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NEW ELECTRONIC CONSTRUCTION KITS

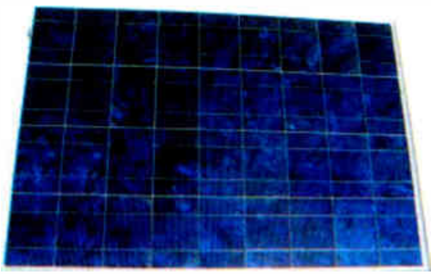
This 30 in 1 electronic kit includes an introduction to electrical and electronic technology. It provides conponents that can be used to make a variety of experiments including Timers and Burglar Alarms. Requires: 3 x AA batteries. £15.00 ref BET1803

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

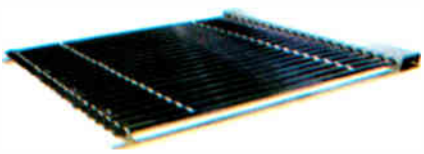
The 75 in 1 electronic kit includes an nintroduction to electrical and electronic technology. It provides conponents that can be used to make and test a wide variety of experiments including Water Sensors, Logic Circuits and Oscillators. The kit then progresses to the use of an intergrated circuit to 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

2kW WIND TURBINE KIT

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

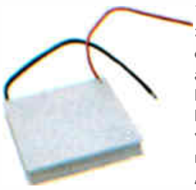
Other sizes available from 200 watts (£299) up to 20kW (£13,999) The 200w system is complete apart from 2x12v batteries and concrete for the tower. These low cost systems can provide substantial amounts of power, even in average wind conditions.

STEAM ENGINE KIT

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

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

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



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

£14 ref TEL1

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

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

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

HEAT PUMPS

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

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

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

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

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

This type of installation offers many advantages.

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

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

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

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

e) No regular maintenance required.

Some tips

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

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

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

ISSN 0262 3617

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

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EPE EVERYDAY PRACTICAL ELECTRONICS

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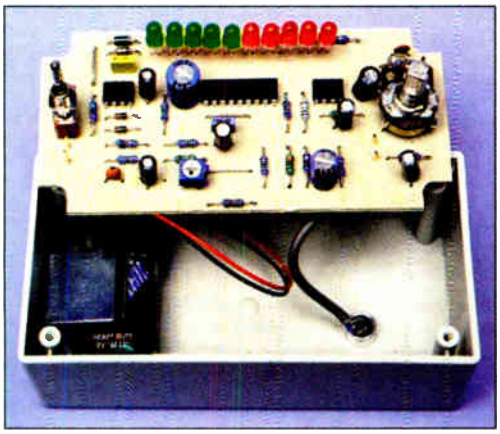

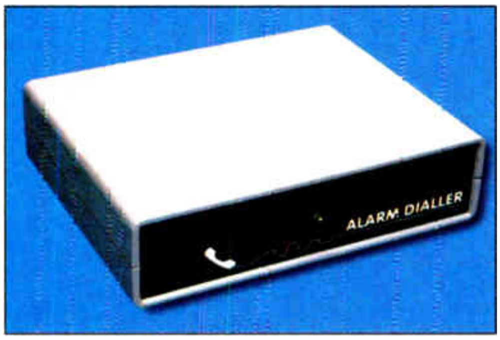

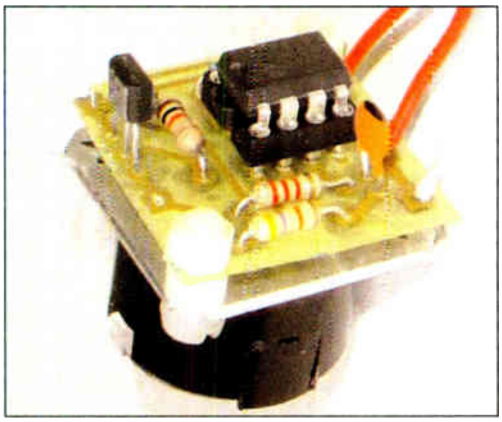

Projects and Circuits

Series and Features

Regulars and Services

Our September 2006 issue will be published on Thursday, 10 August 2006. See page 80 for details

EPE PROJECT PICs

Programmed PICs for EPE Projects

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

1kV/500V Insulation Tester

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

KIT 848...£32.95

DUAL OUTPUT *TENS* UNIT

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

KIT 866 .. £32.90
Inc. 4 electrodes

Set of 4 Spare Electrodes £6.50

EPE MICROCHIP P.I. Treasure Hunter

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

KIT 847 ... £63.95

Kit Includes Headphones, coil and all Hardware

Ultrasonic PEsT Scarers

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

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

MOSFET MKII Bench PSU 0-25V 2.5A

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

Kit 845 ... £64.95

68000 Trainer Kit 621.. 99.95

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MD100 100 step Unipolar..... £9.99
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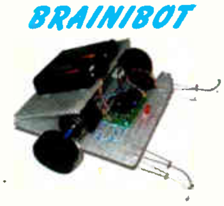
MD24 Type '23' size 200 step..£22.95

MAGENTA BRAINIBOT I & II



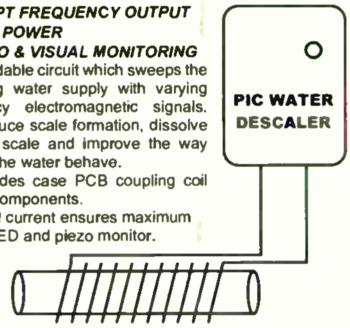
- Full kit with ALL hardware and electronics.
- As featured in *EPE* Feb '03 (KIT 910)
- Seeks light, beeps, and avoids obstacles
- Spins and reverses when 'cornered"
- Uses 8 pin PIC chip
- ALSO KIT 911 - As 910 *PLUS* programmable from PC serial port leads and software CD included

KIT910..£16.99
KIT911..£24.99

PIC PIPE DESCALER

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

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



KIT 868 .. £22.95 PSU £3.99

12V EPROM ERASER

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

KIT 790 ..... £29.90

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

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- **Top quality display** with industry standard driver, data and instructions

KIT 860.£19.99

PIC STEPPING MOTOR DRIVER

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

KIT 863.........£18.99

8 CHANNEL DATA LOGGER

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

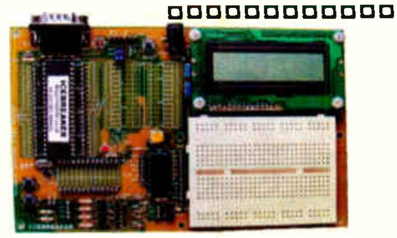
KIT 877.........£49.95

SUPER PIC PROGRAMMER

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

KIT 862. £29.99 Power Supply £3.99

ICEBREAKER



PIC Real Time
In-Circuit Emulator

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

KIT 900..£34.99
PSU £3.99

ICEbreaker uses PIC16F877 in-circuit debugger functions.

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

20W Stereo Amp.

EPE May '05 -- Magenta Stereo/Mono Module

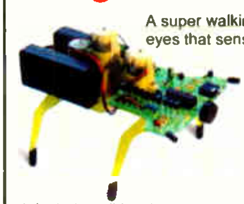
Wide band Low distortion 11W / channel Stereo 20W Mono. True (rms) Real Power

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

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

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

Magenta BrainiBorg



A super walking programmable robot with eyes that sense obstacles and daylight.
BrainiBorg comes with PC software CD *(WIN95+ & XP)* with illustrated construction details, and can be programmed to walk and respond to light and obstacles on any smooth surface.
Kit includes all hardware, components, & 3 motor/gearboxes
Uses 4 AA batteries *(not supplied)*.

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

EPE PIC Toolkit 3

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

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

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

OR - Built & Tested £49.99 & £55.99

EPE TEACH-IN 2004

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

KIT920..£29.99

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

KIT921.£12.99

Reprints £1.00 per part.

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

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Power For The Future

A recent announcement of a wave energy project based in the South West of the UK indicates how environmentally friendly generation of electricity is now coming to the fore. No doubt everyone has now seen a wind farm and this form of generation using "free" energy seems to be one way forward – although it does of course have its attendant problems, like noise and visual pollution.

I expect that wave power no doubt also carries attendant problems and does seem to have been a long time in the development stage. We are aware of wave power generators deployed in Hawaii and New Jersey but now, with the support of the South West of England Regional Development Agency, a "Wave Hub" is being built off the Cornish coast. This will allow development systems to be plugged into a "socket" on the sea bed which will provide a connection to the national grid.

A number of different wave energy generators from various companies will be deployed, in an area about 10 miles out to sea, to undergo long-term testing and further development. Initially three companies have been chosen as partners, each with radically different devices from huge floating articulated tubes to buoys and floating platforms similar to offshore oil rigs.

How much energy can be supplied in this way is yet to be determined, but a report by the Carbon Trust suggests that power from the sea – both wave and tidal systems – could provide up to 20 per cent of the UK's electricity needs. However major investment is required and the Wave Hub is at least a step in the right direction.

Most modern electronic devices need relatively small amounts of power, however, with so many now in use the overall requirement is growing daily. Nuclear power is one obvious answer but if we can find alternative means of generation, even if it is for only part of the requirement, then so much the better. I guess power from the sea is perhaps one of the most environmentally friendly solutions presently available.

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PROJECTS AND CIRCUITS
All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages 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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News . . .

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

DIGITAL SWITCHOVER COSTS

Digital switchover is not quite as straightforward as some had hoped, especially if "spin" is in the air, as Barry Fox reports.

SWITCHING the UK from analogue to digital TV will cost British broadcasters and BBC licence fee payers, £700 million. And that's not counting the cost to consumers of converting or replacing TVs, VCRs and aerials. It's also not counting the money given to "vulnerable" viewers who cannot afford to convert.

With puzzling timing, Digital UK, formerly SwitchCo, launched a campaign on local election results day to try and prepare UK viewers for the end of analogue broadcasting "starting in the Northern Border regions in 2008 and ending in London in 2012", hopefully without denying anyone the chance of watching the London Olympics. In each area there will be a four week grace period at switch-off, with one channel shut down ahead of the rest to warn viewers they cannot wait any longer before converting.

Digital UK

Digital UK was legally registered as a company in May 2005, and started work in earnest in September 2005 when Tessa Jowell (Secretary of State for Culture, Media and Sport) confirmed the 2008-2012 timetable. DUK now occupies plush offices in Central London, once used by Thorn EMI for its ill-fated interactive video ventures.

British broadcasters are paying the £500m it will cost to upgrade the transmitter network and the BBC licence fee – which all viewers are required by law to pay – will pay £200m for communications and assistance. The BBC will also provide an as yet undecided amount from the licence fee pot to help the old, disabled and poor.

The first £5m four week TV advertising campaign features an electronically created robot called Digit Al who appears trapped behind TV screens and explains digital TV, sometimes interrupting adverts from Sony and Guinness. Modelled on the British Gas Sid adverts, Digit Al may be sufficiently irritating to be memorable. All homes in the country will also receive at least two copies of a leaflet explaining what digital TV is all about.

Switchover Figures

DUK's figures, largely coming from regulator Ofcom, show 25m TV households, with 18m digital and 7m to be converted; at an average of 2·4 TVs per household there are over 60m TVs in the UK, so 40m remain to be converted. "Thirty percent of homes are analogue only, 45% have one digital TV and 25% are fully digital", says Ford Ennals of DUK. "Twenty percent of homes have more than four TVs but they are not all in use, for instance in home guest rooms – so some can be converted later".

"About 60% of people say they have heard of switchover, which is not a bad number", says Ennals, "but we should not get a sense of false security. Analogue TVs are still for sale and people are buying more of them than digital TVs. DUK is promoting Ofcom's estimate of £132 to convert an average household with two TVs and one VCR (based on £25 per TV converter box) and believes that only a "small percentage – around 10% – of roof top aerials will need replacing, at a parts and labour cost of between £70 and £150".

Unclear Advice

DUK's figures and advice on VCR conversion are less clear. In response to my question, Ford Ennals estimates there are 30m VCRs in the UK, of which 25% are used for time-shifting, so up to 10m VCRs will have to be changed. "PVRs are now outselling VCRs", he says, but then had to admit that many PVRs are Sky+ boxes which only work if the viewer pays a subscription to Sky. DUK is quoting figures and explanations on the practicality of VCR conversion from Ofcom that I have several times previously queried with Ofcom.

"Viewers will only be able to record the same channel that is being watched unless the viewer uses two boxes, one for the TV and one for the video", says DUK's explanatory note on converting a VCR. Ennals (DUK) and Huw Rossiter of Ofcom both agreed when pressed that converting a VCR requires skill, because the VCR must be switched to record from its Auxiliary sockets, not its off-air analogue tuner, and timer control or VCRPlus/VideoPlus will only switch the analogue tuner unless the system is set to use an IR blaster to switch the digital box.

"We are looking at ways of communicating on this", says Ennals, "We are expecting retailers to answer questions and explain issues like this", says Laurence Harrison.

Conversion Price

The price of converting a TV is put at £25 (the current lowest price for a Freeview box) but the price of converting a VCR is put at £80. When asked why it costs £80 to connect one or two £25 boxes to a VCR, Ford Ennals said that "he believes VCR here means PVR". But DUK spokesperson Joe Smithies contradicted, saying "£80 is the cost of the VCR conversion". Huw Rossiter of Ofcom has now confirmed that Ofcom's reference to VCR means PVR! The £80 figure, he says, is the cost of a PVR, which are now on sale in some UK supermarkets for under £100.

After the launch event, Beth Thoren, communciations Director for DUK, appeared on *BBC TV News* and was asked what proportion of homes have already made the switch? Her answer was clear and misleading: "70% of homes have digital already". Which of course means only that 70% have some form of digital TV reception in at least one room. So spin is already in the air.

Lead-Free Solder Database

ELFNET, the European Lead-Free Soldering Network, has collaborated with COST 531 to deliver a much-needed database of physical and mechanical properties for the new Tin-Silver-Copper (SnAgCu) lead-free solder alloys. This data is key to modelling behaviour of lead-free solder joints that from July 2006 are at the heart of most electrical and electronic equipment in Europe.

"ELFNET has been bringing together communities of research and industry experts to prioritise lead-free technology implementation issues and develop collaborative solutions", comments Dr Jeremy Pearce, ELFNET Co-ordinator. "This database represents a key achievement in exploiting expertise in the academic research community to the direct benefit of the electronics industry."

Some such databases do already exist, although some are closed to public access. COST 531 is a network of over 60 Universities across Europe, coordinated by University of Vienna, Austria. This resource has special expertise in metallurgical research and had already begun to generate data on lead-free solder alloys.

The SnAgCu alloy family was selected as the first priority based on its use as the predominant lead-free solder in the industry.

The data is output as a user-friendly downloadable PDF file, with data presented clearly with diagrams, tables and detailed references. The first version of the new database was launched at the *SEMICON Europa 2006* exhibition in Munich in April 2006 and can be accessed for free on the ELFNET website: **www.europeanleadfree.net**. A second version will expand the range of the database to include SnAg and SnCu alloys.

IMPROVED ESR METER

Peak Electronic Design Limited have announced that their Atlas ESR has undergone a major performance improvement, a real boost for repair engineers and technicians. The Atlas ESR, which measures both capacitance and ESR (equivalent series resistance), can now cope with double the dynamic range of ESR, now 20 ohms instead of 10 ohms. This has been achieved by implementing enhanced hardware and new software without sacrificing accuracy or analysis speed. In fact, accuracy has been improved!

Just connect the Atlas ESR any way round to your capacitor (even in-circuit) and press test. The unit will automatically power-up, measure capacitance (up to 22,000μF) and ESR to a resolution of 0·01Ω! As before, the Atlas ESR can even cope with highly charged capacitors thanks to its automatic controlled discharge function and self-protection feature.

Measurements are made at the industry standard 100kHz using low signal levels to ensure polarity independence and compatability with sensitive circuits. The meter will automatically power down after a period of inactivity, so you'll never forget to switch it off. Measuring just 103mm × 70mm × 20mm, it fits in the palm of your hand or safely in your pocket. This handy device is supplied complete with a fitted alkaline battery, illustrated user guide and capacitor reference chart. Standard probes are gold plated "kelvin wired" croc clips.

The Atlas ESR is available from many distributors including Farnell and Maplin as well as directly from the manufacturer for £89.00 fully inclusive of UK delivery and VAT.

Contact: Peak Electronic Design Ltd, Dept *EPE*, Atlas House, Harpur Hill Business Park, Buxton, Derbys SK17 9JL. Tel: 01298 70012. Fax: 01298 70046. Email: sales@peakelec.co.uk. Web: **www.peakelec.co.uk** (for more information, downloads and online ordering)

Users of the older versions (< V2·2) of the Atlas ESR can contact Peak to discuss hardware and firmware upgrade options.

Pink and Pretty DAB

Bush's TR2005DABPNK Portable DAB Radio with PLL FM Tuner went into ASDA stores recently, boasting DAB Digital technology with a girly edge! The classic look, pink faux leather DAB Digital Radio has cutting-edge DAB Digital Radio technology built-in. There's a choice of DAB Digital Radio stations on offer, as well as your usual FM stations.

The easy-to-read 2-line backlit display shows scrolling text that tells you exactly what you're listening to, plus extra information from the radio station like the program or competition details. Once you switch on, all the DAB stations are automatically tuned in and you can store your favourite 10 DAB and 10 FM stations into the memory.

Features include stereo speakers, battery or mains powered, sleep timer, easy-to-read 2-line LCD display provides track information, News and sports results. Asda's price is £49.50.

European Technology Events

Tech Event Guide Ltd has announced a new searchable online database which aims to become the definitive free listing of technology events throughout Europe. Unlike other listings, the online Tech Event Guide (**www.techeventguide.com**) includes information on key industry shows and conferences as well as company-specific seminars and training days provided by manufacturers and distributors.

Registration to the site is free and electronics engineers can browse a continually updated list of events by date, name or location, or make a selective search for events by location and key products areas. Users can download registration forms and event literature directly from the Tech Event Guide website or to click a link through to the event's own web-site for additional information. Once registered, users can create their own "My Tech Event Guide" profile so that they can monitor every opportunity to improve their skills and industry knowledge within their chosen locations, product groups and industry sectors.

Mike Maynard, Director of Tech Event Guide explained, "Although Event Diaries are already available, they typically focus primarily on major events and rarely include company-specific events".

PLAY EVEN SMARTER

Bluedelta Designs have built-on their award-winning, hassle-free "Smart-SCART" (a user-friendly "Fit & forget" AV SCART Router) with the launch of their advanced Smart-SCART+. This nifty little gismo contains a raft of useful features, including inbuilt signal amplifiers and an internal record loop. What's more its intelligent switching function is fully automatic with no remotes or buttons to press.

The Smart-SCART+ enables users to make the most of their in-home audio-visual entertainment systems by allowing the connection of up to eight devices to the TV screen at once, even if they only have one SCART connector on their TV!

Up to six video devices can be plugged in through the RGB-enabled SCART connectors at the same time as it allows a further two composite video (s-video) sources – that's a total of eight video inputs all into one SCART output. Additionally there is an audio line in.

The smart technology inside the Smart-SCART+ will decide which device has been selected to display on-screen at any given time. This works on a priority base, input 2 overrides input 1, input 3 overrides input 2, etc, and any inputs that do not take priority are then blanked out.

Furthermore, users can record whilst gaming through the internal record loop. The Smart-SCART+ even has a video sensing facility on three of the inputs, which allows a camcorder to play via the SCART automatically. This can also be used for any video source not equipped with automatic SCART control, such as games consoles and VideoCams.

Using the Smart-SCART+ is so easy that you should never have to waste time with cables again, simply plug all the cables in at once. So whether you are a technology savvy multimedia guru or just the average cable-cursed punter the easy to use Smart-SCART+ will help you get the most from your TV, DVD, Video, Games Console and Camcorder with the least bother.

Whether your new techno-weapon of choice be an X-Box or any other games console, DVD, camcorder or a good "old fashioned" VCR they can all be plugged into a single SCART socket input on the TV screen simultaneously.

For more information contact Chris Skelton, Bluedelta, Tel +44 (0)1763 263120. Fax +44 (0)1763 261958. Email information@bluedelta.co.uk

The Loudspeaker Level Meter is built into a small plastic case and is just the job for quickly adjusting the level of each channel in a home theatre system or public address system.

Level meter for home theatre systems

Setting up a home theatre system? Want to adjust all the speaker levels precisely? Here is the way to do it, with this handy little Loudspeaker Level Meter. It has its own in-built microphone and a 10-LED bargraph display to let you quickly set all channels to the same relative level. And you can use it to set up the levels in a PA system as well.

By JOHN CLARKE

YOU MIGHT THINK it is a straightforward matter to set up the levels in your home theatre system but depending on your room layout and the physical positioning of the various speakers, it can be surprisingly tricky. This is especially the case when you are trying to get an overall good balance at a number of listening positions.

Without the correct balance, the surround effect will not be the best it can be. Balance between the centre speaker and the left and right channels is critical since they present the front sound-scape. And as is often the case in many home theatre systems, if the centre loudspeaker is too dominant, it will detract from the imaging.

With the Loudspeaker Level meter, you can set up the levels accurately and quickly. It is just a small box with a 10-LED "bargraph" display on the front. Controls include the power switch and a level adjustment. On the base is a small electret microphone for monitoring the sound level from the loudspeaker.

In use, each loudspeaker is driven with a noise signal in turn and the Loudspeaker Level Meter is placed at the listening position and aimed at the speaker. The LED bargraph meter level adjustment is set so that it reads 0dB for one loudspeaker. Then the noise level of each of the other loudspeakers is adjusted at the amplifier so that they are all the same. Generally, they can be adjusted to within 1dB of each other.

Relative measurements

Note that the Loudspeaker Level Meter does not give an absolute sound level measurement; it is a relative measurement only, with respect to a reference level, usually 0dB, set by the Level control knob. You can then measure sound levels up to 6dB higher or 13dB lower than the reference 0dB level.

Most sound level meters incorporate frequency "weighting" to emulate the perceived loudness at different loudness levels. However, since this Level Meter is intended for loudness comparisons over a relatively narrow range, no frequency weighting is required.

In addition to frequency response, sound level meters can respond rapidly or slowly to changes in sound levels. The Loudspeaker Level Meter LED display has a response similar to VU (Volume Unit) meters used in recording studios to set the audio

Main Features

- 10 LED dot bargraph display
- -13dB to +6dB display range
- Level control
- Attack and decay rate follows VU standard
- Portable battery powered unit

levels for recording. VU response is very similar to the perceived loudness heard by the ear for various signals that include sudden transients.

Dot/Bar display driver

The heart of the Loudspeaker Level Meter is the readily available National Semiconductor LM3914 Dot/Bar Display Driver IC which is configured to drive 10 LEDs in dot mode. We have used the LM3914 in preference to the LM3915 which gives a logarithmic display or the LM3916 which gives a VU response, because the LM3914 is so cheap and readily available.

The drawback of the LM3914 when used as a decibel display is that it has a linear rather than the preferred logarithmic display characteristic. This explains the rather unusual labelling of the 10 LEDs, which turns out to be quite useable in practice. LEDs 5 and 6 correspond to -1dB and +1dB respectively and when they are both illuminated, the level is in between, at 0dB.

Fig.1 shows the internal components of the LM3914 display driver. It comprises a stack of 10 comparators, each with its non-inverting input connected to a resistor string between the R_{HI} input (pin 6) and the R_{LO} input (pin 4). All the inverting inputs of the comparators monitor the input signal at pin 5, via the internal buffer op amp.

If the input voltage is above the threshold set on comparator 1, LED1 will light. Similarly, if the input voltage exceeds the threshold voltage for comparator 2, LED2 will light, and so on. Not shown is the internal circuitry which allows only one LED to light at a time, instead of a whole bar of LEDs which would otherwise result for a high signal level.

Internal 1·25V reference

The internal 1·25V reference allows the IC to be set up to display the range of voltages required. The resistor between the REF_{OUT} and REF_{IN} pins (7 & 8) sets the reference current, so with the 1·2kΩ resistor shown, the current is 1·25V/1·2kΩ or 1·04mA. This current flows through the resistors connecting the REF_{IN} pin to ground (0V).

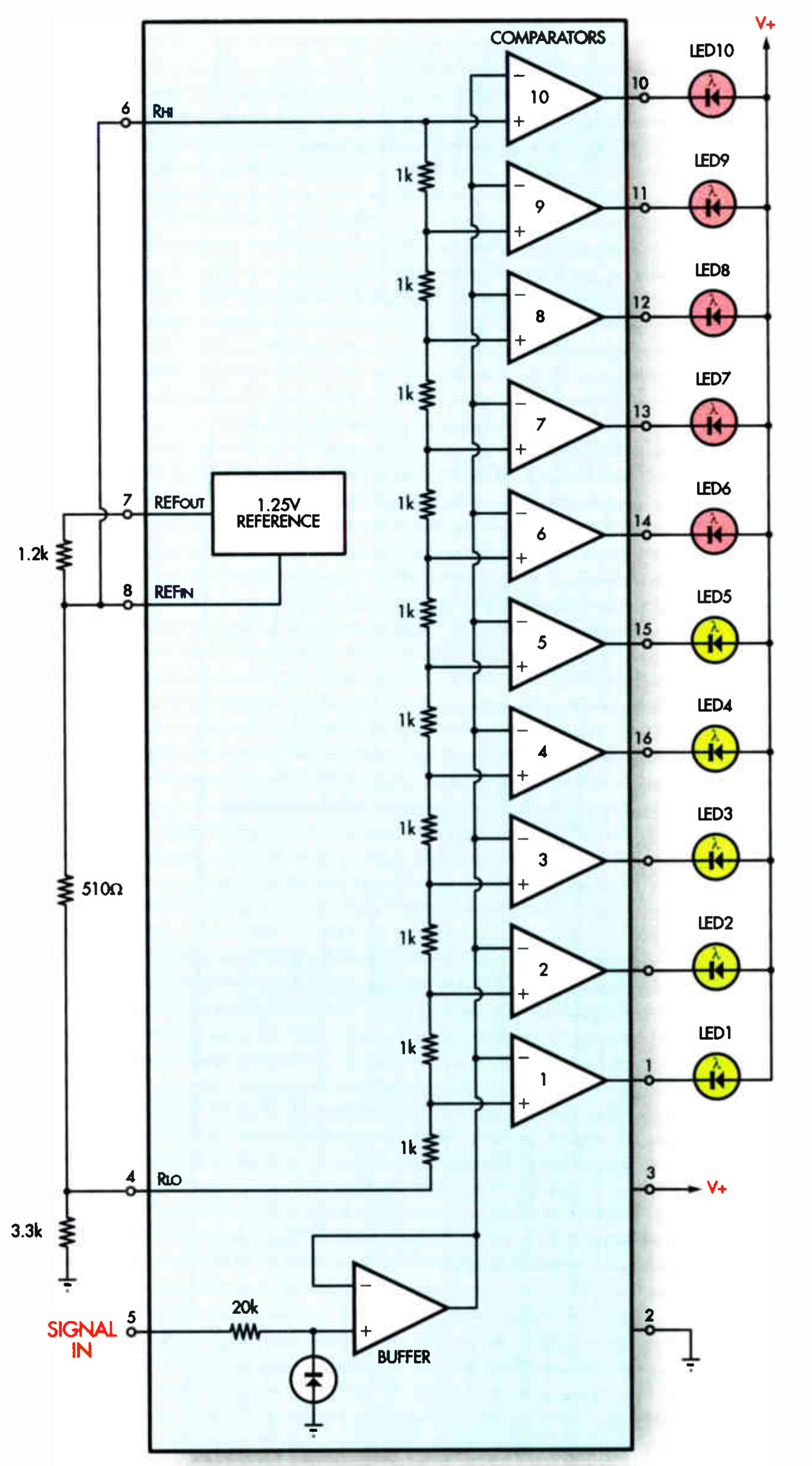


Fig.1: the LM3914 LED display driver IC includes 10 comparators, a 1·25V voltage reference and a signal-input buffer stage.

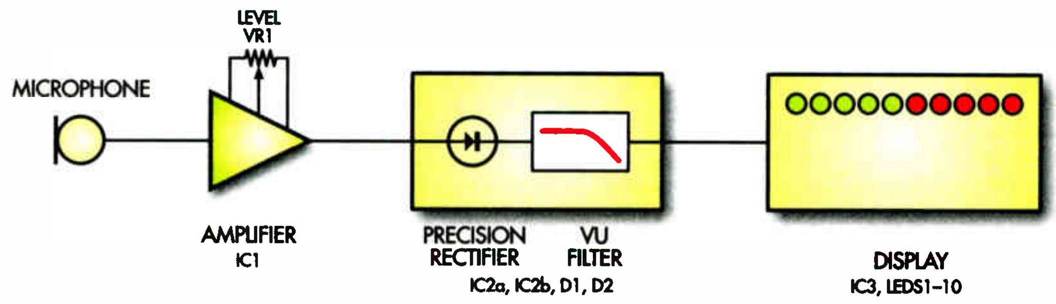


Fig.2: block diagram of the Loudspeaker Level Meter. The microphone signal is amplified by IC1, then precision rectified and filtered before being applied to the bargraph display driver (IC3).

Since we are using 510Ω and 3·3kΩ resistors in series the voltage at the REF_{IN} pin will be 1·04mA x (510Ω + 3·3kΩ) or 3·96V. The voltage at the junction of the 3·3kΩ resistor and 510Ω resistor will be 1.04mA x 3·3kΩ or 3·43V. So this gives us R_{HI} of 3·96V and R_{LO} of 3·43V and so the input voltage applied to pin 5 will light LEDs 1-10 when the voltage goes between 3·43V and 3·96V. This is a nominal 0·53V range.

Block diagram

The block diagram for the Loudspeaker Level Meter is shown in Fig.2. As shown, the microphone signal is amplified by IC1 with the gain set using VR1. Then the signal is precision rectified and filtered (IC2) before being applied to the bargraph display driver (IC3).

Circuit details

The full circuit is shown in Fig.3. The electret microphone is powered via a 22kΩ resistor from a decoupled supply connecting to the 9V supply rail. The decoupling comprises the 10kΩ resistor and 470µF capacitor and is required to prevent the supply rail changes which occur when different LEDs light up from being injected back into this amplifier.

The decoupled supply also applies a bias voltage to pin 3 of op amp IC1 via 100kΩ and 330kΩ resistors. Signal from the microphone is coupled into IC1 via a 1µF capacitor.

IC1's gain is set by the ratio of the feedback resistance between the output (pin 6) and the inverting input (pin 2) to the 100Ω resistor from pin 2. The low frequency response rolls off below about 34Hz due to the time constant of the 100Ω resistor and 47µF capacitor.

In practice, IC1's gain is adjustable from 48 (when potentiometer VR1 is set to minimum) to about 548 (when VR1 is set to 50kΩ). However, if the gain is set to values above about 100, the inherent bandwidth limitation of the TL071 op amp begins to reduce the gain at higher audio frequencies. For example, at a gain of 300, the response will typically roll off above 10kHz. This limitation is not important in this application – we merely note it for readers who may want to employ this circuit in a more critical application.

Precision rectifier

The output from op amp IC1 is coupled via a 1µF capacitor to the full wave precision rectifier which consists of diodes D1 & D2 and op amps IC2a & IC2b. Its operation is as follows:

When the input signal goes positive, output pin 1 of IC2a goes low and forward biases diode D1. The resulting gain of the signal at the anode of diode D1 is set at unity by the 22kΩ resistor. This inverted signal is fed to op amp IC2b via a 150kΩ resistor.

IC2b's gain is -6·66, as set by the ratio of the 1MΩ feedback resistor and the 150kΩ input resistor. Thus, the overall gain due to this signal path is IC2a's gain (-1) times IC2b's gain (-6·66), or +6·66.

In addition, the positive-going input signal is applied via a second path to IC2b, this time via a 300kΩ resistor. The gain of IC2b for this signal is -3·33, due to the ratio of the 1MΩ feedback resistor and the 300kΩ input resistor.

Parts List

1 PC board, code 577, available from the *EPE PCB Service*, 123 x 59mm
1 plastic utility case, 130 x 68 x 43mm
1 electret microphone insert
1 SPDT toggle switch (S1)
1 knob to suit
1 50kΩ 16mm log potentiometer (VR1)
1 50kΩ horizontal trimpot (VR2)
1 9V battery
1 9V U-shaped battery holder
1 9V battery clip lead
1 M3 x 6mm screw
1 M3 nut
11 PC stakes
1 50mm length of single core shielded/screened audio cable

Semiconductors
1 TL071, LF351 op amp (IC1)
1 TL072, LF352 dual op amp (IC2)
1 LM3914 dot/bar display driver (IC3)
1 16V 1W Zener diode (ZD1)
2 1N4148 or 1N914 diodes (D1,D2)
1 1N5819 Schottky diode (D3)
5 5mm green LEDs (LEDs1-5)
5 5mm red LEDs (LEDs 6-10)

Capacitors
2 470µF 16V PC electrolytic
1 100µF 16V PC electrolytic
1 47µF 16V PC electrolytic
3 1µF 16V PC electrolytic
1 1µF NP electrolytic
1 100nF (0·1µF) MKT polyester
1 56nF (0·0056µF) MKT polyester
1 100pF ceramic
1 10pF ceramic

Resistors (0·25W 1%)

1 1MΩ	1 10kΩ
1 330kΩ	1 4·7kΩ
1 300kΩ	1 3·3kΩ
1 220kΩ	1 1·2kΩ
1 150kΩ	1 510Ω
2 100kΩ	1 27Ω
3 22kΩ	

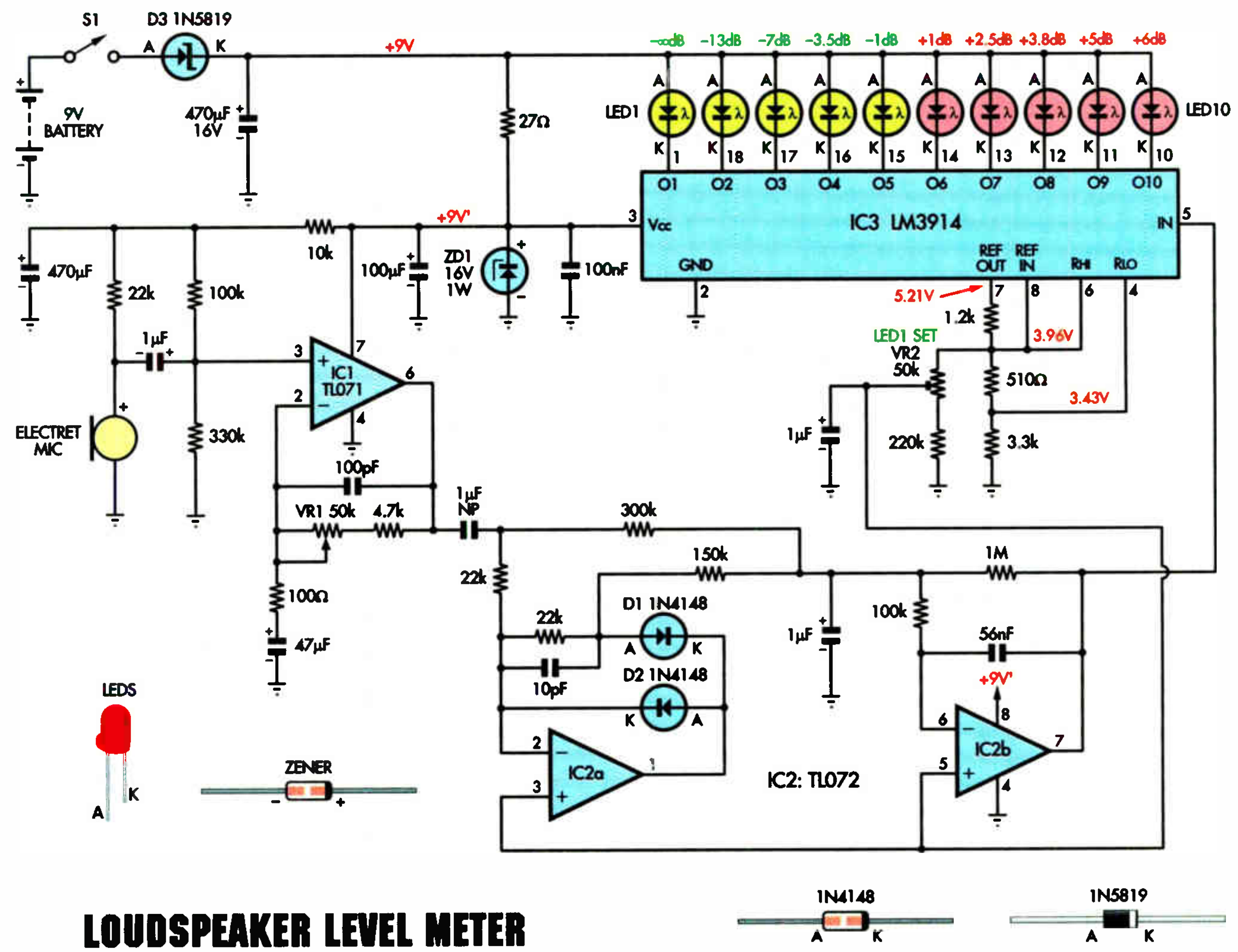


Fig.3: this is the complete circuit diagram for the Loudspeaker Level Meter. IC1 is the microphone preamplifier, while IC2a and diodes D1 & D2 make up the precision rectifier. The output from the precision rectifier is filtered by IC2b and fed to the pin 5 input of the LM3914 LED display driver (IC3).

Thus, the overall signal gain at the output of IC2b is +6·66 - 3·33 = 3·33.

When the signal goes negative, diode D2 is forward biased and so IC2a's output is clamped at 0·6V above the pin 3 reference voltage. IC2a is therefore effectively out of circuit and IC2b then simply amplifies the signal on its own, giving a gain of -3·33. Since the input signal is negative, the output is inverted, at +3·33 times the input. Thus the precision rectifier can be seen to provide a positive output with a gain of 3·33 for both positive and negative going inputs.

VU response

IC2b also provides low pass filtering of the rectified signal to conform roughly to VU (volume unit) standards where the output reaches the input level after 300ms and overshoots by about 1·5%. The filtering is incorporated using the 100kΩ and 1MΩ resistors, the 56nF and 1µF capacitors and the parallel combination of the 300kΩ and 150kΩ resistors. These together provide the 2·1Hz roll-off frequency and a Q (quality factor) of 0·62. The rectified signal is then applied to the input (pin 5) of IC3, the LM3914.

Trimpot VR2 is connected between the REF_{ADJ} pin (pin 8) and a 220kΩ resistor to ground and provides a DC reference voltage to pins 3 & 5 of IC2b. This is adjusted to 3·43V when there is no signal from the microphone and this will light LED1 on the display.

With sufficient signal from the microphone, Level control VR1 is then adjusted to light LEDs 5 & 6, indicating a level of 0dB. Varying the signal from this level will range the display from +6dB to -13dB. LED1 only shows that the signal is below -13dB.

A 9V battery supplies the circuit via a 1N5819 Schottky diode (D3) to provide reverse polarity protection while minimising the voltage drop across the diode; this allows more life from the battery. The 470µF capacitor decouples the supply to the LEDs, while a 27Ω resistor and 100µF capacitor further decouple the supply for IC1, IC2 and IC3.

The 16V Zener diode (ZD1) allows the circuit to be powered from a 12V car battery instead of a 9V battery. The circuit could also be run from a 9V DC plugpack although this would limit its portability while doing tests.

Construction

All the parts for the Loudspeaker Level Meter fit on a PC board, coded

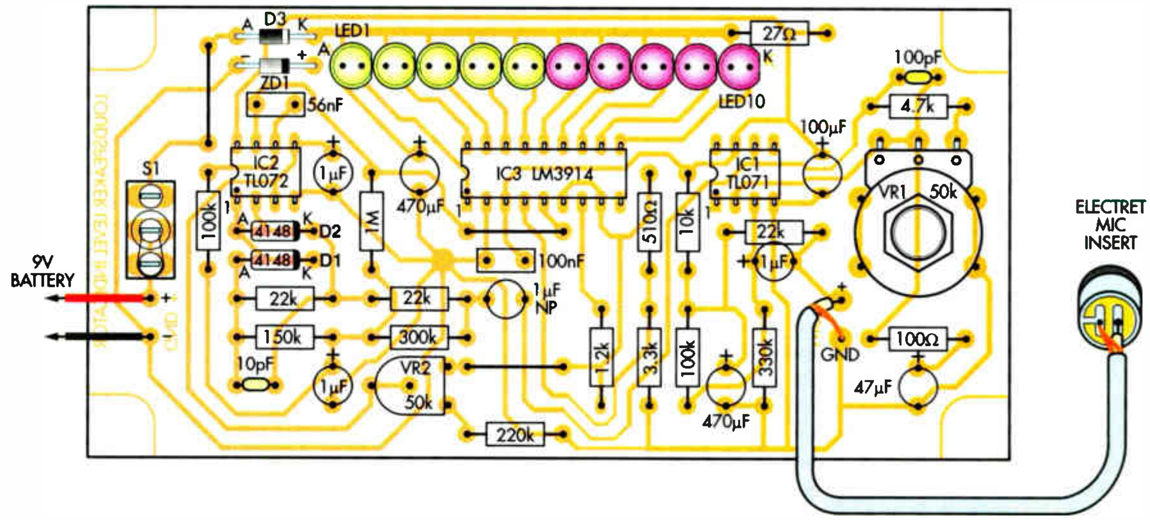
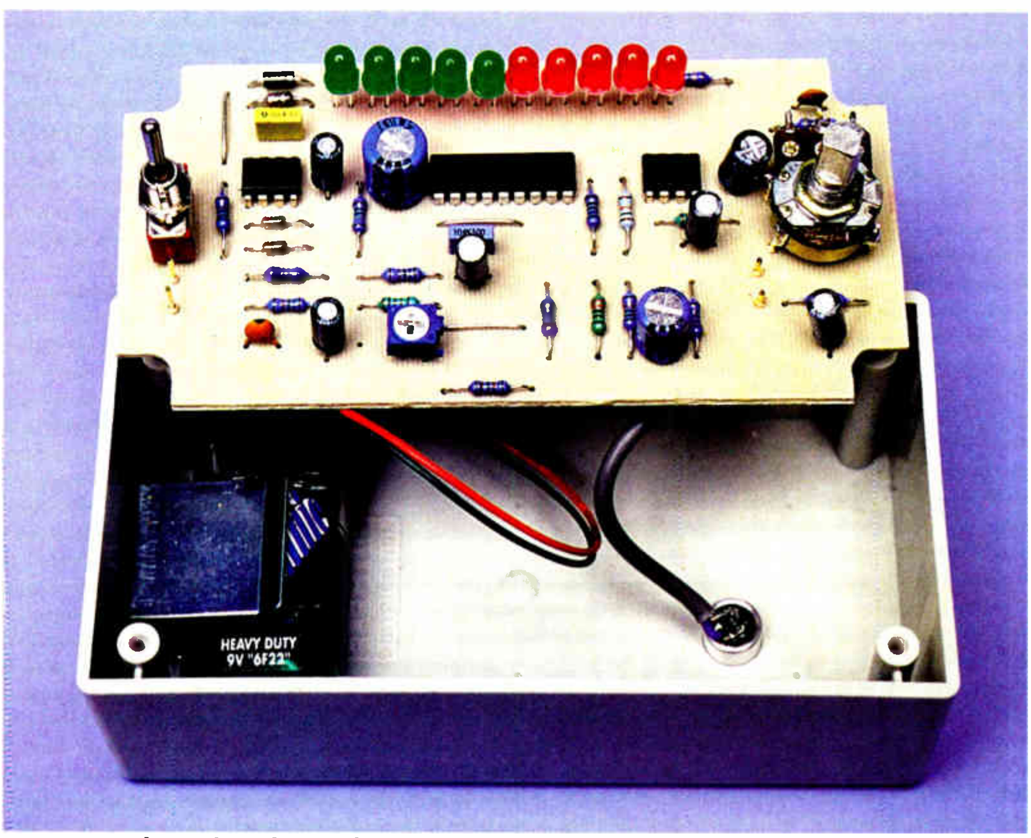


Fig.4: install the parts on the PC board as shown here, taking care to ensure that all polarised parts are correctly orientated. Potentiometer VR1 is secured by soldering its metal body and terminals to adjacent PC stakes (see text).

577, measuring 123 x 59mm. It is housed in a plastic case measuring 130 x 68 x 43mm approx. You can begin the assembly by checking the PC board for any shorted tracks or breaks in the copper pattern. Also check that the hole sizes are correct for the switch and PC stakes. You will need 2mm holes for the switch and 1mm holes for the PC stakes. The corners of the PC board need to be shaped so that the board will clear the corner pillars of the box.

Start with the low profile components such as the ICs, links and the resistors. Make sure that you place the TL071 in the IC1 position and the TL072 in the IC2 position – swapping them won't work at all! The resistors can be selected by using a multimeter to verify their values. Alternatively, use the colour code table to select the values.



The PC board assembly is secured to the back of the front panel by doing up the switch and pot nuts. A metal clamp is used to secure the battery.

Trimpot VR2 and capacitors can be installed next, taking care to place the polarised electrolytics with the correct polarity. The NP (non-polarised) capacitor can be installed either way. Then install the PC stakes and the switch (S1).

The shaft of the potentiometer (VR1) may need to be cut to length to suit the knob. VR1 is mounted about 3mm off the PC board and soldered to the four PC stakes which surround the pot body. Scrape the passivation coating from the pot body at the PC stake positions before soldering it in position. The three terminals are soldered to three adjacent PC stakes.

The lid of the box should now be drilled for the 10 5mm LEDs, the switch and pot. You can use the label artwork in this article (Fig.6) as a drilling template. That done, place the LEDs into their holes on the PC board, ensuring the polarity is correct. Fit the lid of the box over the switch and pot and fit their nuts. Push each LED into its front panel hole and solder each one so it protrudes from the lid by about 1mm.

The battery is fitted into a U-shaped battery clip which is secured with an M3 x 6mm screw and nut – see the

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0·1µF	104	100n
56nF	0·56µF	563	56n
100pF		101	100p
10pF		10	10p

photo for the positioning and orientation of the battery clip. A tip for mounting the clip: place the nut over the hole on the inside of the clip and then push the base of the battery into the clip to hold the nut; then the clip can be easily fastened to the inside of the box with the screw.

Next, drill a hole in the base of the case for the electret microphone insert – make it a tight fit. Then wire up the microphone using a short length of shielded/screened cable. Finally, solder the battery clip leads to the underside of the PC board at the power supply PC stake terminals.

Testing

Carefully check all your work, then switch on and check that the LED display works. You may need to adjust VR2 so that the lefthand LED lights with no noise applied to the microphone. If nothing happens, check voltages. There should be about 8V between pins 4 & 7 of IC1, between pins 4 & 8 of IC2 and between pins 2 & 3 of IC3. Check that the display LEDs light up when you whistle or make a noise. Adjust VR1 and check that the sensitivity increases when it is turned clockwise.

In use, you will need a noise signal to allow setting up the speaker levels. If you are simply setting up a stereo system or measuring sound levels in a PA system, you can use a pink noise source. Alternatively, you can use inter-station noise from an FM tuner (ie, set it to a frequency where there is no signal). ***EPE***

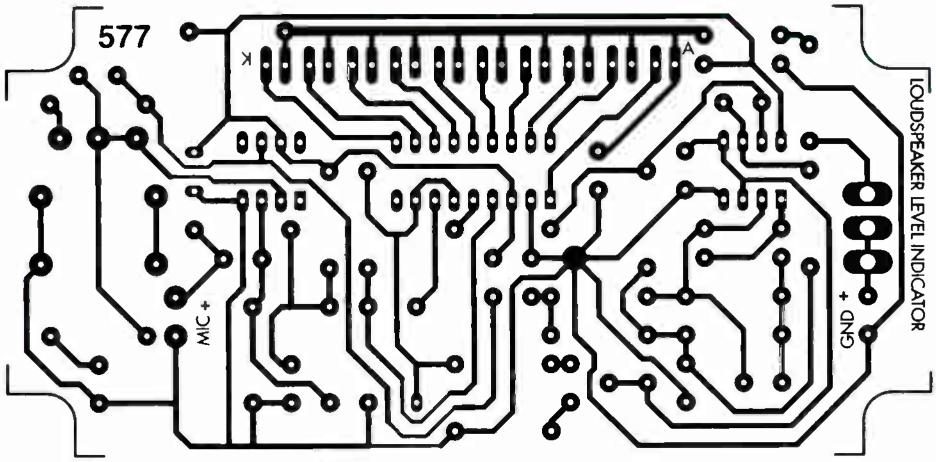


Fig.5: check your board for defects by comparing it with this full-size etching pattern before installing any of the parts.

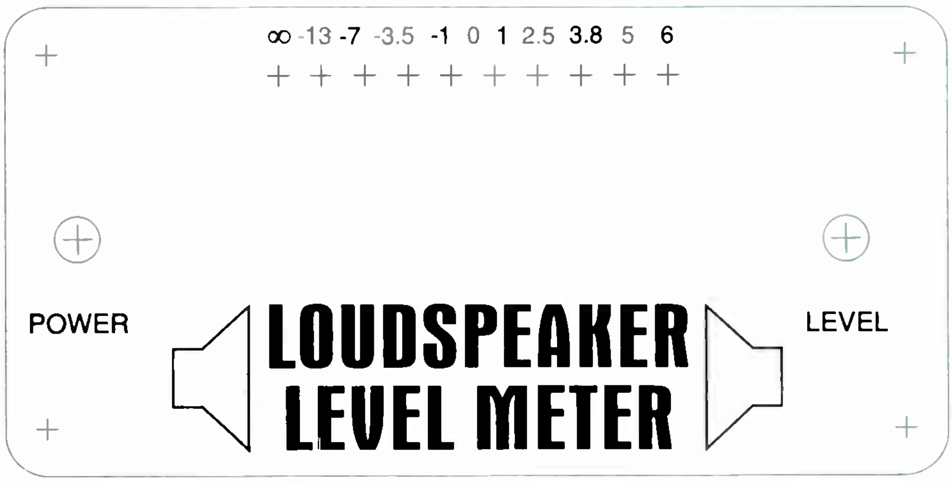


Fig.6: this full-size artwork can be used as a drilling template for the front panel, if necessary.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	1	330kΩ	orange orange yellow brown	orange orange black orange brown
❑	1	300kΩ	orange black yellow brown	orange black black orange brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	1	150kΩ	brown green yellow brown	brown green black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	3	22kΩ	red red orange brown	red red black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	4·7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	3·3kΩ	orange orange red brown	orange orange black brown brown
❑	1	1·2kΩ	brown red red brown	brown red black brown brown
❑	1	510Ω	green brown brown brown	green brown black black brown
❑	1	27Ω	red violet black brown	red violet black gold brown

STRANGE BUT TRUE

Contrary to the futile search in Iraq, the search in 1945 for German weapons of mass deception had spectacular results, as Mark Nelson now relates.

RECENT discussion on the destructive applications of low frequency sound waves on the *EPE Chat Zone* (**www.chatzones.co.uk/discus/messages/7/2836.html**) brought to mind earlier attempts to harness invisible waves for strategic purposes.

In a long-forgotten British book of 1943 (*On The Way To Electro-War* by Kurt Doberer) the author sums up: "The stopping of motor cars, tanks and other vehicles by electricity is effected by throttling their engines, a matter which involves no fatal consequences to the occupants in itself. But the vehicle which has lost mobility is an easy prey to the enemy's guns."

Drowning by Electricity

He goes on to describe the trials of the Danish experimenter Rawn in 1935, whose rays could allegedly put aero engines out of commission at a distance of 50 to 60 miles. He also explains how it could be possible to disable motors by surrounding them with clouds of ionised air, a "drowning by electricity" technique tested successfully in the laboratories of the Westinghouse Company in the USA.

After this he describes a certain stretch of road near Archangel, in the Arctic Circle, where car ignition systems fail repeatedly. Altogether a complete chapter is devoted to mostly unsubstantiated reports of tactical use of electrical rays to disable motors.

Stories of this kind proliferated during the Second World War, such as the allegation that cars would stop mysteriously near Great Bromley radar station in Essex and then just as mysteriously start again. The following story began the same way.

Mullin's Memoirs

John (Jack) T. Mullin, an electronics expert with the American army during the war, was assigned to investigate a similar assertion and writes in his memoirs:

In July 1945 a Lt. Spickelmeyer and I were sent to Germany to look into reports that the Germans had been experimenting with high-frequency energy as a means to jam airplane engines in flight. Our mission was to investigate a tower atop a mountain north of Frankfurt. There, in an enormous basement room, were two gigantic diesel engines and generators, apparently designed to pump out high-frequency energy to resonate the ignition systems of enemy planes. Nothing ever came of it. While we were poking around I met a British army officer who was there on the same mission.

The subject of music and recording came up, and he asked if I had heard the machine they had at Radio Frankfurt. When he told me it was a Magnetophon, the term that Germans used for all tape machines, I assumed it was similar to the recorders we had been junking in Paris. He raved about the musical quality of this recorder and urged me to listen to it, but I thought he simply didn't have a very good ear.

Biggest Decision of My Life

Fortune favours the prepared mind, as they say, and for Mullins this was one of those defining moments. He continues:

On the way back to my unit, we came to the proverbial fork in the road. I could turn right and drive straight back to Paris or turn left to Frankfurt. I chose to turn left.

It was the greatest decision of my life. The radio station ... was then being operated by the Armed Forces Radio Service; the people who were using it to prepare radio programs apparently were unaware of its significance. In response to my request for a demonstration of their Magnetophon, the sergeant spoke in German to an assistant, who clicked his heels and ran off for a roll of tape. When he put the tape on the machine, I really flipped; I couldn't tell from the sound whether it was live or playback. There simply was no background noise.

What Mullin had discovered was the first tape recorder to use high-frequency bias to eliminate hiss and he was well aware of the significance of his discovery. After sending back sample machines to the USA he gave a demonstration to the Institute of Radio Engineers (which became the Institute of Electrical and Electronics Engineers) in May 1946.

Thirteen months later he made a similar presentation to the singer Bing Crosby, who realised that this tape recorder could revolutionise broadcasting and the recording industry. Bear in mind that up to now editing had to be done on movie film soundtrack material or by recording and re-recording on transcription discs. Each of these methods degraded the audio quality; magnetic tape recording did not!

More on Trade Names

My article on the origin of trade names in the June issue caught the eye of reader T. Scrase, who sent in a few more for me to explain. Your wish is my command, so let's see what we can do with these for you.

- Brush Clevite. The Clevite Corporation was formed by the 1952 merger of the Cleveland Graphite Bronze Corporation and the Brush Development Company. Brush was a surname, whilst Clevite was the combination of Cleveland and Graphite.
- Igranic. Igranic Electric used to make valves and other radio components, testgear and coil winding machines, but today their business is in high-voltage switchgear and control panels. They tell me the name is derived from the strength of iron and granite.
- Lancashire Crypto Gryphon electric motors. Lancashire Dynamo & Crypto set up business in the late nineteenth century and was well known for its generators. The word "crypto" is Greek for "secret", implying no doubt that the firm had unique technical knowledge. Better known today as the Crypton Technology Group, its main line of business is electrical testgear used in garages. Gryphon was a manufacturer of dynamos but whether they had any connection I'm not sure.
- MK electrical accessories. MK Electric was founded in 1919 as the Heavy Current Electric Accessories Company and their early developments indicated the need for switches and sockets that would function with consistent reliability. Their ingenious Multy Kontact spring grip socket soon became a market leader, to the extent that the British Electrical Standards Association (BESA) revised its standards to accommodate this novel product.
- Rola Celestion loudspeakers. The name of the Celestion loudspeaker, first launched in 1925 by The Electrical Manufacturing and Plating Company, was intended to reflect the celestial or heavenly sound that it produced. Its makers later merged with the British Rola Company, an offshoot of the Rola Company of Cleveland, Ohio, USA. Rola is a fairly common surname over there.
- Vortexion amplifiers and tape recorders. This one has me stumped, I'm afraid. Like Amplion, Audion, Celestion and Thermion it has the classical Greek ending and I assume the name refers to the power of the sound produced (a vortex is the spiral motion of fluid within a limited area, such as a whirling mass of water or air).

Finally, asks Mr Scrase, what was Rebecca? The American-designed Rebecca-Eureka system was designed to assist the airborne supply of agents and paratroopers on the ground during World War Two. The APN-2 Rebecca airborne beacon was used in connection with the ground-based PPN-2 Eureka for co-ordinating parachute drop operations.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INTERFACE

Robert Penfold

A VISUAL APPROACH TO PRODUCING VIRTUAL CONTROLS

One of the reasons that Visual BASIC is so well suited to software for PC hardware projects is that the visual approach to programming makes it easy to produce virtual controls, meters, indicators, and the like. In general, you do not need to do any programming at all in order to produce the user interface. The various objects and controls in the toolbox are used to produce the readouts, virtual controls, labels, and so on. Having produced the user interface, you then add the program code to make everything work.

The program is often remarkably short due to the fact that the screen objects have been produced without resorting to any conventional programming. Also, the screen objects are designed in such a fashion that they are easily manipulated via software. This is important, since there is no point in producing a very neat and well laid out design that cannot be linked effectively to the controlling software.

Although the screen objects are designed to link with the software as easily as possible, this is not to say that it is possible to produce any desired screen layout and then link it properly to the software. For example, when designing the screen layout you have to make sure that it will be possible to use the mouse to generate suitable events when operating the controls. Often this will not produce any problems, but with the fancier controls it might be necessary to use a little ingenuity in order to get everything operating in the desired manner.

Seeing the Light

Things like indicator lights and bargraph displays are easy to produce and control under Visual BASIC 6, and they provide an easy starting point. There is a shape component in the toolbox, and this produces a rectangle by default. When using any component for the first time it is useful to add it to a Form and then look at the Properties panel. This will usually list parameters that can be altered via the Properties panel.

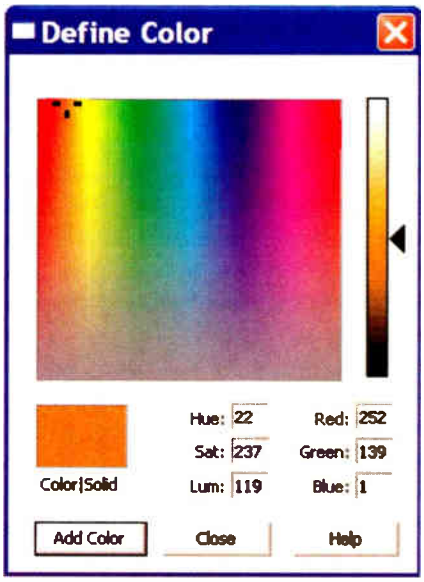

Fig.1. Using this window it is possible to produce your custom colours

An important point to bear in mind is that practically anything that can be changed by way of the Properties panel can also be changed using a software routine. In the case of a shape component the most important parameters are its colour, size, position, whether it is displayed, and its shape. It will probably not be necessary to alter the shape under software control, but it is possible to do so. However, the required shape (round, oval, rectangle, etc.) must be selected via the properties panel.

For a simple indicator light it is the colour of the shape that will normally be handled under software control. It is advisable to set a helpful colour via the Properties panel so that the shape shows up clearly on the form, making it easier to design a good layout. However, thereafter the colour will be set under program control. Actually, shapes and many other visible objects have two colour properties. These are the fill and the border colours, and there can also be a fill style.

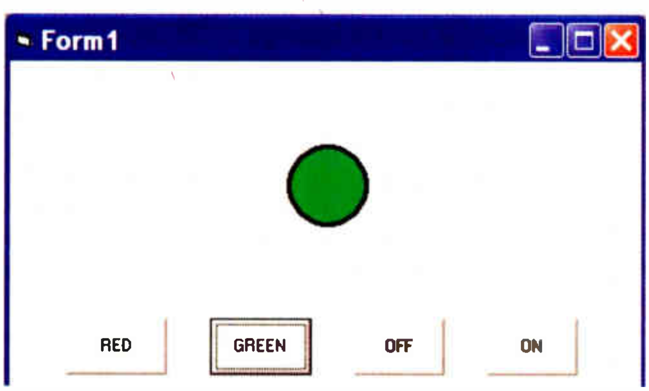

Fig.2. The indicator light program in operation. In addition to changing its colour, the buttons enable the indicator light to be totally removed from the screen

In this case it is the FillColor and FillStyle that are of most importance, since they control the colour of the virtual indicator light. If the shape component does not appear in the selected colour on the form, it is likely that the FillStyle is wrong. It will probably be Transparent by default and must be changed to Solid in order to make the fill appear on screen. The width of the border can be controlled, and I presume that the figure used here is the width of the border in pixels. Set the Border Style to Transparent if no outline is required.

In order to set the fill colour under program control it is just a matter of using a program line that sets the FillColor parameter to the appropriate value. The value is an eight digit hexadecimal number where the first two digits are zero, and the next three pairs respectively control the amount of blue, green, and red. The easy way of finding and entering the correct value is to first use the FillColor menu to set the shape to the required colour. This places the appropriate value in the FillColor section of the Properties panel, where it can be copied and then pasted into the Code window.

Colour Palette

There is a useful range of preset colours in the FillColor palette, but there are sixteen blank squares at the bottom of the palette where custom colours can be added. Right-clicking one of these squares results in the usual Windows Define Color window appearing (Fig.1). This provides a range of colours and saturation levels in the main panel. The slider on the right enables the selected hue to be mixed with white or black to produce paler or darker versions. Operating the Add Color button adds the newly mixed colour to the custom section of the palette.

This short program demonstrates how a simple indicator light can be controlled. Four command buttons are needed in addition to the shape component, and Command1 to Command 4 are respectively labelled "RED", "GREEN", "OFF", and "ON" (Fig.2).

```
Private Sub Command1_Click()
Shape1.FillColor = &HFF&
End Sub

Private Sub Command2_Click()
Shape1.FillColor = &HFF00&
End Sub

Private Sub Command3_Click()
Shape1.Visible = False
End Sub

Private Sub Command4_Click()
Shape1.Visible = True
End Sub
```

Operating the Red and Green buttons sets the FillColor parameter at a value that produces the appropriate colour. The Visual BASIC editor automatically removes leading zeros in the colour values, so there are only two and four digits in the red and green values. The other two buttons control the Visible setting of the light, and can switch it off (False) or on (True). Of course, in a practical application the light would be controlled by something like one line of a digital input port. The virtual light would be set at red or green depending on the level read from the port.

Bargraph

It is not too difficult to produce virtual panel meters using Visual BASIC, but for many purposes a bargraph is perfectly adequate. One way of producing a bargraph is to use a series of individual indicator lights. Each light is set to one colour or the other depending on the value read from an input port, with a separate line of code being used for each one. Provided everything is designed correctly, the individual lights work together to produce a bargraph.

An advantage of using separate indicators is that it is possible to have a more colourful display. For example, with something like an audio level indicator it is possible to use green lights for low levels, orange lights for high levels, and red lights for overloads. The main drawback is that it is a bit cumbersome, especially when dozens of different levels must be accommodated. A bargraph based on a single shape component is then a more practical way of handling things.

The shape component has Width and Height parameters that make it the ideal basis for a bargraph. For a horizontal bargraph a fixed height is used, and the width is varied. The opposite scheme of things is used for a vertical bargraph, with the width being fixed and the height being varied.

The demonstration program of Fig.3 has a horizontal bargraph that is controlled by a horizontal scrollbar set to produce values from 0 to 255. In other words, it is mimicking an eight-bit input port. A simple scale has been added above the bargraph using lines and label components. This is the code needed to make the bargraph respond to adjustments made to the scrollbar.

```
Private Sub HScroll1_Change()
Shape1.Width = (HScroll1.Value * 25)
End Sub
```

This subroutine uses only one line of proper code. This sets the Shape1.Width parameter to the new values produced when the scrollbar is adjusted. However, in most cases it will be necessary to multiply the raw value from the source in order to obtain a reasonably large bargraph. In this case the value from the scrollbar is multiplied by 25, but the multiplier must be chosen to provide a bargraph that has the maximum required size.

Controls

Visual BASIC has components that can act as on-screen controls. Scrollbars can be used to act as variable controls for things like volume, output voltage, etc. In other words, the type of controls that would be provided by potentiometers in a non-computer based design. Command buttons and radio buttons can be used to provide the equivalents of simple switches, banks of switches, and rotary switches in a conventional design.

Of course, it is possible to make your own controls using line and shape components, labels, and so on. The example control of Fig.4 is a virtual five-way rotary switch. The desired setting is selected by left-clicking the appropriate label, and the dot on the control knob moves to indicate the selected range. When designing virtual controls it is important to ensure that the current setting is clearly indicated to the user, as it would be when using the genuine article.

The body of the virtual control knob is comprised of two circular shape components, and it is quite crude but effective. Visual BASIC has the ability to import bitmaps, so it would presumably be possible to import a digital photograph of a real control knob if something a bit more realistic was required.

The listing for the virtual rotary control has a subroutine for each label, and each of these subroutines operates in essentially the same fashion. First, a value is output to a large label. In a real world application this value would be sent to an output port and then on to the project where it would select the appropriate setting. A label is used here so that the user can see that the value has changed correctly. Values from 0 to 4 are used in this example, but any values could be used.

Each subroutine has two lines of code that move the red dot to the appropriate position. The easy way of finding the correct co-ordinates for use in the program is to position the dot correctly and then read the Top and Left co-ordinates from the Properties panel. This process is repeated for each of the five settings. Objects snap to the on-screen grid by default, but with this type of thing it is generally best to position things "by eye".

It is possible to "fine tune" the positions of objects by tweaking their co-ordinates in the Properties panel. Alternatively, select Options from the Tools menu, and then operate the General tab in the Options window (Fig.5). Here it is possible to set a finer grid or to switch it off altogether. Bits can be nibbled out of other objects when labels are positioned close to them. This is caused by the background of the label partially covering the other object. Setting the label's Background Style to Transparent will avoid this problem.

Next time a practical project using virtual controls will be covered.

Listing 1: Rotary Control

```
Private Sub Label1_Click(Index
As Integer)
Label6.Caption = 0
Shape2.Top = 1920
Shape2.Left = 3100
End Sub

Private Sub Label2_Click(Index
As Integer)
Label6.Caption = 1
Shape2.Top = 1440
Shape2.Left = 3240
End Sub

Private Sub Label3_Click(Index
As Integer)
Label6.Caption = 2
Shape2.Top = 1200
Shape2.Left = 3840
End Sub

Private Sub Label4_Click(Index
As Integer)
Label6.Caption = 3
Shape2.Top = 1440
Shape2.Left = 4360
End Sub

Private Sub Label5_Click(Index
As Integer)
Label6.Caption = 4
Shape2.Top = 1920
Shape2.Left = 4620
End Sub
```

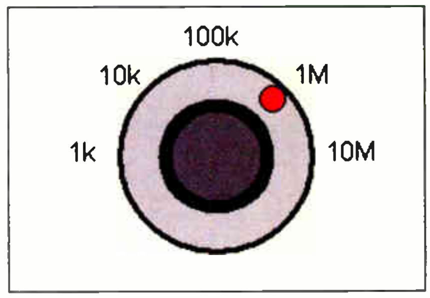

Fig.4. The virtual control knob. Left-clicking one of the labels sets the switch to the appropriate range and generates the required control value

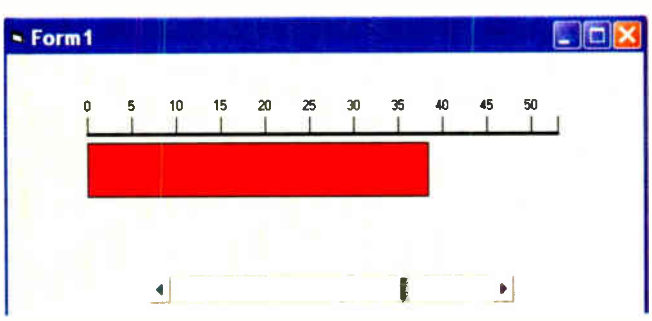

Fig.3. The bargraph display in operation. In terms of conventional programming, it requires a subroutine with just one line of active code

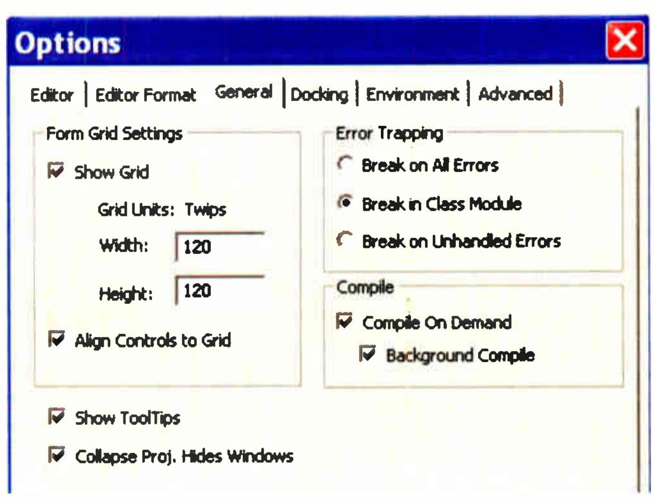

Fig.5. Using this window it is possible to alter the size of the on-screen grid and disable the snap facility

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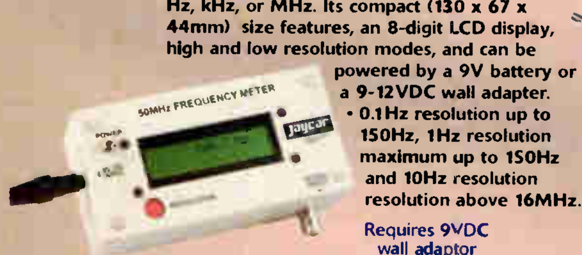

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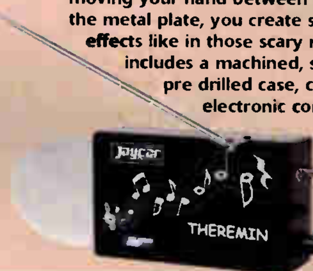

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Suitable for 6, 12 and 24V batteries
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KC-5386 £25.95 + post & packing

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.

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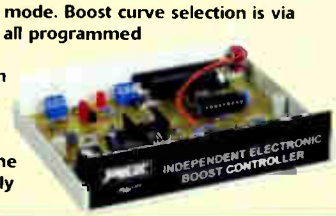
• Suitable for EFI and engine management systems only

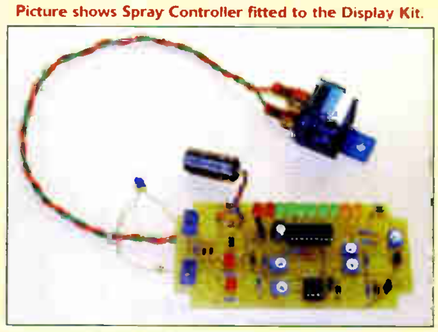


Smart Fuel Mixture Display
KC-5374 £8.95 + post & packing

This kit features auto dimming for night driving, emergency lean-out alarm, better circuit protection, and a 'dancing' display which operates 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-6014) £1.40 each

Picture shows Spray Controller fitted to the Display Kit.



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Simply add these few components to the Smart Fuel Mixture Display Kit (KC-5374) shown above and reduce water consumption by up to two-thirds.

A Telephone Dialler For Burglar Alarms

By LEON WILLIAMS

This project will dial a preprogrammed telephone number and send a warning tone via a modem when its input is triggered. Although primarily intended to connect to the output of an alarm system, it could be used for any purpose where you need to be notified immediately when an event has occurred.

IT'S A SAD FACT of life today that a great many homes are fitted with burglar alarms. Many of these alarms, especially low-cost self installed ones, don't have the facility to telephone the owner when an alarm occurs. If you were unfortunate enough to be away from home and have an unwanted visitor, you are dependent on someone making the effort to contact you, probably well past the time the incident occurred.

With this Alarm Dialler project connected to your alarm system, you will be notified within seconds of an alarm occurring, through a call to your telephone. And if you own a mobile telephone there's the added bonus that you can be virtually anywhere and still receive the call. Once you are notified, you can then contact the authorities or a neighbour or friend for assistance.

As well as this obvious application, the project could also be used for other less critical uses; any time you want to be immediately informed that a particular event has happened.

The Alarm Dialler is an easy-to-build project using a PIC microcontroller and a handful of other inexpensive components, all housed in a small plastic box. The unit connects to a modem via a standard serial interface. It uses the modem to make and answer calls via your telephone line.

There are four alarm connection points on the rear panel, two for the alarm input and two that can be used to reset an external device. When in idle mode, it flashes a front panel LED and continually scans the alarm input connections.

If an alarm condition occurs, it sends commands to the modem to dial a preprogrammed telephone number. When you answer the call, you will hear a calling tone, and if the telephone has a calling identification display, you can also confirm that it is your alarm system calling.

The Alarm Dialler has many options, allowing it to be used in a broad range of applications. The various alarm input configurations are selected with a multi-way DIP switch, while other settings such as stored telephone numbers are programmed using a PC and a simple menu system.

Why use a modem?

You may ask yourself, why do we need to use a modem? While it may seem an unnecessary complication, it does provide an easy solution to a number of design problems. First, it avoids us having to connect our device directly to the telephone line, as the modem provides the necessary safety isolation. Second, a modem provides all the functions we need to make and answer calls, which greatly simplifies the Alarm Dialler hardware circuit.

These functions include looping the line to establish and answer calls, dialling DTMF digits, ring detection, tone generation and connection timers.

The Alarm Dialler communicates with the modem via an RS232 interface. The speed is permanently set in the PIC at 2400bps and while this is slow by today's standards, it's fast enough for our needs and more importantly, eases the burden on the PIC software UART.

The modem requirements are very modest and so it only needs to be a basic type. More than likely you have an old modem lying around somewhere that can be put into service. If you don't, you can buy one secondhand or even a new one at a very reasonable price.

Basically, all modems are 'AT' compatible. This means that they communicate with a PC using the AT command set. The PC sends commands to the modem preceded with the letters AT meaning ATtention. The modem also sends messages to the PC on this interface.

The modem can be configured to talk to the PC using strings of letters (verbose) or single digits (terse). Single digit messages are generally used when a human is not viewing the responses and this is how the modem must be configured to work with the Alarm Dialler.

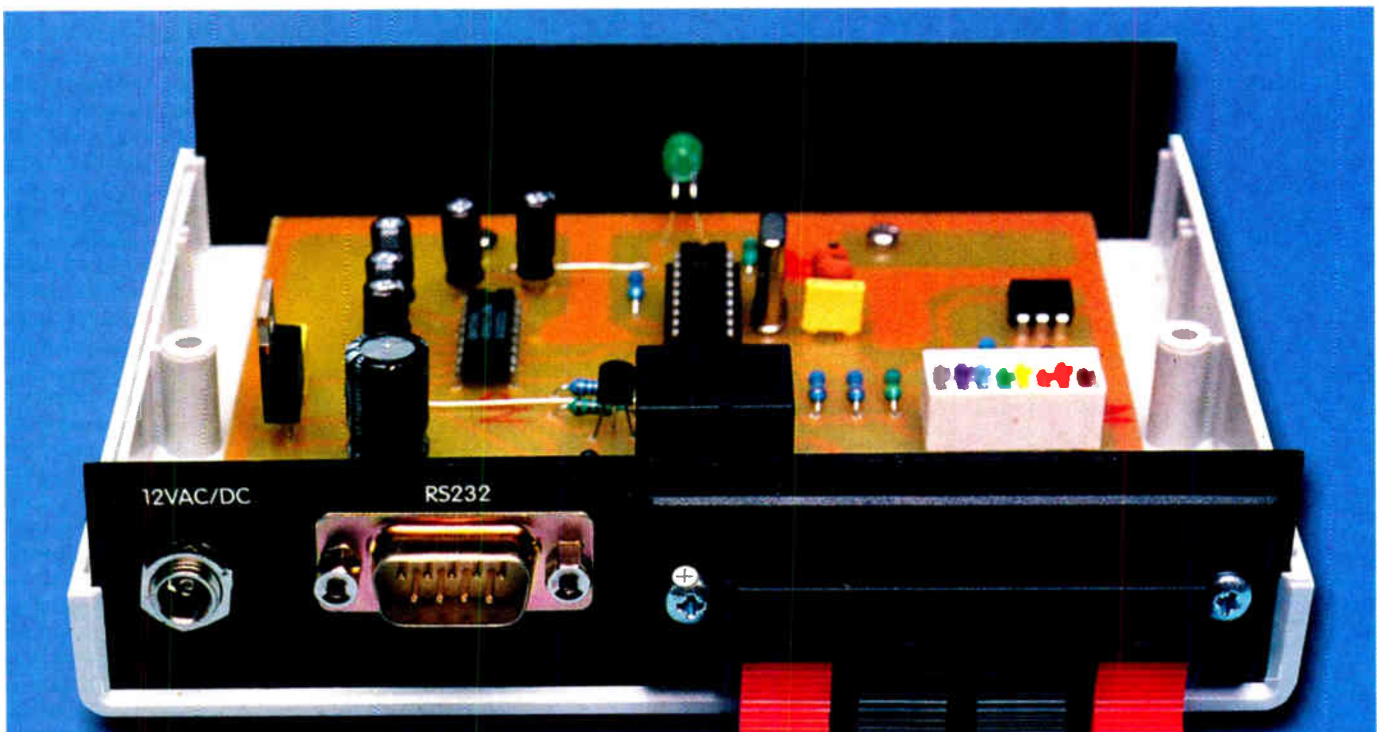
Alarm input options

The Alarm Dialler has a 2-wire connection point and can accept either a contact or switched voltage alarm system output (see Fig.1).

The contact output could be from a standard relay, a switch or perhaps a reed relay, using either normally open (N/O) or normally closed (N/C) contacts. When a contact input is used, the main board is electrically connected to the outside world. For this reason, it is important that the external alarm

Main Features

- PIC microcontroller based.
- Alarm input can monitor N/O or N/C contacts or an external voltage .
- Alarm reset output.
- No direct connection to the telephone line. Uses a standard modem to make and answer calls.
- Dial in and test if system operational.
- Programmed easily via a PC (RS232 connection).
- Programmable retry attempts.
- Primary and Secondary telephone number store.
- Alarm input inhibit switch.
- Automatic alarm reset option.
- EEPROM stores settings in case of power outage.
- Uses low-power 12V AC or DC power supply.
- Cheap and easy to build.



The rear panel carries spring-loaded terminals for the Alarm Input and Alarm Reset signals, a DB9M connector for the modem and a DC socket for the power supply.

Table 1: Alarm Input Options							
Normal Condition	Alarm Condition	S1/1	S1/2	S1/3	S1/4	S1/5	S1/6
Open contacts	Closed contacts	On	Off	On	Off	On	Off
Closed contacts	Open contacts	On	Off	On	Off	On	On
Voltage Off	Voltage On	Off	On	Off	On	Off	Off
Voltage On	Voltage Off	Off	On	Off	On	Off	On

contacts do not have any voltage applied to them and that the cable to the Alarm Dialler is not too long. A very long cable could possibly get noise induced into it, which could lead to false alarms.

Alternatively, if using the external voltage option, the normal state can be either voltage "on" (up to 50V DC) or voltage "off". The normal state means that this is the condition when the alarm is not active.

With this type of input configuration, the Alarm Dialler circuit is electrically isolated from the alarm input by an optocoupler (OPTO1). Only a few mA of current is needed to operate the optocoupler and **this is achieved with around 4V on the alarm input terminals.**

If you want to use a much higher voltage than this, an external resistor should be placed in series with the input to limit the current through the optocoupler LED. Note that DIP switches typically have a maximum rating of 50V DC at 100mA.

The alarm input options are set with DIP switches 1-6 and Table 1 shows the settings for each option.

Alarm reset output

The Alarm Dialler provides a set of output relay contacts that operate for one second and can be used to reset the alarm or some other external device. The PC board has provision to connect either the N/O or N/C contacts for this purpose. The relay will only operate after three incoming calls have been received within 90s after an alarm has been detected or, if Automatic mode is selected, after all outgoing calls have been made.

Program menu items

The program menu is produced by the Alarm Dialler and displayed on the connected PC screen. Each menu item is described below.

Automatic mode: The Alarm Dialler has the option to be in either Automatic mode or non-Automatic mode. When Automatic mode is set to Yes, a non-interactive mode is selected. This is simply where the preprogrammed number or numbers are dialled with a 45-second delay in between calls. After all the calls have been made, the relay operates for one second. The Alarm Dialler will not return to scan mode until the non-alarm state is found. This prevents it from continually calling if the alarm is not reset.

When Automatic mode is set to No, the Alarm Dialler is in interactive mode and it is possible to reset the alarm without having to wait for all the calls to be dialled. During the 45-second wait period between outgoing calls, the Alarm Dialler monitors the modem for a ring message.

If an incoming call is detected during this 45-second inter-call period it then waits a further 90 seconds for two more. It is necessary to receive a total of three calls within the 90-second period to reset the alarm. If only a single incoming call was allowed to do this, a random call from someone else could accidentally reset the alarm before you were contacted.

If three calls are detected, it considers that you called in response to the alarm. It then resets the alarm, cancels all further calls and returns to scan mode.

If an incoming call is not detected or less than three are counted during the 90-second period, the next outgoing call is attempted, unless all the retries have been completed.

Primary number: This is a 19-digit store to hold the telephone number of the first number dialled after an alarm is detected.

Secondary number: This is a 19-digit store to hold the telephone number of the second number dialled after all the Primary number retries have been completed.

Use secondary: If this option is set to Yes, the Secondary number will be dialled after the Primary number is finished. If set to No, the Primary number is the only one dialled and the Secondary number is ignored. While this option is valid in Automatic mode, in general it will only be set to Yes in Non-Automatic mode. In this case, if a response to the Primary number calls is not received, the Secondary number will then be dialled.

Retries: This is the number of retry attempts allowed for each telephone number. The range is 1-9.

Full details of how to program the Alarm Dialler are covered later in this article.

Remote status checks

The Alarm Dialler incorporates extra features that allow you to remotely check its status.

If everything is normal and there are no alarms, the front panel LED will flash and incoming calls will be ignored. However, if there are three separate incoming calls within 90 seconds, the first two calls will be ignored but the third call will be answered. When the modem answers the call by going on-line, it sends an answer tone and then drops off-line after 20 seconds. By using this feature, you can tell if the unit is powered up and operating normally from anywhere that you can use a telephone.

The only indication the Alarm Dialler has of an incoming call is a ring message from the modem. The modem sends the digit "2" each time a burst of ring is received. The Alarm Dialler counts the time in seconds between ring bursts to distinguish between those within the same call and those from separate calls.

When an incoming call is being received from the telephone exchange, ring bursts are two seconds apart. However the time between the last ring burst from one call and the first ring burst from the next call will be much greater than this. The Alarm Dialler will register a new call if the gap is larger than six seconds.

It would be unusual to receive three calls within 90 seconds in normal use and so the unit should rarely answer a random call. Even if someone does call three times in quick succession, all that will happen is that the unit will answer on the third call send the answer tone and then drop off line again. Obviously, if you are unable to get the Alarm Dialler to answer at all, either the unit or the modem has

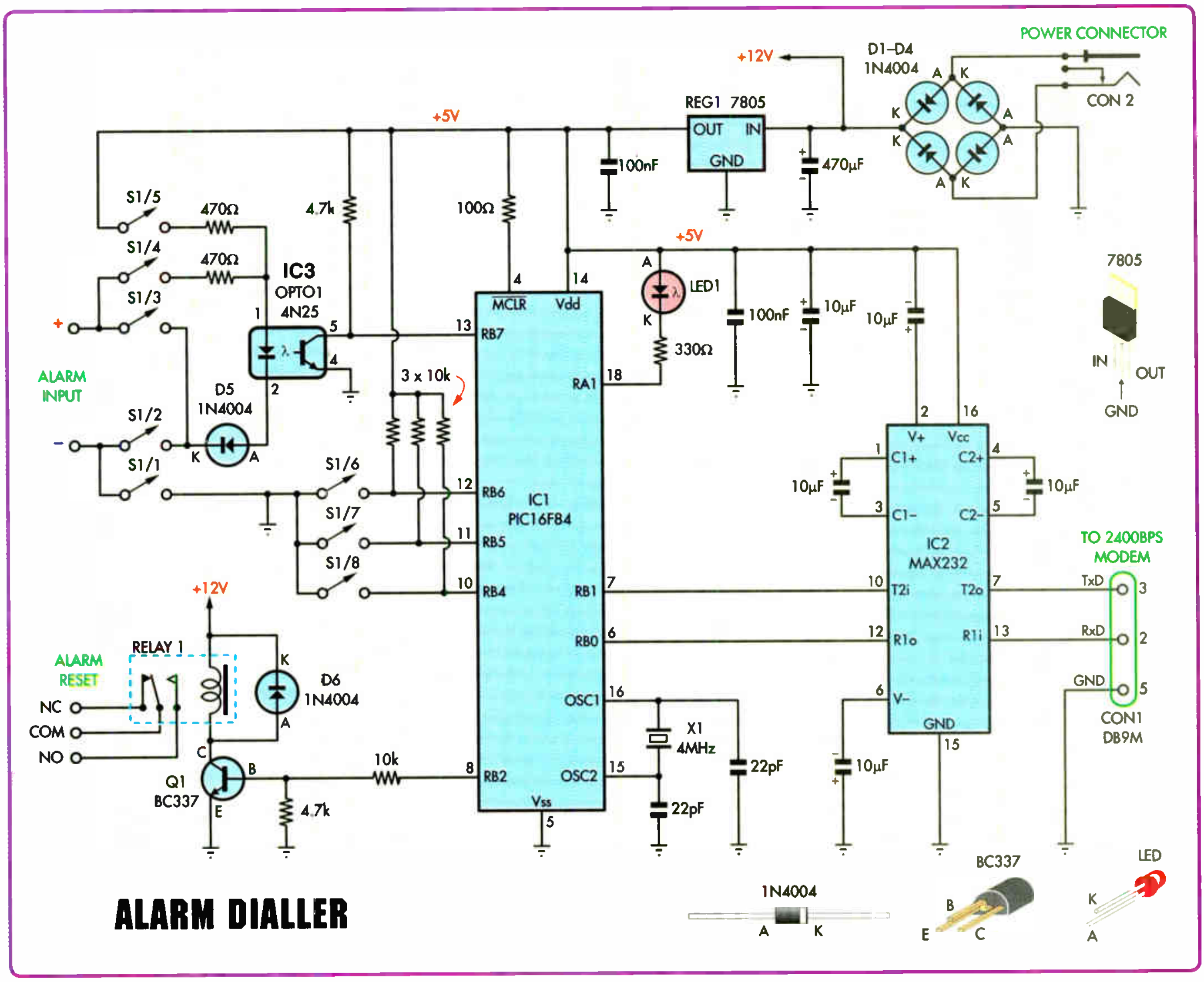


Fig.1: a PIC16F84 microcontroller (IC1) forms the heart of the circuit. It accepts the Alarm Input signal and drives an RS232 transceiver (IC2, MAX232) which interfaces to the modem. The modem, in turn, connects to the telephone line and carries out the dialling.

failed, the power is off or the telephone line is faulty.

Failed call state

If an alarm has occurred and the Alarm Dialler has exhausted all its call retries and did not get an incoming three-call response, it goes into a failed-call state. In this mode, it will not return to normal scan mode until it has received three calls within 90 seconds.

This is done for two reasons. First, it avoids continually sensing an alarm condition and re-dialling if the alarm has not been reset. Second, it allows you to check if an alarm has occurred, if you have not been previously contacted.

While in failed-call mode, the Alarm Dialler will answer every incoming call. So if you call the unit to check its status and it answers immediately, this indicates that an alarm has almost certainly occurred.

To double check that this is the case, call again two more times, within the 90-second period. If the unit answers every call then an alarm has occurred. This three-call sequence will also reset the alarm and return the Alarm Dialler to scan mode. Note that this alarm checking and reset feature is only available in non-Automatic mode.

Receiving an alarm call

If the Alarm Dialler is programmed for Automatic mode, it will simply call the Primary and Secondary numbers, depending on the values set for 'Use secondary' and 'Retries'. It is not possible to call the Alarm Dialler during this process and cancel the calls. For this reason, it's probably a good idea to keep the 'Retries' number low and only use the Secondary number option if really necessary. Each time you answer the call, the modem calling tone will be heard for 20 seconds and then the call will be terminated.

In non-Automatic mode, it is possible to reset the alarm without having to wait for all the calls to be dialled. During the 45-second wait period between outgoing calls, the Alarm Dialler monitors the modem for a ring message. Note, however, that because the modem is online for 20 seconds after the call is made, there is only effectively 25 seconds for you to call the Alarm Dialler before the next call is made.

Parts List

1 PC board, code 579, available from the *EPE PCB Service*, 115 x 99mm
1 plastic case, 140mm x 110mm x 35mm
10 PC board stakes
1 8-way DIP switch (S1)
1 4MHz crystal (X1)
1 DC panel-mount socket
1 9-pin male 'D' connector with locking nuts
1 4-way speaker connector
1 12V SPDT relay (RLY1)
1 18-pin IC socket
2 10mm x 3mm screws and nuts
4 small self-tapping screws
Light duty hook-up wire, tinned copper wire

Semiconductors
1 PIC16F84 (IC1; programmed with ALARM.HEX)
1 MAX232 RS232 transceiver (IC2)
1 4N25 optocoupler (IC3)
1 BC337 NPN transistor (Q1)
6 1N4004 power diodes (D1-D6)
1 7805 positive 5V regulator (REG1)
1 5mm green LED (LED1)

Capacitors
1 470µF 25V PC electrolytic
5 10µF 16V PC electrolytic
2 100nF (0·1µF) MKT polyester
2 22pF ceramic

Resistors (0·5W, 1%)

4 10kΩ	1 330Ω
2 4·7kΩ	1 100Ω
2 470Ω	

When you receive an alarm call you will hear the modem calling tone and you must wait for the modem to time out and go off -line before calling back.

Circuit description

The full circuit for the Alarm Dialler is shown in Fig.1. As you can see, there's not a lot to the hardware because, as mentioned before, the line interfacing functions are handled by the modem.

The microcontroller used is a PIC16F84 (IC1) which does all the hard work. It has 1K of ROM (which is just about all used in this project), 68 bytes of user RAM and 64 bytes of non-volatile EEPROM. The EEPROM holds the configuration settings in case of power failure.

Pin 14 is the power supply pin, while ground (0V) is connected to pin 5. The reset input (pin 4) is held permanently high via a 100Ω resistor and this simple reset system has proved to be effective. The internal oscillator appears at pins 15 and 16 and a 4MHz crystal is used to supply accurate timing for the internal counters.

Pin 10 is connected to the Program switch (S1/8) with an external 10kΩ pull-up resistor, so that with the switch open, the pin is read as high or a one. When the switch is closed, the pin is read as low or a zero. Pin 11 is connected to the Inhibit switch (S1/7) and works in the same manner.

Pin 7 is the transmit data pin and is normally high, pulsing low when a zero data bit is sent. Pin 6 is the receive data pin and is used to both interrupt the PIC when a character is received and to receive the actual data bits.

Normally, pin 6 is high with no data present and goes low when a character start bit is received. This negative edge interrupts the PIC and forces it to enter the interrupt routine. This routine samples the eight character bits and stores them in an internal PIC register. After the stop bit has been received, it exits the interrupt routine and the main code processes the character.

More complex microcontrollers have a dedicated hardware UART to do this receiving but in this less-qualified PIC we must do this in software. The UART operates in half-duplex mode, meaning that it cannot send and receive data at the same time.

Pin 18 controls the LED and when it is low the LED is on and when it is high the LED is off. A 330Ω resistor limits the LED current to around 10mA.

Pin 8 is the relay output pin, which is normally low and goes high for one second to turn on transistor Q1. When the transistor is biased on, relay RLY1 operates, providing the reset signal to the alarm system.

Pin 13 is the alarm input pin. The normal state can be high or low, depending on the input switch settings. Switch S1/6 tells the PIC whether the voltage on the alarm pin is the normal or the alarm state. If S1/6 is off, pin 12 is held high and the alarm state is when pin 13 is low. If S1/6 is on, pin 12 is held low and the alarm state is when pin 13 is high.

IC2 is a MAX232 RS232 transceiver used to interface the 5V logic signals in and out of the PIC to the 9-pin interface. It only requires a 5V power supply and produces the required plus and minus RS232 voltages by an internal inverter using four external 10µF capacitors. IC2 has two receivers and two transmitters but only one receiver and transmitter are used in this circuit.

On the RS232 side, pin 13 is the receive data input and connects to pin 2 of the 'D' connector, while pin 7 is the transmit data output connecting to pin 3 of the 'D' connector. On the logic side, pin 12 is the receive data pin and pin 10 the transmit data pin.

A 4N25 optocoupler (IC3) is used to isolate the PIC from external voltages on the alarm input. When about 3mA of current flows in the internal LED, the transistor within IC3 is turned on. This takes pin 5 of IC3 low and consequently pin 13 of IC1 low.

When DIP switches S1/1, 3 and 5 are off and S1/2 and 4 are on, the input is configured to accept an external voltage input. The current through the optocoupler LED is limited by a 470Ω resistor and protected from reverse polarity by diode D5. In this configuration, the input circuit is completely isolated from the main PC board components. The external positive voltage must be connected to the "+" alarm point, otherwise diode D5 will be reversed-biased and the alarm will not be recognised.

When DIP switches S1/2 & 4 are off and S1/1, 3 & 5 are on, the input is configured to accept a contact input. In this mode there is no external voltage to operate the optocoupler LED, so the internal +5V rail is supplied through the same 470Ω limiting resistor and diode D5.

The power supply is a 3-terminal voltage regulator circuit providing 5V from a range of input voltages. A diode bridge comprising diodes D1-D4 allows both AC and DC supplies to be employed. If a DC supply is used, the positive lead will be directed to the regulator input, irrespective of the polarity of the power connector wiring.

The main reason for using this circuit is to allow a wide range of power supply possibilities. The Alarm Dialler draws minimal current – only about

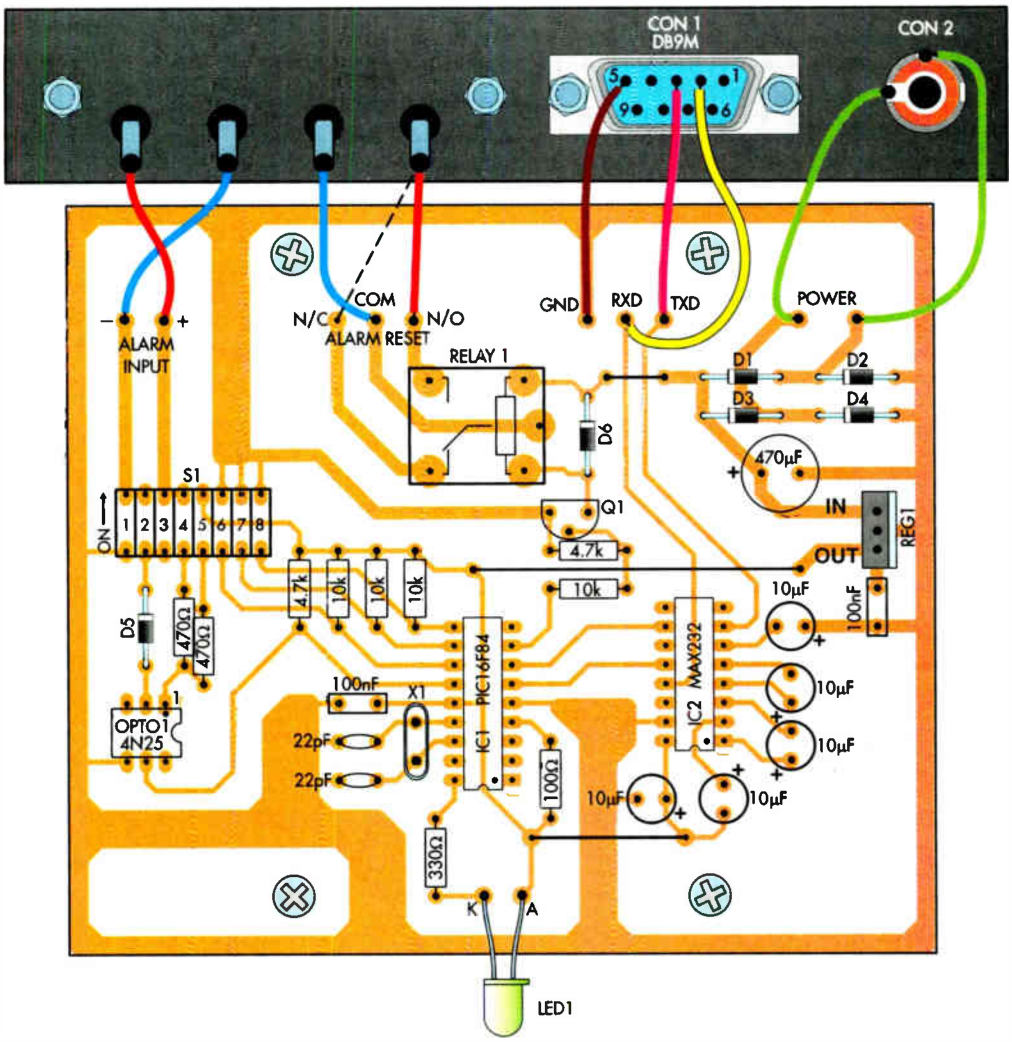


Fig.2: install the parts on the PC board as shown here, taking care to ensure that all polarised parts go in the right way around. The Alarm Reset output has only two connections, so select either the N/O or N/C contact, depending on your application (ie, use one or the other but not both).

50mA maximum when using a 12V DC supply.

Construction

Fig.2 shows the assembly details. Start construction by installing the parts on the PC board. There are three wire links to be installed, so do these first. Ensure they are straight and lay flat on the PC board. Follow these with the smaller components, such as the resistors, diodes and IC socket (IC1).

Next, install the capacitors, ensuring that the electrolytics are installed with correct polarity. The relay, DIP switch and PC stakes can be installed next. Follow this with the transistor, crystal and ICs, leaving the PIC chip till later.

The LED is installed with 15mm of lead length and then bent at right angles so that it can push out through the hole in the case front panel when the PC board is secured in place. The 5V regulator (REG1) runs quite cool and won't need a heatsink under normal circumstances.

Once the PC board is loaded, you can prepare the case – see the photographs as a guide. Start by drilling holes in the

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	2	4·7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	330Ω	orange orange brown brown	orange orange black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown

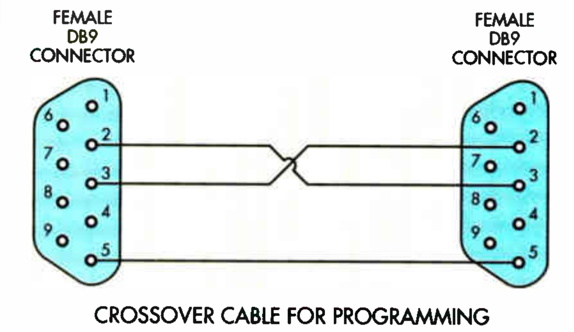


Fig.3: a serial crossover cable is required to connect the Alarm Dialler to a PC for programming. If you don't have a crossover cable, just wire a couple of female DB9 connectors together as shown here.

rear panel to mount the power socket, the alarm connector and 'D' connector – see Fig.6. The alarm connector used in the prototype is a 4-way speaker terminal strip and requires four holes for the connector tabs and two for the mounting holes.

Finally, drill a hole in the centre of the front panel just large enough to allow the LED to slide through.

Once the case has been prepared, install the power socket, the alarm connector with 3mm screws and nuts, and the 'D' connector with locking nuts. Mount the PC board in the case with four small self-tapping screws.

Slide the rear panel into place and then wire the rear panel connectors to the PC board stakes with light duty hook-up wire. The alarm input is polarised, so make sure that the red terminal is wired to the "+" alarm PC stake. The alarm reset output has only two connections, so select either the N/O or N/C contacts, depending on your application.

Note that because we are using a diode bridge at the supply input, you don't have to worry about the polarity of the supply wiring.

When all the wiring is completed push the LED back and slide the front panel into place. Now slide the LED into the hole in the front panel so that it pokes through by a few millimetres.

Initial testing

Once construction is complete, connect the power supply and, using your multimeter, measure the voltage at the power supply stakes on the PC board. The power supply can be anywhere between 12-20V DC or 9-16V AC without requiring a heatsink on the 5V regulator.

If you are going to operate the unit in areas of high temperature, then either a heatsink should be added to the regulator, or preferably, reduce the voltage of the power supply. Although the relay coil is rated for 12V operation, using a higher supply voltage shouldn't be a concern, because the relay is energised for only one second at a time.

Next, measure the voltage at the output of REG1. You should get a reading close to +5V and the same voltage should be at pin 14 of the PIC socket.

Pins 2 & 6 of IC2 will be a volt either way of +9V and -9V, respectively, if this IC is working correctly. If not, remove the power source quickly and look for errors, especially with the power wiring and the installation of the polarised components.

If everything looks OK, remove the power, wait a few seconds and insert the programmed PIC chip into the 18-pin socket. Apply power again and after a short period you should see the LED flash briefly and then repeat after a few seconds delay. Each time the LED flashes, it is sending AT to the modem and looking for an OK (0) response.

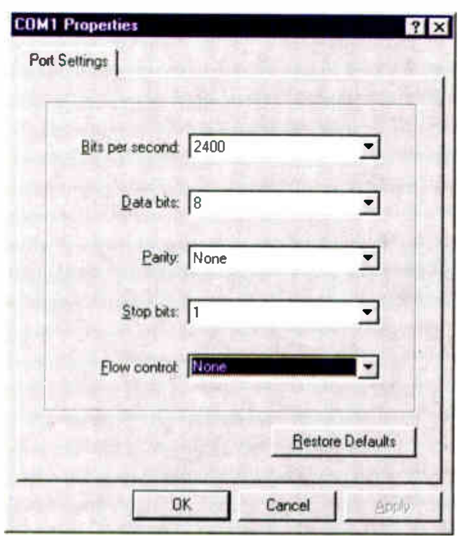
This is done each time the Alarm Dialler powers up and is used to ensure that the modem is connected and the interface is operating at the correct speed before normal alarm monitoring commences.

Alarm Dialler programming

Turn off the power to the Alarm Dialler and connect a PC running a terminal emulation program such as HyperTerminal using a serial crossover cable. The PC needs to be set to 2400bps, 8 data bits, no parity and 1 stop bit with flow control off (Fig4a).

Note that the Alarm Dialler's RS232 interface is similar to the one on your PC and to get them to talk to each other, you need to cross the data lines over. This means that the transmit data pin of the Alarm Dialler goes to the receive data pin of the PC and vice versa.

Fig.3 shows how to make a simple



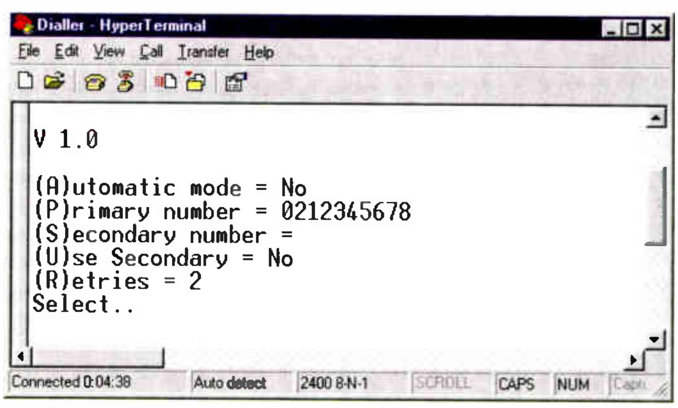
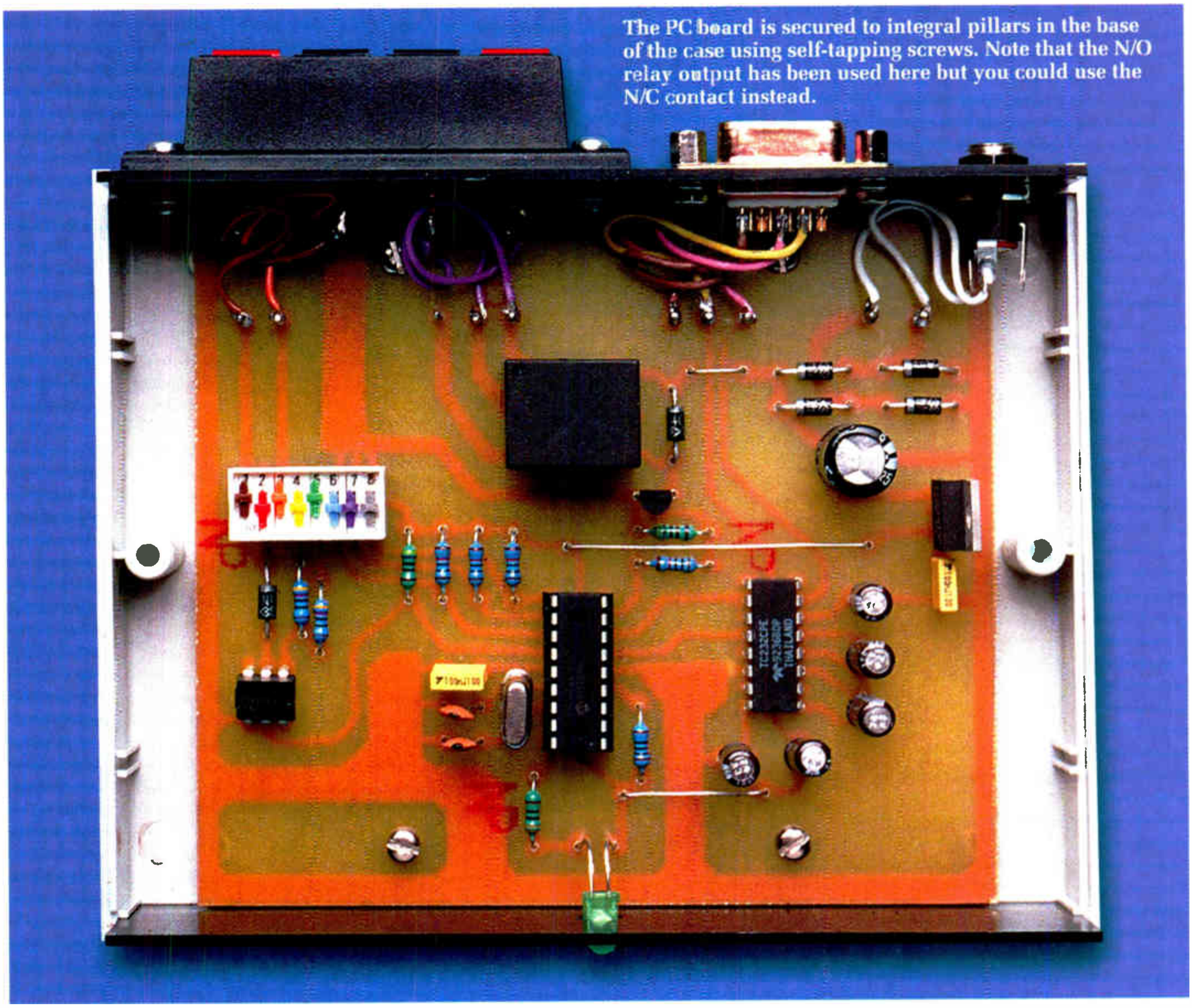


Fig.4a (left) shows how to set up the PC's COM port to communicate with the Alarm Dialler when you start HyperTerminal, while Fig.4b (above) shows the menu that appears in the HyperTerminal window when the Alarm Dialler is in programming mode.



The PC board is secured to integral pillars in the base of the case using self-tapping screws. Note that the N/O relay output has been used here but you could use the N/C contact instead.

crossover data cable, with a couple of 9-pin female 'D' connectors and three pieces of hook-up wire. Or you can buy one if you prefer.

Once connected, place S1/8 into the on position and apply power to the Alarm Dialler. Now move S1/8 to the off position, the LED should turn on and the menu appear on the PC screen. The menu is easy to understand and navigate and the items will be self-explanatory. **Simply select the desired option by pressing the character in brackets for that option and remember to use upper-case characters – see Fig.4b.**

Programming options are stored in the EEPROM as they are entered and there is no need to do a separate save action. If an out-of-range or illegal entry is made, an error message is displayed and the menu refreshed.

To exit the programming mode, place S1/8 into the on position again and then back to the off position. Once this is done successfully, a goodbye message will appear on the screen.

Alarm inhibit

To inhibit alarm detection at any time, move S1/7 to the on position. This could be used to avoid the Alarm Dialler immediately sensing an alarm condition if you are experimenting and changing the input connection or DIP switch settings. When the alarm input wiring and switch settings are in place, S1/7 can then be placed in the normal off position.

Switch S1/7 can also be used to manually reset an alarm after it has been triggered. When an alarm occurs, a software flag is set within the PIC and stored in EEPROM. The reason for this is to remember that an alarm occurred if there is a power outage during an alarm calling sequence. When power is reapplied and an alarm call sequence has not been completed, it starts the sequence again.

To manually reset the alarm flag, switch off power, place S1/7 into the on position, turn on the power again and move S1/7 back to the off position. The alarm flag is also reset each time you enter program mode to make changes to the configuration.

Configuring the modem

To ensure the modem you are using works properly with the Alarm Dialler, you must first configure it with the required settings. To do this, connect a PC running a terminal emulation program such as HyperTerminal to the modem, **using a standard serial**

Table 2: Modem Configuration	
Typical Command	**Required Options**
&K0	Disable RS232 data flow control lines.
S0=0	No auto answer - Alarm Dialler determines when the modem will answer a call by sending it ATA.
&D0	Ignore DTR lead on RS232 interface.
S7=20	Wait 20 seconds after making or answering a call before releasing the line when a carrier is not detected.
V0	Use digits rather than character strings for modem responses.
E0	Do not echo characters received by the modem back to the Alarm Dialler.
&W	Write the settings to non-volatile memory.

cable (ie, not a crossover type). Now type the letters **AT** followed by the **Enter** key.

If the modem receives and decodes this properly, it will respond with the letters **OK**. Now type **AT&F** and then **Enter** to reset the modem to its factory default settings.

Once this is done type the sequence **AT&K0S0=0&D0S7=20V0E0&W**, exactly as shown and terminate by pressing **Enter**. Notice that the 0 is a digit zero and not an upper-case letter.

If the modem accepts the settings, it will respond with a zero, indicating that all is OK. If not, and this is very unlikely, your modem does not recognise these standard commands. In this case, consult your modem's user manual and read the explanations in Table 2 to find and enter the commands that match your modem.

A modem option not shown in Table 2 but referred to throughout this article as the calling-tone option. Some modems will send a calling tone automatically every call, while some do not have this facility. Some others have the capability but require it to be enabled.

If you need this feature and it doesn't seem to operate, you will need to check your modem and see if it is an available option, or get another modem!

The time to wait online after making or answering a call is determined by the value in the modem S7 register. You may find that some modems actually wait longer then the programmed 20 seconds and you may not be able to make three calls within 90 seconds. If you find the wait is too long, then you will need to experiment with the value programmed into the S7 register.

Final testing

To fully check the Alarm Dialler functions, programmable settings and modem operation, you need to make real telephone calls. However, while call charges are relatively inexpensive, you probably don't want to make a lot of calls until you know everything is working OK.

We get around this problem by checking most of the Alarm Dialler functions without making any real calls. The way we do this is to simulate the actions of the modem using the PC.

First, to make life as easy as possible for testing purposes, set the alarm input up for N/O contacts as shown in Table 1. That way, you can later simulate an alarm condition just by shorting the two alarm input terminals.

Now for the test procedure. Start by programming the Alarm Dialler with Automatic mode set to Yes. That done, program the Primary and Secondary numbers to relevant telephone numbers, the 'Use secondary' option to Yes and the 'Retries' to 2. Once programming is finished, leave the PC connected using the serial crossover cable.

You will notice that after you exit programming mode the letters AT appear on the screen. This is the Alarm Dialler looking for a modem. Type the number 0 followed by the **Enter** key. When the Alarm Dialler receives this it thinks it has found the modem, starts flashing the LED and goes into scan mode.

At times during the remainder of the testing we will be simulating the sequence that the modem sends to the Alarm Dialler when it detects an incoming burst of ring. We do this by typing the number **2** on the PC keyboard, followed by the **Enter** key. An incoming call from the telephone line has a burst of ring every two seconds and so a 10-second call would be comprised of five bursts, each two seconds apart.

Checking that it's alive

The first test is to simulate calling the Alarm Dialler from a remote location three times within 90 seconds to check if it is alive.

Ensure the Alarm Dialler is in idle mode and that the LED is flashing normally. Simulate an incoming call for 10 seconds (ie, by repeatedly typing **2** and pressing **Enter** on the PC's keyboard) and check that the LED stops flashing after the first ring burst.

Now wait at least another six seconds and simulate another call. The LED should remain on and nothing else should happen. Finally, wait another six seconds and simulate a third incoming call. If the Alarm Dialler is working correctly, the letters ATA will appear on the screen and, after a

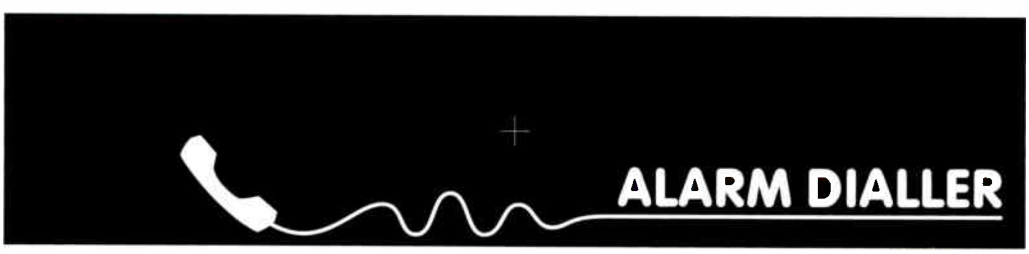


Fig.5: the full-size front panel artwork. There's just one hole to be drilled and that's for the indicator LED.

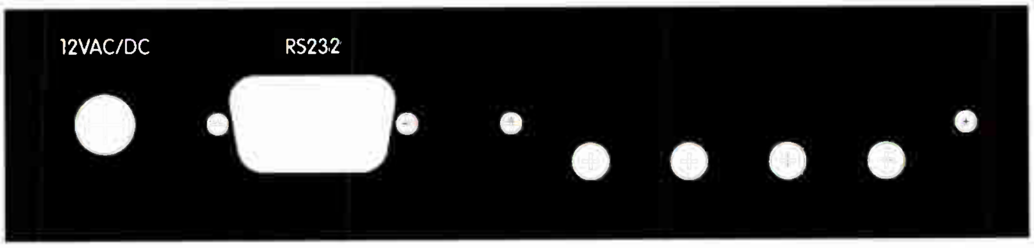


Fig.6: this full-size artwork can be used as a drilling template for the rear panel. The cutout for the DB9 connector can be made by drilling a series of small holes around the inside perimeter and knocking out the centre piece.

couple of seconds, the LED will start to flash again. The sequence ATA instructs the modem to go online and answer the call.

Checking automatic mode

The next test will check that Automatic mode operates correctly. First, simulate an alarm condition on the input. The screen should now show the letters ATDT, followed by the digits for the Primary number that you have entered during programming. The sequence ATDT is the command sent to the modem to tone dial the following number. Wait 45 seconds and the same sequence should appear on the screen again.

At this point the primary number has been dialled twice which is the number set in Retries. As we have set Use Secondary to Yes, the same delayed dialling sequence should occur again, however this time the Secondary number is used. Once all the calls have been made, the Alarm Dialler waits 45 seconds, operates the relay and the LED starts to flash normally.

Checking non-automatic mode

Once you are satisfied that Automatic mode is working correctly, you can test Non-Automatic mode. Program the Alarm Dialler with Automatic mode set to No, leaving everything else the same.

Simulate an alarm as before and check that the letters ATDT followed by the digits for the Primary number are seen on the screen.

Wait around 20 seconds and simulate an incoming call comprised of two bursts of ring. When the Alarm Dialler is in alarm mode it will only answer an incoming call after it has received two ring bursts. After the second burst, the Alarm Dialler should respond by displaying ATA on the screen, instructing the modem to go online and answer the call.

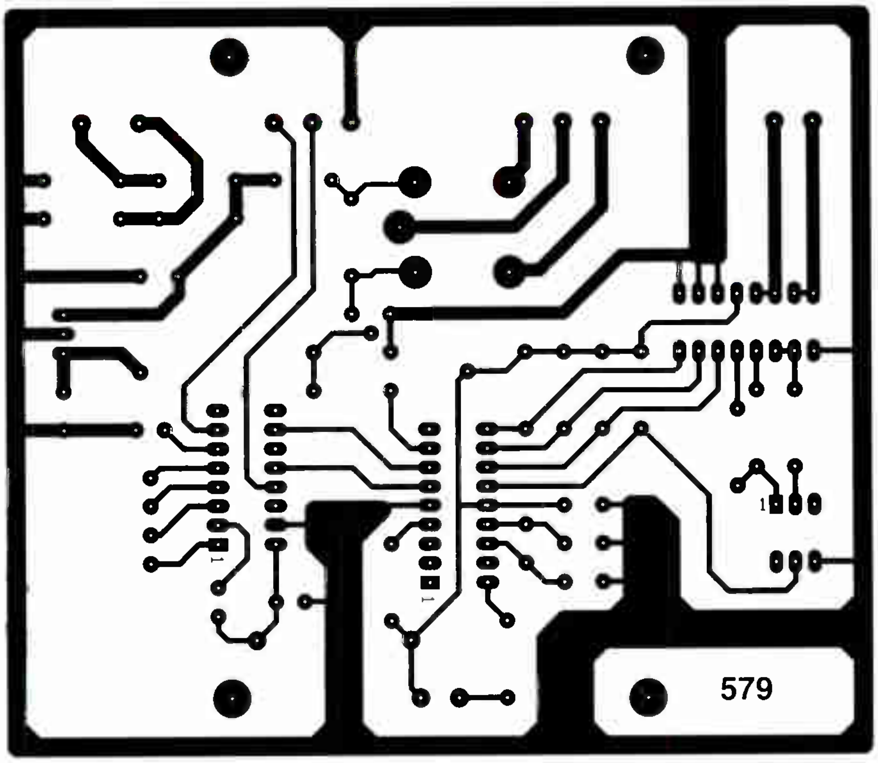


Fig.7: this is the full-size etching pattern for the PC board.

Wait 20 seconds and simulate a second incoming call in the same way. If the second call is detected the letters ATA should appear again indicating that the Alarm Dialler is answering the second call.

Finally, wait another 20 seconds and simulate a third incoming call. The Alarm Dialler should send ATA as before, however this time the relay will operate and the LED will start flashing. This is because three calls within 90 seconds have been registered in response to an alarm call.

If all these off-line checks perform correctly, you can be assured that the Alarm Dialler is working properly. If you want, you can test other features such as the failed call state, changing the number of retries and using the Primary number only and so on.

When you are satisfied that everything is OK, you can connect your modem to the Alarm Dialler and telephone line and test the system for real. Don't forget to reset DIP switch S1 to the alarm input option you require (see Table 1) *EPE*

Where To Get The PIC Software

To obtain the Alarm Dialler software, download the file "ALARM.ZIP" from the *EPE* website at www.epemag.co.uk and unzip it. You can use "ALARM. HEX" to program your own PIC chip, while you can get a better understanding of how it all works by reading the "ALARM.ASM" file. Pre-programmed PICs can be bought from Magenta Electronics (contact details as in their advertisement in this issue).

PIC N' MIX

KEITH ANDERSON

Our periodic column for your PIC programming enlightenment

This month *EPE* reader Keith comes in with useful suggestions about range checking for more advanced PIC users

IN most "How to..." descriptions of PIC microcontrollers, the advice about tables rarely includes range checking and/or PCLATH management, although Malc Wiles looked at Computed GOTOs in depth in Jan '03 and John Waller discussed PCLATH in July '02. Range checking becomes particularly important, and also particularly difficult, when programs are written as linked modules.

Range Checking

The architecture for the 16F series PICs encourages extensive use of lookup tables and jump tables. These are very easy to code and very efficient, but there are several traps.

Computed GOTO is well recognized as a high risk programming technique. In-range checking is usually regarded as essential, or at least very important. Range checking needs more instructions than the Computed GOTO itself, so appears to be inefficient.

PIC memory is very strictly divided into Pages and further, the Page size seen by the ADDWF PCL,F instruction used to implement Computed GOTO is smaller than that seen by normal GOTO and CALL instructions. If the linker is used, the PAGESEL directive manages PCLATH for GOTO and CALL instructions, but not for the ADDWF PCL,F instruction used to implement Computed GOTO.

The linker supplied with the free Microchip development system doesn't allow absolute constants to be GLOBAL or EXTERN. This limits the opportunity to structure the modular components of the program into separate files. INCLUDE files help a bit, but usually the three major components: table, range checking, and the procedure(s) that use the table, must all share a common file.

Solutions

Many PIC programmers have devised a variety of ways of dealing with these problems. Each is a compromise, and any notion of "better" depends upon which criteria are important in any particular application.

One solution, and one with which the author is very pleased, addresses the criteria that are important to him:

- Range checking is essential
- Reliable and painless PCLATH management is essential

He now uses the Microchip linker for all applications, even trivial ones. The strategy needs one macro and a little discipline. Some components of the discipline are a little counter-intuitive, but seem to be necessary.

The Discipline

1. Lookup tables and Computed GOTO tables are always placed in sub-page zero of the full-page containing the code using them.

2. Other code on each full-page starts at the first sub-page of the full-page. The relevant addresses are:

```
ORG 0x0010  ; Page 0, sub-page 0
ORG 0x0100  ; Page 0, sub-page 1
ORG 0x0800  ; Page 1, sub-page 0
ORG 0x0900  ; Page 1, sub-page 1
ORG 0x1000  ; Page 2, sub-page 0
ORG 0x1100  ; Page 2, sub-page 1
ORG 0x1800  ; Page 3, sub-page 0
ORG 0x1900  ; Page 3, sub-page 1
```

The setting for full-page 0, sub-page 0 assumes that most of the reset and interrupt code is located away from the relatively precious space on sub-page 0. However, the necessary interrupt preamble needs 16 bytes, so tables cannot start before 0x0010.

3. PCLATH is maintained to point to full-page boundaries, never to sub-page boundaries.

4. The only overhead allowed on the relatively precious sub-page 0 is the single and essential ADDWF PCL,F instruction that precedes the table.

5. Range checking is always implemented by the macro TableRangeCheck. This generates eight instructions. Out-of-range input is mapped consistently to the last byte in the table, and the tables can be of any size up to 255 bytes. The benefit of TableRangeCheck is so high, and the cost is so low that inferior techniques such as "hope for the best" or range limiting using ANDLW MASK cannot be justified.

6. Each table is in its own CODE section, and this must be defined manually.

7. Each table is defined by two names, of the form:

```
<table>Start
table goes here
<table>End
```

8. Within the same source file, but in a different CODE section, TableRangeCheck is used to constrain W to the size of the table. The structure is:

```
<table>ConstrainCode    CODE
<table>
TableRangeCheck
<table>Start,<table>End
```

9. In the procedure using the table, for table lookup use:

```
MOVF SRC,W
CALL <table>
```

10. In the procedure using the table, for Computed GOTO use:

```
MOVF SRC,W
GOTO <table>
```

11. The linker script must put the code containing the table into a zero sub-page and the other code into a non-zero sub-page within the same page.

Code Example

Here is an example of the type of coding needed, held within the file defining the table:

```
ExampleTableCode      CODE
ExampleTableStart
ADDWF   PCL,f
RETLW   0xAA
RETLW   0xBB
ExampleTableEnd
Other Tables

ExampleTableConstrainCode      CODE
ExampleTable
TableRangeCheck
ExampleTableStart,ExampleTableEnd
constraint code for other tables
```

It is usual, but not essential, for each table and each constraint procedure to have its own CODE section:

```
ExampleCode    CODE
MOVF  SRC,W
CALL  ExampleTable
MOVWF DST
```

Note that the transfer is to the constraint procedure, not to the start of the table.

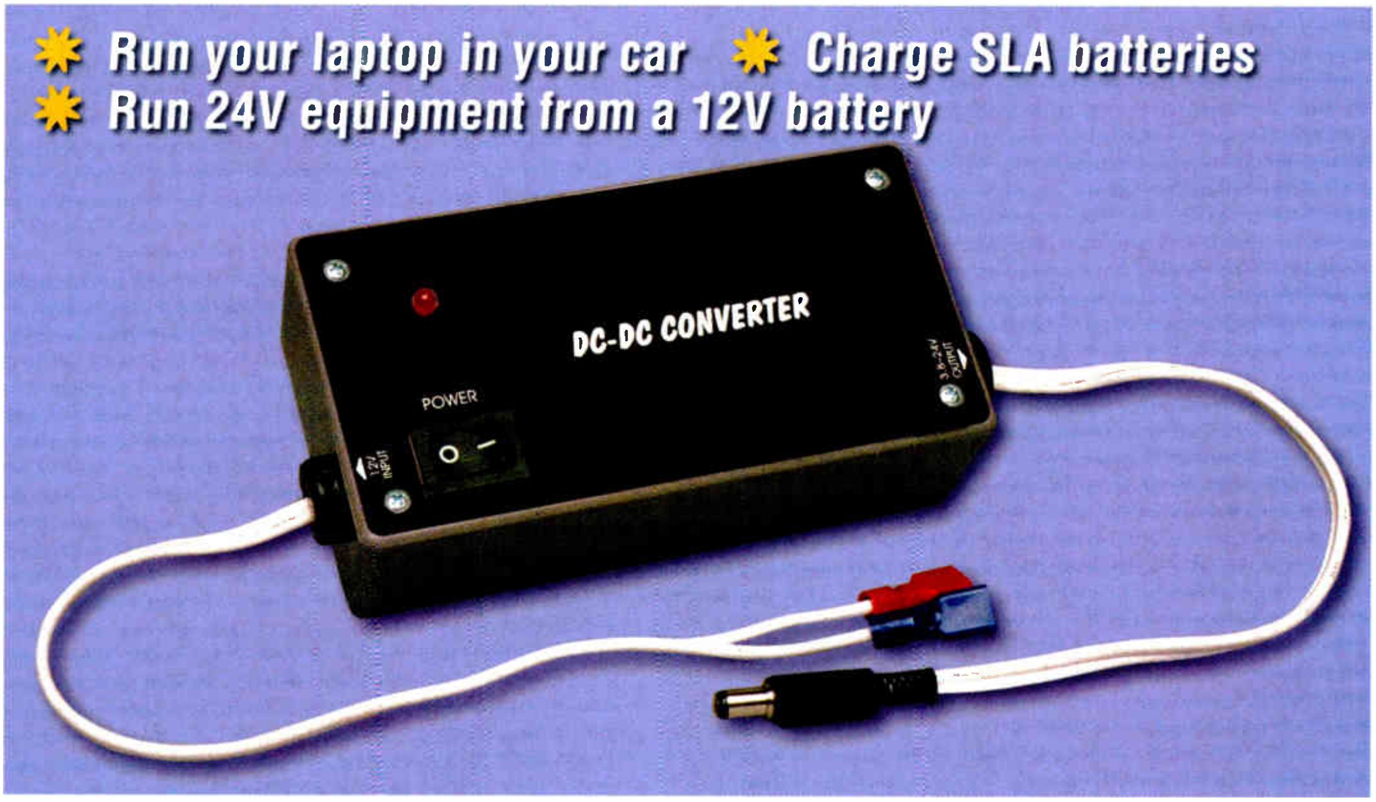
Table Range Check

The TableRangeCheck macro is used to ensure that the value of W used in ADDWF PCL,F in the lookup table addressing is within the range of the table.

W is the zero origin address of the required byte within the table. If W is within range, its value on exit from the macro is the same as its value on entry. If W is not within range, it is set to point to the last item in the table.

PCLATH is constrained to point to sub-page 0 of the current full-page:

```
TableRangeCheck                MACRO
TableStart,TableEnd
BCF    PCLATH,2
BCF    PCLATH,1
BCF    PCLATH,0
ADDLW  TableStart-TableEnd+1
BTFSC  STATUS,C
MOVLW  -1
ADDLW  TableEnd-TableStart-1
GOTO   TableStart
ENDM
```



Adjustable DC-DC converter for cars

Need to run electronic equipment in your car but require more than 12V? Or do you want more voltage than your 12V battery can deliver? This versatile circuit will let you do it. Run your laptop, charge 12V SLA batteries or whatever.

By JOHN CLARKE

Main Features

- Steps up 12V to between 13·8V and 24V
- Maximum current 2A
- Charge 12V 6·5Ah or bigger SLA batteries
- Efficient switchmode design
- Fuse and reverse polarity protection
- Power indication

WE regularly get requests from readers wanting to power electronic equipment in their car. Often they want to run a laptop computer in the car or perhaps charge 12V SLA batteries or whatever.

We have published circuits in the past but now we present an improved design capable of delivering any voltage from 13·8V up to 24V DC.

Typically, laptops require 15V DC or more in order to operate correctly and this voltage is not available directly from the car battery. A car battery normally supplies only a nominal 12V DC when the engine is not running and between 13·8V and 14·4V when being charged by the car's alternator. Hence, if you want to run a laptop, you need this DC-DC Converter.

The unit is housed in a plastic zippy box measuring 130 x 68 x 43mm and can be plugged into your car's cigarette lighter socket. The output can be set to the desired level by adjusting a trimpot.

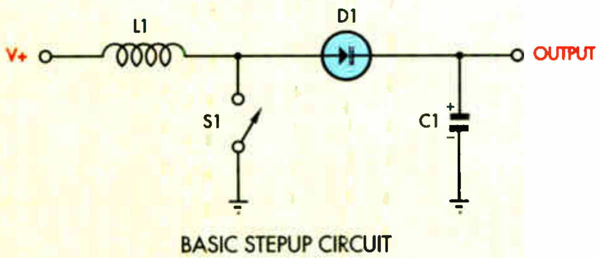
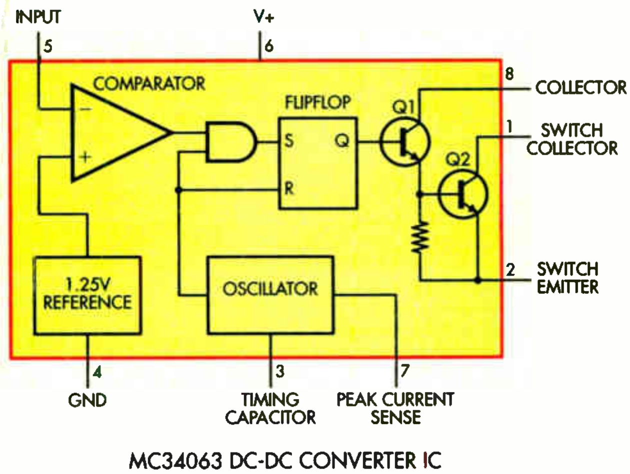


Fig.1: the basic operating principle of the DC-DC converter. When S1 is closed, current flows through L1, which then stores energy in the magnetic flux produced by the inductor. When S1 opens, the energy stored in the inductor is dumped via diode D1 to capacitor C1 and the load.

Fig.2 (right): block diagram of the Motorola MC34063 DC-DC converter IC.



Performance

The performance of the DC-DC Converter is shown in the graph of Fig.3. The output current ranges from a maximum of 2A at 15·7V, dropping to 1·1A at 24V, while still maintaining full regulation. Mind you, if you want to draw this level of current continuously, you would need to improve the heat dissipation of the circuit. We'll come back to this point later.

Output ripple and noise is quite low, nominally 50mV peak-to-peak when delivering 1A. Load regulation is better than 98% from no load to full load.

Performance

Maximum output current	1·1A @ 24V, 2A @ 15·7V
Recommended continuous output	500mA @ 24V, 1A @ 16V
Output ripple	typically 50mVp-p when delivering 1A
Load regulation	better than 98% from no load to full load

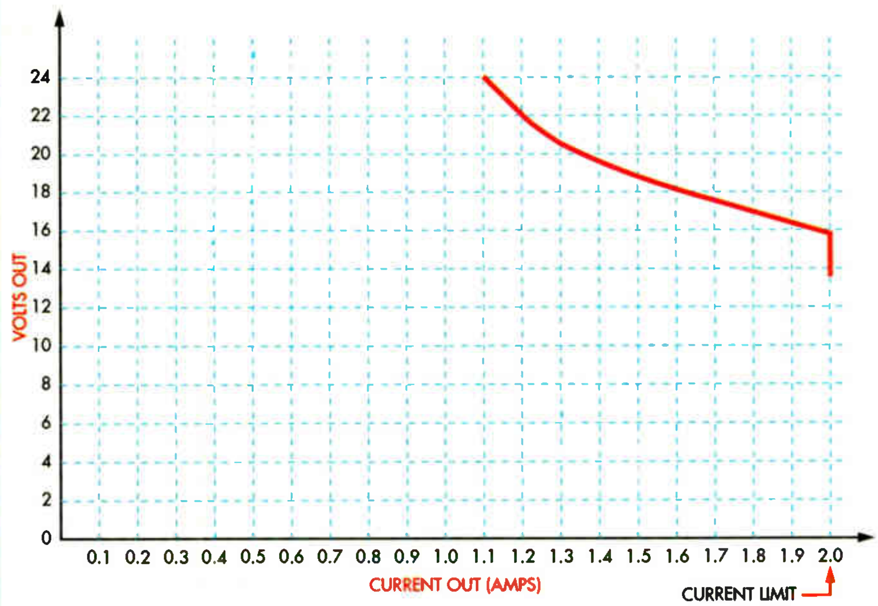


Fig.3: the unit has a maximum output current of 2A at voltages up to 15·7V, dropping to 1·1A at 24V while still maintaining full regulation.

How it works

Fig.1 shows the basic operating principle of the DC-DC Converter. It incorporates an inductor, a diode, a switch and a capacitor. When switch S1 is closed, current (I1) flows through the inductor L1 and S1, which then stores energy in the magnetic flux produced by the inductor. When S1 opens, the energy stored in the inductor is dumped via diode D1 to capacitor C1 and the load.

In practice, the switch is a transistor or MOSFET and the on/off times of the transistor's conduction are varied to maintain the desired load voltage. Our circuit uses a Motorola MC34063 DC to DC converter IC as the control device. Its internal circuit is shown in Fig.2.

The MC34063 IC contains all the necessary circuitry to produce either step-up, step-down or an inverting DC converter. Its internal components comprise a 1·25V reference, a comparator, an oscillator, RS flipflop and output transistors Q1 and Q2.

The switching frequency of the switching transistor (or MOSFET) is set by the capacitor connected to pin 3. We used 1nF to set it at about 30kHz. The oscillator is used to drive the flipflop which in turn drives the output transistors. Inductor current is sensed at pin 7 and when this reaches its peak the flipflop and the output transistors are switched off.

The time when the output transistors are switched on is determined by the comparator which monitors the output voltage. When the pin 5 comparator input exceeds the 1·25V reference, which means the output voltage exceeds the required level, the comparator goes low to keep the flipflop from setting. This holds the transistors off.

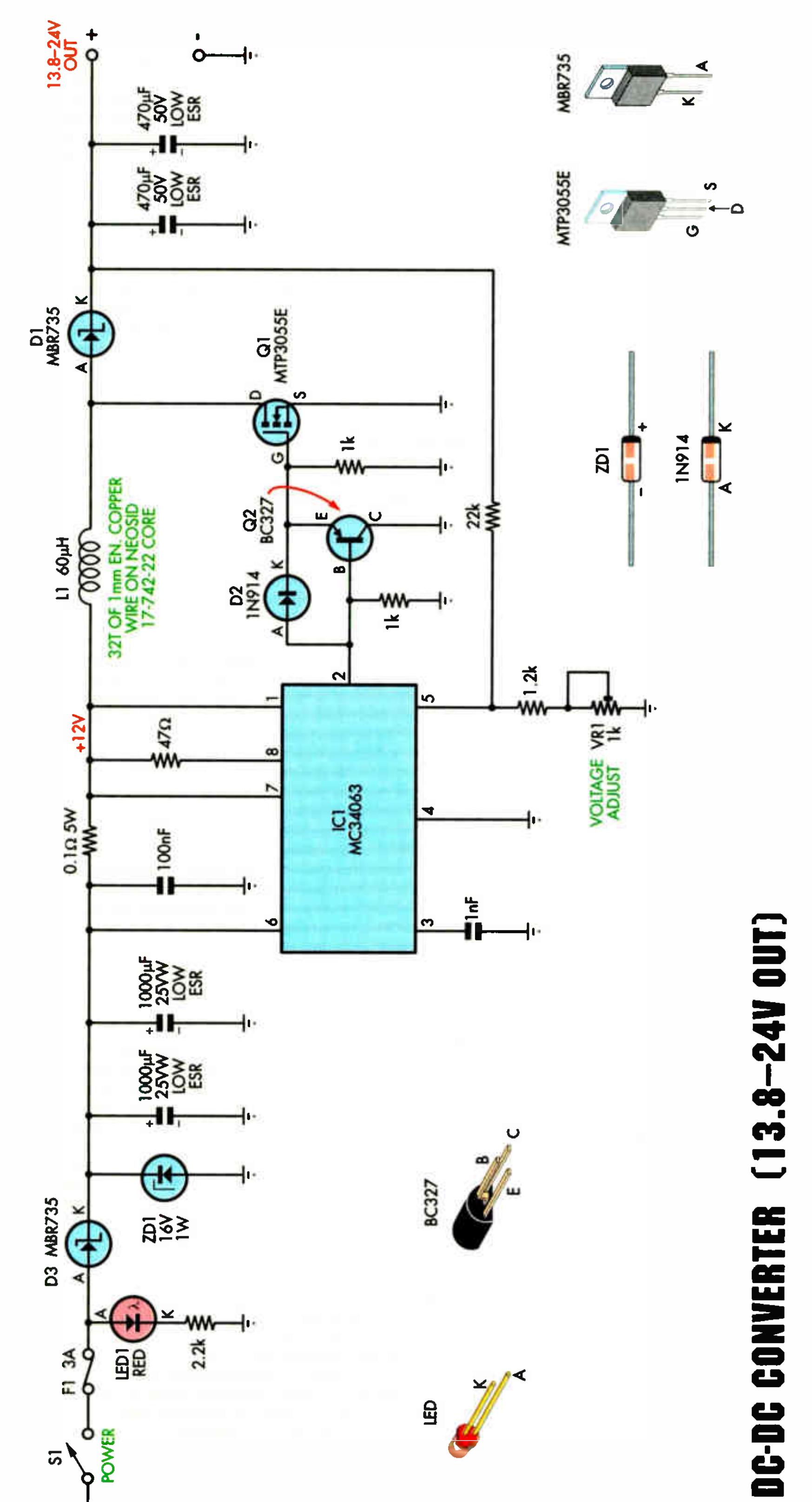


Fig.4: the circuit uses IC1 to drive the gate of MOSFET Q1 via diode D2, while Q2 discharges Q1's gate capacitance each time pin 2 of IC1 goes low. Voltage regulation is provided by the feedback network connected between the output and pin 5 of IC1 (ie, the 22kΩ & 1·2kΩ resistors & trimpot VR1).

Conversely, if the output voltage is too low, the inverting input of the comparator will be below the 1·25V reference and so the output transistors can be toggled by the RS flipflop at the rate set by the oscillator.

Circuit details

Fig.4 shows the full circuit diagram of the DC-DC Converter. The internal transistors of IC1 are connected as a Darlington to drive the gate of MOSFET Q1 high via diode D2 to switch it on.

Current then begins to flow in inductor L1. A 0·1Ω 5W resistor between pins 6 & 7 sets the peak current delivered to the inductor to 0·33V/0·1Ω or about 3·3A peak. The average current delivered to the load via diode D2 is limited to 2A.

When pin 2 goes low to turn off MOSFET Q1, transistor Q2 discharges Q1's gate capacitance for a rapid turn-off. This gives better efficiency than if the gate capacitance was discharged via a resistor.

Each time Q1 turns off, the voltage at its drain rises because of the energy stored in inductor L1. Because the current can no longer flow in Q1 it is diverted by diode D1 and dumped in the two 470µF capacitors. Diode D1 is a Schottky type which has a fast response to cope with the high switching frequencies (ie, 30kHz). It also has a low forward voltage which reduces power dissipation and improves efficiency. The output capacitors are low ESR (effective series resistance) types suitable for high frequency switch-mode operation.

Voltage regulation is provided by the feedback network from the output to pin 5. This comprises the 22kΩ resistor from the output and the 1·2kΩ resistor and series 1kΩ trimpot (VR1) connecting to ground. The output voltage is maintained when the voltage at pin 5 voltage is equal to the internal reference of 1·25V.

So, for example if VR1, is set to 0Ω, the output will be 24V since when this is divided down by the resistors [ie, 1·2kΩ/(1·2kΩ + 22kΩ) or divided by 19·33], the voltage at pin 5 is 1·25V.

Similarly, if VR1 is set to 1kΩ, the divider now will be (1·2kΩ + 1kΩ)/(22kΩ + 1·2kΩ + 1kΩ) or divided by 11 and so the output will be 13·75V when pin 5 is at 1·25V.

Power for the circuit comes in via a 3A fuse and diode D3, a Schottky power diode included for reverse

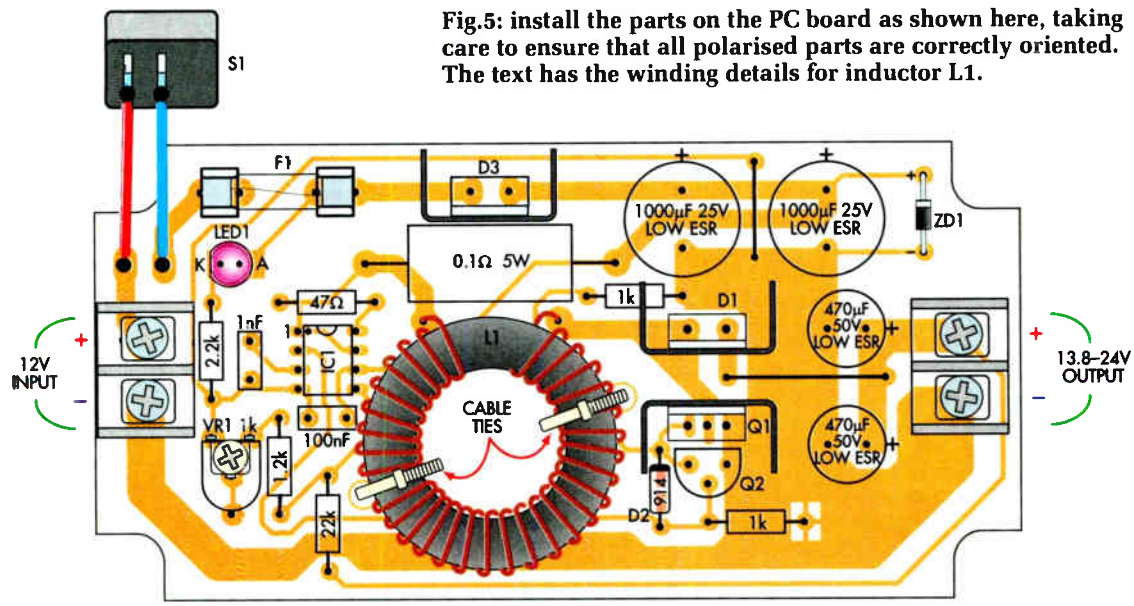


Fig.5: install the parts on the PC board as shown here, taking care to ensure that all polarised parts are correctly oriented. The text has the winding details for inductor L1.

polarity protection. Supply filtering is provided by two 1000μF 25V low ESR capacitors while further transient voltage protection is provided by the 16V Zener diode, ZD1.

There is a secondary reason to include diode D3 and this is to ensure that SLA batteries are not overcharged when the car battery voltage goes as high as 14·4V. Since this is a step-up voltage circuit, it cannot normally deliver less than the input voltage since the MOSFET is permanently off, if this situation is called for. When this happens, there is a direct current path via inductor L1 and diode D1 from the car battery to the SLA battery. Hence, the extra voltage drop via diode D3 helps ensure that SLA batteries are only charged to 13·8V.

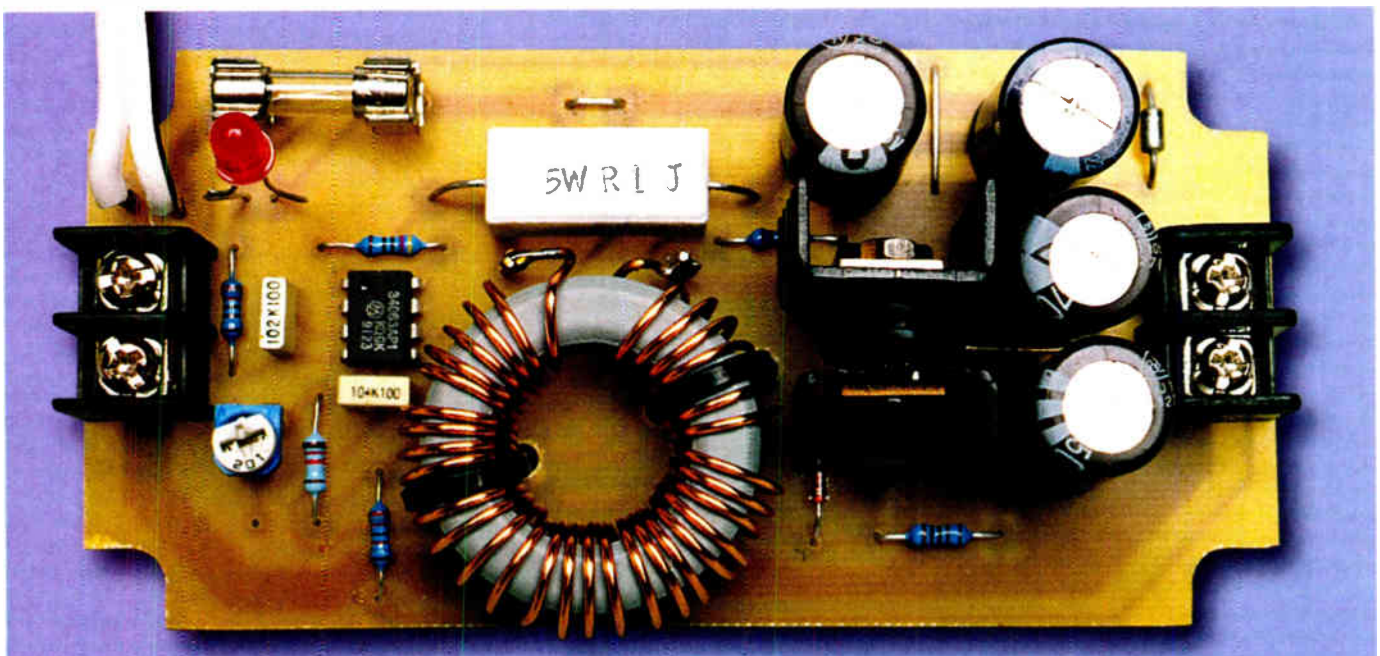
Construction

Construction is easy, with the parts all mounted on a PC board coded 578 and measuring 120 x 60mm. Fig.5 shows the parts layout.

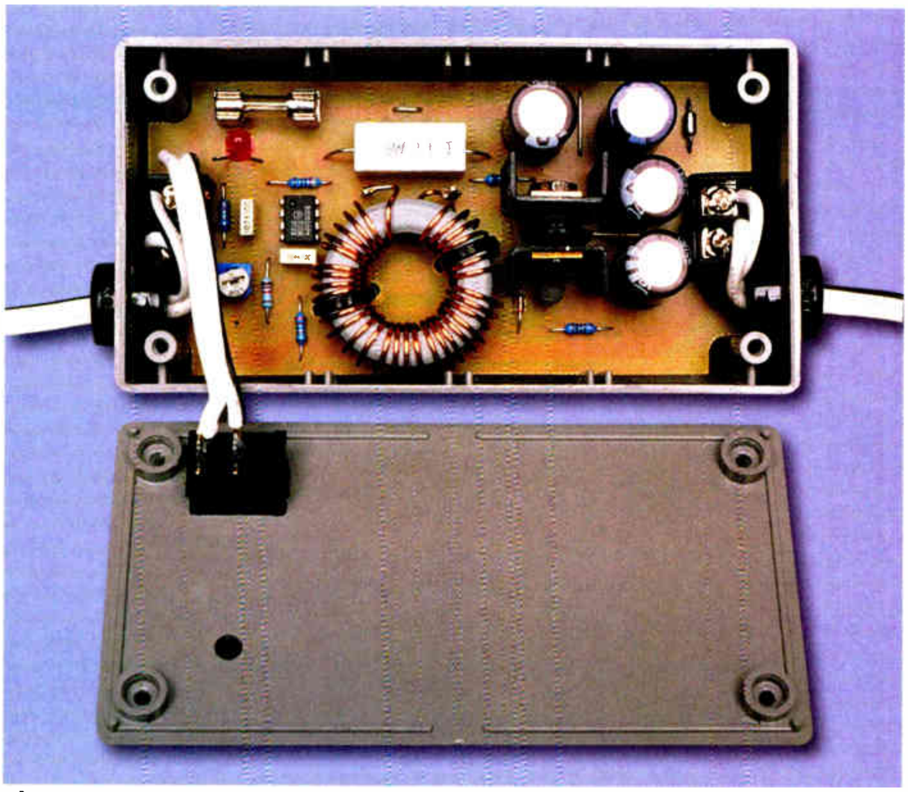
Begin construction by checking the PC board for shorted tracks or breaks in the copper pattern. Fix any defects you discover before going further. Next, insert the PC stakes for S1 and inductor L1 and the wire links.

Insert and solder in all the resistors using Table 1 to guide you in the colour codes. Insert the IC and Zener diode taking care with correct orientation. The capacitors can be mounted next, along with trimpot VR1.

The fuseholder clips must be inserted with the correct orientation. The easiest way to make sure the clips are oriented correctly is to fit the fuse into



This larger-than-life-size view shows the assembled PC board. The toroid is secured in place using cable ties.



The completed PC board fits neatly into a standard plastic case. Note the rubber grommet between the heatsinks attached to Q1 & D1.

the clips, before inserting them into the PC board. The input and output terminals can now be mounted.

D1, D3 and Q1 are mounted vertically on the PC board, each with a heatsink secured with a screw and nut. Note that diode D1 and MOSFET Q1 are held apart with a rubber grommet spacer between their heatsinks. This grommet is held between the heatsink mounting screws and prevents the two from making contact which would cause a short circuit.

Next, mount Q2 and the LED. LED1 is mounted so that its top is 29mm above the PC board.

Winding the inductor

Inductor L1 is wound with 1mm enamelled copper wire. Draw half the length of wire through the centre of the core and neatly wind on 16 turns, side by side. Then with the other end of the wire, wind on another 16 turns so that the toroid has a total of 32 turns neatly wound around the core. The windings are terminated onto the PC stakes as shown. Make sure that the wire ends are correctly stripped of insulation before soldering, by scraping it off with a sharp utility knife.

L1 is secured in place with two cable ties which loop around it and through holes in the PC board. Spread the windings near Q1's heatsink and the 100nF capacitor so that they are clear of these parts.

The completed PC board is housed in a plastic case measuring 130 x 68 x 43mm. Fit the label to the front panel and drill out the holes for the LED and switch S1. You will also need to drill out the holes at each end of the case for the grommets.

Clip the PC board into the case; it clips into the integral side clips within the case. Test the lid to check that the LED passes through its hole with correct alignment. You can adjust it for best fit and height by bending the leads.

Wire up a cigarette lighter plug or alligator clip connectors to a length of twin automotive wire and pass the other end of the lead through the grommet. Terminate the wires to the input PC board terminals and wire switch S1 as shown. Similarly, connect a second length of automotive wire to the output terminals on the PC board and secure with a grommet.

Testing

To test the unit, first apply power from a 12V battery or DC supply and check that the LED lights. If not, check that the LED is oriented correctly. Now measure the voltages on IC1 with a multimeter. There should be about 12V between pins 4 and 6.

Now connect a multimeter across the output leads and adjust VR1. The voltage range should be from 13·8-24V. Note that the voltage will take several seconds to drop from a higher voltage to a lower setting since the only load is the voltage sensing resistors and these need to discharge the output capacitors.

Set the voltage to that required for your application. If you want to charge SLA batteries, set the output to 13·8V.

Now connect the unit to the appliance using a suitable connector. Be sure the output connector polarity is correct before running the appliance. Check that MOSFET Q1 and diodes D1 & D3 run warm rather than hot.

Table 2: Capacitor Codes

Value	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	22kΩ	red red orange brown	red red black red brown
❑	1	2·2kΩ	red red red brown	red red black brown brown
❑	1	1·2kΩ	brown red red brown	brown red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown

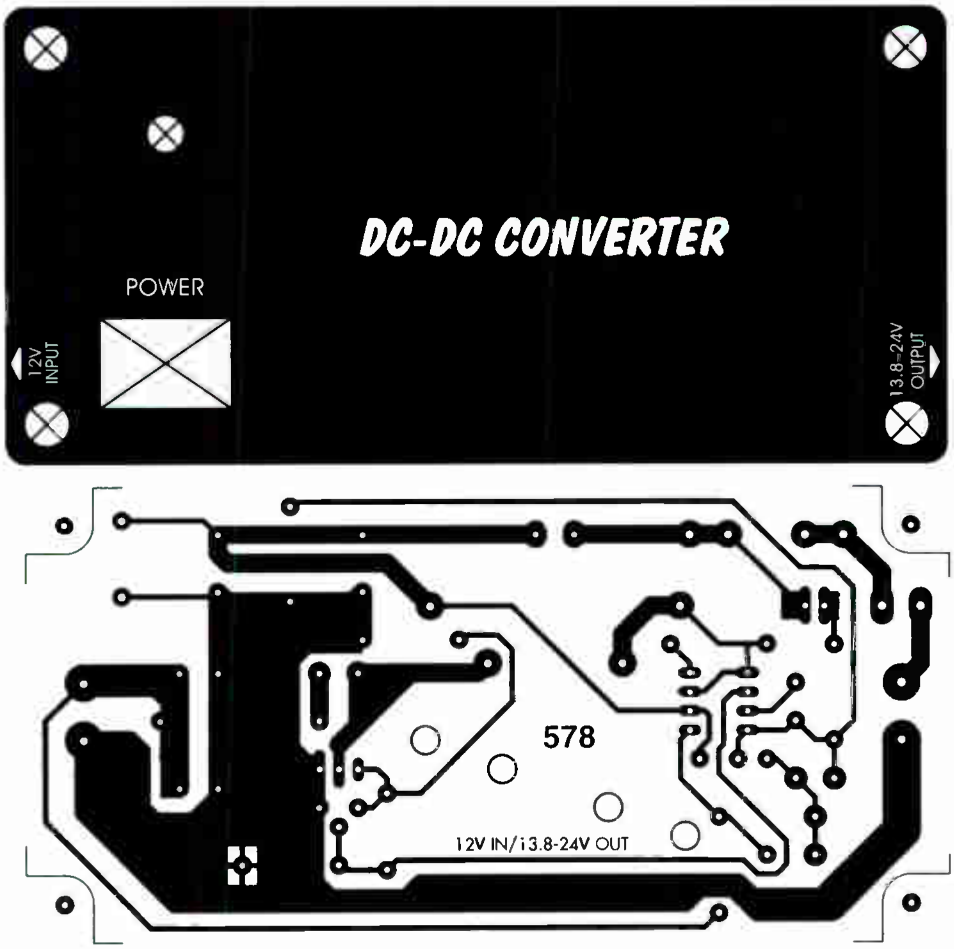
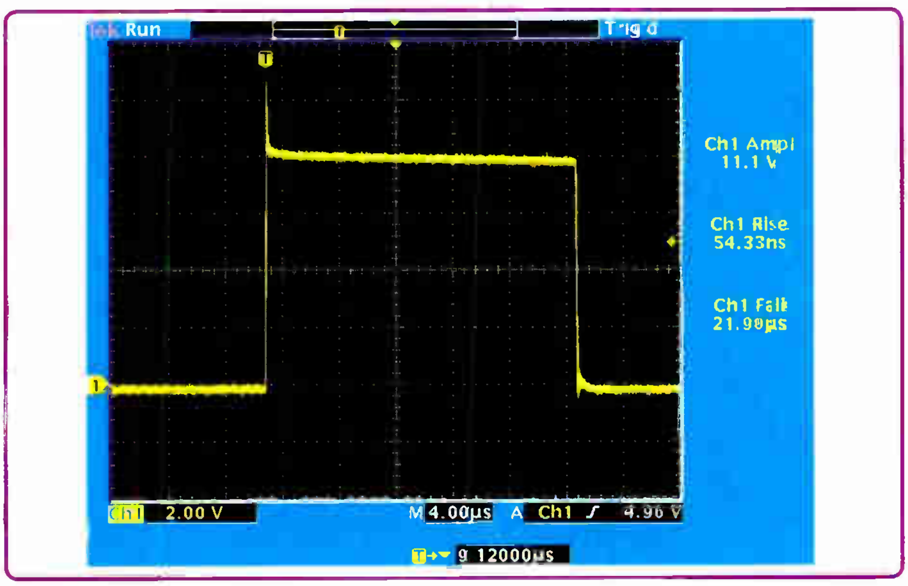


Fig.7: here are the full-size artworks for the front panel and PC board pattern.



This oscilloscope trace shows the gate drive to the MOSFET Q1. There is almost 11V drive with fast rise and fall times. The fast fall time is improved using the Q2 gate discharge transistor which quickly discharges the gate capacitance.

Finally, if you need to continuously run the DC-DC Converter at its full rated output of 2A, it would be wise to run it in a ventilated metal case and possibly use larger heatsinks for Q1, D1 & D3.

EPE

Parts List

1 PC board, code 578, available from the *EPE PCB Service*, 120 x 60mm
1 plastic case, 130 x 68 x 43mm
1 panel label, 126 x 64mm
1 powdered iron core (FERROX-CUBE TN25/15/10 or similar)
1 SPST rocker switch (S1)
2 2-way PC-mount screw terminals 8·25mm pin spacing
3 mini heatsinks, 19 x 19 x 10mm
2 M205 PC-mount fuse clips
1 M205 3A fast-blow fuse (F1)
2 cordgrip grommets
1 14mm OD rubber grommet
1 plug for automotive cigarette lighter socket
1 1m length of red automotive wire
1 1m length of black automotive wire
1 1·2m length of 1mm enamelled copper wire
1 60mm length of 0·7mm tinned copper wire
2 100mm long cable ties
3 M3 x 10mm screws
3 M3 nuts
4 PC stakes
1 1kΩ horizontal trimpot (coded 102) (VR1)

Semiconductors

1 MC34063 DC-DC converter (IC1)
1 MTP3055E N-channel MOSFET (Q1)
1 BC327 PNP transistor (Q2)
2 MBR735 7A 35V Schottky diodes (D1,D3)
1 5mm red LED (LED1)
1 1N914, 1N4148 diode (D2)
1 16V 1W Zener diode (ZD1)

Capacitors

2 1000µF 25V low ESR electrolytic
2 470µF 50V low ESR electrolytic
1 100nF MKT polyester
1 1nF MKT polyester

Resistors (0·25W, 1%)

1 22kΩ	2 1kΩ
1 2·2kΩ	1 47Ω
1 1·2kΩ	1 0·1Ω 5W

Ingenuity Unlimited

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

Adjustable Touch Switch – *Light Fingered*

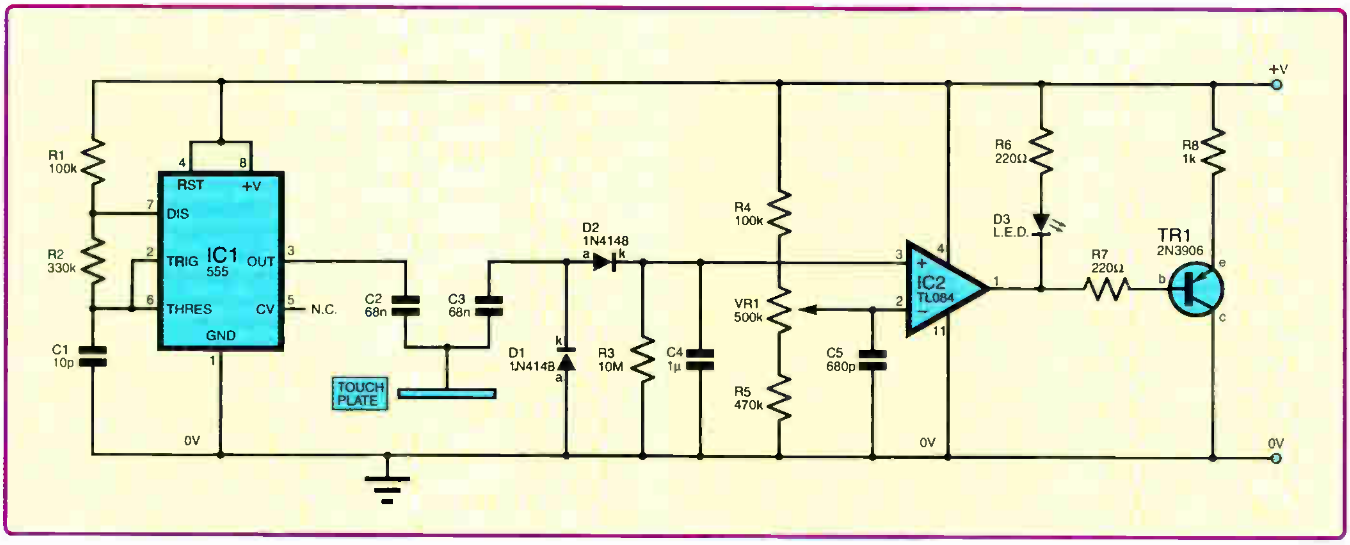


Fig.1: Complete circuit diagram for the Adjustable Touch Switch

THE sensitivity of the Touch Switch shown in Fig.1 can be adjusted between a slight touch or to a larger "pressure" being applied to trigger the switch. Because this switch works on capacitance, it will work through paint or paper labels or plastic.

The input circuit to the switch consists of a free running oscillator, IC1, having an oscillation rate set by capacitor C1 and resistor R2. This transmits a square wave pulse via two capacitors, C2 and C3, to a diode pump circuit formed around diodes D1, D2 and op.amp IC2.

The touch switch plate can be any metal insulated from ground. Touching the switch will increase capacitance of the capacitors C2 and C3, which will raise the voltage on the positive (+) input of the op.amp. The output of IC2 will go low, nearly to 0V. The LED in the circuit is simply for testing purposes.

To adjust, while touching the switch, turn the pot, VR1, until the LED goes out. Then slowly turn the VR1 in the opposite direction until the LED just goes on. This is the correct touch position. This circuit will work on 5V to 12V. The single 555 timer circuit can drive multiple touch switches.

Chris Hegter, George, South Africa

PLEASE TAKE NOTE

Magic Bulb (IU July '06)

Page 40, Fig.1. The lower end (contact) of potentiometer VR1 should be shown connected directly to the "earth" line (0V) and not to the junction of S3 and TR1's base. We apologise for this error.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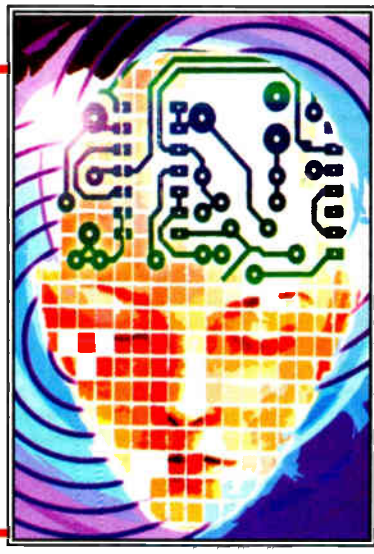
TEACH-IN 2006

Part Ten – PICs and Operational Amplifiers.



MIKE TOOLEY BA

Our Teach-In 2006 series provides a broad-based introduction to electronics for the complete newcomer. The series also provides the more experienced reader with an opportunity to "brush up" on topics which may be less familiar. This month we shall be looking at two very different integrated circuit devices that have both had a huge impact on the world of electronics, the PIC microcontroller and the operational amplifier (op amp). These deceptively simple devices have found their way into a wide variety of electronic applications and both deserve a special mention in our Teach-In series.

PIC Microcontrollers

Last month, we introduced the notion of the microcontroller as a device that can form the basis of a stand-alone (or embedded) electronic application that can perform a variety of programmed functions. A PIC is just such a microcontroller device and it provides a flexible low-cost solution to bridge the gap between single-chip computers and the use of large numbers of discrete logic and other chips. PIC microcontrollers are being increasingly used in "self-contained" applications involving logic, timing and simple analogue-to-digital and digital-to-analogue conversion.

PIC microcontrollers first became popular more than a decade ago. Since then the range and power of these devices has increased dramatically. Nowadays, a PIC device exists for almost any embedded application, from small 6-pin devices ideal for simple control applications, through to powerful high-speed devices packed with diverse I/O (input/output) features and large amounts of program memory.

PICs are based on RISC (Reduced Instruction Set Computer) architecture and, as a consequence, they use a relatively small number of instructions. In fact, some PIC chips have as few as 33 instructions compared with some general-purpose microprocessors (such as the Z80 that we met last month) that may have several hundred.

Because it is only necessary to remember a small number of commands, it is relatively easy to learn to program a PIC using its own assembly language (note, however, that it may take several instructions to achieve on a PIC what can be done in a single instruction using a fully-fledged microprocessor). And, if you don't like the idea of having to learn assembly code programming you can make use of high-level languages such as C, BASIC or Flowcode (a language based almost entirely on flowcharts). Program memory can be ROM, PROM or Flash memory. Data memory, on the other hand, must be read/write memory (commonly known as RAM – see last month).

As mentioned last month, mainstream microprocessors (like the Z80) are often classified by the number of data bits that they can manipulate (i.e. the "width" of the data bus). This can be either 8-, 16-, 32-, 64- or 128-bits. PIC microcontrollers, by contrast, are all based on an 8-bit data bus and, because of this, they can only operate on 8-bits of data at a time (despite this, you will sometimes encounter program instructions that reference data in 12-, 14-, and 16-bit units). The program memory of a PIC usually varies in width from 12-bits to 16-bits.

PIC Families

In the early 1990s, PIC microcontrollers were grouped in three families, often referred to as "Base-Line", "Mid-Range", and "High-End". Unfortunately, many of these devices are incompatible with the latest PIC development platforms and software tools. Despite this, it is usually possible to locate a modern device that is compatible with (and will generally outperform) one of these early devices.

Another important feature of modern PIC devices is the use of electrically erasable and programmable Flash memory for program storage. These Flash memory devices are often denoted by the use of the letter "F" as part of the device coding (e.g. PIC16F877A). Note, as we shall see later, Flash devices are much easier to work with for one-off prototyping because erasure and reprogramming is greatly simplified.

Choosing a PIC Device

When choosing a PIC device for a particular project it is important to select a device that is well supported, both in terms of being a member of one of the current PIC families but also in relation to the programming environment that you intend to use for software development. It is also important to ensure that the device incorporates all of the peripheral I/O facilities that you will need. These features might include:

- Communication interfaces (such as RS232/RS485, USB, etc)
- Display peripheral interfaces (such as LED or LCD drivers)
- Capture/compare facilities
- Pulse Width Modulators (PWM)
- Counters/timers
- Watchdog facilities
- Analogue-to-digital (A/D) converters
- Analogue comparators and operational amplifiers
- Brown-out detectors
- Low-voltage detectors
- Temperature sensors
- Oscillators
- Voltage references
- Digital-to-analogue (D/A) converters.

The PIC16F84

The PIC16F84 is an excellent example of a simple PIC device for use with a wide variety of simple microcontroller projects. The chip offers the following features:

- 35 single-word instructions
- 1K × 14-bit EEPROM (Flash) program memory
- 68 × 8-bit general purpose static RAM registers
- 15 × 8-bit special function hardware registers
- 64 × 8-bit EEPROM data memory
- 1,000,000 data memory erase/write cycles (typical)
- Data retention > 40 years
- 5 data input/output pins (Port A)
- 8 data input/output pins (Port B)
- 25mA current sink maximum per pin
- 20mA current source per pin
- 8-bit timer/counter with pre-scaler
- Power-on reset (POR)

● Power-up timer (PWRT)
● Oscillator start-up timer (OST)
● Watchdog timer (WDT) with its own on-chip RC oscillator
● Power saving "sleep" function
● Serial in-system programming (see later)
● Selectable oscillator options (including low-cost R-C as well as crystal controlled clock options)
● Operating voltage range: 2·0V to 6·0V
● Power consumption: < 2mA at 5V, 4MHz
● 60μA typical at 2V, 32kHz
● < 1μA typical standby at 2V.

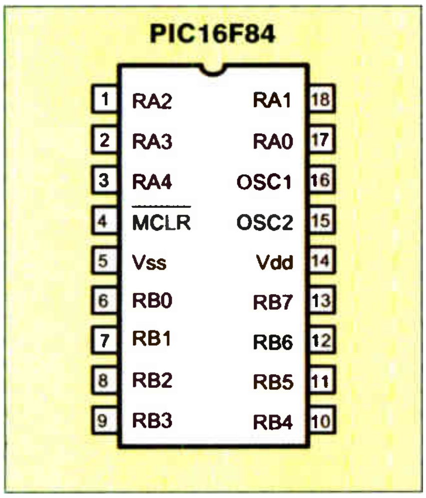


Fig.10.1. Pin connections for the PIC16F84

A Simple PIC Application

A simple PIC application based on the PIC16F84 is shown in Fig.10.2. The circuit provides control for two relays (RL1 and RL2) based on the state of four single-pole single-throw (SPST) switches (S1 to S4). The switches are connected to four lines on Port B which are configured as inputs whilst the two relays are connected to two lines on Port A configured as outputs. Because the relays demand more power than can be supplied by the PIC, additional transistor current amplifier stages (TR1 and TR2) are used as "drivers".

These two transistors are connected in common-emitter mode such that a *high* (logic 1) output from the respective Port A output line (either RA0 or RA1) will supply base current to TR1 or TR2 resulting in the transistor conducting heavily with sufficient collector current to operate either RL1 or RL2, as appropriate. The diodes, D1 and D2, are connected across the respective relay coils in order to limit the *back e.m.f.* generated when the current in the coil ceases and the flux collapses. Without these diodes there is a danger that the collector voltage may rise to a value that can cause the collector-base junction of TR1 and/or TR2 to break down.

The clock frequency (4MHz) of IC1 is determined by the crystal, X1. Note that, as an alternative to the use of a quartz crystal, the internal clock circuit of the 16F84 can also make use of low-cost (but less-accurate and less-stable) ceramic resonators and R-C (resistor-capacitor) networks.

In order to reset the PIC device, pin 4 ($\overline{MCLR}$) on IC1 must be taken *low* (logic 0, i.e. to 0V). In normal operation this pin is held high (i.e. +5V) via R5. On power-up (i.e. when the +5V supply is first connected) this pin will go low until C2 has become charged.

The four input pin lines (RB0 to RB3) are pulled high by R1 to R4 respectively. This arrangement produces a high (logic 1) input on a particular port line when its respective input switch (S1 to S4) is open. When the switch is closed, the corresponding input will be taken low (i.e. to logic 0).

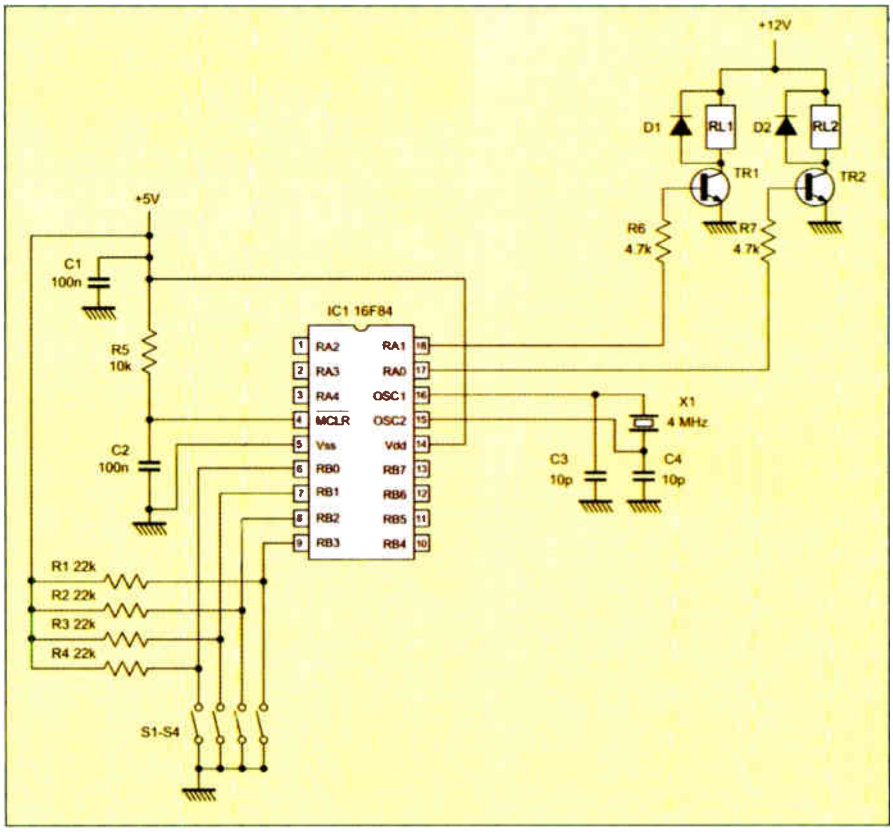


Fig.10.2. A simple PIC application based on the PIC16F84 chip

The PIC16F877

The PIC16F877 is a more advanced PIC device that is found in many "state of the art" microcontroller applications. The chip operates at up to 20MHz and has an 8K (14-bit EEPROM, Flash, program memory). The pin connections of the 16F877 are shown in Fig.10.3 and its internal architecture is shown in Fig.10.4. Note that the device has five output ports; Port A with six data pins, Ports B, C and D each with eight I/O pins, and Port E with three further I/O pins. The device can thus control a total of 33 I/O lines. In addition, the 16F877 has a 10-bit 8-channel analogue-to-digital converter and two analogue comparators with programmable on-chip voltage reference, programmable input multiplexing, and externally accessible comparator output.

PIC Programming

Programming a PIC is not quite as onerous as it might sound. As mentioned earlier, you can use assembly language or a high-level language such as C, BASIC, or Flowcode, or a mixture of these languages. Software and a programmer (see Fig.10.5 for an example) will be required to do this. There are many low-cost PIC programming and development systems readily available.

The two most commonly used methods of programming a PIC chip are shown in Fig.10.6. In Fig.10.6a a dedicated PIC programmer is used whilst in Fig.10.6b the PIC is programmed whilst resident in the target system. In either case, the programming software and source code is resident on a PC and downloaded as hex code into the PIC.

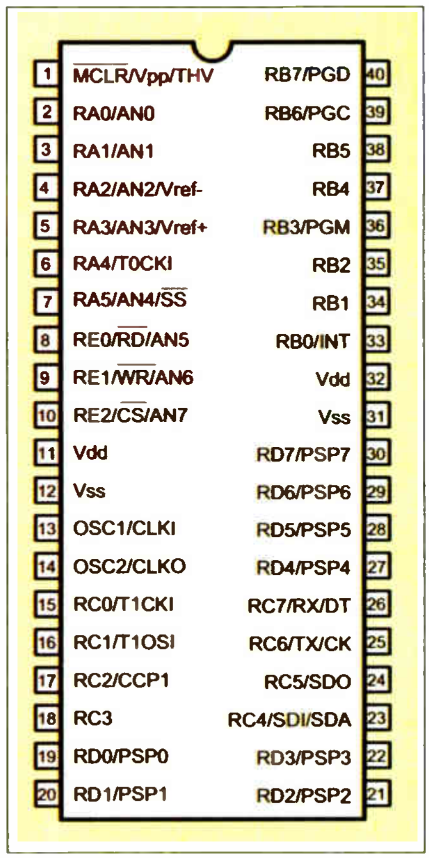


Fig.10.3. Pin connections for the PIC16F877 chip

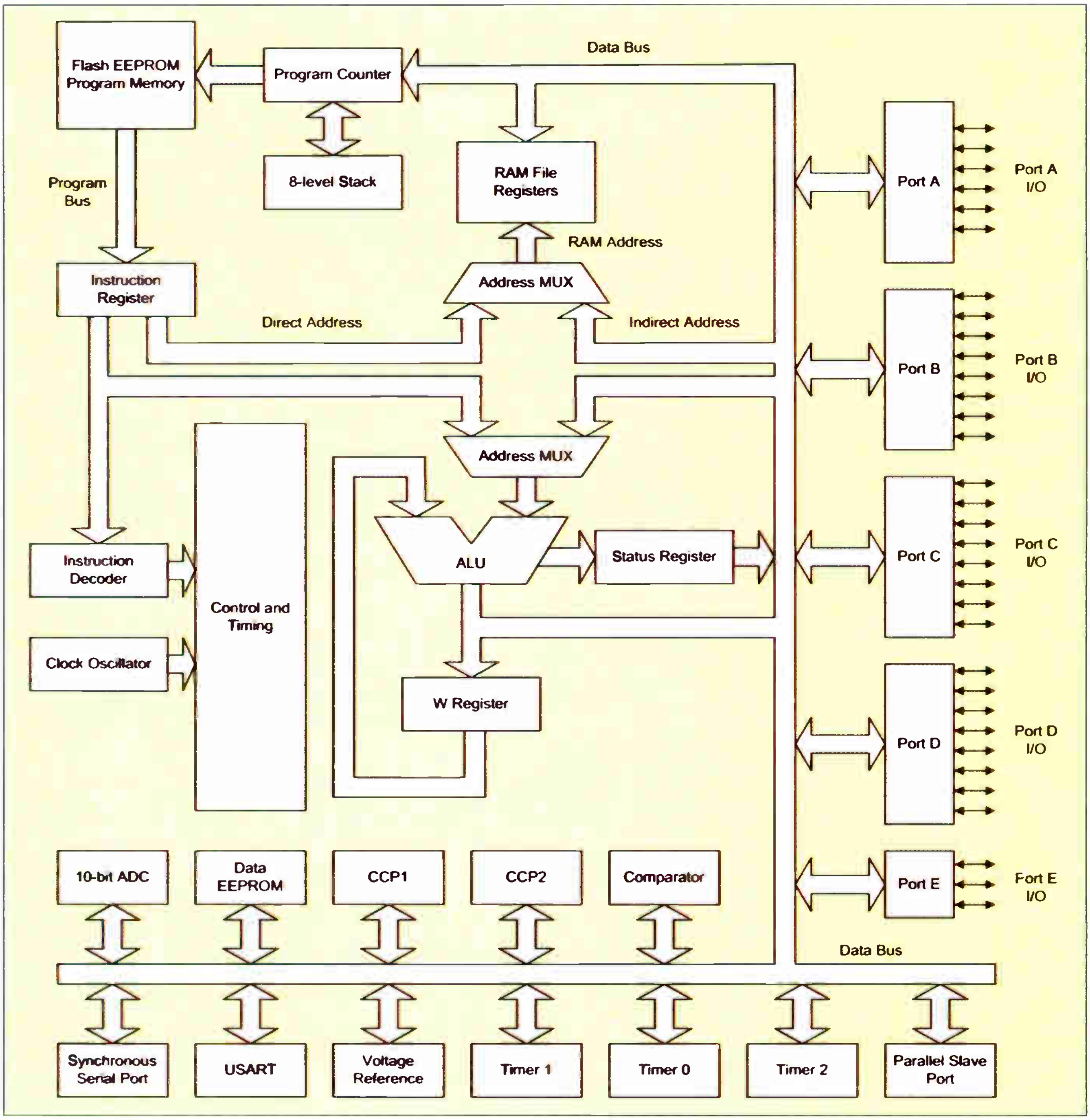


Fig.10.4. Internal architecture of the PIC16F877 chip

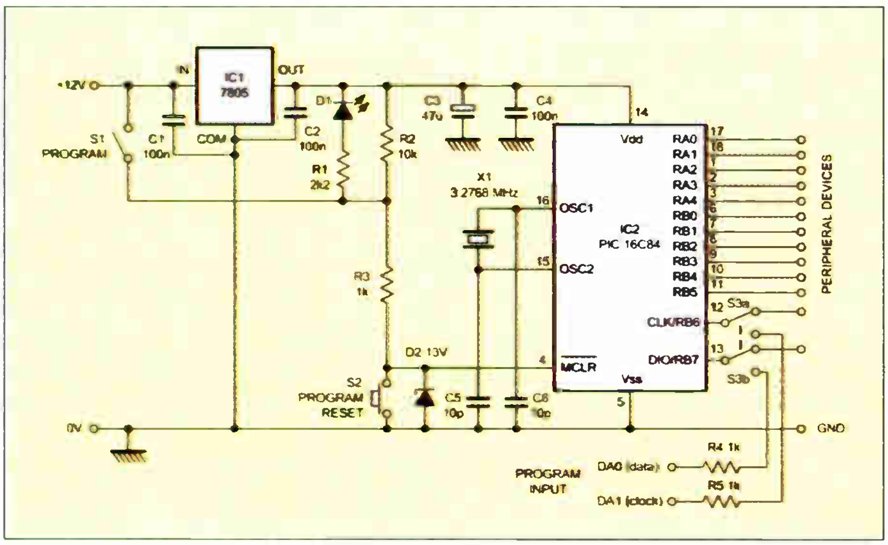


Fig.10.5. A simple PIC programmer

Check Point 10.1

PIC microcontrollers provide a flexible low-cost solution for use in a wide range of control applications involving logic, timing and simple analogue-to-digital and digital-to-analogue conversion.

Questions 10.1

Refering to Fig.10.2:

Q1. Which pin of IC1 is used for the positive supply voltage?

Q2. Which pin of IC1 is used for ground or common?

Q3. Which port lines on IC1 are unused?

Q4. What approximate current will be supplied by the Port A output lines when they are taken high?

The process of generating the source code, compiling and/or assembling it into hex code (see Fig.10.7) is invariably performed by software that is included as part of an Integrated Development Environment (IDE). Software is also available that can be used to simulate a PIC, allowing you to check program operation on a virtual (rather than a real) system.

Finally, if you plan to make regular use of PIC devices you might consider investing in a PIC Development System which will provide you with a breadboarding area complete with a variety of external devices such as keypads, LED and LCD displays, temperature sensors, etc.

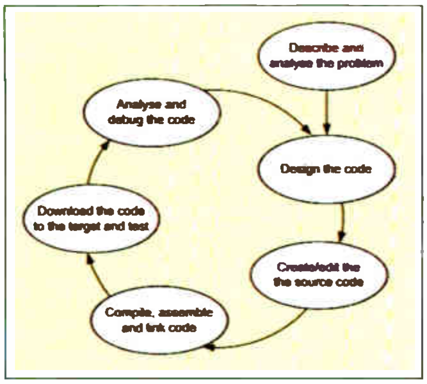


Fig.10.7. The PIC software development cycle

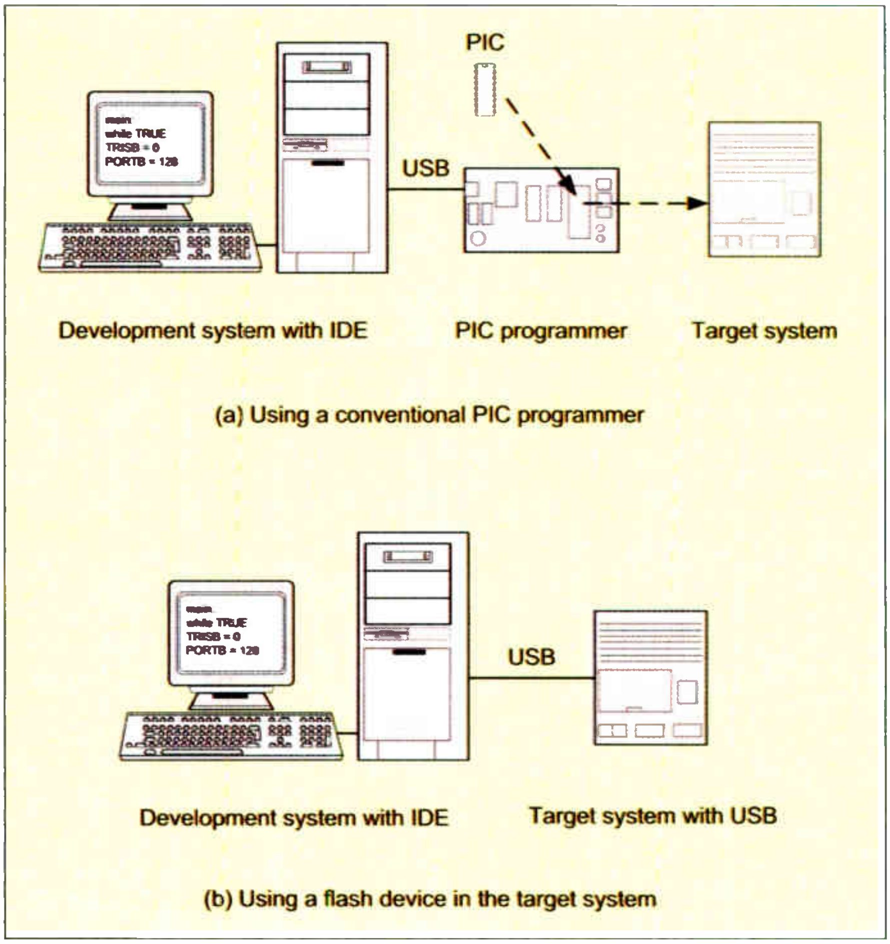


Fig.10.6. The PIC development process: (a) using a conventional PIC programmer, and (b) using a PIC Flash device in the target system

Operational Amplifiers (Op Amps)

Operational amplifiers (op amps) are analogue integrated circuits designed for linear amplification that offer near-ideal characteristics (very high voltage gain and input resistance coupled with low output resistance and wide bandwidth).

Op amps can be thought of as universal *gain blocks* to which external components are added in order to define their function within a circuit. For example, by adding just two or three resistors, we can produce an amplifier having a precisely defined gain. Alternatively, with three resistors and two capacitors we can realise a low-pass filter. From this you might begin to suspect that op amps are really easy to use. The good news is that they are!

The symbol for an op amp is shown in Fig.10.8. There are several important things to note about this. The device has two inputs and one output and no common connection. Furthermore, we often do not show the supply connections – it is often clearer to leave them out of the circuit altogether!

In Fig.10.8, one of the inputs is marked "–" and the other is marked "+". These polarity markings have nothing to do with the supply connections – they indicate the overall phase shift between each input and the output. The "+" sign indicates zero phase shift whilst the "–" sign indicates 180° phase shift. Since 180° phase shift produces an inverted (turned "upside down") waveform, the "–" input is often referred to as the *inverting input*. Similarly, the "+" input is known as the *non-inverting* input.

Most (but not all) op amps require a symmetrical supply (typically ±5V to

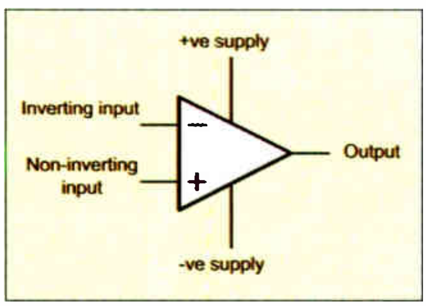


Fig.10.8. Symbol for an op amp

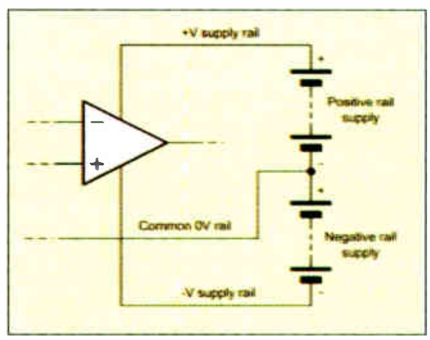


Fig.10.9. Supply rails for an op amp

±15V). This allows the output voltage to swing both positive (above 0V) and negative (below 0V). Fig.10.9 shows how the supply connections would appear if we decided to include them. Note that we usually have two separate supplies; a positive supply and an equal, but opposite, negative supply. The common connection to these two supplies (i.e. the 0V rail) acts as the common rail in our circuit. The input and output voltages are usually measured relative to this rail.

The 741 Op Amp

The type 741 is an example of a typical op amp based on bipolar junction transistors (BJT). The internal circuit of a 741 is shown in Fig.10.10. The input stage is a *differential amplifier* with Q1 and Q2 acting as emitter followers feeding a common base amplifier stage formed by Q3 and Q4. Q5 and Q6 provide a constant current collector supply for Q3 and Q4 respectively. Q8/Q9, Q10/Q11 and Q12/Q13 act as *current mirrors* that ensure that the collector

Check Point 10.2

Op amps are linear integrated circuits that can be used as versatile *gain blocks* within a wide variety of linear circuits.

currents of each pair are closely matched. Q14 and Q15 form a *Darlington pair* that produces a very high value of current gain. Unconditional stability is ensured by means of a small value internal capacitor, C1, which provides high frequency *negative feedback*.

Components Q18, R7 and R8 form a V_{BE} *multiplier* which provides a constant base voltage supply for the complementary output stage, Q16 (NPN) and Q17 (PNP). Finally, Q19 provides a measure of protection for the output stage in the event that excessive current is demanded from it. When conducting, Q19 *clamps*

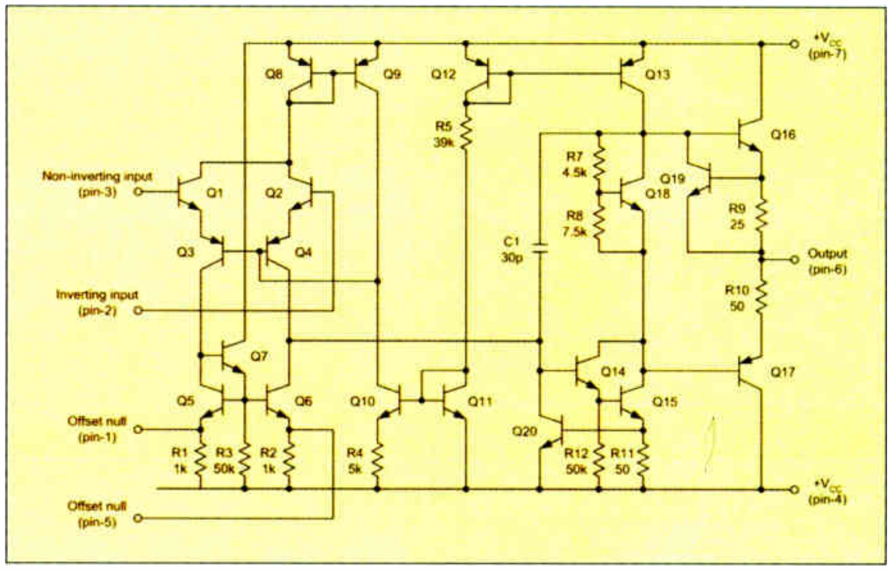


Fig.10.10. Internal circuit of a 741 op amp

Table 10.1 Characteristics of an op amp compared with those of an ideal amplifier

Parameter	Ideal	Real
Voltage gain	Gain Infinite	100,000
Input resistance	Infinite	100MΩ
Output resistance	Zero	20Ω
Bandwidth	Infinite	2MHz
Slew-rate	Infinite	10V/μs
Input offset	Zero	Less than 5mV

the base-emitter voltage of Q16 to a low value, reducing the base bias and consequently limiting the output current that can be supplied by the output stage.

Op Amp Characteristics

Before we can decide how good an op amp is (and how close it gets to the *ideal*), it's worth summarising the characteristics of a *perfect* amplifier. These might run along the following lines:

- The *voltage gain* should be very high (ideally infinite).
- The *input resistance* should be very high (ideally infinite).
- The *output resistance* should be very low (ideally zero).
- *Full-power bandwidth* (the range of frequencies over which the amplifier can deliver its rated output power) should be as wide as possible.
- *Slew-rate* (the speed at which the output voltage changes in response to a change in input voltage) should be as large as possible.
- *Input offset* (the value of input voltage required to make the output exactly zero) should be as small as possible.

In fact, the characteristics of most modern integrated circuit op amps come very close to those of an *ideal* op amp, as witnessed by Table 10.1.

Before we look at some representative circuits involving op amps it's worth expanding on some of the terms introduced in Table 10.1.

Voltage Gain

The open-loop (or internal) voltage gain of an op amp is very high (often 100,000 or more). In practice gains of this magnitude are not particularly useful for a number of reasons like poor stability and very limited bandwidth. Also, due to manufacturing tolerance, the internal voltage gain can vary widely from one device to another.

In order to reduce the gain to a manageable and predictable amount a precise amount of negative feedback is applied. In the circuit shown in Fig.10.11 the amount of negative feedback is determine by the ratio of resistor R2 to R1. Provided that the open-loop voltage gain is very high, the closed-loop voltage gain (i.e. the voltage gain with feedback applied) will be given by:

$$A_{VCL} = \frac{V_{OUT}}{V_{IN}} = \frac{R2}{R1}$$

where A_{VCL} is the closed-loop voltage gain, V_{OUT} and V_{IN} are the output and input voltages respectively under closed-loop conditions. Note that the closed-loop voltage gain is normally very much less than the open-loop voltage gain.

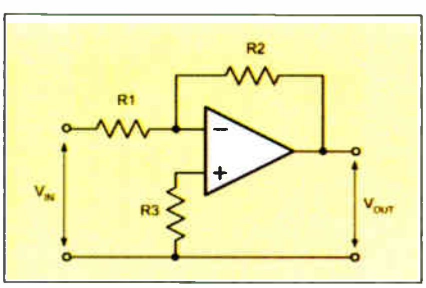


Fig.10.11. Op amp with negative feedback

Resistor R3 in Fig.10.11 has been included in order to improve the symmetry of the stage. The optimum value for R3 is given by:

$$R3 = \frac{R1 \times R2}{R1 + R2}$$

However, if R2 is large compared with R1, we often simply make R3 equal in value to R1.

Input Resistance

The input resistance of an op amp is defined as the ratio of input voltage to input current expressed in ohms. It is often expedient to assume that the input of an op amp is purely resistive, though this is not the case at high frequencies where shunt capacitive reactance may become significant. The input resistance of op amps is very much dependent on the semiconductor technology employed. In practice values range from about 2MΩ for common bipolar types, to over 10^{12}Ω for FET and CMOS devices.

Input resistance is the ratio of input voltage to input current:

$$R_{IN} = \frac{V_{IN}}{I_{IN}}$$

where R_{IN} is the input resistance (in ohms), V_{IN} is the input voltage (in volts) and I_{IN} is the input current (in amps).

However, regardless of the type of device, when negative feedback is applied (as in Fig.10.11) the input resistance will become equal to R1.

Output Resistance

The output resistance of an op amp is defined as the ratio of open-circuit output voltage to short-circuit output current expressed in ohms. Typical values of output resistance range from less than 10Ω to around 100Ω depending upon the configuration and amount of feedback employed.

Output resistance is the ratio of open-circuit output voltage to short-circuit output current, hence:

$$R_{OUT} = \frac{V_{OUT(OC)}}{I_{OUT(SC)}}$$

where R_{OUT} is the output resistance (in ohms), $V_{OUT(OC)}$ is the open-circuit output voltage (in volts) and $I_{OUT(SC)}$ is the short-circuit output current (in amps).

Input Offset Voltage

An ideal op amp would provide zero output voltage when 0V difference is applied to its inputs. In practice, due to imperfect internal balance, there may be some small voltage present at the output. The voltage that must be applied differentially to the op amp input in order to make the output exactly zero is known as the *input offset voltage.*

Input offset voltage may be minimized by applying relatively large amounts of negative feedback or by using the offset null facility provided by a number of op amp devices. Typical values of input offset voltage range from 1mV to 15mV. Where AC rather than DC coupling is employed, offset voltage is not normally a problem and can be happily ignored.

Full-Power Bandwidth

The full-power bandwidth for an op amp is equivalent to the frequency at which the maximum undistorted peak output voltage swing falls to 0·707 of its low frequency (DC) value (the sinusoidal input voltage remaining constant). Typical full-power bandwidths range from 10kHz to over 1MHz for some high-speed devices.

Slew rate

Slew rate is the rate of change of output voltage with time, when a rectangular step input voltage is applied. The slew-rate of an op amp is the rate of change of output voltage with time in response to a perfect step-function input. Hence:

$$\text{Slew rate} = \frac{\Delta V_{OUT}}{\Delta t}$$

where ΔV_{OUT} is the change in output voltage (in volts) and Δt is the corresponding interval of time (in s).

Slew rate is measured in V/s (or V/μs) and typical values range from 0·2V/μs to over 20V/μs. Slew rate imposes a limitation on circuits in which large amplitude pulses rather than small amplitude sinusoidal signals are likely to be encountered.

Gain and Bandwidth

It is important to note that the product of gain and bandwidth is a constant for any particular op amp. Hence, an increase in gain can only be achieved at the expense of bandwidth, and vice versa.

Fig.10.12 shows the relationship between voltage gain and bandwidth for a typical op amp (note that the axes use logarithmic, rather than linear scales). The open-loop voltage gain (i.e. that obtained with no feedback applied) is 100,000 (or 100dB) and the bandwidth obtained in this condition is a mere 10Hz. The effect of applying increasing amounts of negative feedback (and consequently reducing the gain to a more manageable amount) is that the bandwidth increases in direct proportion.

The frequency response curves in Fig.10.12 show the effect on the bandwidth of making the closed-loop gains equal to 10,000, 1,000, 100, and 10. Table 10.2 summarises these results. You should also note that the gain × bandwidth product for this amplifier is 1 × 10^6Hz (i.e. 1MHz).

Op Amp Configurations

The three basic configurations for op amps are shown in Fig.10.13. Supply rails have been omitted from these diagrams for clarity but are assumed to be symmetrical about 0V. Expressions for input resistance, voltage gain, and phase shift for the three basic amplifier configurations are shown in Table 10.3.

Finally, all of the amplifier circuits described previously have used direct coupling and thus have frequency response characteristics that extend to DC. This, of course, is undesirable for many applications, particularly where a wanted AC signal may be superimposed on an unwanted DC voltage level. In such cases a capacitor of appropriate value may be inserted in series with the input, as shown in Fig.10.14. The value of this capacitor should be chosen so that its reactance is very much smaller than the input resistance at the lower applied input frequency.

We can also use a capacitor to restrict the upper frequency response of an amplifier. This time, the capacitor is connected as part of the feedback path. Indeed, by selecting appropriate values of capacitor, the frequency

Table 10.2 Corresponding values of voltage gain and bandwidth for an op amp with a gain × bandwidth product of 1MHz

Voltage gain (A_V)	Bandwidth
1	DC to 1MHz
10	DC to 100kHz
1,000	DC to 10kHz
10,000	DC to 1kHz
100,000	DC to 100Hz
1,000,000	DC to 10Hz

Check Point 10.3

Op amps have characteristics that are very close to those of an ideal amplifier. The voltage gain of an op amp is reduced to a modest and predictable value by means of negative feedback.

Check Point 10.4

The product of gain and bandwidth for an op amp is a constant. Thus an increase in gain can only be achieved at the expense of bandwidth, and vice versa.

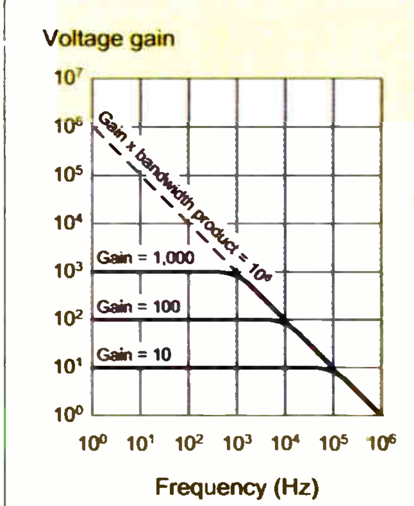


Fig.10.12. Frequency response curves for an op amp

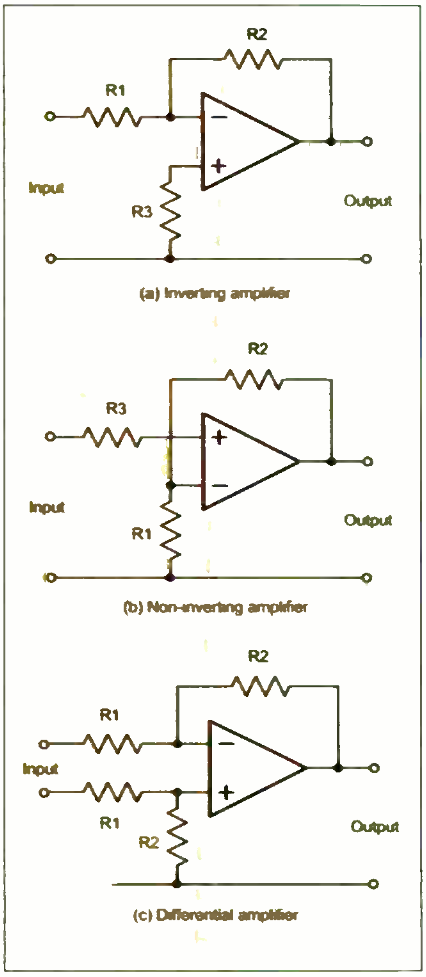


Fig.10.13. The three basic configurations for op amps

Table 10.3 Expression for input resistance, voltage gain, and phase shift for the three basic op amp configurations shown in Fig.10.13

Configuration	Input resistance	Voltage gain	Phase shift
Inverting amplifier (Fig. 10.13a)	R1	R2/R1	180°
Non-inverting amplifier (Fig. 10.13b)	Very high	1 + (R2/R1)	0°
Differential amplifier (Fig. 10.13c)	2R1	R2/R1	180°

response of an inverting op amp may be very easily tailored to suit individual requirements.

The lower cut-off frequency is determined by the value of the input capacitance, C1, and input resistance, R1. The lower cut-off frequency is given by:

$$f_l = \frac{1}{2\pi C1R1} = \frac{0{\cdot}159}{C1R1}$$

where C1 is in Farads and R1 is in ohms.

Provided the upper frequency response it not limited by the gain × bandwidth product, the upper cut-off frequency will be determined by the feedback capacitance, C2, and feedback resistance, R2, such that:

$$f_2 = \frac{1}{2\pi C2R2} = \frac{0{\cdot}159}{C2R2}$$

where C2 is in Farads and R2 is in ohms.

The bandwidth of the amplifier shown in Fig.10.14 is simply the difference between the upper and lower cut-off frequencies hence:

Bandwidth = $f_2 - f_1$

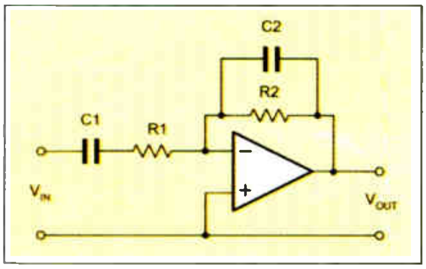


Fig.10.14. A practical inverting amplifier with capacitors to limit both the low and the high frequency response

Questions 10.2

Q10.5 Devise a circuit using an op amp that will perform according to the following specification:

Voltage gain = 40
Input resistance (at mid-band) = 5kΩ
Lower cut-off frequency = 20Hz
Upper cut-off frequency = 20kHz

Practical Investigation 10.1

Objective: To investigate the operation of an op amp.

Components and materials: Plug-in breadboard; 9V DC power source (PP9 9V battery or AC mains adapter with a 9V 400mA output); digital multimeter; 741 8-pin DIL op amp; resistors of 470kΩ, 47kΩ (2 required), 1kΩ (2 required) and 10kΩ (2 required); 10kΩ variable potentiometer; capacitor of 47μF (2 required); insulated wire links (various lengths); short lengths of black and red insulated solid wire.

Circuit diagram: See Fig.10.15

Wiring diagram: See Fig.10.16

Procedure: The required breadboard wiring is shown in Table 10.4.

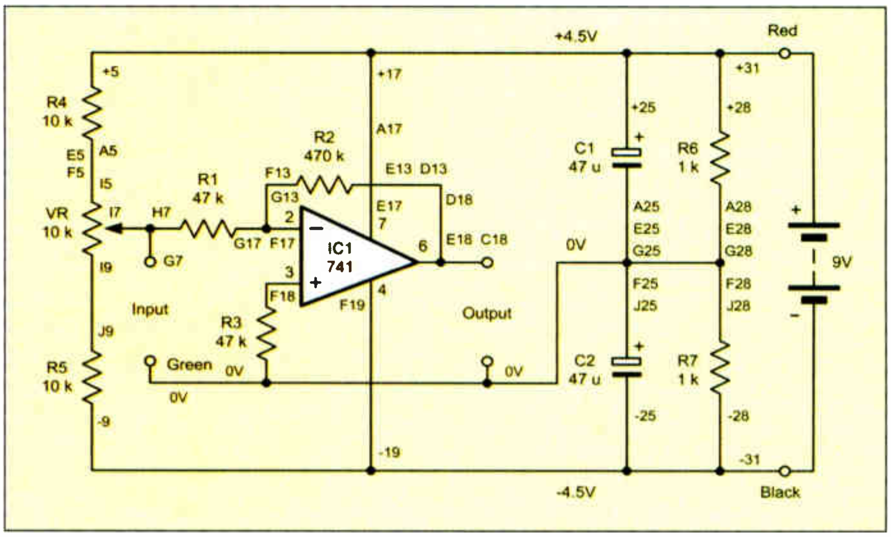


Fig.10.15. Circuit diagram for Practical Investigation 10.1

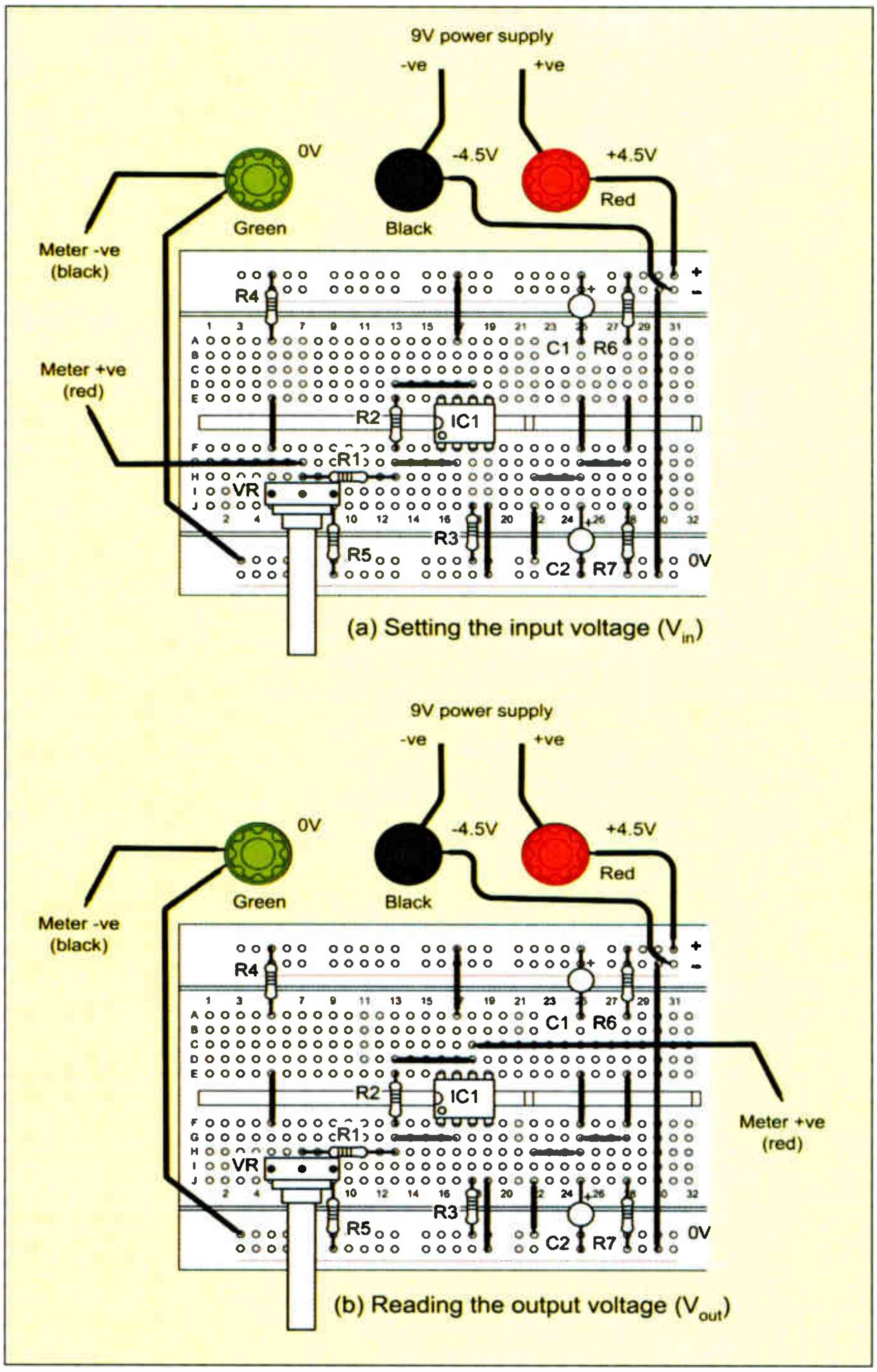


Fig.10.16. Wiring diagram for Practical Investigation 10.1

1. Connect the circuit as shown in Table 10.4 and in Fig.10.16a.

2. Set the digital multimeter to the 20V DC range and switch on (or connect the battery) the supply.

3. Read the voltage on the meter and vary the setting of VR1 to produce an input voltage of exactly 0V.

4. Now transfer the positive meter lead in order to measure the output voltage (see Table 10.4 and Fig.10.16b).

5. Record the output voltage (which should be very close to 0V when the input is 0V).

6. Repeat steps 2 to 5 with the input voltage set to 0·05V, 0·10V, 0·15V, 0·20V, etc., as shown in Table 10.5.

Note: For this Practical Investigation it may be useful to check that the supply voltage has been correctly split to produce the +4·5V and -4·5V supply rails. To do this you can temporarily disconnect the meter leads, connect the -ve (black) lead to the green terminal and the +ve (red) lead first to the red terminal and then to the black terminal. The readings obtained should respectively be approximately +4·5V and –4·5V.

Results: Use the data from Table 10.5 to plot a graph showing output voltage plotted against input voltage (see Fig.10.17).

Conclusion: Verify that the op amp provides a voltage gain of exactly 10 (i.e. the value of R2 divided by the value of R1). Verify also that the graph is linear and identify the maximum possible swing in output voltage (this should be a little less than the supply voltage). Repeat with different values for R1 and R2.

Answers To Questions

Q1. Pin 14
Q2. Pin 5
Q3. RA2 to RA4 and RB4 to RB7
Q4. 1mA
Q5. The circuit is the same as that shown in Fig.10.14 with:
C1 = 1·59μF, R1 = 5kΩ, C2 = 39pF, R2 = 200kΩ

Next Month

In our final part, next month, we shall be introducing radio and bringing the series to a conclusion with a practical project. In the meantime you might like to see how you get on with our on-line quiz for Part 10. You will find this at:

www.miketooley.info/teach-in/quiz10.htm

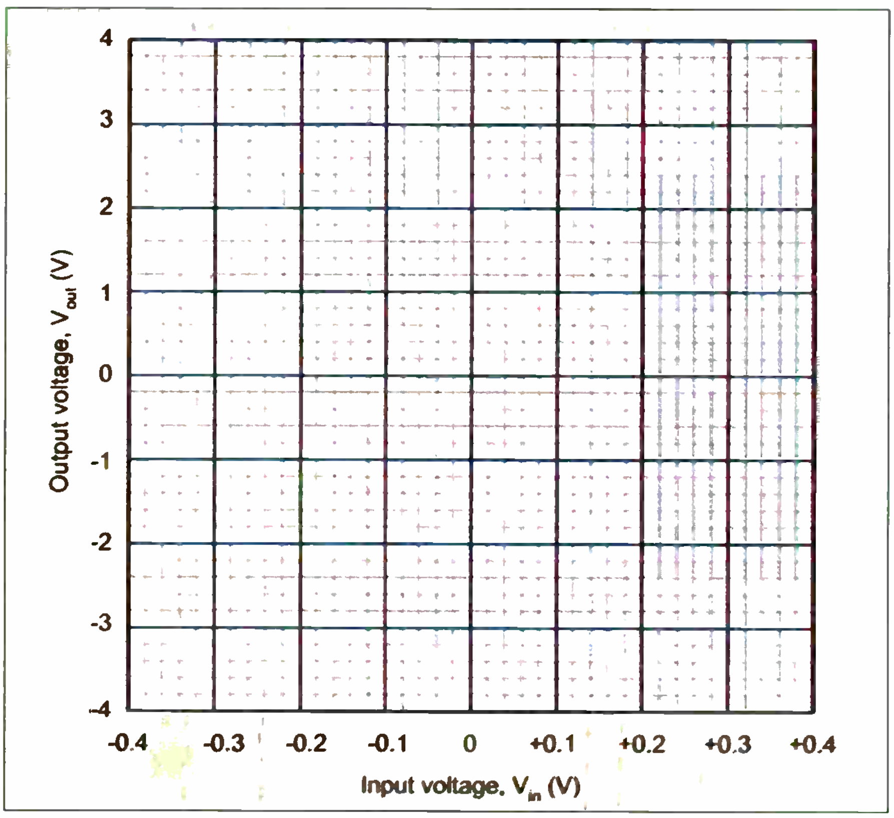
Fig.10.17(right). Graph for plotting the results of Practical Investigation 10.1

Table 10.4 Initial wiring and input voltage setting (Fig.10.16a):

Step	Connection, link or component	From	To
1	9V supply (negative)	Supply negative	Black terminal
2	9V supply (+9V)	Supply positive	Red terminal
3	Red wire	Red terminal	+31
4	Black wire	Black terminal	-31
5	Link	-30 (top)	-30 (bottom)
6	Link	+17	A17
7	Link	E5	F5
8	Link	E28	F28
9	Link	D13	D18
10	Link	G13	G17
11	Link	H22	H25
12	Link	G25	G28
13	Link	J19	-19 (bottom)
14	Link	J22	0V 22
15	Link	0V 3	Green terminal
16	IC1 741	Pin 1	F16
17	IC1 (as above)	Pin 4	F19
18	IC1 (as above)	Pin 5	E19
19	IC1 (as above)	Pin 8	E16
20	R1 47kΩ	H7	H13
21	R2 470kΩ	E13	F13
22	R3 47kΩ	J18	0V 18
23	R4 10kΩ	+5	A5
24	R5 10kΩ	J9	-9 (bottom)
25	R6 1kΩ	+28	A28
26	R7 1kΩ	J28	-28
27	VR1 (end)	I5	
28	VR1 (slider)	I7	
29	VR1 (end)	I9	
30	C1 47μF	+25 (positive)	A25
31	C2 47μF	J25 (positive)	-25 (bottom)
32	Meter (input voltage measurement)	-ve (black)	Green terminal
33	Meter (input voltage measurement)	+ve (red)	G7
34	Meter (output voltage measurement)	-ve (black)	Green terminal
35	Meter (output voltage measurement)	+ve (red)	C18

Table 10.5 Table of results for Practical Investigation 10.1

Input voltage (V)	0	0·05	0·10	0·15	0·20	0·25	0·30	0·35	0·40
Output voltage (V)									
Input voltage (V)		-0·05	-0·10	-0·15	-0·20	-0·25	-0·30	-0·35	-0·40
Output voltage (V)									



Regular Clinic

Circuit Surgery

Ian Bell

Logic Level Conversion

FREQUENT *EPE Chatzone* contributor ***Amr Bekjit*** posted the following question: *"I recently bought a GPS module and its datasheet states that the input and output pins work at LV TTL (Low Voltage TTL) levels. Now the worrying thing for me is that the GPS module is said to be a 5V version. Will I be able to interface to this module with something like a PIC, which uses 5V signals?"*.

I think that in the end Amr discovered that the GPS module was compatible with his 5V PIC, but his question raises the general issue of logic level conversion, which we will discuss this month. For many years most digital ICs either used exclusively 5V supplies or were happy working at 5V (within a larger possible range). However, modern technology demands have driven supply voltages lower and lower so we now have ICs and subsystems (such as displays and GPS modules) that work on other voltages such as 3·3V, 2·5V, 1·8V, 1·5V and 1·2V. Thus it is not uncommon to find that two key devices in your design require different supply voltages and hence have potentially incompatible logic levels.

Defining Levels

We'll start by looking at what we mean by logic levels. In simple terms it is what voltage is associated with a logic 1 and a logic 0, but we have to be a bit more precise than that when considering how we actually represent 1 and 0 in a real-life electronic circuit. We could use two voltages, say +5V for logic 1 and 0V for logic 0, but this is arbitrary. It could be -2V for 0 and +2V for 1, or 0V for 1 and +5V for 0.

In general, if the more positive voltage is used for logic 1 we refer to this as *positive logic* and if the more negative voltage is used for logic 1 we have *negative logic*. We can also build logic circuits using currents to represent 1s and 0s.

Most ICs that you are likely to encounter will use voltage signals and positive logic. If we select 5V for logic 1 and 0V for logic 0 then what does 4.9V mean? In real circuits we have to define a range of voltages that represent a valid logic level, say 0V to 2V for 0, and 3V to 5V for 1. We need to do this because we cannot build circuits which handle precisely fixed voltages under varying conditions of loading, temperature and factors affecting manufacture, particularly as they must be as small and as fast as possible.

In general, logic gates will accept a given range of inputs as 1 or 0 and are guaranteed to produce a *smaller* range of possible output voltages, closer to the ideal voltage. This means that each gate tends to *restore* the voltage towards the ideal for that logic level. This is illustrated in Fig.1.

In this article we will illustrate logic interfacing using two inverters connected together. In practice the input and output can be from any logic device in the appropriate technology.

Noise Margin

The difference between the worst case output level and worst acceptable input level for a given logic value is called the *noise margin*. This figure indicates how well the gate can cope with disturbances (such as external electrical interference) without losing the correct value of the input data.

In order to define noise margin more precisely we need to take note of minimum and maximum voltages for logic 0 (Low, L) and logic 1 (High, H) at both the input and the output of the gate, as follows:

Input Voltages
Maximum Logic 0 - V_{ILmax}
Maximum Logic 1 - V_{IHmax}
Minimum Logic 0 - V_{ILmin}
Minimum Logic 1 - V_{IHmin}

Output Voltages
Maximum Logic 0 - V_{OLmax}
Maximum Logic 1 - V_{OHmax}
Minimum Logic 0 - V_{OLmin}
Minimum Logic 1 - V_{OHmin}

We can then define noise margins for logic 0 (NML) and logic 1 (NMH)

$$NML = V_{ILmax} - V_{OLmax}$$
$$NMH = V_{OHmin} - V_{IHmin}$$

If the voltage is *in between* the defined logic levels for any reason (except for the brief time when switching between levels) then we have an undefined logic value and the circuit may behave unpredictably or even suffer damage.

Incompatible Logic

Now we have defined some basics we can look at the problems of connecting different gates together. There are two key things that can be different and hence cause us potential interfacing problems; these are the logic technology (e.g. CMOS and TTL) and the supply voltage. Different technologies may pose problems with incompatibility even on the same supply voltage. This is illustrated in Fig.2 which shows two possible problems in this situation – poor noise margin and mismatched logic ranges.

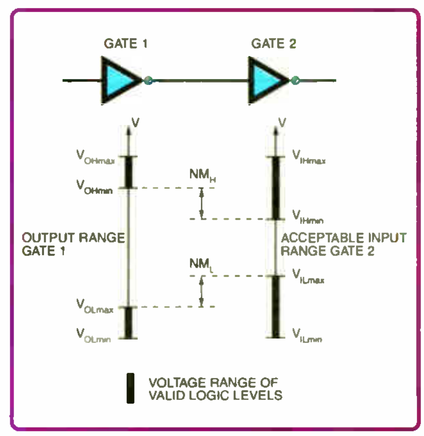


Fig.1. Logic Levels and Noise Margins. The output range of a gate for logic 0 and 1 is smaller than acceptable input range, thus restoring the voltage level to a more ideal one.

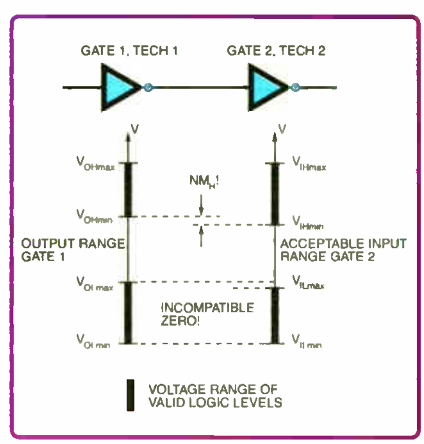


Fig.2. Example incompatible circuits: different technologies on the same supply. Logic 0 output range of technology 1 is too large for technology 2 – not all valid 0 outputs from gate 1 will be recognised by gate 2. Logic 1 is ok, but the logic margin is very low, the logic 1 level will be sensitive to noise.

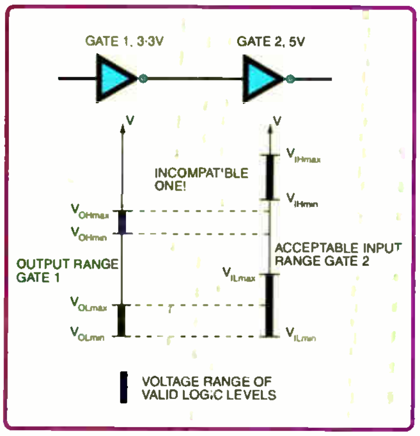


Fig.3. Example of incompatible circuits: a low voltage gate drives a higher voltage gate. Logic 0 is ok, but the logic 1 output voltage is insufficient to be recognised by the second gate.

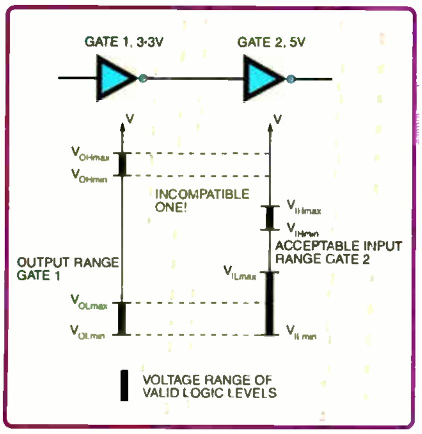


Fig.4. Example of incompatible circuits: a high voltage gate drives a lower voltage gate. Logic 0 is ok, but the logic 1 output voltage is too high and may even damage the second gate.

Fig.3 and Fig.4 illustrate typical situations when logic gates operating on different voltages are connected together. In most cases at least one logic level will be fundamentally incompatible. There may also be range or logic margin problems with the other level. Applying an input voltage more than about 0·3V volts above the supply voltage or below ground will cause many devices to stop working or even suffer damage. Datasheets will provide the exact details of what input voltages can be tolerated.

Sometimes it is possible to connect a lower voltage logic output directly to one operating on a higher supply. This is illustrated in Fig.5.

When connecting gates of the same technology and supply voltage together we generally only have to worry about loading. The voltages ranges should automatically be compatible. However, for any technology there will be a limit to the number of inputs a gate's output can drive correctly. Loading effects will be relatively easy to assess for a single technology (with details readily available in datasheets), but when connecting two technologies together the situation may be more difficult to assess. We will see later (Fig.7) that loading may need to be considered when setting up a conversion interface.

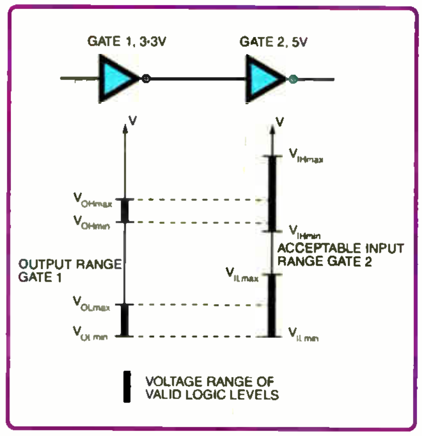


Fig.5. Example of compatible circuits operating on different supply voltages. The logic 1 input voltage range goes insufficiently low for the low voltage logic 1 outputs to be correctly interpreted.

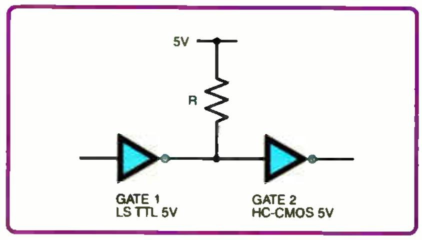


Fig.6. LS TTL to HC-CMOS interfacing.

Connecting Families

There are a very large number of logic families that can potentially operate on the same voltage so we cannot discuss every possible interfacing situation. In many cases direct connection is possible, in particular if you are not concerned about things working under all possible device variations. We will look at just one example – driving HC-CMOS from LS TTL.

LS TTL specifications guarantee a 2·7V logic 1 output level, but HC-CMOS requires a 3·5V logic 1 input on a 5V supply. In practice the LS TTL output will probably be sufficient, but compatibility is not guaranteed by the worst case characteristics.

To ensure compatibility the output logic 1 from the LS TTL device can be raised by placing a pull-up resistor from the output to V_{CC} (see Fig.6). When the output goes high, the resistor pulls the voltage very close to V_{CC}. The value of the resistor should be chosen based on the number of other LS TTL inputs the gate is driving in addition to CMOS input(s) (referred to as the LS TTL fanout) using the graph in Fig.7. For example, if an LS TTL device is driving only CMOS circuits then the LS TTL fanout is 0 so the resistor value is chosen from the left axis of the graph.

The data in Fig.7 comes from a detailed application note on logic interfacing from Fairchild Semiconductor (**www.fairchildsemi.com/an/AN/AN-314.pdf**) which considers interfacing problems for a wide range of logic families and is a useful resource on this topic.

Different Voltages

When logic circuits are operating on different voltages, direct connection is not possible and we need some kind of interface circuit. Perhaps the simplest is to use a potential divider to reduce the output level of the higher voltage circuit to make it compatible with a lower one (see Fig.8). Typical values might be R1 = 18kΩ and R2 = 33kΩ for 5V to 3·3V.

Use of a potential divider will increase power consumption and may result in slow switching. To make sure that this will work you need to make sure that voltages ranges produced by the divider are compatible (i.e. such as in Fig.1) taking supply voltage variations for gate 1 and resistor tolerances into account.

A diode may be used to shift logic output voltages up by about 0·6V as shown in Fig.9. This may make the logic 1 voltages compatible, for example for translating 3·3V logic up to 5V logic. A problem is that the logic 0 levels get shifted up as well and may become incompatible, or suffer poor noise margin.

For converting to a lower level from a higher level a transistor switch can be used. This is shown in Fig.10. If resistor R2 is large the switching may be slow, if it is small the power consumption will increase.

The CD4049 and CD4050 CMOS buffer ICs can be used to interface from higher to lower level logic voltages as shown in Fig.11. Note that the CD4050's V_{DD} is connected to lower of the two supplies.

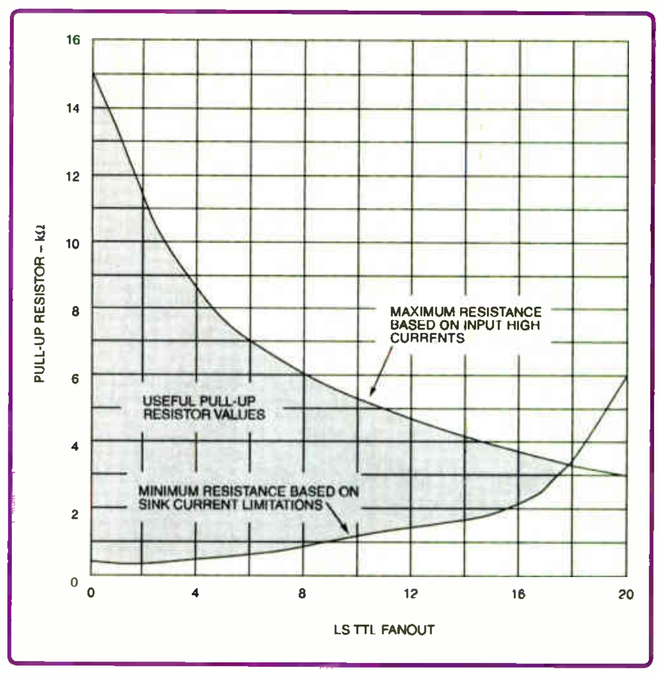


Fig.7. Choice of pull-up resistor for LS TTL to HC-CMOS interfacing (source: Fairchild Semiconductor application note AN-314)

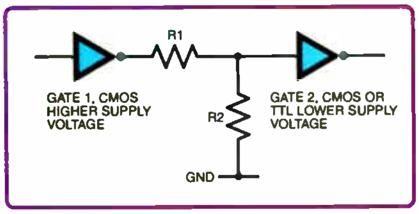


Fig.8. Potential divider logic interface.

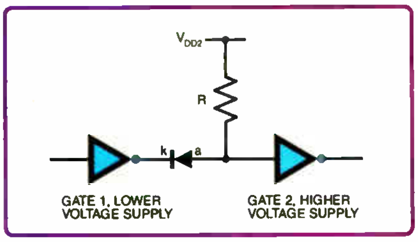


Fig.9. Diode voltage shift logic interface.

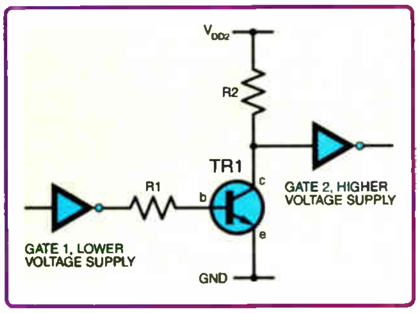


Fig.10. Transistor switch logic interface.

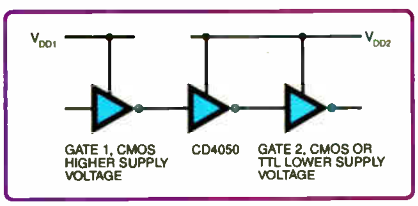


Fig.11. High to low level conversion using the CD4050.

Two-Way Conversions

The situation we have discussed so far – the connection of one logic output to one logic input – is relatively straightforward, but we also have to deal with situations such as data buses where information flows in both directions between the two subsystems on different supplies. Here special interface ICs are particularly useful.

The 74LVC4245A is an octal dual supply translating transceiver IC from Philips Semiconductors. It has non-inverting 3-state bus compatible outputs in both send and receive directions. Fig.12 shows an internal schematic of the device and Fig.13 shows its pinout.

The 74LVC4245A is designed to interface between a 3V and 5V bus in a mixed 3V and 5V supply environment. It has two power supplies, V_{CCB} for the 3V system, which actually has a range of 1·5V to 3·6V, and V_{CCA} for the 5V system, which has a range of 1·5V to 5·5V. The 74LVC4245A has an output enable input ($\overline{OE}$) so that the two buses may be isolated, and a send/receive input (DIR) for controlling

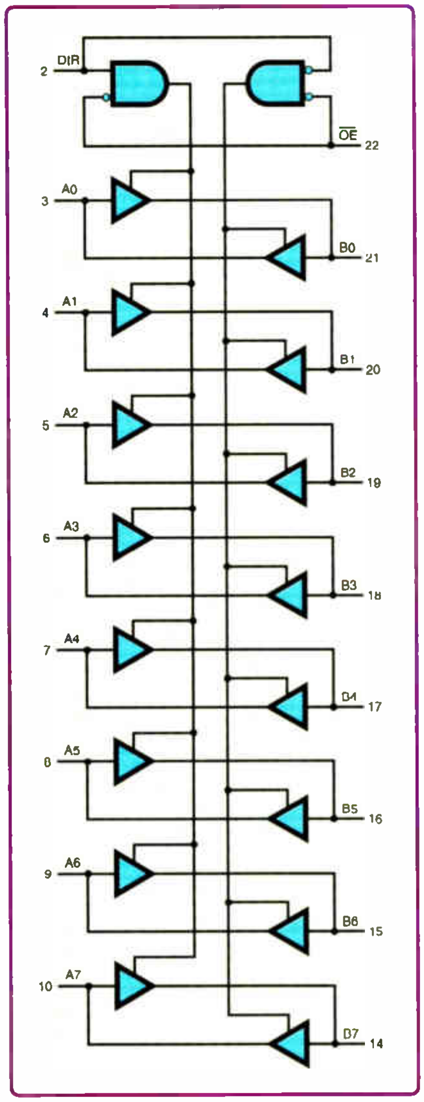


Fig.12. The 74LVC4245A internal schematic (Source: Philips datasheet).

the direction of data flow between the two buses. The device could be used for a single direction interface by fixing the DIR pin at the appropriate level.

For further reading on logic interfacing consult the Philips Application note AN240 (**www.semiconductors.philips.com/acrobat_download/applicationnotes /AN240.pdf**), which discusses 5V/3V interfacing in depth.

5V Tolerant Inputs

Fortunately, sometimes you do not have to take a lot of effort to provide 5V to 3V interfacing. Some 3·3V microcontrollers (including some PICs) have "5V tolerant inputs". That is, unlike the small over-voltages permissible with most logic devices these chips can have 5V logic signals connected to them when operating on 3·3V. This is achieved by changing the design of the electrostatic discharge (ESD) protection circuits (it is usually the ESD clamps switching on that causes problems with over-voltage logic inputs connected to conventional CMOS devices). The 3·3V logic outputs are designed to fit with 5V TTL input levels (as in Fig.4). For connecting 3·3V outputs to 5V CMOS inputs a pull-up resistor is used with the output configured as on open drain.

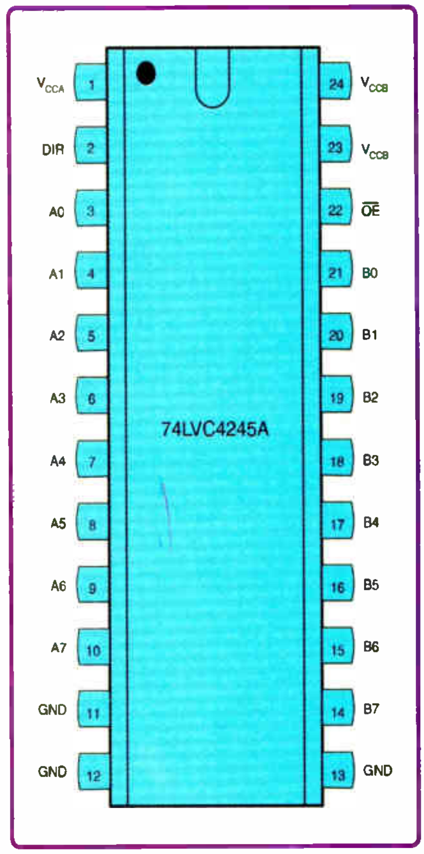


Fig.13. The 74LVC4245A pin connections (Source: Philips datasheet).

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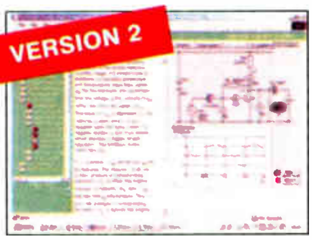

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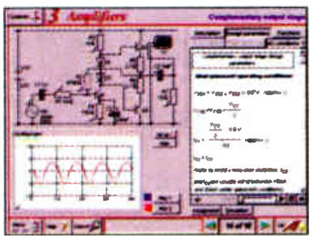

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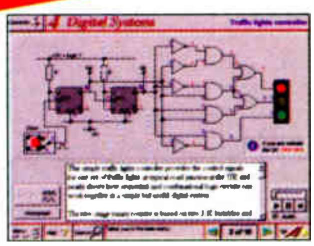

Virtual laboratory – Traffic Lights

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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.

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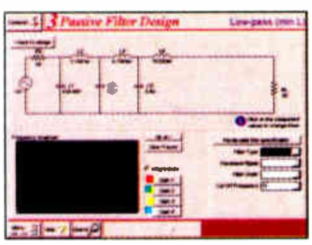

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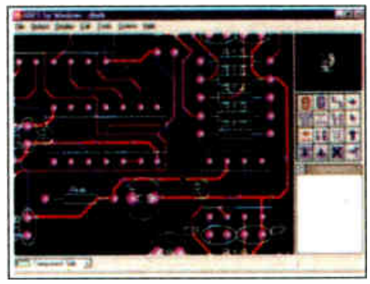

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(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

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

'C' FOR PICmicro VERSION 2

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

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

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

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

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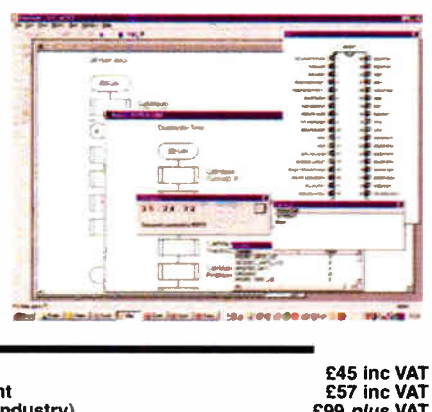
Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

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

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

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



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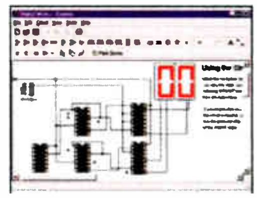

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HIGH INTENSITY TORCH

Build a brighter torch with variable intensity and flashlight options

By Gerard Samblancat

IN spite of their higher price, white l.e.d.s are increasingly being used in lighting applications. There are many advantages to using them, such as longevity, output, solidity, compactness, etc. A majority of commercial l.e.d.-based lamps now use white "high luminosity" l.e.d.s, and the recently introduced "super power l.e.d." family is increasingly finding favour.

It is one of the latter that is used here, the Lumileds Luxeon Star/O. This l.e.d. can deliver a luminous power equivalent to 20 white high intensity 5mm l.e.d.s. Its integrated optics allow the production of a very narrow beam.

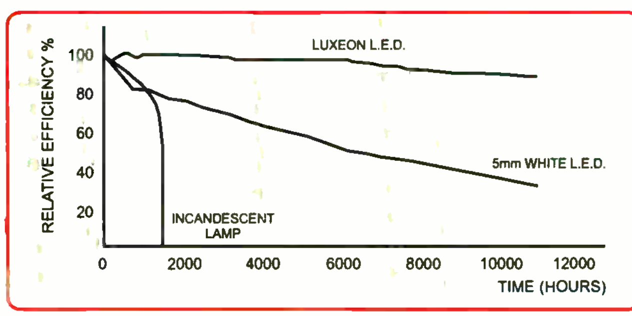


Fig.1: Typical life expectancy of various light sources

Luxeon L.E.D.s

The Luxeon family includes the world's most powerful l.e.d.s, available with up to 120 lumens in white light for the 5W model. Several powers are available from 1W to 5W, including white, blue and red. With glass optics rather than epoxy (which degrades with time) and improved thermal dissipation, these l.e.d.s provide a longevity far superior to that of filament lamps (see Fig.1).

The Luxeon l.e.d. used here retains 70% of its initial efficiency after five years of continuous use! By comparison, a standard Krypton lamp is only guaranteed for 15 operating hours. But the Luxeon's longevity is conditional upon the recommended operating conditions being met. In particular, the current flow through it has to be fairly tightly supervised.

In Response

A graph of the current/voltage response of the Star/O l.e.d. is shown in Fig.2. Its recommended maximum steady current flow is 350mA (500mA in pulse mode). At this value, light intensity reaches about 180cd (candelas) in the axis of the lens, for a total luminous output of 18lm (lumens) at an angle of 20°. In effect, the light output is in a beam, as illustrated in Fig.3.

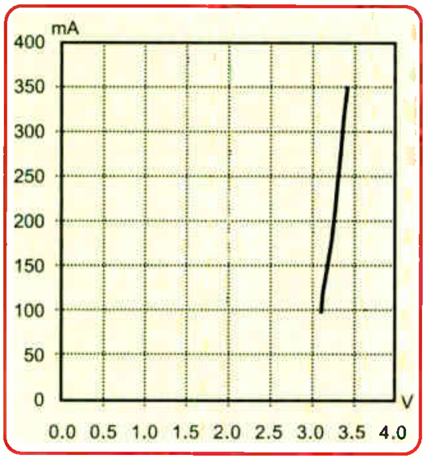


Fig.2: Graph of current to voltage ratio of the Star/O l.e.d.

LUMEN or CANDELA?

Suppliers of l.e.d.s don't always use the same unit of light intensity, sometimes speaking of "mcd" (milli-candela), sometimes of "lm" (lumens). The candela unit specifies the light intensity at a given point, and in relation to the beam width. The lumen unit is equivalent to the product of the light intensity in relation to the angular surface from which it is emitted.

Thus the measurement is of *luminous power* (L), and 1 lumen = 1 candela x 1 steradian, where: the steradian (Sr) measures a solid angle (cone) projecting from a surface of "L r2/4" on the sphere when the observer is located, and where the angle of radiation is equal to *r*.

Example:

With a high intensity white 5mm l.e.d. of 8500mcd having a beam cone of 15°, we get:

15° = 0·26rad, equivalent to a cone of 0·05sr, and the luminous power = 0·05 x 8500/1000 = 0·46lm

A comparison of the relative intensity of a Krypton 3·6V lamp and a Luxeon Star/O l.e.d. is shown in Fig.4. The two curves correspond to the complete discharge of the same battery (4·5V alkaline).

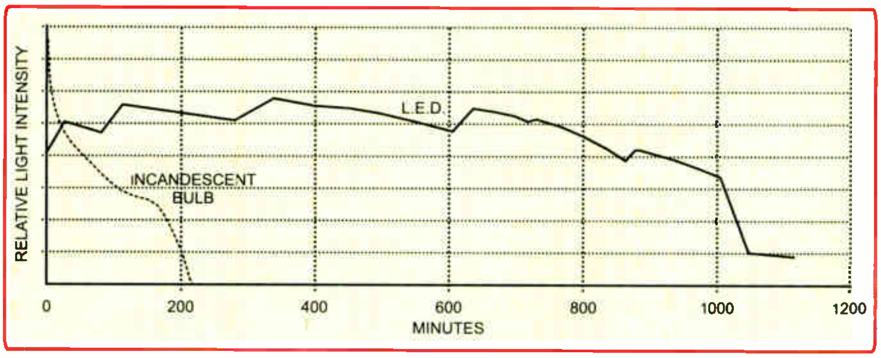


Fig.4: Comparison of the light output of a Krypton 3·6V lamp and a Luxeon Star/O l.e.d. as the controlling battery discharges.

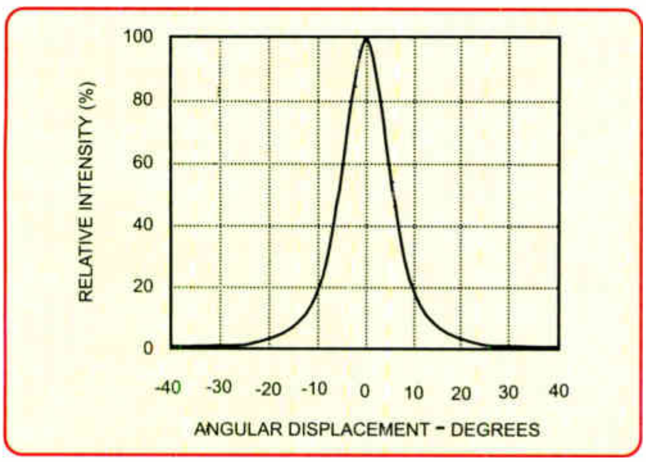
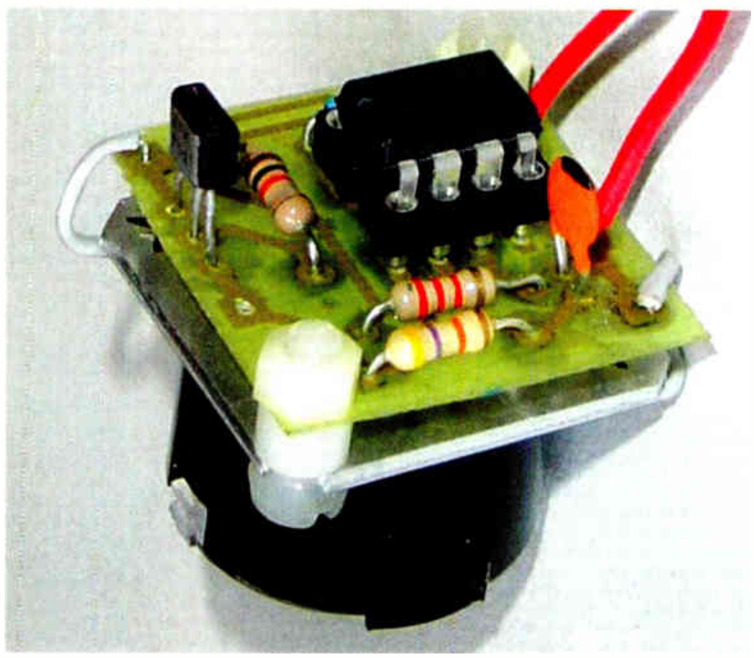


Fig.3: Illustrating the production of the light output "beam" when the relative intensity (%) is taken against angular displacement (degrees)



Operating Principle

The torch described here uses a PIC12F629 microcontroller to control the Luxeon l.e.d. The complete circuit diagram is shown in Fig.5.

The function of the PIC (IC1) is to control the current delivered to the l.e.d. (D1), keeping it to a maximum of 350mA for a supply voltage of up to 3·42V. This is done by using pulse width modulation (PWM) of the power-switching transistor, TR1. This allows the l.e.d. to be controlled without using a current limiting resistor, while also compensating for the supply voltage falling as the battery discharges over time.

In full power mode, the pulse width ratio is controlled at about 50% for a supply voltage of 4·5V, reaching 95% with 3V.

To do this, the PIC has to constantly determine the battery's supply voltage. This task is complicated by the PIC itself being subject to that same supply voltage. Consequently, a Zener diode (D2) is used to provide a 2·7V reference to the PIC's internal comparator via the GP1 pin. From this reference, the PIC's internal programmable voltage reference option then allows V_{dd} to be estimated in respect of the value held by the VRCON register.

The four least significant bits of the VRCON register are inversely proportional to the supply voltage. The software uses this information to control the l.e.d.'s intensity.

Measurement of the supply voltage is done every 0·7 seconds. The software varies the internal programmable voltage reference until the internal comparator's output level changes state. The value of VRCON is then inversely proportional to V_{dd} (3V >15, 5V >8, etc). Table SETVDDMES allows the correct value for the pulse width modulation to be selected.

The Zener diode is powered by PIC pin GP4, buffered by resistor R2, but only on an intermittent basis, thus reducing the total power consumption.

Power saving is also achieved by controlling the PIC at a slow clock rate, around 300kHz, as set by capacitor C1 and resistor R3.

Light Intensity

Pushbutton switch S1 is the light intensity control, connected to pin GP2. This is used as an input with its "weak pull-up" activated, holding it normally high. The pin goes low when the switch is pressed. The software counts the number of presses in a given time, and sets the intensity accordingly.

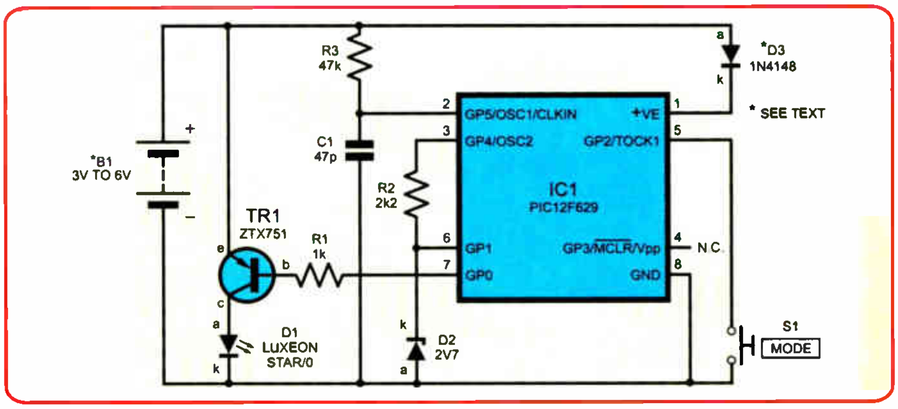


Fig.5: Complete circuit diagram for the High Intensity Torch

The circuit is basically intended to be powered at 6V. It can, though, be powered at between 3V and 5·5V if diode D3 is omitted. Note, though, that the maximum brightness level requires a minimum supply voltage of 4V.

Software Considerations

The software is based on a main loop, in which the PWM signal is generated at about 150Hz, depending on the battery's voltage. Any change of state on switch S1 is also detected. Switch presses are counted during 256 successive iterations. The total number of presses is then tested in order to modify the lighting mode.

A 0·7 second period is used as the timebase for the CTROFFL/H counters. Its goal is to measure the period at the end of which the light level is automatically lowered.

Construction

Printed circuit board component and track layout details are shown in Fig.6. This board is available from the *EPE PCB Service*, code 580.

The board's dimensions are based on the aluminium plate of the Star/O l.e.d. and the p.c.b. can be bolted to it for a compact assembly.

Assemble the board in order of ascending component size, and use a socket for the PIC. Only insert the pre-programmed PIC once the board assembly has been fully checked. Ensure that it is inserted the correct way round.

Parts List – High Intensity Torch

1 PC board, code 580, available from the *EPE PCB Service*, size 29mm × 27mm
1 miniature single-pole push-button switch, push-to-make
1 plastic case (torch), see text
2 nylon bolts to secure PCB to aluminium LED plate
4 nylon nuts (two to act as spacers) for PCB mounting
1 8-pin DIL socket
5 solder stakes
1 3V to 6V battery, with connectors (see text)
Multistrand connecting wire, solder etc.

Semiconductors
1 white LED, Luxeon Star/O (350mA at 3·4V) (D1)
1 2·7V Zener diode (D2)
1 1N4148 signal diode – see text (D3)
1 ZTX751 *pnp* transistor (TR1)
1 PIC12F629 microcontroller, pre-programmed (see text) (IC1)

Capacitors
1 47p ceramic disc (C1)

Resistors (0·25W 5%)
1 1k (R1)
1 2k2 (R2)
1 47k (R3)

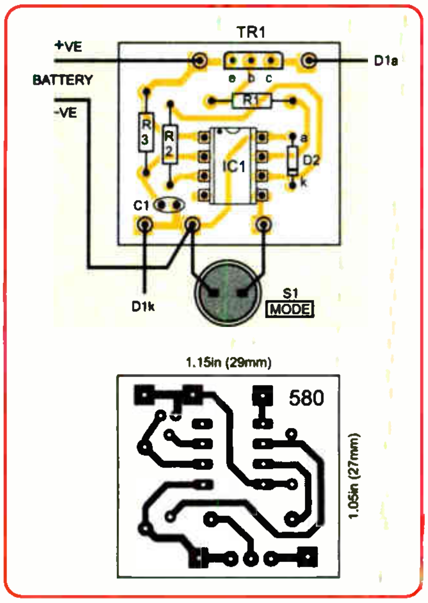


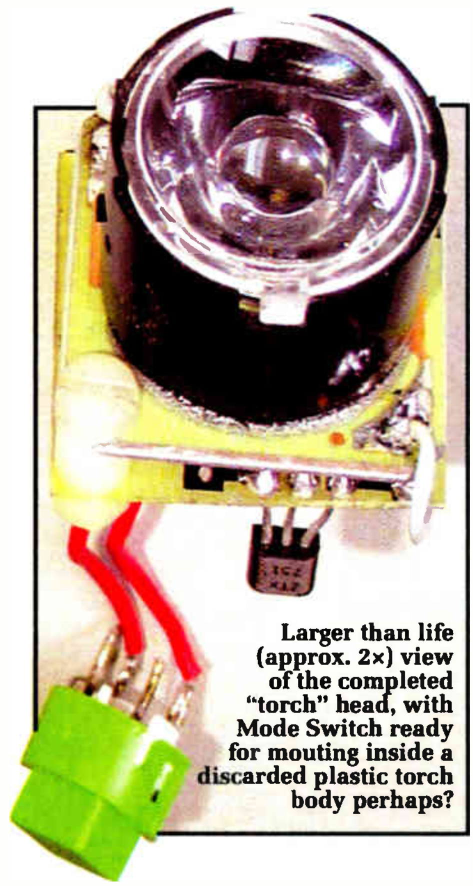
Fig.6: Printed circuit board component and track layout details

Resources

Software for the PIC, including source code, can be downloaded free from the EPE Downloads site, accessible via the homepage at **www.epemag.co.uk**. It is held in the PICs folder. Download all the files within that folder. Note that the comments within the ASM file are in French, although the commands are in standard MPASM dialect. The hex file is also in standard MPASM format, and it has configuration commands embedded in it.

Pre-programmed PICs can be bought from Magenta Electronics (contact details as in their advert in this issue).

References
www.luxeon.com
www.luxeonstar.com
www.microchip.com
www.jaycarelectronics.co.uk



Larger than life (approx. 2×) view of the completed "torch" head, with Mode Switch ready for mouting inside a discarded plastic torch body perhaps?

No particular case is suggested for this design and any plastic type in which the assembly and battery can be mounted is suitable. Holes must be drilled to suit the l.e.d. and the switch.

In Use

There is no on/off switch used with this circuit. When power is applied to the board, the program goes immediately into sleep mode, in which the current consumption is negligible (about 50µA).

To switch on the l.e.d. press switch S1. This turns on the l.e.d. in half-power mode. The next press of S1 sets the l.e.d. into full power mode.

If a brief (or longer) pause is then made, the next press of S1 reduces the l.e.d. brightness to half-way. The following switch press then turns off the l.e.d. and the PIC then goes again into sleep mode, until woken by another switch press.

The switch press sequence is thus:

off -> mid-power -> full power

then:

from full power -> mid-power -> off

However, when the l.e.d. is already off, three presses of S1 in quick succession launch the flash mode. The flash sequence is that held in the program's ASM code as table SOSTAB. As written, the sequence flashes the Morse Code message SOS.

Those readers with programming facilities for the PIC12F629 can modify the code for this section so that other flash sequences can be generated. In the SOSTAB table, the "retlw" values hold the flash code. The values return the length of the time intervals between each flash.

Experimenting with S1 will make its use clear.

In full power mode (under 4·2V), the current consumption is around 350mA. Note also that there is a 30 minute timeout after which the l.e.d. is turned off automatically. *EPE*

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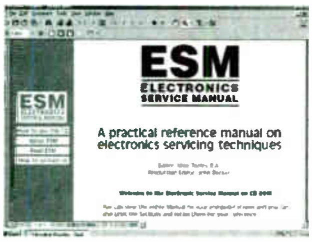

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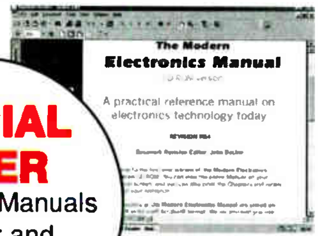

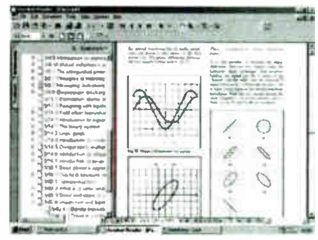

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Email: john.becker@wimborne.co.uk

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 ★

Extreme Electronics

The reference to Mysterious Lights in Mark Nelson's *Techno Talk* of May '06 was most interesting. I have witnessed both phenomena. Firstly, my understanding of the "will of the wisp" is that whilst it is marsh gas (methane) that actually burns thus causing a light to be seen, methane is not itself self-combusting but it is hydrogen phosphide which is also present with the methane and this is self-combusting in air and ignites the methane. From my limited experience I get the impression that this phenomenon is not seen consistently in a particular location as one might expect so there could be other factors involved, such as atmospheric conditions, temperature etc.

I witnessed ball lightening some years ago. It would be about 1941 when at the age of 10, I was up a step ladder cleaning the downstairs windows of my parents home. It was a "muggy" sort of very dull day with dark clouds overhead and rumblings of thunder in the distance.

Suddenly, there was a vivid flash of lightening and an extremely loud thunder crack at one and the same time. I nearly fell of the steps and although I did not see the actual lightening strike it must have been extremely close by. About half a minute later I was looking over a neighbour's hedge when suddenly a round ball of light a bit bigger than a football appeared as though just about a foot above the hedge.

The colour was a dull orange akin to the colour of boiled carrots. The ball moved relatively slowly, drifted along for about four yards then just disappeared. There was no noise, no smell. The ball of light did not fade, nor alter in any way. It just suddenly appeared then disappeared.

I had read about ball lightening but the perceived wisdom at the time was that there was no real evidence that it really existed, suggesting that those who had claimed to have seen it were suffering from delusions. I even asked myself if I had really witnessed it or imagined it but I know that it was real.

The other curious light not mentioned in your article is that of St. Elmo's Fire which is a corona discharge occasionally seen at the top of the masts of the old sailing vessels and well documented. This is akin to the coronas often seen on misty dark nights surrounding high voltage power lines frequently accompanied by crackling noises and causing local interference on radios particularly portable ones.

I hope that the above observations are of interest.

Frank W. Adams, Sheffield, via email

They are Frank. Although I've seen many natural phenomena, I've not seen those such as you describe. Has anyone else?

Junk-box Sales and Wants

Dear EPE,

I recently posted a note on your *Chat Zone* (access via **www.epemag.co.uk**) about Junk-box Sales and Wants, and which I think is worthy of greater publicity... something that I think could be of great value to fellow fiddlers-about! It's a very basic site at present, it may get prettified a little in future when I know how! The CZ note reads:

I've started a very basic webpage on **www.madoc.eclipse.co.uk** to advertise the contents of my junkbox, electronics- and radio-related, but not completely – some of the contents anyway! I'm a great hoarder and I've had the space to do it but time and times change...

If there's support I propose to keep this site going in order that people of like mind can post their own lists of for-sale and wanted; there would be no charge for this but I won't put up lists of modern amateur plug-and-play equipment.

Ant Astley, via email

Thanks Ant, that sounds very useful.

eChip Review Update

Dear EPE,

Thanks for the complimentary review of eChip in the April Issue. However, just a few items to correct and some additional updates to the system to mention since the evaluation system was sent to you.

In the review it stated that a printer needs to be attached and online for the IDE software to work. This is not correct, only a printer needs to be installed, since most PCs have a printer installed this is never an issue. However, laptop users will need to install a suitable printer via the Windows printer settings dialogue. As to the use of the serial port vs USB issue, eChip will function with USB-Serial convertors which are ready available for a low cost. A better solution available from May is the eChip USB downloader, which gives a USB connection to a USB powered test PCB with switches, LEDs etc. Approx cost £17.00.

Secondly, there have been some upgrades to the software and the latest version (V185) offers refinements to the DEBUG system and support more importantly for eChip 18e, an enhanced eChip operating at 8MHz, twice as fast as the eChip 18 used in the review, which offers an ADC block and is self-configuring if selected during circuit design. It also supports the eChip 28-pin which is due June/July. Also due at about the same time is a free non-graphical IDE, which allows the user more flexibility in connecting blocks and can be updated via the web with new blocks.

Finally, the only key item the review missed is that eChip is fully multi-tasking and it can operate more than one virtual circuit at once so long as you don't exceed the 13 cell limit, normally to create a PIC solution that can do that is quite a complex task for many users.

eChip has quite a large and growing user base in schools, as it is used in GCSE Electronics for teaching and project work, the eChip website is starting to publish these and other projects, along with links to supporting materials, which *EPE* readers might like to browse for ideas or to get a better feel for the system.

On a personal note as an *EPE* reader, started in 1972 as a pupil, and now as a teacher, I've always found *EPE* an invaluable resource and it's pleasure to "contribute" to the magazine, it also gains plenty of "street cred" with my pupils!

Brian Smith, www.echip.org.uk

Thank you Brian, we are pleased to publicise the amendments, and to wish you well with your pupils.

VB 2005 Express

Dear EPE,

In a recent *EPE*, I found that Robert Penfold's *Interface* was covering PC Interfacing Software. As the article was on the VB 2005 Express edition I would have expected it to cover using the new serial port control now supplied with this edition. After reading the article I was left feeling extremely dissapointed, considering that it does state that VB 2005 Express is a new version and that the article is all about how to cobble together an old routine (**Inpout32.dll**) into it. It briefly mentions near the end there is a "potentially useful serial port component" but that's it.

How about actually looking into using this component as it was designed for Express edition rather than doing a "cut and shut bodge". Or, if there are issues with the new command making it difficult to use then at least make us aware of them and why it should not be used.

Bobby Garrett, via email

Robert replied:

I think we need to get things in context. I did an *Interface* article on the free beta version of VB 2005 Express Edition some time ago, and it provoked quite a lot of feedback from readers. In particular, there were suggestions about ways of using it with existing *EPE* projects and **pout32.dll**. I did not go any further with VB 2005 Express Edition at that time, since it was only a beta version.

After one or two false starts, the final version was finally made available, and I did the offending *Interface* article. This incorporated the lessons learned by myself and others when using the beta version, and demonstrated that it was (sort of) possible to use it as a free alternative to VB6. I would expect this program to be popular with *EPE* readers, and feel that the article was well worthwhile.

There was insufficient space available to go into detail about the serial port component, but I thought I should at least point out that it was included, and that it was not one of the things that had been omitted from the Express Edition. I still feel that it is a bit strange that Microsoft has waited until the serial port is on the verge of obsolescence before finally including proper support for it. The serial port component might be covered in a future *Interface* article, but anyone contemplating serial port interfacing should face a few facts. Serial port interfacing is never straightforward and is often problematic.

UARTs and other serial interfacing chips have been discontinued, although it is still possible to use discrete logic or a PIC-based interface. The serial interface is the next legacy port to be phased out, and this type of port is now something of a rarity on new PCs. Perhaps it is time to forget serial interfacing and move on to the USB variety.

Robert Penfold, via email

LED Car Lighting

Dear EPE,

I was interested to read the project on *LED Lighting For Your Car*, May '06. I have just spent many weeks searching for suitable replacement LED light units for my wife's Corsa C and in the process I have learnt some interesting points about the legalities of vehicle lighting etc. which I feel I should now pass on to your readers.

Firstly, all vehicle mandatory light units i.e. front/rear side lights, headlights, brake lights and indicators are "E" approved at design and any replacement bulbs used in these units must also be "E" approved. The "E" approval for a bulb covers amongst other things the Luminance and the angle of light transmission, 270 degrees minimum when mounted.

The only LED replacement units I found to be given "E" approval are those with a cylindrical hexagonal assembly having at least two LEDs on each of the six sides and two or more on the end. These give a similar light distribution to a bulb when in the reflector of the light unit.

Secondly, although there are many similar designs on the market to those described in the project for stop/tail etc., I could find none with "E" approval, making them only suitable for off-road use. This is because they do not have the equivalent light distribution and consequently when fitted the particular light unit will no longer meet "E" approval.

Thirdly, and most important as was pointed out to me, that if in the event of an accident the lights in question were deemed to be ineffective it could possibly invalidate your insurance.

Finally, if you look at the modern vehicles fitted with LED light units you will notice the design incorporates many more LEDs covering a much larger area and the lens designed to increase the viewing angle similar to that of a bulb.

Alan Gladwell, via email

Thanks Alan. Similar comments recently appeared on our Chat Zone, *access via* **www.epemag.co.uk**, *to which Editor Mike replied:*

We feel we should point out that these lights are intended for extra safety in extra stop lamps i.e. CHMSL or extra caravan or trailer stop lights as indicated in the article. We also suggest other uses like emergency breakdown lights, boot lights etc. in the article. They are not intended to replace bulbs in "normal" stop lamps. Sorry if we have misled anyone – not our intention.

Mike Kenward, Editor

Piezo Electric Minerals

Dear EPE,

I was wondering if it is possible to determine mineral types by using the piezo electric effect. Assuming current flows into a crystal, the crystal flexes, the current is then removed, and some electrons are kicked out, based on a measurement of the voltage one should be able to determine the mineral type. Would be great for geologists. A little far fetched, perhaps, but what do you think?

Matthew Scarborough, Cape Town, South Africa

Hi Matthew, your question is an interesting one. But I don't know the answer, and I suspect I would maybe have discovered it inadvertently while making and researching my Earth Resistivity Logger *a while back, which uses electrical current flowing into the ground, but did not.*

I sent your query on to Nick Tile, who helped me on ER, and has professional experience of seismology. He replied:

Minerals by piezo – guess it would work in theory, but the difficulty is that minerals are held in a matrix of other material, with varying density, and varying over-burden, so getting an impulse in that which was predictable enough to get something out would be horribly difficult, but there is some work being done to detect earthquakes, and there is some evidence that when quakes occur, there are pre-cursors caused by the piezo effect that are measurable, or at least detectable.

There's loads of stuff on the web, but it's light on real data. Detectors are easy enough to build, they're just wide band LF noise amplifiers. Research links LF/ELF signals to pressure on the rocks and noise in the bottom end of the spectrum. It still seems to be an area where no-one really knows what's going on, so ripe for investigation. There's even speculation that some rocks give off infra red.

Given that there are about 200 quakes a year in the UK, and tens of thousands of *EPE* readers, if we can persuade 10% of them to build simple broadband LF receivers, and publish the results, we could actually push knowledge forward.

There are some other effects that are associated with the phenomena, one is called the "Taos Hum", and there are suggestions that it causes ball lightning in some places too that lead to UFO reports – following leads to the hum will find them.

Matthew might also care to browse:

www.copernicus.org/EGS/nhess/1/nh1/99.pdf

www.censsis.neu.edu/documents/QuakeData/em.html

www.stanford.edu/dept/news/pr/91/911231Arc1006.html

Hope that helps Matthew. Your Dad, Thomas, tells us that you've just started Environmental and Geographical Sciences at the University of Cape Town. Let me know if you find out anything more on the piezo subject. We send our best wishes.

About the Mains

Dear EPE,

Further to Mark Nelson's April *Techno Talk* about the mains, I have a further oddity to add to his dossier. I live in south Belfast and each autumn when we change the clocks and the dark evenings begin, some of our fluorescent lights repeatedly go out and restart between 5.20pm and 6pm and when it's dark at breakfast time too.

In previous winters I replaced some tubes and starters which helped in the short term. I replaced one kitchen under-cupboard unit completely. Last autumn the same thing happened to the kitchen ceiling light, a 6ft fitting whose tube had been replaced less than a year earlier. This time I complained to NIE. They told me the nominal voltage was 230V plus or minus 6% which gives a permissible low of 216V. My measurements showed the light to begin flashing at 225V. After putting a voltage logger on my distribution board for a week, NIE wrote that they were within the limits and need take no further action.

For my part I swapped the problem fitting with a 6ft unit from the attic, which disposed of the health and safety issue in the kitchen. Later, I replaced the choke in the faulty fitting, because it was the only active component which had not been swap tested with the working fitting. I could only find one supplier who knew what a choke was and had one in stock. It turned out to be made by Helvar the same as the original one. It did not cure the restarting problem!

The only difference between the working 6ft fitting and the restarting one is that the working one has a choke by a different manufacturer and it also has a capacitor which I understand is for power factor correction and does not assist the function. I feel that I could still have the same problem even if I bought a new fitting. It is unpleasant standing in a cold attic to check it when the family is sitting down to their dinner. I've even considered an auto transformer to boost the voltage on that particular fitting but I'm wary of using unconventional circuitry. The light works fine at off-peak times.

If anyone has a definite remedy I would be pleased to hear it.

David Howton, via email

That's a sorry state of affairs, Dave, and I regret I don't have an answer. I sent your comments on to Mark Nelson for his interest; he can't help either. But by quoting your letter here we'll see if any reader has any advice.

Solid-State Valve Power Supply

Dear EPE,

Some observations on your *Solid-State Valve Power Supply*, Dec '05. I welcome anything that encourages people to experiment, and there is a renewed interest in valves and difficulty getting the high voltage required, so an inverter-based supply is a reasonable answer. But I feel the heater supplies deserve some comment.

The author could be misunderstood to say that 6·3RMS AC equates to 6·0V DC for heating effect. To be clear, the RMS value of an AC wave is exactly equal to its DC heating effect, therefore 6·3V AC RMS equates to 6·3V DC, not 6·0V DC.

The tolerance on typical valve heater voltage is ±5% at the heater pins, so the suggested 6·0V supply will be at the lower limit. This could be overcome by using a 5V regulator with two diodes forward biassed in the ground leg. But there are other potential problems powering "your favorite vintage amp".

One side of this heater supply is grounded, while in many valve amps the heater line is balanced to chassis. Where the amp is fitted with an adjustable balance or "hum-dinger" there is the potential to short this unbalanced supply and smoke the pot.

"Twelve volt" heaters such as the 12AX7 are almost always run in parallel on 6·3V so that the heater supply is balanced to both cathodes, rather than neither.

While this may be an issue with inverter frazzle, or induced mains hum on the heater line due to a ground loop being formed by two grounds, it is certainly an issue if the amp or design being developed is ever expected to run from the mains. Your favorite amp is also likely to want a lot more than only one amp of heater current. Even the most humble power valve will eat most of this.

A discussion of these and other valve heater issues can be found at

http://ozvalveamps.elands.com/heaters.htm.

My experience with crowbar polarity protection when used with battery sets is that the diode shorts before the fuse blows due to the high surge current available. A better method with battery supply is a relay with a diode in the coil circuit so it can only energise when the power is correct. This also allows the main current to be switched by a puny switch in the coil circuit.

Roly Roper, Melbourne, Australia, via email

Hi again Roly, thanks for that, which hopefully will be helpful to readers.

PIC16F877 Problem

Dear EPE,

I am a hardware man now retired. I have in the past only modified software in assembler or written straightforward routines in BASIC. I have been having a go at the PIC programming. I have TK3 V3.5 running under WIN98SE. I have been working through your *EPE PIC Tutorial*. No problems there, as such, except for my memory retention!

But I have acquired a seondhand PIC16F877. Wanting to start with a clean slate I cleared the program and EEPROM. For good measure, I used the Clear CP function. I must have completely misunderstood the "caveat" warning and thought that I was not in danger of locking out the PIC. I was wrong!

I understand what the data sheets are saying about the low voltage programming, and I can modify my hardware to achieve the correct conditions. But I am not at all clear how to write the code to achieve the complete erase as described in the PIC16F877 data sheet. Would you please enlighten me how to get myself out of this or point me in the right direction.

Is Low Voltage ICSP a suitable subject perhaps, for an article in *EPE*? I enjoy your articles and find them very clear. I would most certainly appreciate some John Becker clarity on this topic. If you can throw some light on this problem I would be most grateful and a lot wiser.

Len Knott, Ringwood, Hants, via email

Len, I've never used LVP and have not encountered the problem directly, but I have recently had trouble when using the F628's internal oscillator with MCLR controlled internally, which prevented me from programming it. I had programmed the PIC on its own board for another circuit I'm working on, under control from TK3. *I did a CP Clear and then found a similar problem you've got due to that. I managed to get out of it by using* TK3's *Config option, with the PIC in* TK3's *board (nothing connected to the LV control pin), sending an External Oscillator config code to the PIC. You could try similar, playing around with the various options if necessary.* TK3 *must have the F877 PIC selected in the usual way.*

I've suggested to Mike Hibbett that he might like to cover LVP in PIC n' Mix *sometime, and he's agreed that he will.*

Extended Controls

Dear EPE,

Some designs require a control (such as a variable capacitor in a radio circuit) to be sited well away from its knob. In the old days, spindle extensions and panel-mounted support bushes were standard items. Now you'd be pushed to find them – and they're expensive if available.

At less than 50p from, say, Rapid, a cheap commercial potentiometer can yield both an extension and a bush if the back is prised off and discarded. I don't believe in waste but haven't found a use for the redundant back section yet! Spindle couplers are also hard to find, but some suppliers offer a range of similar devices (including with 6mm diameter through-hole, Rapid 43-1062) intended for (radio-controlled) models.

Another thought is that Farnell sell tommy bar T34 which is 1/4-inch dia (part 04-6712 at a mere 52p + VAT), plated steel and a generous 153mm long, intended for turning box spanners, would make a stronger spindle extension.

Godfrey Manning G4GLM, Edgware, Middx, via email

Net Work

Alan Winstanley

This month's *Net Work* – the Internet column – suggests an alternative to Skype, the hugely popular VoIP and video messaging service described in previous months. Skype is now owned by eBay and is unashamedly focusing on VoIP communications: just around the corner, Skype-Me links could be embedded into eBay items for sale, so you could talk directly with sellers.

MSN Messenger is Microsoft's instant messaging program that arrives on every modern Windows-based PC (with not a complaint from the EU anti-competition lobby to be heard), though it may need a free download to update it.

MSN Messenger is an attractive instant messenger (IM) product with many added bells and whistles. It incorporates some interactive features of the kind seen years ago in ICQ, which adds to the enjoyment of peer-to-peer real time communications. In terminal-style Chat mode you can add emoticons (smilies) to messages and send a "Nudge", which plays a sound and "shakes the window" of the recipient's PC display. Send "winks" too, which plays an animated graphic at the other end.

You can add a microphone and loudspeakers (or a headset) and talk to other MSN users over IP (if they choose to accept your call), calling long distance in effect is free of charge apart from the cost of a broadband connection. It is easy to create a "voice clip" too – press F2 and record up to 15 seconds of speech to send to your contact.

With broadband's increased coverage, one of the main uses of MSN Messenger is conversing via webcam such as the types discussed in previous months (remembering that some webcams require a separate microphone – check before you buy). The MSN Messenger window incorporates a simple VU meter display to help monitor sound levels.

A "whiteboard" application is included – just doodle something on the whiteboard with a mouse to share sketches in real time with your friends. There is a simple PC-to-mobile phone service, where you can send and receive instant messages, useful when your friends are away from their PC. Check out the costs first though. There are a number of other aspects that will appeal to younger users, and indeed MSN Messenger does make conversing more fun.

Windows XP usually has MSN Messenger installed and ready to be enabled (very possibly the obsolete Version 4 – look for the "Windows Messenger" icon in the Programs list, via the Start button). Before you do anything, check that your antivirus service is up to date, and whether you are protected against virus-infected file exchanges via IM networks: something quickly overlooked in the heat of the moment. The writer's preferred Avast! antivirus package (free for home users from **www.avast.com**), includes an IM shield for MSN Messenger, Yahoo! Messenger, Skype, ICQ, AIM and many more.

MSN Messenger – no messing?

How is MSN Messenger in practice? The writer found it necessary to jump through a series of hoops before signing up successfully with MSN. This was a frustrating and time consuming process, and a long way removed from the simplicity of installing Skype.

There are many other facets to MSN Messenger, and rather like ICQ it takes some practice to get to grips with its many features. Some users will consider it an over-elaborate package compared against Skype but others will enjoy the extra interaction that MSN Messenger brings.

In use, the signing-on process is fast enough, and then some tabbed advertising applets fill with marketing messages (e.g. recruitment, dating, eBay, the UK National Lottery and BBC Radio 1). The contact lists tab then populates to show which of your friends are online. Like similar packages, you can set your online status (e.g. Do Not Disturb, Away) with a mouse click. There are plenty more options to explore.

The writer wanted especially to compare MSN's video conferencing service with Skype. In fact with both services there is some noticeable lag in voice communications which takes away from the spontaneity of chatting and needs some getting used to. This is noticeable when you speak before the other party has finished talking and you cut across what they say, cutting off their speech. On a 1MB broadband service, MSN Messenger did not seem quite as sprightly as Skype when compared on a like-for-like basis, but both had some speech lag. This is bound to depend on the volume of network traffic and time of day though.

Windows Live Messenger

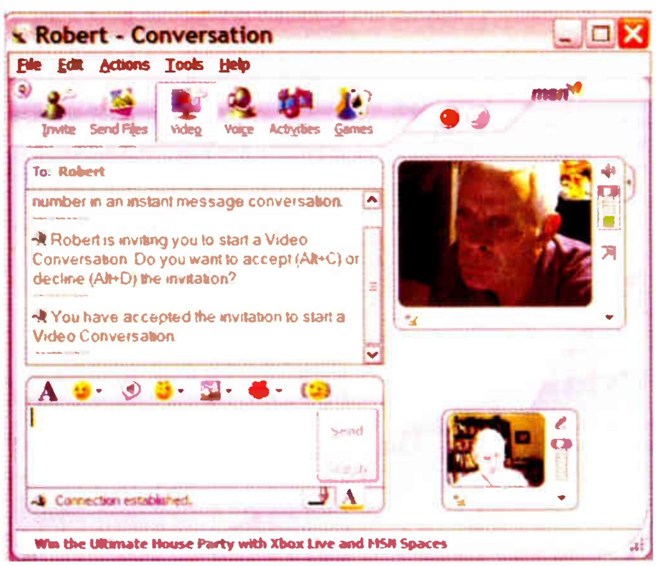
When it comes to downloading or upgrading Messenger, Microsoft wants you to use the newest Windows *Live* Messenger which is just becoming available in Beta at: **http://get.live.com/messenger/overview**

Windows Live Messenger shows which way the technology is heading, with PC-to-PC Calling, the ability to communicate with landlines or mobile phones, interfacing with Yahoo! Messenger (soon) and more enhancements.

What if you are not a Windows user? If you use an AppleMac or other operating systems, then consider Skype (Windows, Mac, Linux, Pocket PC), ICQ (Windows or Mac), AIM AOL Instant Messenger (Windows, Mac, Pocket PC, some Siemens/Nokia phones).

The VoIP revolution is here to stay, and as bandwidth increases, which it surely will, in years to come we will not give a second thought about calling on a packet network our friends or colleagues anywhere in the world, often using higher resolution video and mobile communications to reach across thousands of miles for next to no cost – except for the mountains of obsolete hardware that we will discard along the way.

Next month – a security application for your webcam. You can email the writer at **alan@epemag.demon.co.uk**



MSN Messenger Video Conversation, with Chat window on the left. The latest Live Messenger is starting to supersede the version shown

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This book offers a number of power supply designs, including simple unstabilised types, and variable voltage stabilised designs, the latter being primarily intended for use as bench power supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits. The information in this book should also help the reader to design his own power supplies. Includes cassette PSU, Ni-Cad charger, voltage step-up circuit and a simple inverter.

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HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of variouus fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers and crystal calibrators.

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ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

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

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

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

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TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:-

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RADIO

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

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EXPERIMENTAL ANTENNA TOPICS
H. C. Wright

Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

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E. M. Noll

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This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

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TICKLING THE CRYSTAL Domestic British Crystal Sets of the 1920's
Ian L. Sanders

The first book dedicated to the topic of British crystal sets to be published in the last 25 years. For a very brief period during the early 1920's, these simple receivers played a crucial role in the expansion of domestic wireless throughout the United Kingdom. For many families, rich and poor, the crystal set provided an introduction to the new pastime of listening-in to broadcast programmes. Rapidly made obsolete from homes as suddenly as it had arrived, but not without leaving its mark on the history of wireless.

Written by a long-time authority and enthusiast, *Tickling the Crystal* is the most comprehensive work on the subject ever assembled. Containing almost two hundred excellent quality photographs and a wealth of previously unpublished material, it cannot fail to be an invaluable reference for anyone interested in the history of early wireless receivers.

256 pages hardback | **Order code TC1** | **£34.00**

THEORY AND REFERENCE

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

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate.

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

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

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

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Jonathan Hill

A celebration in words and pictures of the development of the British wireless set from it's experimental beginnings in Victorian England, to the foundation of a domestic wireless manufacturing industry and the inception of broadcasting in the early 1920's. The story continues on through the design-conscious 1930's (where the radio really came into it's own as a piece of furniture), to the war-torn and austere days of the 1940's.

The first transistor radios began to appear in the second half of the 1950s and in this new edition, this rather neglected area has been fully covered by a section all of it's own which includes a directory listing of nearly 3,000 different transistor models. The book finishes after the 1960s, by which time our long established and once great radio industry had all but been destroyed by foreign imports.

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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

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Provides a practical and comprehensive collection of circuits, rules of thumb and design data for professional engineers, students and enthusaists, and therefore enough background to allow the understanding and development of a range of basic circuits.

Contents: Passive components, Active discrete components, Circuits, Linear I.C.s, Energy conversion components, Digital I.C.s, Microprocessors and microprocessor systems, Transferring digital data, Digital-analogue conversions, Computer aids in electronics, Hardware components and practical work, Micro-controllers and PLCs, Digital broadcasting, Electronic security.

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QUICK GUIDE TO ANALOGUE SYNTHESIS
Ian Waugh

Even though music production has moved into the digital domain, modern synthesisers invariably use analogue synthesis techniques. The reason is simple – analogue synthesis is flexible and versatile, and it's relatively easy for us to understand. The basics are the same for all analogue synths, and you'll quickly be able to adapt the principles to any instrument, to edit existing sounds and create exciting new ones. This book describes: How analogue synthesis works; The essential modules every synthesiser has; The three steps to synthesis; How to create phat bass sounds; How to generate filter sweeps; Advanced synth modules, How to create simple and complex synth patches; Where to find soft synths on the Web.

If you want to take your synthesiser – of the hardware or software variety – past the presets, and program your own sounds and effects, this practical and well-illustrated book tells you what you need to know.

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Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

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R. A. Penfold

This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail, no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

109 pages **Order code BP356** **£5.45**

THE INVENTOR OF STEREO – THE LIFE AND WORKS OF ALAN DOWER BLUMLEIN
Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first elecronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

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

420 pages **Order code NE32** **£17.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

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

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

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DISCOVERING PICS

BOOK + CDROM + HARDWARE

W.D.Phillips

A good introduction to PIC programming, covering everything you need to know to get you started. No previous knowledge of microcontrollers is required, but some previous experience with electronic circuits is assumed. Covers the basic concept of a microcontroller, fundamentals of a PIC-based circuit and using the MPLAB program. Further chapters introduce binary, PIC architecture, the instruction set, the PIC memory map and special registers plus real world programming. Four simple projects are also fully described; a Wavy Wand, an Electronic Dice, a Games Timer and a Pulse Monitor.

The associated CDROM contains the book in PDF format, MPLAB (plus instruction manuals in PDF format) and all the programs covered in the book as assembler (ASM) files. Those that wish to program their own PICs will require a PIC programmer.

In addition a p.c.b. based hardware kit is also available that makes up into the Wavy Wand which will spell out a short message via a line of l.e.d.s when waved through the air.

190 pages, A4 spiral bound

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A. Flind

Extensive coverage is given to circuits using capacitors and resistors to control frequency. Designs using CMOS, timer i.c.s and op.amps are all described in detail, with a special chapter on "waveform generator" i.c.s. Reliable "white" and "pink" noise generator circuits are also included. Various circuits using inductors and capacitors are covered, with emphasis on stable low frequency generation. Some of these are amazingly simple, but are still very useful signal sources.

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David W. Smith

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B. B. Babani

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PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING

Robin Pain

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

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

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

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R. A. Penfold

The first part of this book covers standard operational amplifier based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signalgenerator, simple video fader, and many more.

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R. A. Penfold

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A unique hands-on guide for anyone working with valve (*tube* in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

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A must for audio enthusiasts with more sense than money!

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Second Edition. Morgan Jones

This book allows those with a limited knowledge of the field to understand both the theory and practice of valve audio amplifier design, such that they can analyse and modify circuits, and build or restore an amplifier. Design principles and construction techniques are provided so readers can devise and build from scratch, designs that actually work.

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FEATURES • Interface • Circuit Surgery • Ingenuity Unlimited • Techno Talk • PIC 'N' Mix • Teach-In 2006 – Part 8 • Net Work – The Internet Page

JUL '06

PROJECTS • PIC Sudoku Unit • A Dirt Cheap High Current Bench Supply • PC Power Monitor • Digital Instrument Display For Cars – Part 2.
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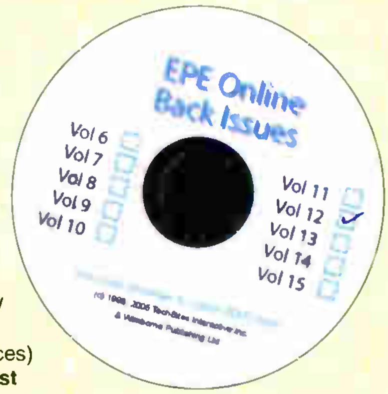

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