind visible components such as buttons and labels. This can often be used to good effect, as in the alternative version of the virtual voltmeter front panel design of Fig.4. Only three graphics instructions are needed to produce this design:

```
Private Sub Form1_Paint(ByVal sender As Object, ByVal e As System.Windows.Forms.PaintEventArgs) Handles Me.Paint

e.Graphics.FillRectangle(Brushes.Red, 40,
    350, 480, 100)

e.Graphics.FillRectangle(Brushes.Red,
    580, 350, 120, 100)

e.Graphics.FillEllipse(Brushes.Red, 98, 65,
    550, 250)

End Sub
```

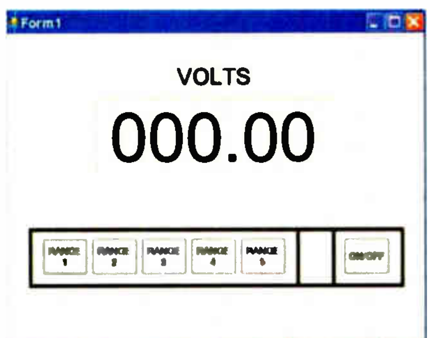


Fig.3. Thick lines can be produced by programming filled rectangles. Using this method it is possible to have line widths of any desired number of pixels

It is permissible to use numeric variables for the co-ordinates in the graphics instructions, so it is possible to produce simple animated graphics. In theory, it should therefore be possible to produce virtual panel meters, bargraphs, and so on. However, the Visual BASIC 2005 Express graphics seem to be designed primarily as a means of producing backgrounds rather than animated graphics. Getting the graphics to move requires relatively clumsy techniques, and it has to be regarded as doing things the hard way. This type of thing is much easier using Visual BASIC.Net or, better still, Visual BASIC 6.0.

Background

Some commercial software that includes a virtual control panel has a fancy background, such as one that looks remarkably like real brushed aluminium. The reason that most of these panels look so realistic is that they are produced using a photograph

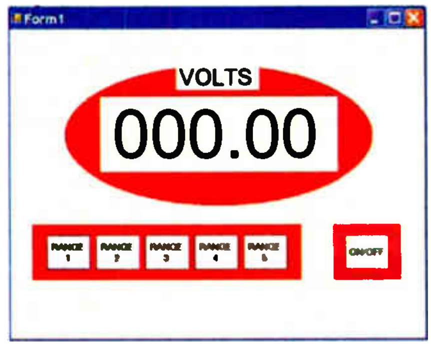


Fig.4. Filled rectangles and ellipses are easily programmed. They can be positioned behind buttons, labels, and other visible components

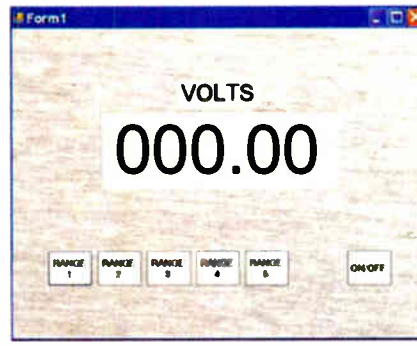


Fig.5. In this example the background is provided by a photograph of an aluminium panel. Any bitmap in JPG, GIF or BMP format can be added to the form

of the genuine article. It is possible to add a background image using any modern version of Visual BASIC, including Visual BASIC 2005 Express.

One way of doing it is to add a PictureBox component to the form. This can then be dragged to the required size, and if necessary it can cover the entire form. To add an image to the PictureBox go to its properties window and operate the button in the Image section. This produces a pop-up window where the image can be selected if it has already been added to the project as a resource.

Preloading the image is not really necessary though, and an image file on the computer's hard drive can be loaded by operating the Import button. A file browser then appears, and this is used to locate and load the image file in the normal way.

Note that the image must be in JPG, GIF, or BMP format. In the example of Fig.5 I have photographed a small area of sheet aluminium and the used the JPG image in a PictureBox.

In order to ensure that the image is in the background with everything else visible on top of it, make sure that the background image is added before any visible components are added to the form. Alternatively, select the PictureBox, go to the Format menu, and then select Order and Send to Back.

Finally

When using Visual BASIC 2005 Express or Visual BASIC.Net it is important to bear in mind that the underlying programming language is not the same as the one used in earlier versions of Visual BASIC. There are also differences when using the visual approach to programming. It is no good trying to do things in exactly the same way as you would when using Visual BASIC 5.0 or 6.0.

Those familiar with earlier versions of Visual BASIC will have to learn new ways of doing things in order to use the modern versions to full effect.

C for PICs

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

Part 2 – Creating Programs

By Mike Hibbett

FOLLOWING on from last month's whistle-stop tour of the Microchip C compiler, we now take a closer look at how programs are created, and what files are involved in the build. We will start by looking at the contents of a typical C program.

Program Groups

Once compiled, a C program typically consists of four groups of code: C-Startup, Standard Library Code, Application Code and Library Code. We will go through these in reverse order.

Library Code consists of source files that you have compiled previously, or perhaps obtained from a third party, that you are making use of in your application. Library code is pre-compiled to a binary code file and does not require its original source code to be present (although source code will help when debugging). The code is often supplied packaged together in a 'library' file (with a **.lib** extension), or as a single object file (with a **.o** or **.obj** extension).

You add these files to your project by creating links to them in the **.mcw** window within the IDE. You simply right-click over 'Library Files', then select 'Add Files...'. Library files generally hold useful functions that you can call from your application. To get access to the functions within a library you must also include its associated header file, which normally has the same name but an extension of **.h**. You add the header files to your project in a similar way to adding the library files – right-click over the 'Header Files' option in the **.mcw** window on your IDE. We will come back to header files in a minute.

Application Code is, well, your stuff; the result of compiling all your source code. Where exactly that gets placed in the code address space is normally unknown to you, and most of the time of little interest. An exception would be the code that goes into the interrupt vector locations, which we will cover in more detail next month.

Standard Library Code is a set of useful functions that are supplied as standard by all C compilers; **printf**, for example, is a standard library function. Because these are standard libraries you do not have to add them to your project – they are automatically referenced by the linker program. You must include the appropriate header file in your source code, of course.

Library code – be it standard or user supplied – is only added once, since it is a set of functions. The linker program will find out which library functions are used by your application code and copies them in from the appropriate library file into your program. It only includes the functions that you call (directly, or in-directly), which helps to minimise the amount of code memory used. The compilation process is quite smart and does its best to be as efficient as possible with your limited code and data resources.

So, if we do not know where our code ends up in memory, how do we tell the compiler where to place our startup routine, our **main()** function? Well, this is the role of the final group of code, **C-Startup**. This is a small piece of software that handles the operation of the microcontroller as it leaves the reset state, initialises various variables and jumps to the user's application code.

That was an over-simplification of what **C-Startup** does, so lets go into a little more detail.

C-Startup Detail

When the processor comes out of reset, it starts executing software at code location 0. In assembly language programs, we use an **ORG 0** statement and follow that with our initialisation code. **C-Startup** contains the code that runs from location 0. It sets up the software stack – a reserved area of RAM used by the C language to pass parameters to functions – then initialises all of our global variables.

Remember, global variables (outside of any function), or statically declared variables inside of functions, will be initialised after reset to either zero or whatever value you specify when you declared the variable. Having done that, **C-Startup** finishes by passing control (i.e., jumping to) our **main()** function. Your application code takes over from there.

General purpose embedded C compilers would normally supply a skeleton **C-Startup** file which you have to modify to suit your hardware. You would be expected to define the code and data memory layout, what address the processor jumps to after reset, etc. As the PIC has all its code and data storage internally, all these 'options' are effectively fixed by Microchip and a single **C-Startup** routine will suit all processors and projects. Thus, you should never need to edit the file.

C-Startup Versions

There are, however, three versions of the **C-Startup** code for you to choose from: **c018i.o**, **c018iz.o** and **c018.o**. Version **c018i.o** is the default startup routine. The other two provide extra or fewer features, which affect the size of your program file.

The reason for the choice is related to what C does with variable initialisation. If you declare a global or static variable and initialise it to a value at the same time, for example:

int baudRate = 9600;

C-Startup is responsible for performing the initialisation of the variable's value before your **main()** function is called. The default startup file, **c018i.o**, does this for you. The C language standard also dictates that global or static variables that are not initialised to a value must be set to 0. To save code space, **c018i.o** does not do this; if you want fully standard compliant variable initialisation, use the file **c018iz.o**. The third file, **c018.o**, performs no variable initialisation at all, which means you must perform your initialisation manually. i.e.:

int baudRate;
...
baudRate = 9600;

In some cases this restriction is acceptable, and will save you a few hundred bytes of code space.

Linker File

You specify the **C-Startup** file to use in the linker file that you include in your project. If you edit the linker file that we used in last week's example, **18f2420.lkr**, you will see lines like the following:

FILES c018i.o
FILES clib.lib
FILES p18f2420.lib

If you want to change the choice of startup file just change the reference in the linker file, save it, and re-build your program. You can experiment with this, and then look at the map file to see how the code size changes. Building the code with **c018.o, c018i.o** and then **c018iz.o** resulted in code sizes of 145, 307 and 327 bytes. As you can see, for small projects the startup code has quite an effect on the code size. As project size increases, however, the overhead of the startup code reduces. Our recommendation is to stick with the default startup file and consider changing only if you are running out of code space.

Table Block

To assist **C-Startup** perform the initialisation of global variables there is another block of information, a table, that gets stored in your code and placed in flash memory. As you might imagine, when the **C-Startup** code is filling in all your global variable initialisations, it needs an efficient way to store a list of those variables, their type and the value to write into them. This information is held in a table.

Global variable initialisation has an interesting implication on the size of your code. If you want to define a variable that will never change – for example, the number of seconds in a minute – you might be inclined to write the following:

int secondsPerMinute = 60;

This is not very efficient. The reason for this is that the C compiler will allocate some RAM space for your variable, and it will store the value '60' into the code table, and then at startup copy the value 60 into the variable. What would be better would be to do this:

const rom int secondsPerMinute = 60;

The 'const rom' qualifier (called a storage qualifier, as it affects the way a variable is stored) tells the compiler that this variable will never change, and that it should place it directly in flash memory. No precious RAM space is used. Doing this has the added benefit that the compiler will be able to detect coding errors like this:

if (secondsPerMinute = count)

The compiler 'knows' that **secondsPerMinute** is a constant and will raise an error on the accidental attempt to assign a new value to it (a very common mistake!).

It's a good idea to experiment with these kinds of issue, making small changes, building the program and comparing the results in the **.map** file with previous builds. You will quickly discover how different features affect the code size.

Other Linker Information

We mentioned earlier that the linker file holds the definition of which type of **C-Startup** code will be called. The linker file holds other vital information too; it is the key to how the various variables and functions get arranged into the final binary code.

To a certain extent, the choice of where objects get placed in memory is removed from you, and this is a blessing – you want to concentrate on writing software, not deciding where things are placed. Sometimes, however, you will want to specify where objects are placed. Interrupt routines are a typical example, where you must explicitly tell the compiler things like 'This function must start at code location 0x18'.

The compiler also wants to be able to specify where objects should go; variables into RAM, functions into code space. The linker file is the link (sic) between the memory layout of your particular device and the C compiler. The compiler is a general purpose program and is not expected to know individual processor configurations, and so it will examine the project's linker file to find out. That is why you will find a linker file for each processor in the microchip PIC18 range, and they all follow a similar layout.

Some Linker Detail

Let's take a look at the linker file we used last month, **18f2420.lkr**. After specifying the standard library files and the startup code, it lists a number of memory sections. For example:

CODEPAGE NAME=vectors START=0x0 END=0x29 PROTECTED

This is an area of memory reserved for interrupt vectors. The compiler will avoid placing user code in this section. Next up:

CODEPAGE NAME=page START=0x2A END=0x3FFF

This identifies the remaining space available in code for user functions. If the code you write exceeds 0x3FFF bytes, the compiler will indicate an error that you have used too much memory.

You will not normally need to change this file unless you are writing some complex code, or you want to reserve some memory that should not be used by the compiler – perhaps because you have a bootloader on the chip.

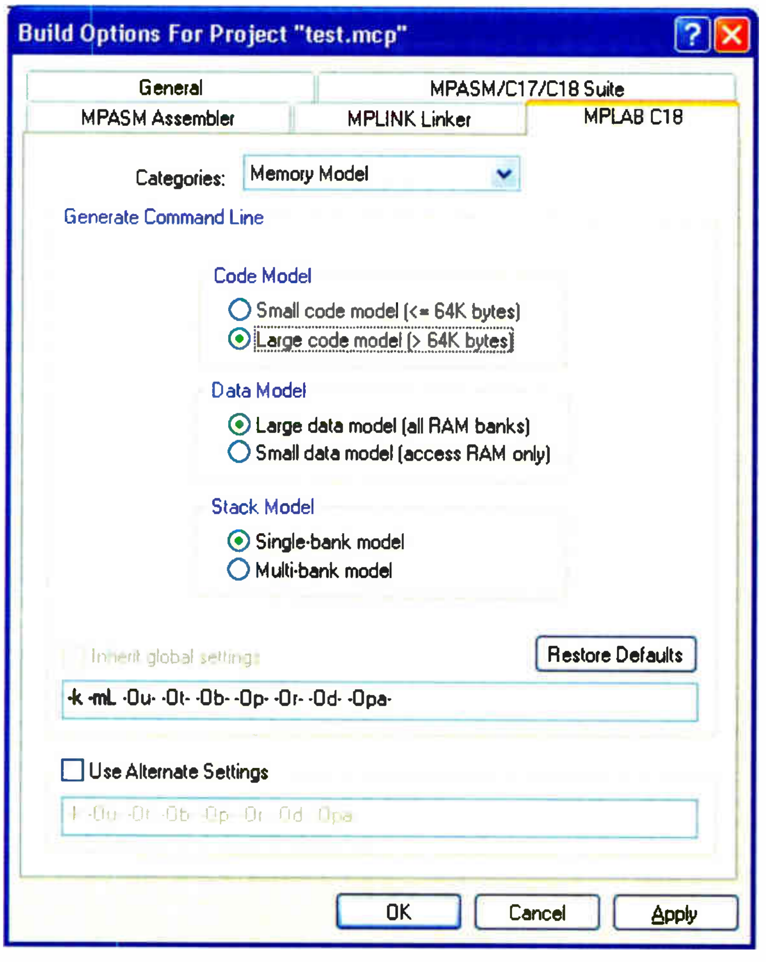


Fig.1. Typical Build Options window

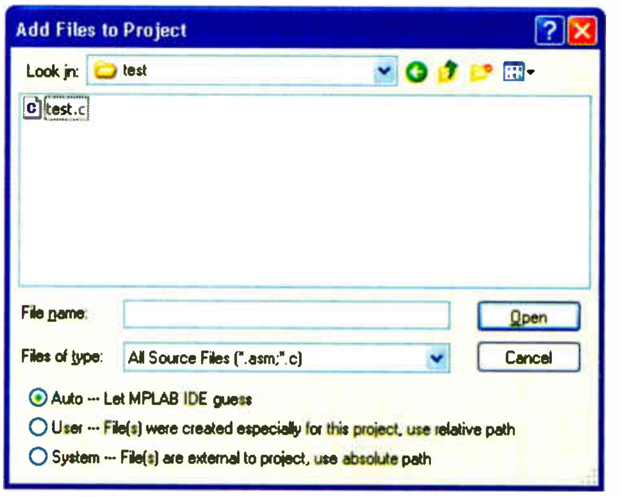


Fig.2. Add Files window

.MCP and .MCW Files

There are a couple of files that are created when you make a new project; a **.mcp** and a **.mcw** file. The **.mcw** file is a binary file that contains information about your current IDE setup; what windows are open, for example, which **.mcp** file you are using. It is the file that you double-click on if you want to open up your project in the IDE.

The **.mcp** file contains a list of your project files and the build options you have chosen. Several other files are created, and it is best not to delete them. The main output files from your source code will be the **.hex file** (the actual program code), a **.lst** listing file and a **.map** file which lists the actual locations of all the variables and functions, plus a summary of how much code space has been used up.

Build Process

Let's move back to the build process. If you think back to last month, we built the project by selecting 'Project' then 'Build All' from the main menu. You may not realise it yet, but there is a large number of options available to us to change the way the compiler works when it is translating our source files into the program code.

There are two types of build options available; *project build* options and *file build* options. Project build options allow us to define the default compiler options for the whole project, such as where to find system files and default build options for source files. File build options enable you to 'over-ride' the project build settings on individual files. Most of these options can (and should) be left at defaults until you have become experienced with the compiler.

There is one important option that should be changed, however, which we should cover. If you right click over the **.mcp** reference at the top of the **.mcw** window within the IDE and then select 'Build Options...', an options dialog window will appear. Click on the **MPLAB C18** tab, to display the compiler options page. There are too many options to fit on one page, so they are grouped into categories. Select 'Memory Model' from the Categories drop down list, and you should see the options as shown in Fig.1.

These options are very important because they affect the assumptions the compiler makes about how it should be addressing memory. The 'Code Model' option allows you to specify whether the compiler should expect code to potentially grow to a size greater than 64K byte, therefore requiring it to use large (24-bit) pointers for jump instructions. The 'Data Model' allows the compiler to ignore the Bank Select bits when accessing RAM variables, and assume that all variables are within the Access RAM area.

Choosing small code and data models will result in the smallest code utilisation, but is only suitable if your application will fit in 64KB and never use more than 128 bytes of RAM. When the C compiler is deciding on RAM utilisation it's rather difficult to know these things in advance. That's not a problem though, because you can change any of these options at any time and simply rebuild the code; you do not need to change your source code or start a fresh project. It's quite normal to tinker with these parameters and then look at the **.map** file to see how the changes affect the code size and data utilisation.

There is one big caveat to the memory model options: The standard C libraries (those supplied by Microchip that implement all the standard functions such as **printf**, etc) have been built with the large code memory model. Functions in these libraries therefore expect to be passed large pointers rather than small ones. You must therefore select the Large Code model as shown in Fig.1 for all your application source files when you use library functions. You only need to do this once; changes you make to your project settings are stored in the **.mcp** and **.mcw** project files.

Adding Files

Adding a file to the project can be a little confusing because there are several options, and it is not particularly intuitive as to how you should do it. If you have an existing file that you want to add (a source file or header file, for example) then first copy that file into your project directory. Simply copying a file into the directory does not add it to your project – the C compiler will ignore it unless you add a reference to it in the **.mcw** window. To do that right click over the appropriate heading ('Source Files' or 'Header Files') and click on 'Add Files...'. A dialog like that in Fig. 2 will appear.

Navigate to the file you want to add to the project and click once on it. You should now specify the way in which the file is added: Auto, User or System. Any files that are in your project directory are 'User', while files outside your project directory – such as a linker file, for example – are 'System'. All that happens when you do this is that references to user files are stored with a path name relative to your directory (e.g. **utils\file.c**) whereas system files would be stored with the full path name (e.g. **C:\myproject\utils\file.c**).

This will seem a strange requirement until you start moving your project directory around your hard disk. System files will always be in the directory in which they were installed, but you want to be free to move your project directory to another directory without having to re-specify all your file paths. It's not uncommon to have many tens of source files in a project, so this is a useful feature.

The reason why there is a section for source files and another for header files is to do with the way in which the C compiler builds your program. First, the C compiler only compiles files in the source files list. If, however, a source file has not changed since the last time the project was built, that file will not need to be re-built. When you have many source files in a project, this can save a lot of time.

Header files are not compiled by the C compiler, but it will look though the list of files in the Header Files section to see if any of them have changed. If they have, the compiler will re-compile any source file that uses those header files.

If a header file is not included in the Header Files section, it is not uncommon for very nasty, difficult to locate bugs to appear in your project as a result of a change to a header file not being detected. Consider two source files that share the same header file – one file implementing a function, the other file using it – the header file defines the parameters that are passed to and returned from the function. If the two source files have a different view of how the function works, the resulting code will crash or behave unpredictably. Always include your header files in the project! There is no need to include the standard header files, such as **stdio.h** in your project – these files are system files that do not change.

Structuring Programs

The final point we will cover this time is how you should structure your programs. Structuring programs in any language is always a difficult task. It's never easy when faced with a blank piece of paper or an empty editing window, and the temptation is to just start writing, keeping going until the code is finished. Subroutines may appear on occasions, or there may be long sequences of repeated code.

There is nothing wrong with this for small applications. Indeed the author has seen more than one commercial program written like this. There are, however, problems with this 'monolithic' style of programming. Your code will very quickly become difficult to maintain. A pain in fact. It will be almost impossible to re-use code that you have previously designed, because it will have become tightly coupled with the rest of your code.

Do we really want this pain, or do we want to enjoy the craft of creating new software? Nobody enjoys re-inventing the wheel. Here are some useful tips:

Think about what your program is going to do, and try to break it down into some high level functions like 'Read from EEPROM' or 'Get ADC value'. Write functions to do these before writing your main application. When you come to start writing your main application you will be able to write code and think at a higher 'level' of abstraction, which means thinking of questions like 'Is the signal above two volts' rather than 'Should I skip on Carry or Not Carry'?

Function Source Files

The functions you have created can go in their own source files, with a header file that describes the interface into them. So, for example, an EEPROM module will have a source file called **eeprom.c** and a header file **eeprom.h** that contains a list of the functions such as **init_eeprom, read_eeprom, write-eeprom**, etc that are the 'interface' into this module. Those functions can then be re-used in later projects by simply including the header file and the compiled **.o** file of the module.

We don't have space in this series of articles to go into code structuring in any detail, but fortunately there is an excellent book on the subject. *Code Complete* by Steve McConnell offers some excellent tips on how to write good software, tips that are not just for professional writers. It's also a fun read, and your local library can probably get hold of a copy.

For those of you who are learning the C language from scratch, there are plenty of tutorials and even books published free of charge on the Internet. Two good examples are listed at the end of this article.

Next Month

We have covered important ground in this part and hopefully de-mystified some of the issues. Next month we will look at some practical issues with embedded C programming and hopefully guide you through some of the pitfalls that have welcomed many a programmer in the past.

References

Online C book: **http://publications.gbdirect.co.uk/c_book/**

C guidelines: **http://syque.com/cstyle/**

SEASONS

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This hand controller is used for mapping/programming the independant electronic boost controller Kit (shown below). It features a two line LCD, and easy to use push buttons. It can be used to program the adjusters then removed, or left permanently connected to display the adjuster's operation. It is designed as an interface and display, and is not required for general adjuster functions after they have been programmed. Kit supplied with silkscreened and machined case, PCB, LCD, and all electronic components.

Smart Fuel Mixture Display Kit

KC-5374 £8.95 + post & packing

This kit features auto dimming for night driving, emergency lean-out alarm, better circuit protection, and a 'dancing' display which functions when the ECU is operating in closed loop. Kit supplied with PCB and all electronic components.

- Car must be fitted with air flow and EGO sensors (standard on all EFI systems) for full functionality.

Recommended box UB3 (HB-6013) £1.40 each

IR Remote Control Extender MKII

KC-5432 £7.25 + post & packing

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

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

Improved Model!

Independent Electronic Boost Controller

KC-5387 £25.95 + post & packing

It can be used in cars fitted with factory electronic boost control using the factory control solenoid, or cars without electronic boost control using a solenoid from a wrecker etc. It has two different completely programmable boost curves. This is ideal for switching between say, a race/street mode, or a performance/wet weather mode. Boost curve selection is via a dashboard switch, and is all programmed using the handheld digital controller KC-5386 (shown above). Kit supplied with PCB, machined case, and all electronic components.

- Suitable for EFI and engine management systems only

Intelligent Turbo Timer Kit

KC-5383 £14.75 + post & packing

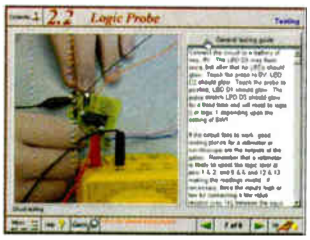
This great module uses input from an airflow, oxygen, or MAP sensor to determine how hard the car has been driven. It then uses this information to calculate how long the car needs to idle, reducing unnecessary idle time. The sensitivity and maximum idle time are both adjustable, so you can be sure your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

Recommended box UB3 (HB-6013) £1.40 each

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

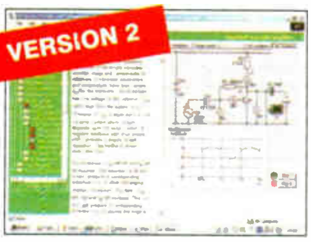


Logic Probe testing

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

ELECTRONIC CIRCUITS & COMPONENTS V2.0

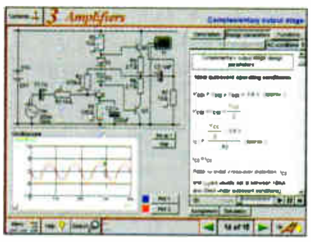
VERSION 2



Circuit simulation screen

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

ANALOGUE ELECTRONICS



Complimentary output stage

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

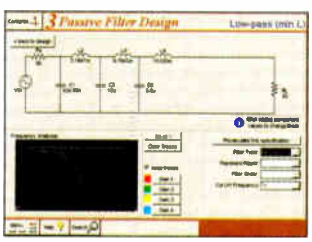
DIGITAL ELECTRONICS V2.0

VERSION 2

Virtual laboratory – Traffic Lights

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

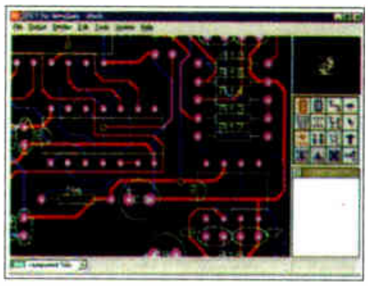
ANALOGUE FILTERS



Filter synthesis

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

ELECTRONICS CAD PACK



PCB Layout

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

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

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

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

PRICES

Prices for each of the CD-ROMs above are:

(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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ELECTRONICS

Newnes

BOOKS FROM NEWNES

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A Project-based Approach

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David W Smith

Learn about the PIC through practical project work - PIC in Practice offers engaging projects and a painless learning curve

- **Gentle introduction to using PICs for electronic applications**
- **Introduces applications using the popular 16F84 device as well as the 16F627, 16F877, 12C508, 12C629 and 12C675**
- **Includes 16F818 and writing and documenting programs**

Dave Smith has based the book on his popular short courses on the PIC for professionals, students and teachers at Manchester Metropolitan University. The result is a graded text, formulated around practical exercises, which truly guides the reader from square one. Newcomers to the PIC will find it a painless introduction, whilst electronics hobbyists will enjoy the practical nature of this first course in microcontrollers.

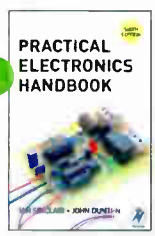
CONTENTS INCLUDE:

Programming the 16F84; Introductory projects; Using inputs; Understanding the headers; Keypad scanning; Program examples; The 16C54 microcontroller; Alpha numeric displays; Analogue to digital conversion; Radio transmitters and receivers; EEPROM data memory; The 12 series 8 pin microcontroller; The 16F87X Microcontroller: The 16F62X Microcontroller; Instruction set, files and registers.

Jan 2006 • ISBN-10: 0750668261 • ISBN-13: 9780750668262
304pp • 156 X 234 mm

Practical Electronics Handbook

NEW



6th edition

£19.99 / €28.95

Ian Sinclair & John Dunton

- **Invaluable handbook and reference for hobbyists, students and technicians**
- **Essential day-to-day electronics information, clear explanations and practical guidance in one compact volume**
- **Assumes some previous electronics knowledge but coverage to interest beginners and professionals alike**

Ian Sinclair's *Practical Electronics Handbook* combines a wealth of useful day-to-day electronics information, concise explanations and practical guidance in this essential companion to anyone involved in electronics design and construction. The compact collection of key data, fundamental principles and circuit design basics provides an ideal reference for a wide range of students, enthusiasts, technicians and practitioners of electronics who have progressed beyond the basics. The sixth edition is updated throughout with new material on microcontrollers and computer assistance, and a new chapter on digital signal processing.

CONTENTS INCLUDE:

Resistors; Capacitors; Inductors; Cells and batteries; Discrete semiconductors; Integrated circuits; Sensors and transducers; Digital ICs; introduction to microcontrollers; Digital input and output; Analogue and digital conversions; Transferring digital data; Microcontrollers and PLCs; Digital signal processing.

Dec 2006 • ISBN-10: 0750680717 • ISBN-13: 9780750680714
480pp • 156 X 234 mm

Audio Power Amplifier Design Handbook

NEW

4th edition

£26.99 / €36.95

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Renowned audio design guru Douglas Self demystifies the design, analysis and construction of the different classes of audio amplifiers in this classic handbook

- **Includes Douglas Self's classic amp designs for readers to build and adapt**
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Douglas Self offers a tried and tested method for designing audio amplifiers in a way that improves performance at every point in the circuit where distortion can creep in – without significantly increasing cost. His quest for the Blameless Amplifier takes readers through the causes of distortion, measurement techniques, and design solutions to minimise distortion and efficiency. The result is a book that is crammed with unique insights into audio design and performance, as well as complete amplifier designs and schematics.

CONTENTS INCLUDE:

Principles of power amplifiers; The small signal stages; The Class-B output stage; Compensation, slew-rate, and stability; Power supplies and PSRR; Class-A power amplifiers; Class D power amplifiers; Class-G power amplifiers; FET output stages; Amplifier and loudspeaker protection; Grounding and practical matters; Testing and safety.

July 2006 • ISBN-10: 0750680725 • ISBN-13: 9780750680721
488pp • 156 X 234 mm

EMC for Product Designers

NEW

4th edition

£34.99 / €49.95

Tim Williams

The indispensable resource on EMC product design; now thoroughly expanded and updated to cover all the major and latest directives

Widely regarded as the standard text on EMC, Tim Williams' book provides all the key information needed to meet the requirements of the latest EMC Directive. Most importantly, it shows how to incorporate EMC principles into the product design process, avoiding cost and performance penalties, meeting the needs of specific standards and resulting in a better overall product. As well as covering the very latest legal requirements, the fourth edition has been thoroughly updated in line with the latest best practice in EMC compliance and product design. Coverage has been considerably expanded to include the R&TTE and Automotive EMC Directives, as well the military aerospace standards of MIL STD 461F, DEF STAN 59-41 and DO160E. A new chapter on systems EMC is included, while short case studies demonstrate how EMC product design is put into practice.

CONTENTS INCLUDE:

Legislation and standards; Introduction; The EMC Directive; The R & TTE Directive; Commercial standards; Other standards & legislation; RF emissions measurements; Immunity tests; Low frequency tests; Test planning; Design principles; Interference coupling mechanisms; layout & grounding; Digital & analogue circuit design; Interfaces & filtering; Shielding; Systems EMC; EMC management; Design checklist; CAD for EMC; Case studies, Useful tables & formulae, The EU & EEA countries; Glossary; Index

Nov 2006 • ISBN-10: 0750681705 • ISBN-13: 9780750681704
512pp • 156 X 234 mm

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Interfacing PIC Microcontrollers

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Embedded Design by Interactive Simulation

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Martin P. Bates

An essential guide to PIC interfacing techniques, using circuit simulation to aid learning

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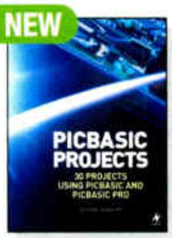
- Comprehensive coverage of a topic not widely explored in the wealth of PIC books on the market, concentrating on the popular PIC16F877 device
- Circuit simulation software allows step-by-step examples, supplied as assembly source code, to be run interactively – aiding student, technician and hobbyist learning
- A companion CD-ROM includes a restricted version of the simulation software, application circuits and code, the standard Microchip development system, MPLAB, and the data sheet for the PIC 16F877

Interfacing PIC Microcontrollers provides a thorough introduction to interfacing techniques for students, hobbyists and engineers looking to take their knowledge of PIC application development to the next level. Each chapter ends with suggestions for further applications, based on the examples given, and numerous line drawings illustrate application of the hardware.

Aug 2006 • ISBN-10: 0750680288
ISBN-13: 9780750680288 • 312pp • 189 X 246mm

PIC Basic Projects:



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30 Projects using PIC BASIC and PIC BASIC PRO

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Dogan Ibrahim

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Covering the PIC BASIC and PIC BASIC PRO compilers, *PIC Basic Projects* provides an easy-to-use toolkit for developing applications with PIC BASIC. Numerous simple projects give clear and concrete examples of how PIC BASIC can be used to develop electronics applications, while larger and more advanced projects describe program operation in detail and give useful insights into developing more involved microcontroller applications. This is a thoroughly practical, hands-on introduction to PIC BASIC for the hobbyist, student and electronics design engineer.

July 2006 • ISBN-10: 0750668792 :
ISBN-13: 9780750668798 • 376pp • 175 X 235mm

PIC Microcontrollers:

An Introduction to Microelectronics

2nd edition

£17.99 / €26.95

Martin P. Bates

A comprehensive, highly illustrated introduction to microelectronic systems using the PIC microcontroller

- Uses the latest Windows development software, MPLAB, and the most popular types of PIC, for accessible and low-cost practical work
- Focuses on the 16F84 as the starting point for introducing the basic architecture of the PIC, but also covers newer chips in the 16F8X range, and 8-pin mini-PICs

Assuming no prior knowledge of microprocessors, Martin Bates provides a comprehensive introduction to microprocessor systems and applications covering all the basic principles of microelectronics.

June 2004 • ISBN-10: 0750662670
ISBN-13: 9780750662673 • 390pp • 189 X 246mm

Programmable Logic Controllers

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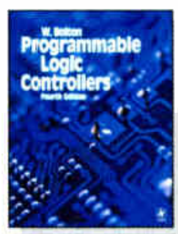
4th edition

£24.99 / €36.95

Bill Bolton



A concise, thoroughly practical and accessible introduction to Programmable Logic Controllers

- Thoroughly practical introduction to PLC use and application – not device specific, ensuring relevance to a wide range of courses
- New edition expanded with increased coverage of IEC 1131-3, industrial control scenarios and communications
- Problems included at the end of each chapter, with a complete set of answers given at the back of the book

This is the introduction to PLCs for which baffled students, technicians and managers have been waiting. In this straightforward, easy-to-read guide, Bill Bolton has kept the jargon to a minimum, considered all the programming methods in the standard IEC 1131-3 - in particular ladder programming, and presented the subject in a way that is not device specific to ensure maximum applicability to courses in electronics and control systems.

July 2006 • ISBN-10: 0750681128 :
ISBN-13: 9780750681124 • 304pp • 189 X 246mm

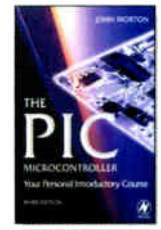
The PIC Microcontroller:

Your Personal Introductory Course

3rd edtion

£16.99 / €24.95

John Morton



A uniquely concise and practical guide to getting up and running with the PIC Microcontroller.

- Demystifies the leading microcontroller for students, engineers an hobbyists
- The revised 3rd edition focuses on the re-programmable flash PIC microcontrollers such as PIC16F54, PIC16F84 and the 8-pin PIC12F508 and PIC12F675 devices
- Simple programs and circuits introduce key features and commands through project work

Assuming no prior knowledge of microcontrollers and introducing the PIC Microcontroller's capabilities through simple projects, this book is ideal for electronics hobbyists, students, school pupils and technicians. The step-by-step explanations and the useful projects make it ideal for lab work and self-study: this is not just a reference book - you start work with the PIC microcontroller straight away.

Sept 2005 • ISBN-10: 0750666641
ISBN-13: 9780750666640 • 320pp • 156 X 234mm

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NEW

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Mingliang (Michael) Liu

Make your designs more power-efficient with this intuitive approach to switched-capacitor circuits!

- Step-by-step tutorials and practical design examples which emphasize the most fundamental principals of switched-capacitor circuits
- Few tedious mathematical equations
- The first easy-to-understand compilation on this subject

This book helps engineers to grasp fundamental theories and design principles by presenting physical and intuitive explanations of switched-capacitor circuits. Numerous circuit examples are discussed and the author emphasizes the most important and fundamental principles involved in implementing state-of-the-art switched-capacitor circuits for analog signal processing and power management applications. While some quantitative analysis is necessary to understand underlying concepts, tedious mathematical equations and formal proofs are avoided.

June 2006 • ISBN-10: 0750679077
ISBN-13: 9780750679077 • 336pp • 191 X 235mm

Networks on Chips:

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Giovanni De Micheli, Luca Benini et al

In-depth overview of Networks-on-Chips – the leading edge technology, vital to anyone doing System-on-Chip design!

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This book is the first to provide a unified overview of NoC technology. It includes in-depth analysis of all the on-chip communication challenges, from physical wiring implementation up to software architecture, and a complete classification of their various Network-on-Chip approaches and solutions.

Aug 2006 • ISBN-10: 0123705215
ISBN-13: 9780123705211 • 408pp • 191 X 235mm

Designing SOCs with Configured Cores:

NEW

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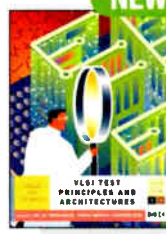
"Designing SOCs with Configured Processor Cores is an essential reference for system-on-chip designers. This well-written book gives a practical introduction to three basic techniques of modern SOC design: use of optimized standard CPU and DSP processors cores, application-specific configuration of processor cores, and system-level design of SOCs using configured cores as the key building block. Readers will find it is often the first book they reach for in defining and designing their next chip."

Chris Rowen, President and CEO, Tensilica, Inc.

Aug 2006 • ISBN-10: 0123724988
ISBN-13: 9780123724984 • 344pp • 191 X 235mm

VLSI Test Principles and Architectures:

NEW



Design for Testability (Systems on Silicon Series)

£34.99 / €49.95

Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen, et al.

The most up-to-date coverage available of VLSI Testing and Design-for-Testability!

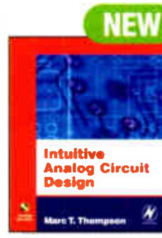
- **Delivers coverage of industry practices commonly found in commercial DFT tools but not discussed in other books**
- **Includes numerous, practical examples in each chapter illustrating basic VLSI test principles and DFT architectures**

This book is a comprehensive guide to new DFT methods that shows how to design a testable and quality product, drive down test cost, improve product quality and yield, and speed up time-to-market and time-to-volume.

Aug 2006 : ISBN-10: 0123705975 :
ISBN-13: 9780123705976 : 808pp : 191 X 235mm

Intuitive Analog Circuit Design

NEW



£39.99 / €57.50

Marc Thompson

How to apply an intuitive approach to analog circuit design!

- **Introduces analog circuit design with a minimum of mathematics**
- **Gives readers an intuitive "feel" for analog circuit operation and rules-of-thumb for their design**
- **Uses numerous analogies from digital design to help readers whose main background is in digital make the transition to analog design**

This book reflects Dr. Thompson's twenty years of experience designing and teaching analog circuit design. The application of some simple rules-of-thumb and design techniques is the first step in developing an intuitive understanding of the behaviour of complex electrical systems. This book outlines some ways of thinking about analog circuits and systems to help develop such "circuit intuition" and a "feel" for what a good, working analog circuit design should be.

June 2006 : ISBN-10: 0750677864
ISBN-13: 9780750677868 • 496pp • 191 X 235mm

Self on Audio 2e

NEW

£26.99 / €39.95

Douglas Self

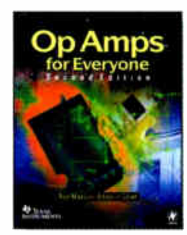
Renowned audio design guru Douglas Self's collected works from 25 years of magazine writing: all the legendary audio amplifier designs in their original form, ideal for project and design work.

- **An audio amp design cookbook, comprising 35 of Douglas Self's definitive audio design articles**
- **Complete designs for readers to build and adapt**
- **An anthology of classic designs for electronics enthusiasts, Hi-Fi devotees and professional designers alike**

Whether you are a dedicated audiophile who wants to gain a more complete understanding of the design issues behind a truly great amp, or a professional electronic designer seeking to learn more about the art of amplifier design, there can be no better place to start than with the 35 classic magazine articles collected together in this book.

June 2006 • ISBN-10: 0750681667
ISBN-13: 9780750681667 • 488pp • 156 X 234mm

Op Amps for Everyone



£39.99 / €59.95

Ron Mancini

Texas Instruments' complete professional-level tutorial and reference to operational amplifiers

- **Published in conjunction with Texas Instruments**
- **A single volume, professional-level guide to op amp theory and applications**
- **Covers circuit board layout techniques for manufacturing op amp circuits**

Unlike textbook treatments of op amp theory that tend to focus on idealized op amp models and configuration, this title uses idealized models only when necessary to explain op amp theory. The bulk of this book is on real-world op amps and their applications; considerations such as thermal effects, circuit noise, circuit buffering, selection of appropriate op amps for a given application, and unexpected effects in passive components are all discussed in detail.

May 2003 • ISBN-10: 0750677015
ISBN-13: 9780750677011 • 472pp • 187 X 235mm

Valve Amplifiers

3rd edition

£29.99 / €44.95

Morgan Jones

The definitive modern guide to tube amplifiers for home and professional audio applications.

- The practical guide to analysis, modification, design, construction and maintenance of valve amplifiers
- The fully up-to-date approach to valve electronics
- Essential reading for audio designers and music and electronics enthusiasts alike

CONTENTS INCLUDE: Circuit analysis; Basic building blocks; Distortion; Component technology; Power supplies; The power amplifier; The pre-amplifier.

Aug 2003 • ISBN-10: 0750656948
ISBN-13: 9780750656948 • 640pp • 156 X 234mm

Building Valve Amplifiers

£19.99 / €29.95

Morgan Jones

The definitive valve amplifier cookbook for classic and modern equipment

- The practical guide to building, modifying, fault-finding and repairing vacuum tube amplifiers.
- Design, fault-finding, and testing are each illustrated by step-by-step examples
- Written by the author of the audiophile cult classic, Valve Amplifiers

CONTENTS INCLUDE: Planning; Metalwork for Poets; Wiring; Test equipment principles; fault-finding to fettling; Performance testing

June 2004 • ISBN-10: 0750656956
ISBN-13: 9780750656955 • 368pp • 156 X 234mm

Starting Electronics Construction:

Techniques, Equipment and Projects

£12.99 / €17.95

Keith Brindley

From circuit design to finished product – a guide to selecting tools, techniques and components with step-by-step explanations of the essential practical techniques

- Master the practical techniques of electronics construction, from using a soldering iron to etching a printed circuit board, and mounting the finished product in a case
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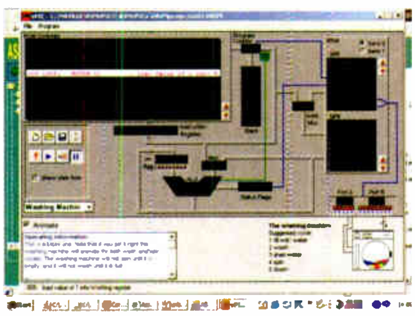

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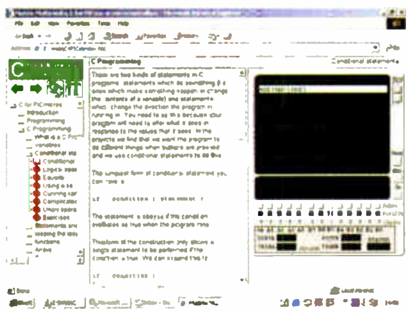

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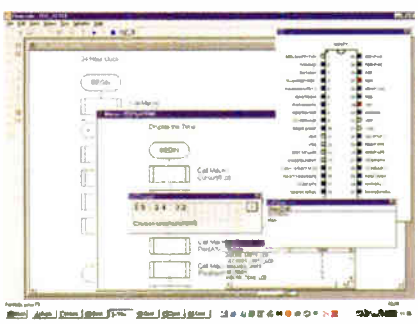

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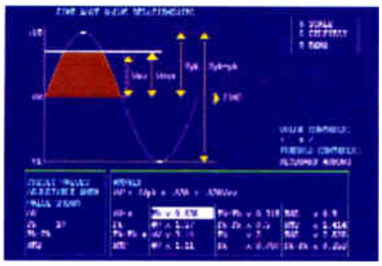

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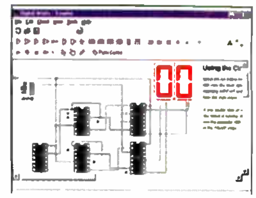

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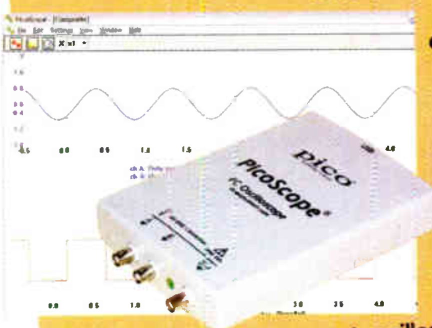

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1000-Year Flasher – *Heralding the Next Millennium*

THE author is not certain how one would define a micropower circuit. He would put it at less than about 20μA. Very few integrated circuits work with such low power – but those that do include the quad NAND Schmitt trigger IC1 shown in the simple flasher circuit of Fig.1. In fact IC1 ordinarily draws more than 500μA at 9V.

Flash Time

However, IC1 can be persuaded to use much less power than this, simply by restricting the current flow through resistor R2. With the component values shown in Fig.1, this circuit will brightly flash an ultrabright LED at 0.5Hz for more than twenty years – drawing 12μA off six high capacity AA batteries. If the component values in Table 1 are used, it will flash, although more dimly, for close to one thousand years – drawing just 0.3μA.

The circuit is unorthodox, in that IC1 requires a minimum of 3V, yet when LED D1 flashes, the voltage across IC1a drops to 2V. At this point, the circuit is theoretically non-functional – yet it does permit capacitor C1 to recharge through R1 and R2. As the voltage across IC1a again approaches 3V, IC1a kicks into life, and the discharge of C1 is again permitted, through LED D1. Unused gates are tied high to conserve power as well as prevent them from 'floating'.

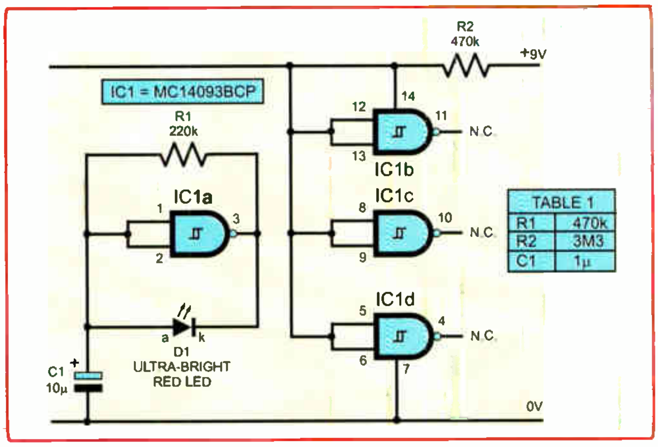

Fig.1. Circuit diagram for the 1000-Year Flasher

Components

The author used the Motorola version of IC1 (the MC14093BCP). While other CMOS 4093 ICs should work in this position, this has not been tested. D1 should be an ultrabright red LED. Capacitor C1 should be a new good quality, low-leakage component.

He would be obliged if readers who build this circuit confirm in due course that it has conformed to its descriptive title!

Thomas Scarborough,
Cape Town, South Africa

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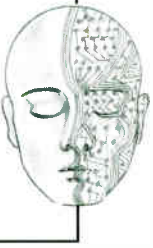


This simple adaptor allows commonly available electret lapel and headset microphones to be used with public address systems. It features a balanced output and is built into a compact case that can be clipped to a belt or slipped into a pocket.

By JOHN CLARKE

Lapel microphone adaptor for PA systems

WHILE STANDARD HAND-HELD microphones are generally used for most public address (PA) applications, there are times when a lapel microphone is much more convenient. A lapel microphone not only frees up a user's hands but also allows the wearer to roam about easily. They are ideal when giving talks and lectures, and for certain types of theatre work.

Another advantage of lapel microphones is that they provide a reasonably consistent output, even when the person speaking turns their head. That's because a lapel microphone is usually clipped to the user's clothing around the chest area and so remains at a similar distance from the mouth regardless of head movement. By contrast, hand-held microphones must always be held close to the mouth, otherwise the signal level will vary drastically.

Lapel microphones are generally available in two forms. By far the most common form for PA use at the present time is the radio microphone. This consists of the lapel microphone itself plus a small radio transmitter which is worn by the user – eg, inside a shirt pocket or by attaching it to a belt. The signals from the transmitter are picked up by a corresponding receiver which then feeds the signal to the PA system.

The big advantage of the radio microphone is that it allows the user

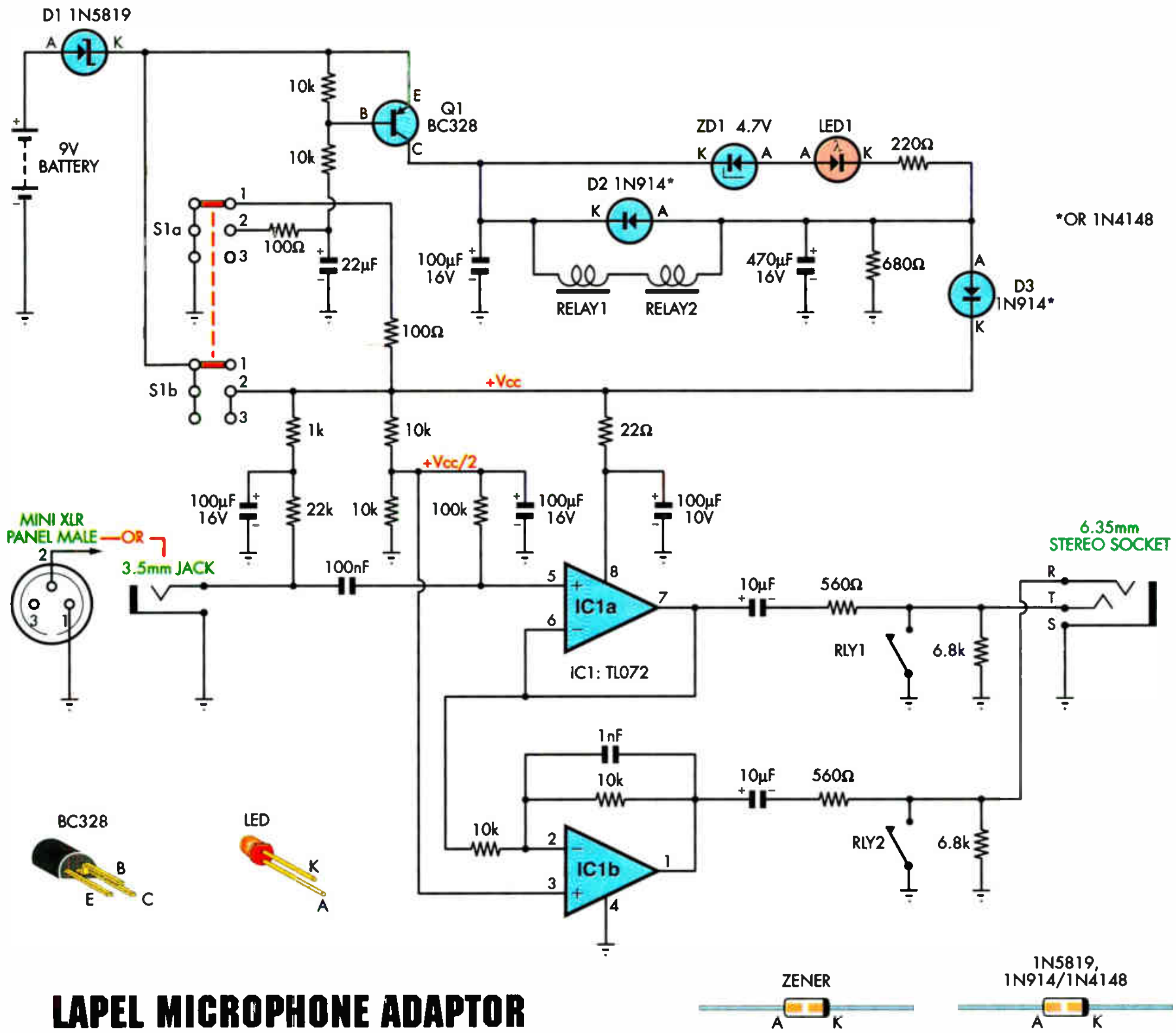


Fig.1: the circuit uses op amps IC1a & IC1b to provide a balanced output signal, while relays RLY1 & RLY2 shunt the signal to ground when activated, to provide muting.

to roam freely over several tens of metres without being tethered to a lead. However, this freedom comes at a high cost.

Despite its advantages, this high cost cannot always be justified, especially when full use of the radio transmitting feature is not exploited. This particularly applies to applications where the user doesn't need to roam too far. In those situations, a much cheaper solution is to dispense with the radio system and instead use a tethered lapel microphone – ie, one that's tethered to the PA amplifier via a lead.

However, obtaining such a wired lapel system is quite another matter. Music shops are keen to sell the wireless microphones but are usually at a loss when asked to supply a wired type. The older-style dynamic lapel microphones simply no longer appear to be available, while the smaller electret microphones require a power source.

So why can't you simply use an electret microphone and power it from the phantom supply that's sometimes available in PA mixers? Unfortunately, it's not as simple as that, for a couple of reasons.

First, many mixers do not have phantom power and if they do, the current available is well in excess of that required for an electret microphone. Electrets require only 0.5mA or less for correct operation, whereas the phantom power from a PA mixer is usually between 14mA and 60mA

Main Features

- Uses standard electret lapel microphone
- Adaptor attached to belt or in pocket
- Battery powered (9V)
- Balanced output
- Muting facility
- Battery indicator

Parts List – Lapel Microphone Adaptor

1 PC board, code 593 available from the *EPE PCB Service*
1 case measuring 135 x 70 x 24mm, with separate battery compartment
2 panel labels, 59 x 16mm and 114 x 50mm
1 belt/pocket clip
1 lapel electret microphone
2 5V reed relays (RLY1, RLY2)
1 double-pole 3-position slide switch (S1), with 2 x M2.6 mounting screws
1 3.5mm PC board jack socket (Jaycar PS 0133) or 3-pin chassis male miniature XLR connector – see text
1 right-angle stereo 6.35mm jack plug to 3-pin XLR line plug lead – see text
5 metres of dual-screened microphone cable
1 stereo 6.35mm metal line socket
1 9V battery clip lead
1 9V battery
3 M3 x 6mm screws
1 M3 x 10mm countersunk screw
1 M3 x 20mm countersunk screw
1 M3 x 10mm tapped spacer
1 50mm cable tie
13 PC stakes

Semiconductors
1 TL072 dual op amp (IC1)
1 BC328 PNP transistor (Q1)
1 4.7V 1W Zener diode (ZD1)
1 1N5819 Schottky diode (D1)
2 1N4148 or 1N914 diodes (D2,D3)
1 3mm green LED (LED1)

Capacitors
1 470µF 16V PC electrolytic
4 100µF 16V PC electrolytic
1 22µF 16V PC electrolytic
2 10µF 16V PC electrolytic
1 100nF MKT polyester
1 1nF MKT polyester

Resistors (1% 0.25W)

1 100kΩ	1 680Ω
1 22kΩ	2 560Ω
6 10kΩ	1 220Ω
2 6.8kΩ	2 100Ω
1 1kΩ	1 22Ω

– enough to destroy an electret unless precautions are taken.

Second, an electret microphone provides only a single 'unbalanced' output. This means that there are just two output connections – ie, the shield or screening and the signal wire. However, any leads that are several metres long or more in a PA system can readily pick up 50Hz mains frequency hum which is then amplified and fed through to the loudspeakers as an annoying buzz.

Balanced output

The way around this problem is to use what's known as a 'balanced' output. This type of output has two signal outputs plus a shield lead, with one output inverted with respect to the other.

In this case, both signal leads still pick up mains frequency hum but because the lines are balanced, the hum signal can be rejected to just leave the wanted microphone signal. This is done in the PA mixer – it receives the balanced signal and subtracts the non-inverted microphone signal from the inverted microphone signal. This removes the mains hum signal, since the same signal will be present in both leads. By contrast, the microphone signal is doubled, since subtracting an inverted signal from the non-inverted signal gives twice the signal level.

Lapel Microphone Adaptor

That's where the Lapel Microphone Adaptor comes in – it not only provides power to a standard electret microphone but also includes all the necessary circuitry to provide balanced output signals. In addition, it also includes a muting facility which shorts the signal output to ground, so that sound is no longer heard through the PA system. This muting function is completely silent in operation – ie, there are no clicks and pops in the sound when the muting is switched in or out.

As shown in the photos, the unit is housed in a small case which contains a separate battery compartment. The lapel microphone plugs into a socket at the top of the case, while the output lead plugs into a 6.35mm stereo socket on one side.

A single 3-position slide switch is used to switch the power on/off and to select the muting. An adjacent green indicator LED flashes when the power is switched on and this can also be used to indicate the battery condition. A bright flash indicates a good battery, with the LED becoming increasingly dim as the battery goes flat.

In addition, the LED serves as an indicator by glowing faintly when the switch is in the Mute position. It also flashes brightly and decays when the unit is switched off, to acknowledge the switch selection.

Specifications

Frequency response: 16Hz to 16kHz (actual response depends on the microphone used)

Output level: typically 100mV

Current consumption: 4mA when on, 11mA on mute, 0.1µA when off

Circuit details

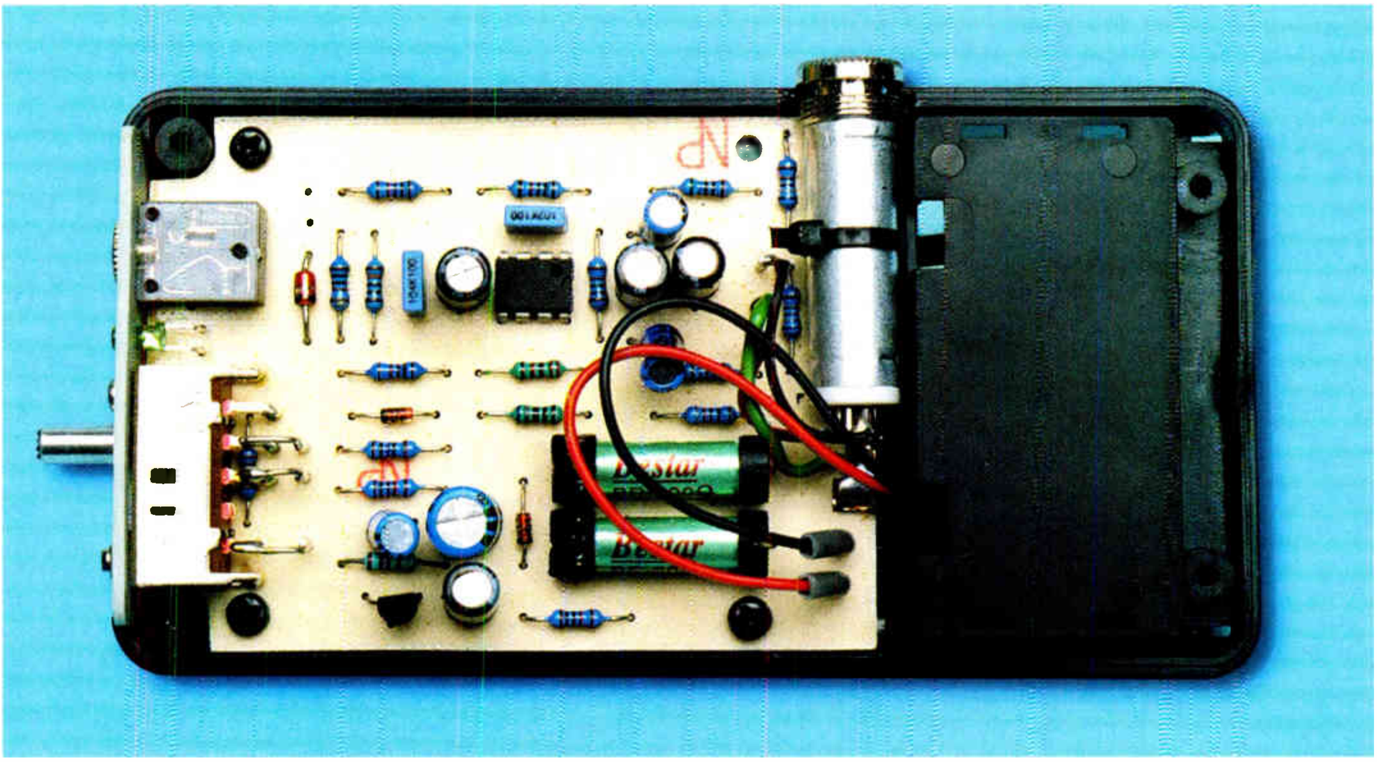
Fig.1 shows the full circuit details of the Lapel Microphone Adaptor. It includes a dual op amp package (IC1) to do the audio signal processing, plus two relays to shunt the signal on each balanced line to ground during muting. Power for the circuit is derived from a 9V battery and is applied via reverse polarity protection diode D1 and power switch S1.

The electret microphone is plugged into a mini XLR male socket or a 3.5mm jack socket, depending on the type of electret used. It is powered from the 9V battery via 1kΩ & 22kΩ resistors and a 100µF filter capacitor. This decoupling is necessary to keep supply noise and ripple from degrading the microphone signal.

The output signal from the microphone is fed to the pin 5 (non-inverting) input of op amp IC1a via a 100nF capacitor. This capacitor and its associated 100kΩ resistor roll off the low-frequency response below 16Hz

Note that IC1a's pin 5 input is biased at half-supply (ie, Vcc/2) via the 100kΩ resistor which is connected to a voltage divider consisting of two 10kΩ resistors across the 9V rail. This allows the op amp's output to swing symmetrically above and below Vcc/2.

IC1a is wired as a non-inverting buffer stage and provides an output



This is the view inside the completed prototype. The 6.35mm jack socket has its outer cover removed and is secured to the PC board using a cable tie. The socket is then further secured by its threaded boss when the lid is fastened down.

which is in phase with the microphone signal. By contrast, IC1b is connected as an inverting amplifier. It operates with a gain of -1, as set by the two 10kΩ input and feedback resistors.

IC1b is fed from IC1a's output (pin 7) and provides a complementary out of phase signal at its pin 1 output. The 1nF capacitor across the feedback resistor rolls the signal off above about 16kHz to ensure stability.

As a result, IC1a's output provides the in-phase signal while IC1b's output provides the out-of-phase (or inverted) signal. The op amp outputs are then AC-coupled to the output socket via series 10µF capacitors and 560Ω resistors. The 560Ω resistors provide a nominal 600Ω output impedance and prevent the op amps from oscillating (due to the extra capacitance) when the balanced microphone cable is connected.

The 10µF capacitors are necessary to remove the DC levels that are present at the outputs of IC1a and IC1b.

Muting

As previously mentioned, the outputs can be muted and this is achieved using relays RLY1 and RLY2 which short the outputs to ground when powered.

In addition, the outputs are muted at switch-on. This is necessary because when power is initially applied to op amps IC1a & IC1b (via switch S1b), their outputs quickly rise to half supply (Vcc/2). Without muting, this voltage would be coupled into the PA system and cause large switch-on thumps. To circumvent this, relays RLY1 & RLY2 are switched on at power up to short the signal outputs to ground until the voltages settle.

The relays are switched via switch S1a and its associated circuitry based on transistor Q1. This works as follows.

Switch S1 is a double-pole 3-position switch and when S1 is in position 1, no power is applied to the circuit. In position 2, S1b's contacts feed power to op amp IC1, while the corresponding contacts in S1a connect transistor Q1's 10kΩ base resistor to ground via a 100Ω resistor. As a result, Q1 turns on and applies power to the relay coils.

As shown on Fig.1, the relay coils are connected in series, with one side going to ground via a 470µF capacitor and a 680Ω resistor connected in parallel. Initially, the 470µF capacitor is discharged and so the full 9V is applied across the series-connected relay coils – ie, 4.5V for each relay. This is quite sufficient to activate the 5V relay coils and close the contacts, RLY1&2.

As the 470µF capacitor charges, the voltage across the relay coils decreases. However, the relays remain closed because their dropout voltage is much lower than the voltage required to activate them. The 680Ω resistor sets the minimum voltage across the relay coils to around 2.7V per relay. This resistor is included to reduce the current drawn from the battery while the relays are closed.

The resistor and capacitor also cause LED1 to momentarily flash when the power is switched on. Initially, when power is applied and the 470µF capacitor is discharged, LED1 is fed via a 4.7V Zener diode (ZD1) and the series 220Ω resistor. The LED will glow brightly with a fresh battery but as the battery voltage falls to around 7.2V, there will be insufficient current to light it at full brightness.

It works like this: since there is 4.7V across ZD1 and a nominal 2V across the LED, this leaves only 0.5V across the 220Ω resistor when the battery is at 7.2V. As a result, the LED current is only about 2.3mA and so the LED will only glow dimly.

By contrast, if the battery is at 9V, the resistor will have 2.3V across it and so the LED current will be around 10mA. As a result, LED1 will glow brightly. However, the LED does not light for long, as the 470µF capacitor quickly

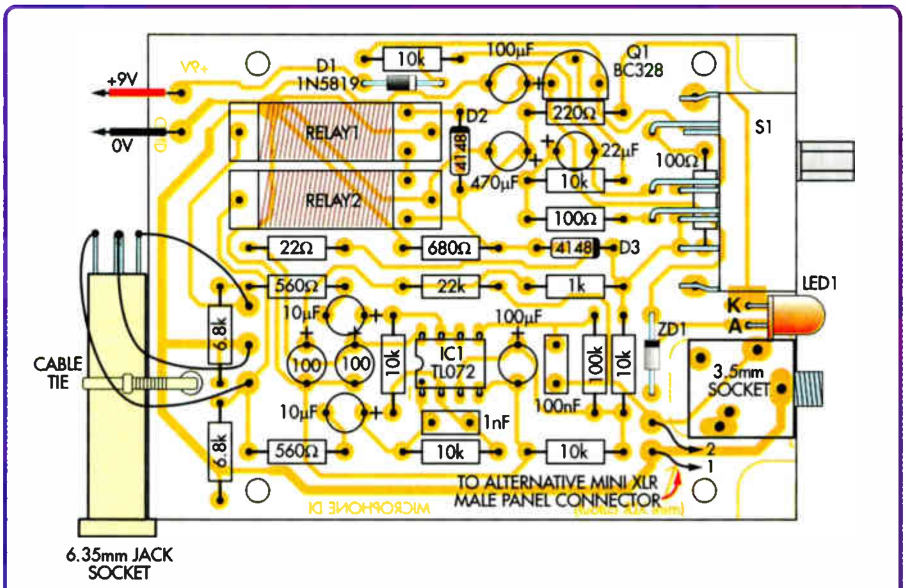


Fig.2: here is the parts layout for the PC board. Make sure that all polarised parts are correctly oriented and that the correct component is installed at each location.

charges via the relay coils and turns LED1 off again.

When S1 is placed in position 3, IC1 is still powered but Q1's 10kΩ base resistor is disconnected from ground. As a result, the 22µF capacitor is now left to supply Q1's base current for a short time as it charges towards the 9V supply rail via the two series 10kΩ resistors. After about 1s, Q1 switches off and the relays also turn off, thereby releasing the shorts across the output lines from IC1a and IC1b.

Diode D3 quenches the back-EMF voltage that's generated when the relay coils are switched off. This back-EMF voltage is further damped by the 100µF capacitor at D2's cathode.

Note that the muting can be reactivated at any time by switching S1 back to position 2, so that the relays are switched on again. In addition, when the power is fully switched off (S1 switched to position 1), the relays remain on for one second while the 22µF capacitor charges. This ensures that IC1 is fully powered down before the relays are switched off, to prevent loud switching thumps in the PA system.

As a further precaution, the 100µF capacitor that's used to decouple IC1's supply rail is quickly discharged via a 100Ω resistor and position 1 of S1a. Diode D2 is included to ensure that the 470µF capacitor also discharges, so that the relays turn on if power is quickly applied again.

The 22Ω resistor in series with pin 8 of IC1 limits the surge current through the switch when power is applied. Similarly, the 100Ω resistor at position 2 of S1a limits the discharge current from the associated 22µF capacitor when S1a switches this contact to ground.

Construction

The assembly is straightforward since all the parts are mounted on a single PC board. This board is available from the *EPE PCB Service*, code 593.

Begin by checking the PC board for any possible shorts between tracks or breaks in the copper pattern. Check also that the hole sizes are correct. Note that a cutout will need to be made in the board to provide space for a mini XLR panel-mount socket if you are using a lapel microphone fitted with a mini XLR (female) plug.

The XLR cutout is shown as an outline on the PC board. You also need to file the edge of the PC board slightly where shown, to allow room for the XLR securing nut to encroach into the PC board space.

Alternatively, if you are using a microphone with a 3.5mm jack plug, you can use a PC-mount 3.5mm socket instead. In that case, you won't need to make the cutout.

Fig.2 shows the assembly details. Start by installing all the PC stakes at the wiring and switch terminal points, then install the resistors, diodes D1 to D3, Zener diode ZD1 and the IC. Make sure you place each component in its correct position and with the correct orientation.

Table 1 shows the resistor colour codes but it's also a good idea to check the values using a digital multimeter as some of the colours can be difficult to distinguish.

The relays and transistor Q1 can go in next, followed by the capacitors. Be sure to install the electrolytic capacitors with the polarity shown. The 3.5mm socket can also now be installed if it is being fitted.

The 3-position slide switch (S1) is mounted on its side, with its top face aligned with the edge of the PC board. Five of its bottom terminals are soldered directly to the previously

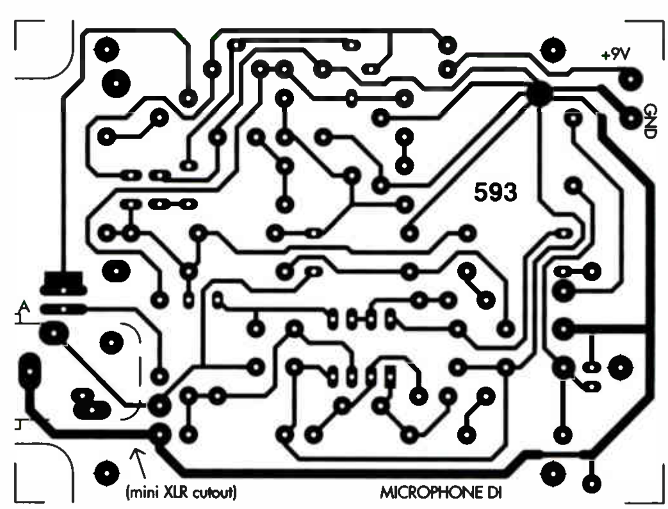


Fig.3: here is the full-size etching pattern for the PC board.

installed PC stakes as shown on Fig.2, while three of the top terminals connect to their PC stakes via short lengths of tinned copper wire.

Drilling the front panel

The front panel can now be drilled to accept the switch, LED and microphone input socket, see Fig.5. Note that you will need to drill out a slot for the slide switch operating toggle. That done, attach the front panel label, then attach the front panel to the PC board assembly by installing the supplied switch screws and by fitting the securing nut to the 3.5mm jack socket.

That done, the LED's leads can be bent at right angles about 4mm from its body and the LED slipped into position so that it protrudes through the front panel. Adjust its leads as necessary and make sure that it is oriented correctly before finally soldering it into position.

In particular, note that anode lead (A) is the longer of the two. This lead goes towards the bottom edge of the PC board as shown on Fig.2.

A separate battery compartment accommodates the 9V battery that's used to power the circuit. The screw in the back of the case (just above the 6.35mm jack socket) is used to secure the 10mm tapped spacer to the PC board (see Fig.4).

6.35mm jack socket

A hole is needed in the side of the box for the 6.35mm jack socket which is used without its outer cover. Mark the hole location with the case clipped together, noting that the socket sits directly on the PC board and against the battery compartment.

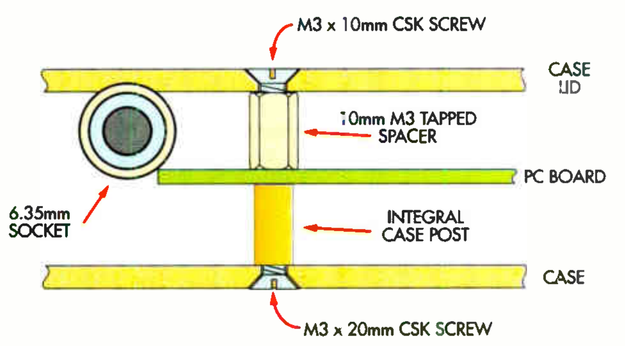


Fig.4: this diagram shows how the M3 × 10mm tapped spacer is secured to the PC board. This helps secure the 6.35mm socket when the lid is screwed down.

Table 2: Capacitor Codes

Value	µF code	IEC Code	EIA Code
100nF	0.1µF	100n	104
1nF	0.001µF	1n0	102

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	6	10kΩ	brown black orange brown	brown black black red brown
❑	2	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	2	560Ω	green blue brown brown	green blue black black brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	2	100Ω	brown black brown brown	brown black black black brown
❑	1	22Ω	red red black brown	red red black gold brown

Fig.5: this artwork can be used as a drilling template for the front panel.

The mounting hole must be drilled and reamed out to 10mm diameter, which will not be large enough for the threaded section of the socket. That done, place the PC board in the case and secure it in position using three M3 screws (two at the top and one at bottom right).

Next, position the socket in its mounting hole and tighten down the case lid with the four self-tapping screws supplied. Now heat the socket using your soldering iron until the plastic case begins to melt, at the same time pressing the case together so that it forms a tight fit around the socket and closes correctly.

Finally, remove the iron and wait for the heated case to cool.

The case will now have formed a moulding around the threaded section of the 6.35mm jack socket. It should then be prised open again and the socket secured in position using a cable tie which passes through a hole in the PC board and then around the edge of the board.

To further secure the socket, a 10mm M3 spacer is installed on the PC board adjacent to it so that the lid can be firmly screwed down at this point. To do this, the mounting post in the base of the case adjacent to the socket is drilled out to 3mm and this hole goes right through the case. In addition, you have to drill out the post in the case lid directly above this point.

That done, countersink the holes and cut off the post in the lid using a sharp utility knife. The 10mm M3 spacer can then be fitted in position and secured using an M3 x 20mm screw installed from the bottom of the case as shown in Fig.4.

All that remains now is to complete the wiring to the stereo socket and connect the battery clip lead. Note that the leads from the battery clip will have to be fed through from the battery compartment before soldering them to the supply terminals on the PC board.

Testing

To test the unit, apply power and check that the relay contacts close and that the LED flashes. If not, check that transistor Q1 has been installed correctly and check its associated components. If the relays do close but the LED doesn't flash, check that the LED has been installed with the correct polarity and check the orientation of ZD1.

Finally, check that pins 1 and 7 of IC1 are at about 4.5V (ie, Vcc/2). This voltage should also be present on pins 3 & 5 (ie, the non-inverting inputs). If everything checks out, then it is likely that the unit is working correctly and it can be tested by connecting it to a PA system and plugging in an electret microphone. *EPE*

Fig.6: this is the full-size artwork for the case label.

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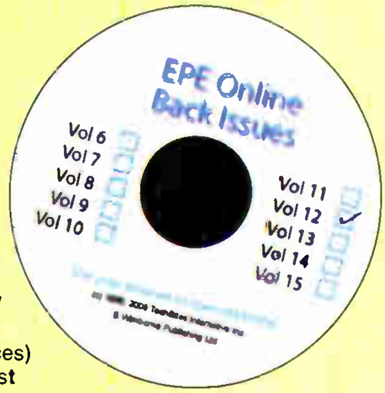

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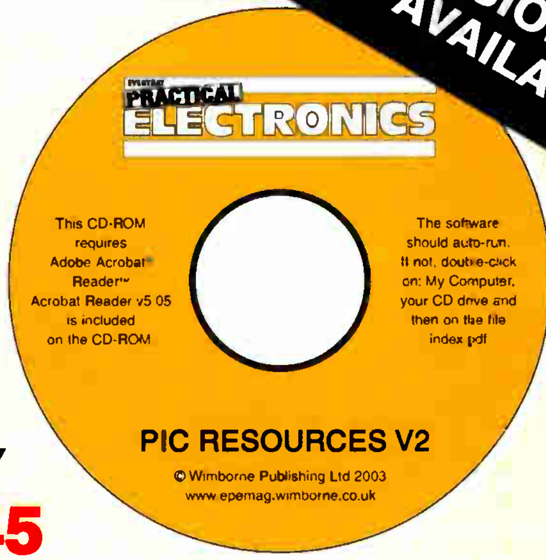
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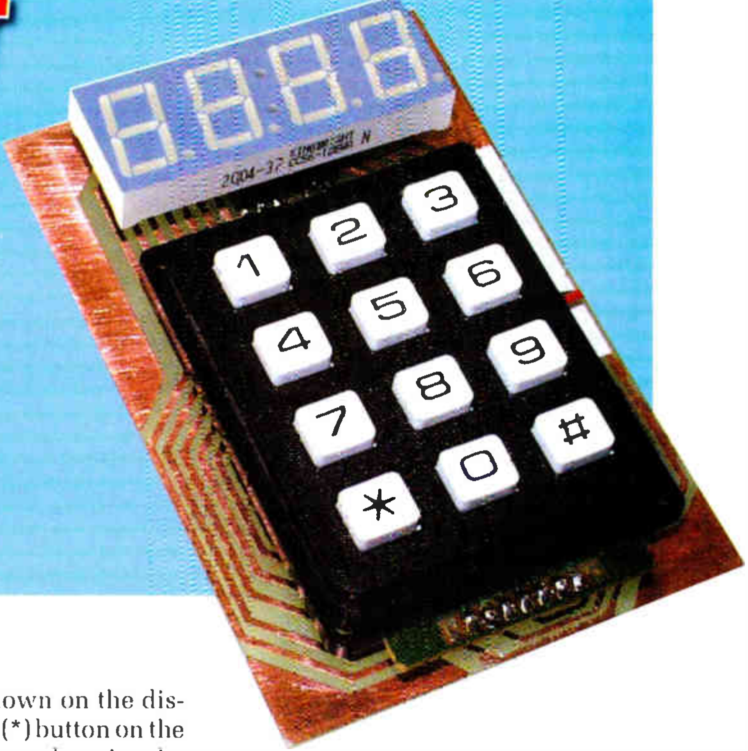


Exercise your mind in an enjoyable way!

By BART TREPAK

THE idea behind the Mind Trainer is quite simple but it requires a good deal of thought. It is based on an old brain-testing game normally played with coloured pegs. Although it is really a game for only one player, two are required to play – one of them being a 'dummy'!

In this version, a PIC microcontroller is cast in the role of the dummy (an excellent position for it as it will never get bored if the player takes too long considering a next move, or comment on incorrect choices).

In the original game, the dummy arranges four coloured pegs in a board out of view of the player and the player has to guess the colour and position of the pegs in the smallest number of attempts by placing further coloured pegs in holes on the board. The dummy helps in this by indicating the number of correct colours and/or correct positions in each attempt, but not which ones are correct.

Electronic equivalent

This game is the electronic equivalent of this but instead of coloured pegs a 4-digit LED display is used. The PIC selects four digits randomly and as these are not displayed, they are therefore unknown to the player. This is done at the start of each game by pressing the hash (#) button on the keypad.

The player then tries to guess the 4-digit number by entering it via a keypad and this is shown on the display. Pressing the star (*) button on the keypad enters this guess, changing the display to two digits; the right hand one showing how many correct numbers have been entered in their correct position, while the left hand one displays the number of correct digits that are in the wrong positions.

Hidden numbers

For example, suppose that the hidden number is 1234 and the user has entered 3514. On pressing the * button, 2--1 will be displayed (where '-' indicates a blank digit) because although three correct numbers have been chosen (1, 3 and 4), two are in the wrong position and only one (the 4) is in its correct position. Note that no indication is given as to which the incorrect number is or which one is in its correct position. Pressing the * button also automatically increases the score counter.

Pressing the # key will reveal the last entry again and enable a new 4-digit number to be entered. The entered digits scroll across the display from right to left as they would if they had been entered on a calculator. Note that a guess is only accepted by the unit when the * button is pressed, so that keys pressed incorrectly may be overwritten and the entry made only when the player is satisfied with the new 4-digit number chosen.

Eventually, after a number of unsuccessful guesses, the correct number will be entered and this time when the * button is pressed a display in the form --XX will be shown, again the '-' signifying a blank digit and the XX the number of entries made. Since the idea of the game is to make this score as low as possible, a 2-digit score display (i.e. 99 attempts) should be more than enough for even the most illogical thinker!

Circuit description

The circuit, shown in Fig.1, consists of the PIC (IC1) plus the 4-digit LED display (X1) and a 12-way keypad (S2), together with the usual LED current limiting and pull-up resistors, R1 to R8 and R14 to R16 respectively. The PIC's clock frequency is not critical and so a simple resistor-capacitor option has been chosen (R13/C1).

The limited number of PIC I/O (input/output) lines means that both the display and the keypad have been multiplexed. Multiplexing is a widely used technique and operates (as far as the display is concerned) by outputting the seven-segment code for each digit on Port B while switching on each corresponding digit sequentially via four lines of Port A. This is done so fast that the eye perceives it as a continuous display so that all four digits appear to be on simultaneously.

After displaying the digits, four lines of port B (RB4 to RB7) are switched to function as outputs and driven low in turn while RB0 to RB2 are designated as inputs. If a key is being pressed, one of the inputs will now read low and depending on which input is low, the program determines which key is pressed.

Because the same port is used to output the 7-segment data and both drive and read the keypad, isolating resistors R9 to R12 are used to prevent key presses affecting the display.

Construction

The printed circuit board component and track layouts are shown in Fig.2. This board is available from the *EPE PCB Service*, code 598.

Assembly should begin with the resistors, followed by the capacitors

Parts List – Mind Trainer

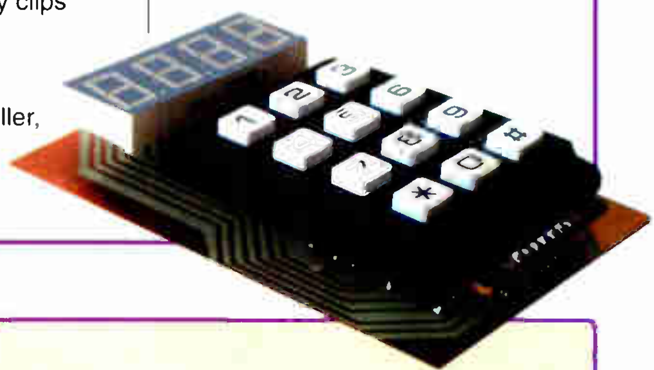
1 PC board, code 598, available from the *EPE PCB Service*, size 51mm × 76mm
1 Plastic case (optional), size and type to invidual choice
1 12-key, 3 × 4 matrix, keypad (S2)
1 SPST miniature toggle switch (S1)
1 4-digit, common cathode, red LED display (CC56-12EWA) (X1)
1 battery holder for two AA or AAA cells, with battery clips
1 18-pin DIL socket

Semiconductors
1 PIC16F54 microcontroller, preprogrammed – see text (IC1)

Capacitors
1 22p ceramic disc (C1)
1 100n ceramic disc (C2)
1 47µ radial elect. 10V (C3)

Resistors (0.25W 5% carbon film)
8 100Ω (R1 to R8)
5 4k7 (R9 to R13)
3 100k (R14 to R16)

Multistrand connecting wire; ribbon cable, optional – see text; solder, etc.



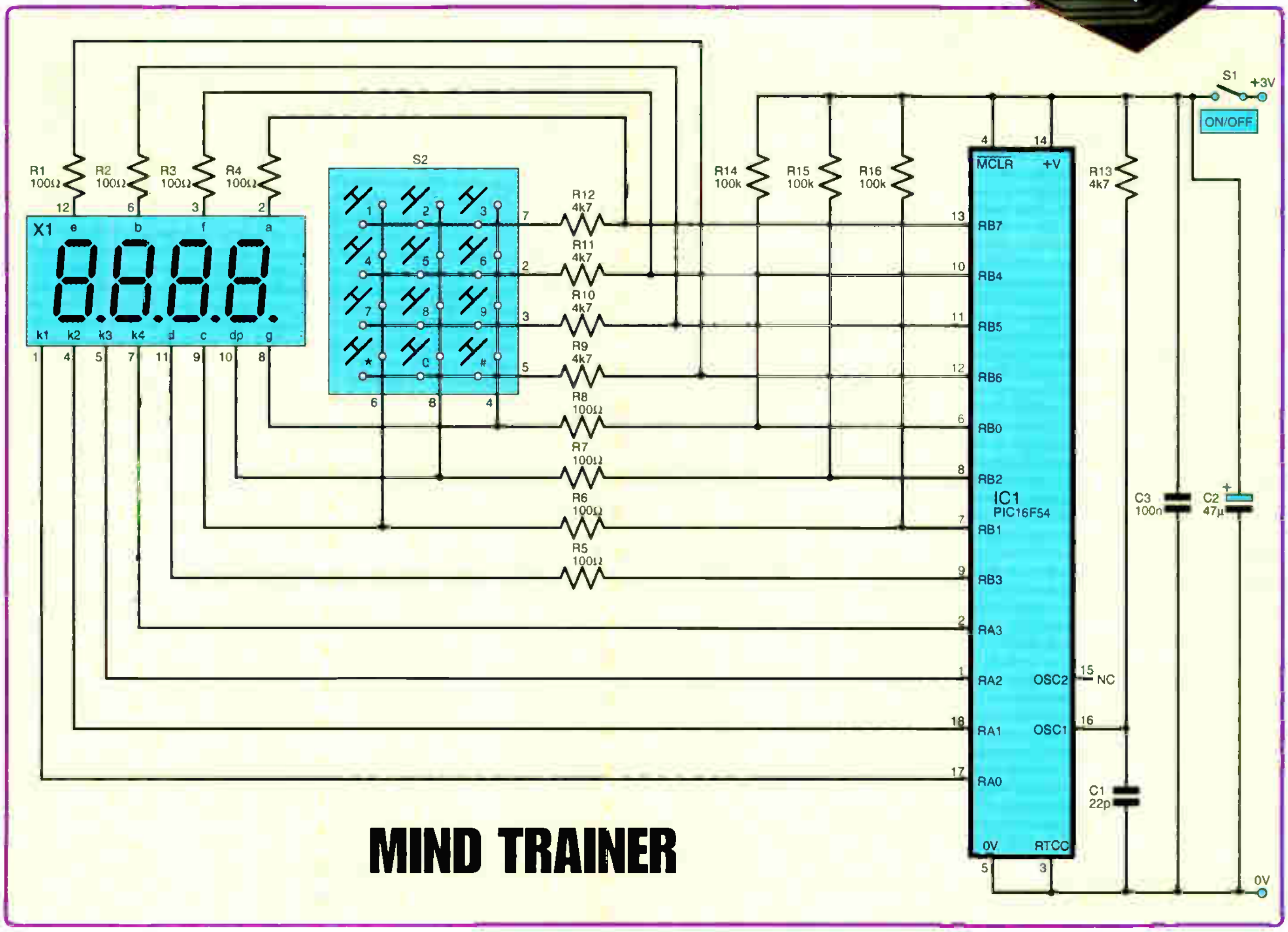


Fig.1. Complete circuit diagram for the Mind Trainer. Power is supplied by two AA or AAA type cells

and higher profile components, with the PIC's socket mounted last.

The pinouts for the display and keypad are shown in Fig.3 and Fig.4. These items should be mounted on the track side of the PCB, using short lengths of discarded resistor leads or ribbon cable as preferred.

When assembly is finished check all of the connections to ensure that there are no solder splashes between adjacent copper tracks or pins, and that the joints are all sound. If this is so, the preprogrammed PIC should be plugged in, ensuring that it is the correct way around.

The circuit can now be powered up, using a 3V battery or two 1.5V cells in series (AA or AAA are suitable). These are best mounted in a battery holder which should be connected to the PCB, either directly or via a suitable connector. On/off switch S1 is inserted in the +3V battery lead.

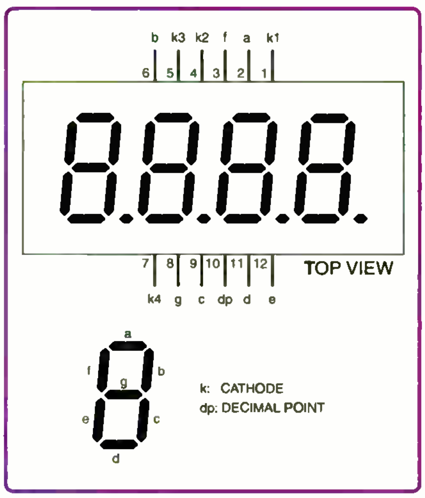


Fig.3. LED display pinout details

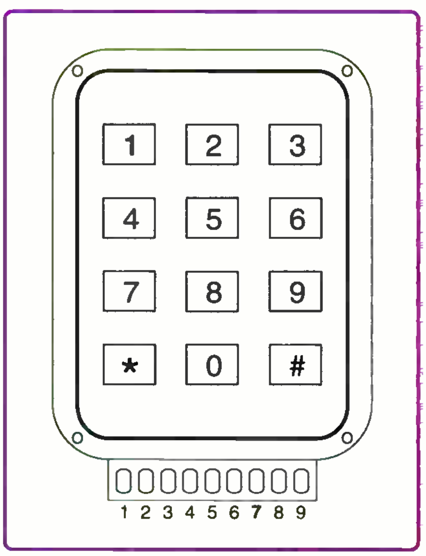


Fig.4. Keyboard connection details. End pads 1 and 9 are not connected on the PCB

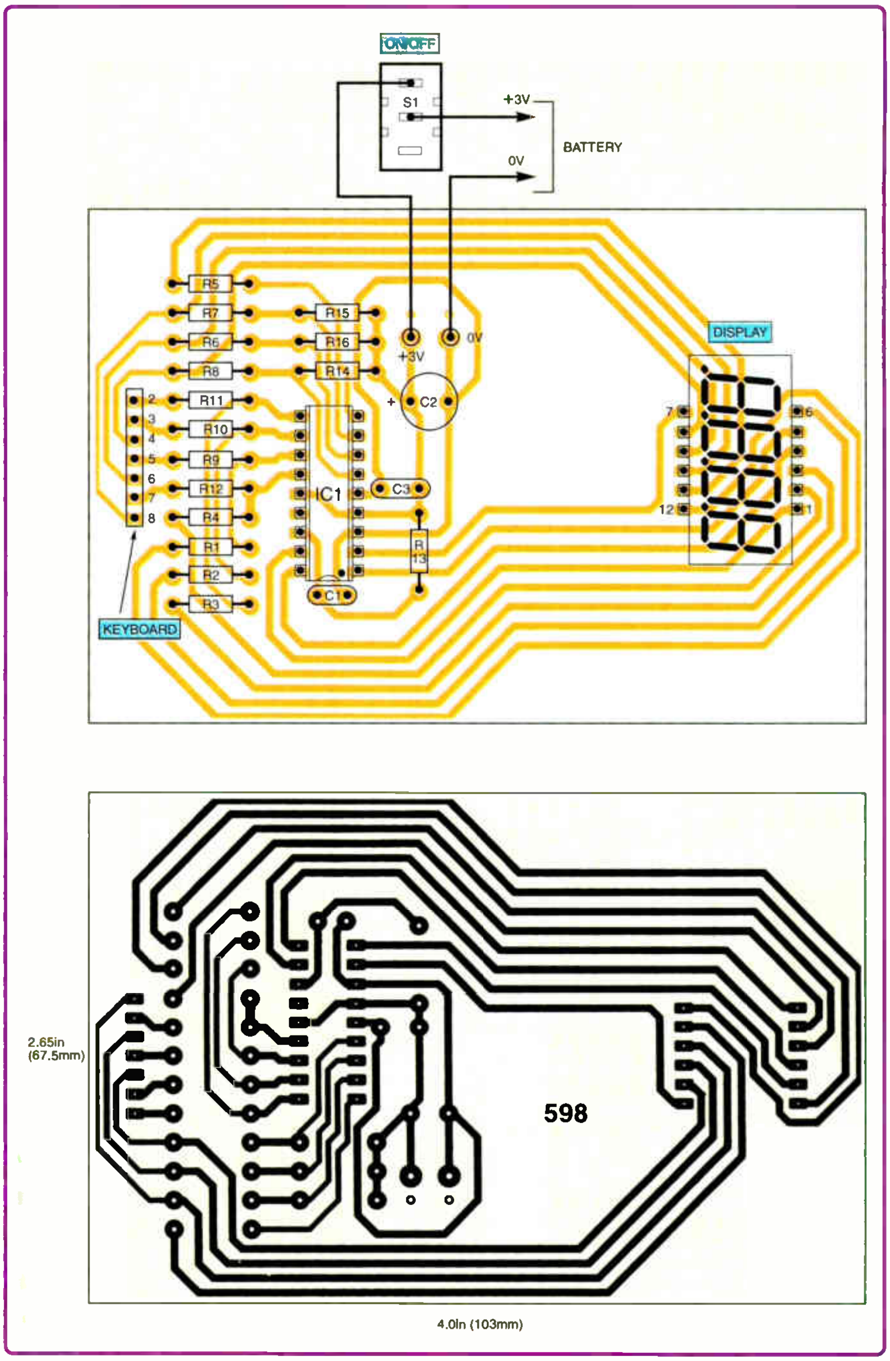


Fig.2. Mind Trainer printed circuit board component layout, full size copper foil master and wiring to the On/Off battery supply switch. Note that keypad pins/pads 1 and 9 are not connected to the board. Use an IC socket for the PIC

There are no adjustments to be made and provided the circuit has been correctly assembled, it should work as described.

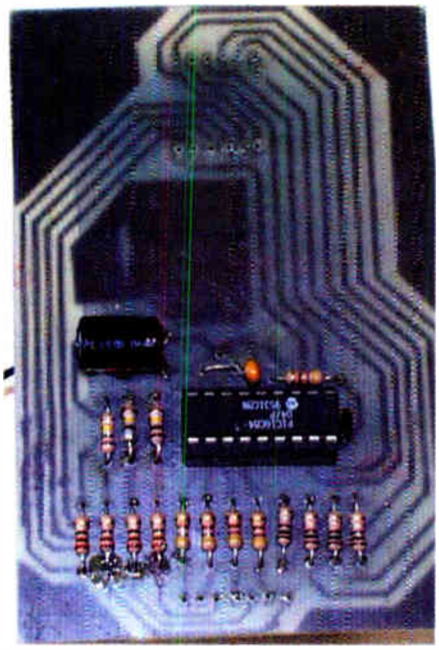
The circuit draws about 15mA when operating which, although not too high for battery operation, would soon drain an AA battery if left on for extended periods.

Playing the game

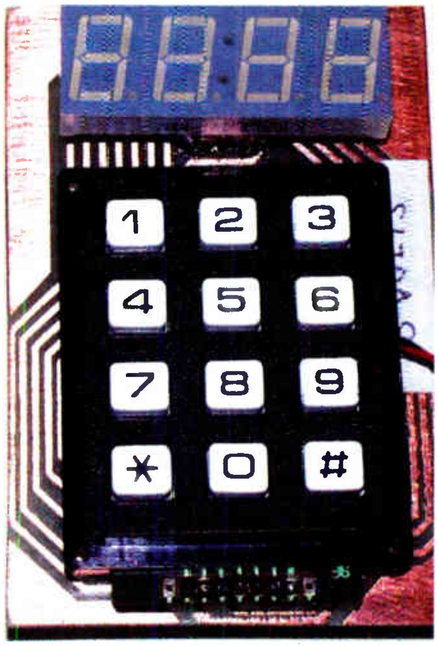
As a further example of how the game is played, the sequence of a real game is reproduced in Table 1. The unknown number happened to be 2489 and the first digits entered were 1234 as shown, which resulted in the display 2--0 indicating that two of these digits were correct but neither was in its correct position.

Table 1. Example game play

Guess	*Result No.*	*Position*
1234	2	0
1256	1	0
1356	0	0
2478	1	2
2489	Final score 05	



Topside PCB component layout. Note the radial electroytic is mounted on it's side



Underside view of the board showing the display and keypad

Resources

Software for the PIC can be downloaded free from the EPE Downloads site, accessible via the home page at www.epemag.co.uk. It is held in the PICs folder. Download all the files within that folder.

Preprogrammed PICs are available from Magenta Electronics Ltd, contact details as in their advert in this issue.

It was assumed that the digits 1 and 2 were correct and that 3 and 4 were not part of the hidden number, so that the next entry made was 1256 which gave the result 1--0. From this it was guessed that 5 and 6 were probably not part of the hidden number and that only one of the remaining numbers 1 or 2 was correct.

The hidden number thus included 1 or 2 and 3 or 4. To find out which, a further guess was made by assuming that the correct numbers were 1 and 3 so that 1356 was entered which gave the result 0--0. This was lucky as it immediately showed that 2 and 4 were two of the numbers required and 5 and 6 were definitely not part of the hidden number.

At this point it was still not known what the other two numbers were, except that they could be 7, 8, 9, 0 or indeed 2 and 4 again, as each correct digit is only counted once even if it appears again in the hidden number. The next entry made was therefore 2478 and this gave the result 1--2 showing that either 7 or 8 also figured in the final number and, as a bonus, two of the digits were also in their correct positions.

The last entry was the result of two lucky guesses where it was assumed that it was 2 and 4 that were in their correct positions, and that 8 was the correct number but in the wrong position. Changing its position and trying the next number by entering 2489 displayed the final score as --05.

This shows that to achieve a low score, a certain amount of luck is also required, but this does not mean that a logical thinking process is not involved. No doubt the final number could have been found by randomly entering numbers into the unit, but this would almost certainly result in a higher final score than by extracting the maximum amount of information from the results obtained from each entry.

Demo mode

As a further aid to understanding the game, the software is designed so that when the unit is first switched on, a 'random number' is entered into its memory. The user can then press the # key and enter any digits preferred to see how the unit processes the guess. This will give the player an insight into what display is to be expected when, for example, the random number contains repeated digits.

In general, any number which is in its correct position is displayed in the 'correct position' score and is not counted again even if it also appears in another position in the random number. Thus the right-hand display shows the number of correct digits in the correct position and the left-hand display the number of remaining correct digits in the wrong position.

After this, to start a game, simply enter the correct number and press * (which will display your score) and then press the # key again. This will blank the display and generate a new (this time hidden) random number when the # key is pressed again. The score will be reset to zero and the display will change to 0000, ready to accept the first guess.

If the practice session is not required, press the * button after switching the unit on, followed by the # button which will blank the display, and then the # key again before entering your first guess. The practice feature is available only after the unit has first been switched on, so that after subsequent games the # key should be pressed twice to start each new game.

The unit also features a recall of the previous entry so that the last number entered and the result obtained can be re-examined. This is done by pressing the # button when the number has been entered and the result will be displayed alternately. Pressing the * key is always treated as a new entry so this key should be pressed only when you are ready to make a new guess.

The circuit does not keep a record of previous numbers entered or the results obtained, so that if this function is required, an older technology (pencil and paper) will need to be used)! Alternatively, it could be argued that a person who could not remember previous entries was not thinking very logically anyway and should be penalised if the same 4-digit number was entered two or more times!

Finally, the efficacy of this unit in maintaining mental faculties obviously requires further independent research. The author considers himself much too young to have lost any of those he possessed and therefore is not a suitable subject. Modesty prevents him revealing his best score but suffice it to say that a third digit to display this has not been required (yet)! *EPE*

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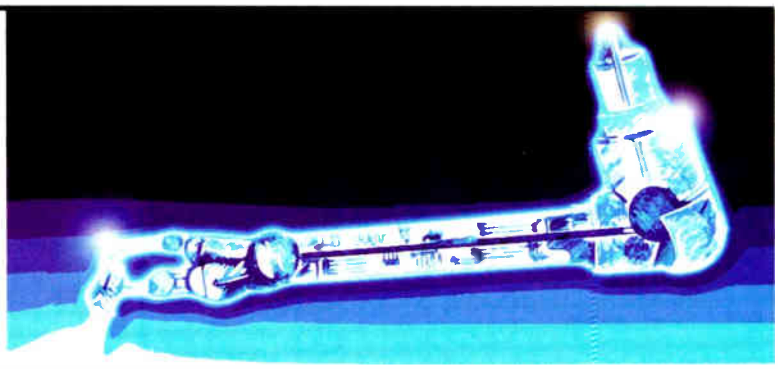


Ian Bell

The final part of our close-up view of 555 timer circuit formulae

THIS is the third and final part of our extended answer to **CherryTree's** question from the *EPE Chat Zone* about where the formulae used in 555 (and similar) RC-based timer circuits come from. Over the past couple of months we have looked at the mathematics behind a resistor charging through a capacitor – which is more advanced than you might expect for such an apparently simple circuit. In fact you need calculus and differential equations to describe what is happening.

The results of performing the calculus are equations for the voltage at given times after the capacitor starts charging, and for the time taken to reach a particular voltage. These formulae can be applied in many circuit situations without the need to go back to calculus. The formulae involve the exponential function or natural logarithms, which we looked at in depth last month. For reference, see the basic RC Equations panel.

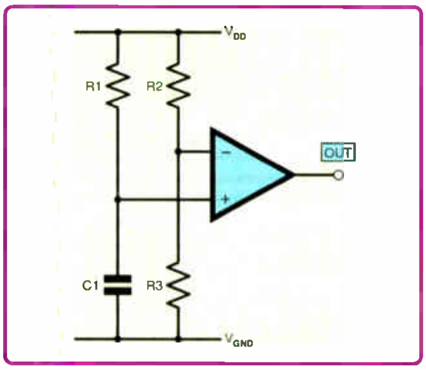


Fig.1. Simple comparator-based timer triggered at power up

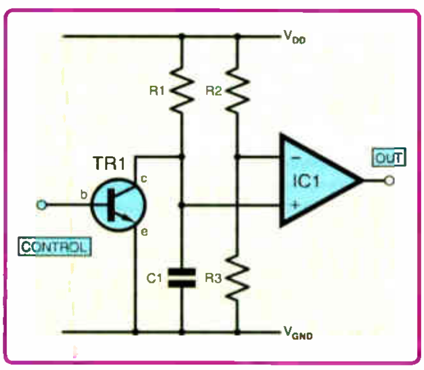


Fig.2. A discharge transistor added to the circuit in Fig.1 allows it to perform its timing operation more than once after power-on

Last month we started looking at more practical aspects of RC timing. We arrived at the circuit shown in Fig.1.

This circuit uses a comparator to detect when a charging capacitor reaches a particular voltage, determined by the potential divider R2 and R3. This circuit represents a portion of the 555 and we will develop it from this point to the full 555 block diagram by adding extra functionality. First, though, a quick word on timing formulae.

Timing Formulae

Rather than thinking of the comparator switching point for Fig.1 as being at a particular voltage, it is better to consider it as a fraction of the supply voltage. If we do this, then as we saw last month, the applied voltage (supply voltage) can be cancelled from the charging equation. We get

$$t = -RC \cdot \ln(1 - k_1)$$

where in the specific case of the circuit in Fig.1

$$k_1 = \frac{R3}{R2 + R3}$$

For which we can find the value of the natural log (call this k_2) to get

$$t = k_2 RC$$

Table 1 shows some RC timing formulae for a few simple fractions (k_1 values) and special case of $k_1 = 0.632$ for which $k_2 = 1$

The circuit in Fig.1 is not particularly useful because it only times once when power is applied. This is easily solved by adding a transistor to discharge the capacitor, which is what is done in the 555. Applying a signal to the control input to turn on TR1 will discharge the capacitor. If the control input is then held at 0V, C1 will start charging and the comparator will switch at the time determined by the

Table 1. Example RC charging equations for different fractions of applied voltage

Fraction of applied voltage	*Timing Equation (comp switches at)*
1/3	$t = 0.405RC$
1/2	$t = 0.693RC$
0.632	$t = RC$
2/3	$t = 1.10RC$
3/4	$t = 1.39RC$

supply voltage fraction set by resistors R2 and R3. The timing formulae in Table 1 can be applied (R = R1 times C = C1) in this situation.

Triggering

In general, if we want to start a timing operation in a circuit it is better to trigger it using the edge of the control waveform, that is a 1 to 0 or 0 to 1 transition, rather than requiring that the control signal is held in place for at least the duration of the timed period, as is the case with the circuit in Fig.2. To achieve this we can use a flip-flop to hold the control signal in the appropriate state – see Fig.3.

In the circuit in Fig.3, when the circuit is idle the output is low and the control signal is high, so the transistor is on and the capacitor is discharged. When the trigger input goes low, the flip-flop sets, so Q (and hence the output) goes high, and $\overline{Q}$ goes low, causing the transistor to

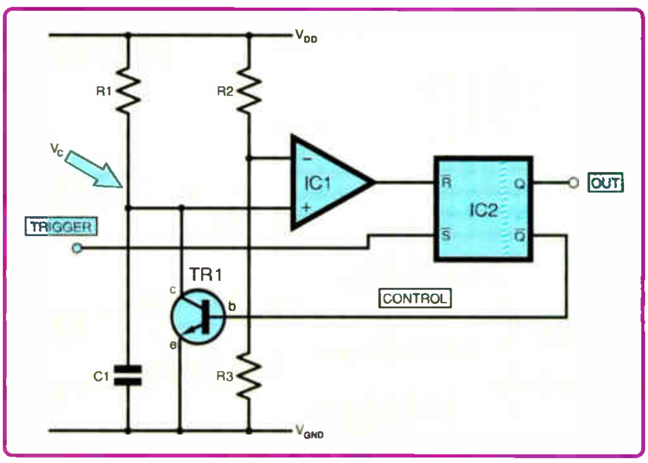


Fig.3. Timer with edge-triggered start

turn off, allowing the capacitor to charge. Thus the timing cycle starts and V_C charges towards the supply voltage.

When V_C reaches the comparator (IC1) threshold set by R2 and R3, the comparator switches (output goes low) and the flip-flop (IC2) is reset. The circuit output (flip-flop Q) goes low again and the transistor switches on, discharging the capacitor. This removes the reset signal from the flip-flop so it is ready for the next trigger input. The circuit waveforms (for two timing operations) are shown in Fig.4.

The timing period for the circuit in Fig.3 is the same as that in Fig.2. The circuit in Fig.3 performs in almost the same way as the 555 in monostable mode. For the 555, the comparator switching threshold is set at two-thirds of the supply voltage by internal resistors (equivalent to R2 and R3), thus from Table 1 (or formulae given above) the timed period, T, is

T= 1.1RC

The circuit in Fig.3 requires a short trigger pulse, just as the 555 does, which only has to be long enough to set the flip-flop and which must be shorter than the monostable timing period. In standard 555 monostable circuits, R1 and C1 are the external timing components (R2 and R3 are internal, as already mentioned).

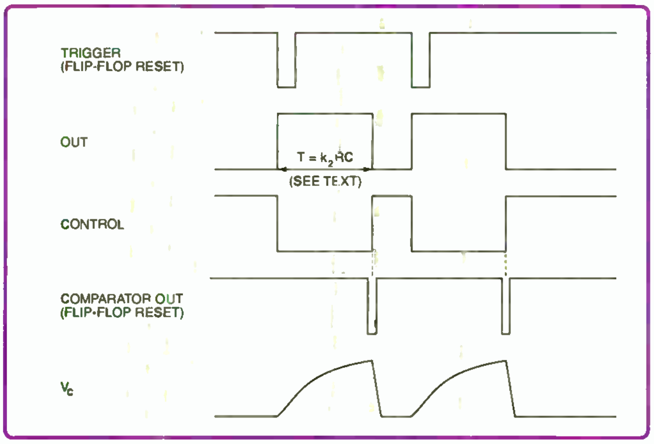


Fig.4. Waveforms for the circuit in Fig.3 for two timing operations

Continuous Pulses

So far all the circuits we have discussed have provided monostable or 'one-shot' timing. It is also common to need a continuous sequence of timed pulses, referred to as astable or 'free running' operation. To achieve this we need to continuously switch between charging and discharging the timing capacitor.

The waveform in Fig.4 shows the capacitor voltage falling very quickly once the transistor turns on to discharge it. The capacitor will follow a discharge curve whose timing is governed by the effective collector to emitter resistance of the transistor. This resistance is small and so the discharge is rapid, however, if we insert a resistor in series with the transistor we can slow down the discharge to be similar to the charging time.

In Fig.5 is shown part of the circuit from Fig.3 with the addition of a possible way of including a discharge resistor. This is perhaps the most obvious way to do it, but it is not ideal because R1 and R4 create a potential divider which would prevent the capacitor fully discharging. Hopefully this can be seen clearly in the simplified equivalent circuit.

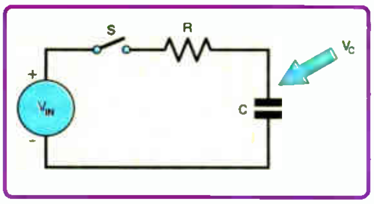
A better approach is shown in Fig.6, in which the capacitor charges through both R1 and R4 and discharges through R4. Note that in Fig.6 when the switch is closed and the capacitor is discharging, resistor R1 is effectively connected to ground and does not contribute to the timing or voltage on the capacitor. This resistor arrangement is used in the standard 555 astable circuit, in which resistors R1 and R4 are the external timing resistors.

Our current circuit (Fig.3) has a single comparator which detects when the capacitor voltage reaches the limit to

RC EQUATIONS

Capacitor Charging

C charges from 0V towards V_{in} through R when S closes at time $t = 0$



Voltage at time t after S closes

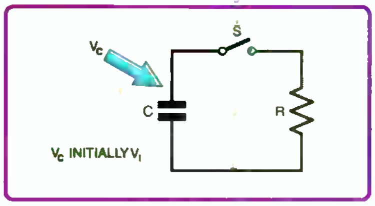
$$V_C = V_{in}\left[1 - exp\left(\frac{-t}{RC}\right)\right]$$

Time after S closes taken to reach voltage V_C

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

Capacitor Discharging

C discharges from V_i towards 0V through R when S closes at time $t = 0$



Voltage at time t after S closes

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

Time after S closes taken to reach voltage V_c

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

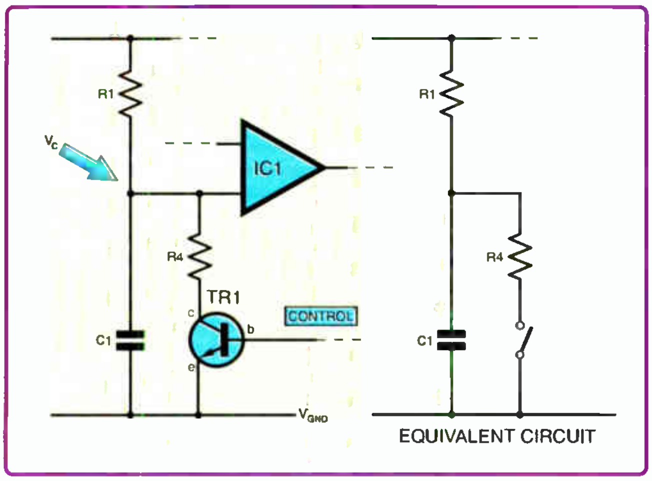


Fig.5. Showing where a resistor could be inserted in the circuit in Fig.3 to set the discharge time. Fig.6 shows a better approach

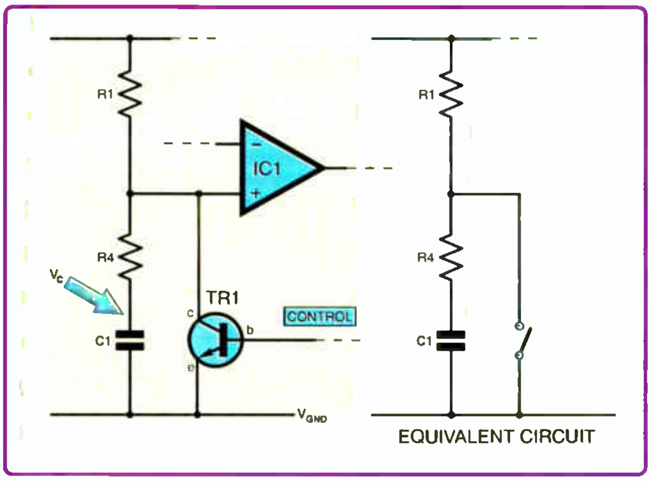


Fig.6. Better approach to adding a resistor to control discharge timing.

which we want it to charge (at the end of the charging period). For astable operation we also need to define the end of the discharge period and detect when the capacitor reaches this voltage. We need another comparator to accomplish this. Obviously the discharge limit voltage must always be less than the charging limit voltage. A good circuit arrangement for this is shown in Fig.7.

In Fig.7, comparator 1 (IC1) is used to detect the charging limit. This is equivalent to the comparator we have already used. Comparator 2 (IC2) is a new addition to our circuit and detects the discharge limit.

Both comparator thresholds can be expressed as fractions of the supply voltage as follows:

$$k_{comp1} = \frac{R3 + R5}{R2 + R3 + R5} \quad k_{comp2} = \frac{R5}{R2 + R3 + R5}$$

If all three resistors have the same value (R2 = R3 = R5) we get k_{comp1} = 2/3 and k_{comp2} = 1/3. This is what is done in the 555 (these resistors are internal components).

Astable Operation

Fig.8 shows the full circuit for astable operation – Fig.3 with the additional circuitry that we have just discussed. The circuit operates as follows. At power-up C1 is fully discharged. The voltage is below the lower threshold, so comparator 2 will set the flip-flop and the transistor will be off, allowing the capacitor to charge towards V_{DD} through R1 and R4.

As V_C passes $k_{comp2}V_{DD}$ (one-third supply for the 555) comparator 2 switches and removes the set signal from the flip-flop, but it remains in the set state. The capacitor continues to charge. When V_C reaches $k_{comp1}V_{DD}$ (two-thirds supply for the 555) comparator 1 switches and resets the flip-flop. This switches the transistor on and C1 starts discharging via R4 and TR1.

V_C will very quickly drop below $k_{comp1}V_{DD}$ (two-thirds supply) switching comparator 1 and removing the reset signal from the flip-flop, which however will remain in the reset state. The capacitor continues to discharge through R4 and the transistor. When V_C passes $k_{comp2}V_{DD}$ (one-third supply) comparator 2 will switch and apply a set to the flip-flop. This will switch off the transistor allowing C1 to charge again through R1 and R4. V_C will very quickly rise above $k_{comp2}V_{DD}$ (one-third supply) again switching comparator 2 and removing the set signal from the flip-flop, which however will remain in the set state.

This process will repeat indefinitely so that V_C will charge up to $k_{comp1}V_{DD}$ and then discharge to $k_{comp2}V_{DD}$. For the 555, the capacitor voltage oscillates between one and two-thirds of the supply voltage.

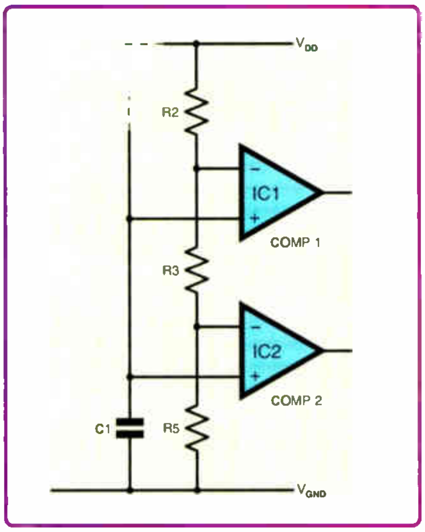


Fig.7. Resistor and comparator arrangement to detect charge and discharge limits for astable operation (timing resistors and discharge transistor not shown)

Calculating Astable Timing

To calculate the timing period of the astable, we have to work out the charge time and the discharge time and add these together. For this we will assume that the charge and discharge limits are set to two-thirds and one-third of the supply voltage respectively, as they are in the 555.

In these articles we have not developed a formula to directly give us the time taken to charge from one-third to two-thirds of the supply (or similar situations), but this is straightforward to work out. All we have to do is take the time taken to reach two-thirds of the supply charging from 0, and subtract the time taken to reach one-third of the supply voltage charging from 0.

$$t_{charge} = -RC \cdot \ln(1 - 2/3) - -RC \cdot \ln(1-1/3)$$
$$t_{charge} = -RC \cdot \ln(1/3) + RC \cdot \ln(2/3)$$
$$t_{charge} = 1.09861RC - 0.40546RC$$
$$t_{charge} = 0.693RC$$

For charging we have R = R1+R4 and C = C1 so for the circuit in Fig 8 we get

$$t_{charge} = 0.963(R1 + R4)C1$$

For the discharge phase the situation is simpler – we can use the discharge formula we have discussed before directly (see RC panel). Written in terms of initial voltage fraction k_I, the formula becomes:

$$t = RC \cdot \ln\left(\frac{1}{k_I}\right)$$

If the initial voltage is two-thirds of the supply and the voltage we are interested in is one-third of the supply, so we have a situation where the capacitor voltage falls to half its initial value, that is k_I = 1/2. So the discharge time is:

$$t_{discharge} = RC \cdot \ln(2)$$
$$t_{discharge} = 0.693RC$$

For discharge we have R = R4 and C = C1, so for the circuit in Fig.8 we get:

$$t_{discharge} = 0.693R4C1$$

The total time of one cycle, T, is the sum of the charge and discharge times:

$$T = t_{charge} + t_{discharge} = 0.693(R1 + R4)C1 + 0.693\ R4C1$$

$$T = 0.693(R1 + 2R4)C1$$

The frequency of oscillation of the astable is $f = 1/T$ so:

$$f = \frac{1.44}{(R1 + 2R4)C1}$$

These formulae (T and f) give the timing for the standard 555 astable.

The modified circuit in Fig.8 can also be used to form the basis of the monostable shown in Fig.3 (note that R4 is not present in the monostable). One difference is that the trigger signal passes through comparator 2 rather than being connected directly to the flip-flop. This means that the monostable trigger activates as the trigger voltage falls below one-third of the supply. Note that the trigger signal is connected to the external trigger, not to the capacitor for monostable operation.

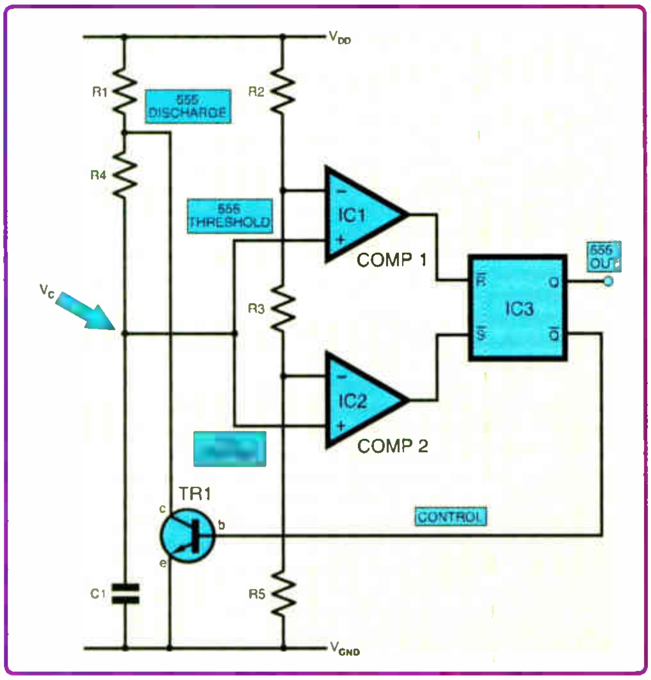
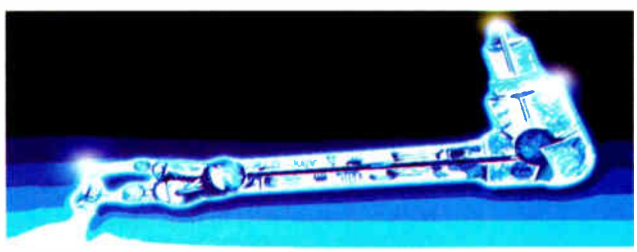


Fig.8. Astable timer circuit. This is very similar to the 555 in astable mode. Signals corresponding with pins on the 555 are indicated on the schematic



Net Work

Alan Winstanley

Recycle Risk Confirmed

This month's *Net Work* is over to you, readers, with your feedback following up on recent articles.

In October's issue I described how old computers and personal data dumped by consumers onto British rubbish tips were finding their way into the hands of Nigerian dealers. I suggested various software products that could shred personal data thoroughly, to protect against data theft once a disk is discarded. A reader supplied more background:

"Your October 2006 column queried how personal computer hardware and data could end up on sale in Nigeria. I run an electronics repair company, and I buy faulty discarded electronic equipment that I refurbish and sell on: for years my source of this faulty equipment has been the local authority rubbish tip or 'recycling centre'.

"Most people associate the word 'recycling' with items that have been smashed up, melted down and made into something else, but in reality this is far from the truth. Go to your local recycling centre with a pocket full of cash and you can buy anything on display, of course items such as TVs and videos will probably be faulty and require some sort of repair – no problem to someone like myself, but computers are usually thrown away working because people have upgraded to the latest model.

"Two computers I have bought in the past come to mind, one was from a solicitor's office and contained confidential files and letters, and another came from a florist and had company accounts, names and addresses of bad payers etc. One guy I met was removing hard drives and buying them for a couple of pounds a time, when I questioned what use he had for them he said: "none at all, I just put them on eBay and sell them at a profit". It's not really difficult to see how your old hard drive can end up in Nigeria." ***Name and address supplied.***

Thank you for confirming what I half-suspected. It is also why I remove disk drive platters and destroy them completely, rather than allow them to be 'recycled'. In my local county, however, it seems the policy is to 'rotate' the staff on duty at recycling centres to prevent people becoming too friendly with them.

A Better VNC?

Thomas Stratford writes: "In last month's *Net Work* article you mention Real VNC as a way of remotely operating a PC. We use it all the time at work as it works really well but the screen refresh is a little slow. I have recently found out that there were security flaws in Real VNC, see the Techtarget web site at **http://tinyurl.com/y95h6q**

"One of our customers was hacked, they had Real VNC loaded. The hacker opened Microsoft Word and defaced a document, closed Word again then disconnected. If we find Real VNC installed now we are removing it and installing Tight VNC instead, from **www.tightvnc.com**."

Tight VNC is claimed to be an enhanced version of Real VNC. An upgrade claiming to fix all known security issues was posted by Real VNC in May 2006, and a limited version of the latest version 4.1.2 is available as a free download from **www.realvnc.com**. Incidentally readers, Thomas does a sterling job of running the Official *EPE* PIC Mirror Site at **http://homepages.nildram.co.uk/%7Estarbug/epepic.htm** or link via the *EPE* Downloads page. This is a very useful web-style front end to almost every *EPE* PIC source code ever published.

IP Cameras

My thanks to regular reader ***Allan Sancto EA/G0LFM (via email)*** who writes from Spain:

"I read with great interest your *Net Work* article about webcams in September 2006 *EPE*. We have lived in rural Spain for a few months and were just beginning to feel at home and reasonably secure, when my nearest neighbour some 200 metres away was burgled in spite of a very expensive alarm system connected (via mobile phone technology I believe) to the nearest Police Station! I have the same system!

"Consequently your piece on Webcam security looks very interesting for our purposes. If I wish to connect more than one camera, would it not be necessary to provide some amplification on cable runs longer than the average webcam connection to the PC?"

For reliable operation, there is a theoretical limit on a USB lead length of 5 metres or so. The simplest solution is an Active 5 Metre USB repeater cable, which amplifies the signal over longer cable runs. One supplier claims that you can daisy-chain up to five of them together, so you could make up to a 25 metre USB link. Examples are on eBay (search for 'USB repeater') for roughly £6 to £10 each. This becomes a bit pricey for a multipie camera setup, though.

Note that webcams tend to use a fair amount of power (judging by how warm mine becomes) so if you use multiple cameras it might be worth trying a powered USB hub, running from a mains adaptor (see our *USB Power Injector* in this issue).

A smarter but far more expensive solution to the cable problem is to use an 802.11g wireless IP camera – the IP (Internet Protocol) bit means that it acts as its own server with its own IP address (so no host PC is needed), so it can be hooked directly to a TCP/ IP network wirelessly. The clever Panasonic BLC30 (see photo) is a tripod-mountable indoor wireless camera offering PIR motion detection, remote control of pan and tilt via a PC or Internet-connected mobile phone, a Privacy button and E-mail snapshots.

The wireless signal is encrypted to prevent unauthorised interception. Panasonic claims that setup is very simple but a bit of experience of handling an IP network might be handy. Wireless network users will know that brick walls, copper pipes, wiring etc. tend to interfere with the signal range. More details and a data sheet from **www.panasonic.co.uk/ip-cameras/blc30.html**. Online vendors of the BLC30 include **www.ipcctvcameras.co.uk**

A wide range of wireless CCTV cameras and other dedicated devices are available by mail order from Cricklewood Electronics (**www.cricklewoodelectronics.co.uk**) and Henrys Electronics (**www.henrys.co.uk**).

If you have any comments or possible suggestions for future topics, you can email the author at **alan epemag.demon.co.uk**

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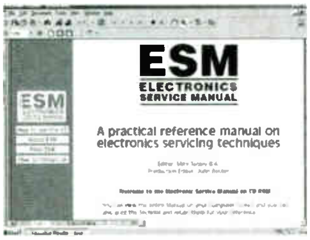

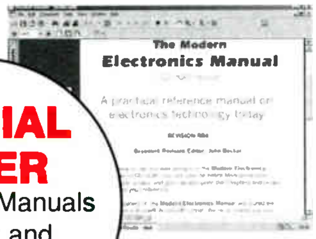

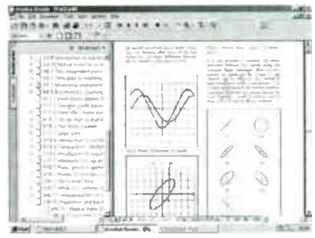

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READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

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★ LETTER OF THE MONTH ★

Un-flash PICs!

Dear EPE,

I know John is always interested in PICs, so this is what happened to me recently.

There was a terrific storm here with tremendous thunder and lightning. There was one almighty flash and an instant roll of thunder and I thought it had hit the house. In fact, it had hit a tree about 100 yards away and several houses nearby had their windows blown in. In my case it blew the modem, completely dead, and it had to be replaced.

My HAL project, which controls the house, had its LCD display completely destroyed. There was nothing – it was completely dead. I replaced it and then found that the PIC16F877 controlling the system was completely unharmed. It was ticking away quite merrily. The 877 must have been extremely robust.

Peter (*Chat Zone* user Merlin), via email

That's an amazing tale Peter. You were lucky in many ways. The nearest I've been to a lightning strike was in Malaya many years ago, it felled a tree near where we were in a jungle hut sheltering from the monsoon rain while filming (when the rain stops!), and long before PICs were invented. Only just missed the hut.

Li-ion Batteries

Dear EPE,

Batteries for lions (*Readout* Sept '06)? What will they think of next?

Seriously though, I have at least three of them in various units and I have not experienced the problems highlighted by Godfrey Manning. With all these new batteries, like NiCads, they all loose a small percentage of the stored charge weekly and I can only assume that Godfrey's friend had an older digital camera which was battery hungry.

I still have a four-year old Ricoh camera, complete with power zoom, which needed four sets of four spare AA rechargeables if you went out for the day and just took about 40 shots, and that was not using flash either. I later got hold of a set of big 1.2V rechargeables from JPG Electronics (see their ad) which I wired up into two sets of four and carried them around in a holdall connected to the camera by a three-foot cable, and even then I used to exhaust one set after about 60 shots.

Luckily the camera could only support a 32 meg memory card. If it had supported a one gig card, like the present camera, it would have needed a shopping trolley to carry enough batteries.

My latest camera is a two-year old Fuji that has twice the resolution, a 256 meg card and a spare battery I carry around, and I have never had cause to use it yet.

George Chatley, via email

Thanks George, I passed your comments on to Godfrey.

On the subject of unusual uses for batteries, I once jokingly commented to a woman that the discarded batteries in the pond we were both looking at were food for the electric eels in there. And she believed me!

Screwdrivers Update

Dear EPE,

I've an update for my letter, *Screwdrivers* in *Readout* Oct '06. I've just received the latest Maplin catalogue and see that they now include a triangular screwdriver bit in a 62-piece set, order code N53AW. Unfortunately, it costs £19.99 (plus carriage if a small order). Anyway, as nothing else was forthcoming, I stumped up the cash, the set arrived and indeed there is a 2 × 2 × 2mm equilateral-triangle bit.

It's a slightly sloppy fit to the No.4 self-tapper that's shown with my letter, also it's on a 6mm hex shank and so can't go far down a counterbore. But it's better than nothing. The set also contains ranges of the more established security bits, but includes some of the unusual sizes, plus a rather nice ratcheting handle for holding the bits. So, worth buying for these various features put together.

Godfrey Manning, via email

That's good news Godfrey. A happy ending to a very detailed search.

Readout Error and Food Allergy

Dear EPE,

I've spotted an error in *Readout* Oct '06 regarding Robert Powell's good idea for fluorescent light capacitor testing. Fig.1 text says 'all in series' = 13.8 ohm, but the resistors are shown drawn in parallel = 3.33 ohm, oops!

A quickie about food allergy testing with a Vega? electronic machine – a lady friend of ours has just had a food allergy test and described how different glass phials with various food substances were used to diagnose her reaction by measuring skin resistance. As she described the test I could not see how her body could react to anything in an insulated glass tube.

I then did a bit of research on the net and found that the BBC had run a program de-bunking the machine. Now my total medical knowledge is confined to an aspirin tablet, but... are there any of your readers who can explain how such a machine could work? What if an AC carrier/current of x-frequency was passed through the substance in the glass tube as a capacitive dielectric and then through the person under test? Food for thought?

Great mag, eagerly awaited every month!

Bryon Epps, via email

Whoops, that oversight is down to me! I no longer have Robert Powell's email address, and cannot check with him, what he really meant to say/show. Robert – are you tuned in here? If so, drop me an email via HQ please.

Regarding the question, readers can you help Bryon?

Chip off the Old Block?

Dear EPE,

It's nice to know that there are still people who make good use of salvaged components – not to mention pieces of kitchen chopping boards – in order to create something new and useful (*Human Powered Torches*, Sep '06).

Thank you for the interesting article. Now I know what to do with my old stepper motors.

Francis K. Hall, Meinerzhagen, Germany

So many things, Francis, have uses well beyond that which they were designed for. That's a general philosophy I follow when I'm designing something and am looking for unusual non-electronic parts. Amazing what you can find that has multiple uses if you put your mind to it.

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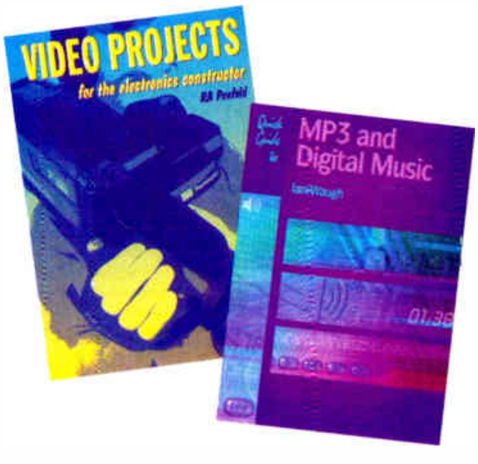

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Robert Charles Alexander

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During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

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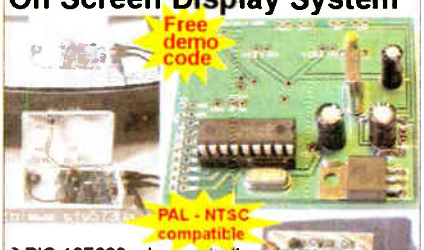

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