THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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A 'SMART' SLAVE FLASH TRIGGER for digital cameras

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* SIX PRESET LEVELS
* CHECKS FROM 1Ω TO 100Ω

APRIL 2006 £3.30

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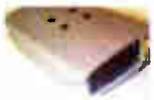
Colour CCTV camera, 8mm lens, 12vdc200m a 582X628 Res 380 lines Automatic aperture lens Mirror function PAL Back Light Comp MLR, 100x40x40mm ref EE2 £75.90

Built in Audio .15lux CCD camera 12vdc 200ma 480 lines s/n ratio >48 db 1v P-P output 110x60x50mm ref EE1 £108.90



Metal CCTV camera housings for internal or external use. Made from aluminium and plastic they are suitable for mounting body cameras in.Available in two sizes 1- 100x70x170mm and 2- 100x70x280mm Ref EE6 £22 EE7 £26 Multi position brackets Ref EE8 £8.80

Excellent quality multi purpose TV/ TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV ideal for use in boats and caravans 49.75mhz-91.75mhz VHF channels 1-5, 168.25mhz-222.75mhz VHF channels 6-12, 471.25mhz-869.75mhz, Cable channels 112.325mhz-166.75mhz Z1-Z7 Cable channels 224.25mhz-446.75mhz Z8-Z35 5" colour screen.Audio output 150mW.Connections, external aerial, earphone jack, audio/video input,12vdc or mains. Accessories supplied Power supply Remote control Cigar lead power supply Headphone Stand/bracket. 5" model £139 Ref EE9.

Self cocking pistol plcr002 crossbow with metal body. Selfcocking for precise string alignment Aluminium alloy construction High tec fibre glass limbs Automatic safety catch Supplied with three bolts Track style for greater accuracy Adjustable rear sight 50lb draw weight 150ft sec velocity Break action 17" string 30m range £23.84 Ref PLCR002

Fully cased **IR light source** suitable for CCTV applications. The unit measures 10x10x150mm, is mains operated and contains 54 infra red LEDs. Designed to mount on a standard CCTV camera bracket. The unit also contains a daylight sensor that will only activate the infra red lamp when the light level drops below a preset level. The infrared lamp is suitable for indoor or exterior use, typical useage would be to provide additional IR illumination for CCTV cameras. £53.90 ref EE11

Colour CCTV Camera measures 60x45mm and has a built in light level detector and 12 IR leds .2lux 12 IR leds 12vdc Bracket Easy connect leads £75.90 Ref EE15

A high quality external colour CCTV camera with built in Infra red LEDs measuring 60x60x60mm Easy connect leads colour Waterproof PAL 1/4" CCD542x588 pixels 420 lines .05 lux 3.6mm F2 78 deg lens 12vdc 400ma Built in light level sensor. £108.90 Ref EE13

3km Long range video and audio link complete with transmitter, receiver, 12.5m cables with pre fitted connectors and aerials. Acheive up to 3km. Cameras not included Ideal for stables, remote buildings etc. Mains power required £299

A small colour CCTV camera just 35x28x30mm Supplied with bracket, easy connect leads. Built in audio. Colour 380 line res. PAL 0.2lux +18db sensitivity Effective pixels 628x582 6-12vdc Power 200mw £39.60 Ref EE16

Complete wireless CCTV sytem with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4ghz 3 lux 6-12vdc manual tuning Available in two versions, pinhole and standard. £79 (pinhole) Ref EE17, £86.90 (standard) Ref EE18

Peltier module. Each module is supplied with a comprehensive 18 page Peltier design manual featuring circuit designs, design information etc etc. The Peltier manual is also available separately Maximum watts 56.2 40x40mm Imax 5.5A Vmax 16.7 Tmax (c-dry N2) 72 £32.95 (inc manual) REF PELT1, just manual £4.40 ref PELT2

GASTON SEALED LEAD ACID BATTERIES
1.3AH 12V @ £5.50 GT1213
3.4AH 12V @ £8.80 GT1234
7AH 12V @ £8.80 GT127
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All new and boxed, bargain prices. Good quality sealed lead acid batteries

COMPAQ 1000mA 12vdc power supplies, new and boxed, 2 metre lead DC power plug 2.4mmx10mm £5.25 each, 25+ £3.50 100+ £2.50

1.2ghz wireless receiver Fully cased audio and video 1.2ghz wirelessreceiver 190x140x30mm, metal case, 4 channel, 12vdc Adjustable time delay, 4s, 8s, 12s, 16s. £49.50 Ref EE20

The smallest PMR446 radios currently available (54x87x37mm). These tiny handheld PMR radios look great, user friendly & packed with features including VOX, Scan & Dual Watch. Priced at £59.99 PER PAIR they are excellent value for money. Our new favourite PMR radios! Standby: - 35 hours Includes:- 2 x Radios, 2x Belt Clips & 2 x Carry Strap £59.95 Ref ALAN1 Or supplied with 2 sets of rechargeable batteries and two mains chargers £93.49 Ref Alan2

The TENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart pacemaker. Batteries supplied. £21.95Ref TEN327 Spare pack of electrodes £6.59 Ref TEN327X

Dummy CCTV cameras These motorised cameras will work either on 2 AA batteries or with a standard DC adapter (not supplied) They have a built in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with fixing screws. Camera also has a flashing red led. £10.95 Ref CAMERAB

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infrared output using standard light bulbs Easily cut to shape. 6" square £16.50 ref IRF2 or a 12" sq for £34.07 IRF2A

THE TIDE CLOCK These clocks indicate the state of the tide, Most areas in the world have two high tides and two low tides a day, so the tide clock has been specially designed to rotate twice each lunar day (every 12 hours and 25 minutes) giving you a quick and easy indication of high and low water. The Quartz tide clock will always stay calibrated to the moon. £23.10 REF TIDEC

LINEAR ACCTUATORS 12-36VDC BUILT IN ADJUSTABLE LIMIT SWITCHES POWDER COATED 18" THROW UP TO 1,000 LB THRUST (400LB RECOMMENDED LOAD) SUPPLIED WITH MOUNTING BRACKETS DESIGNED FOR OUTDOOR USE These brackets originally made for moving very large satellite dishes are possibly more suitable for closing gates, mechanical machinery, robot wars etc. Our first sale was to a company building solar panels that track the sun! Two sizes available, 12" and 18" throw. £32.95 REF ACT12,

Samarium magnets are 57mm x 20mm and have a hole (5/16th UNF) in the centre and a magnetic strength of 2.2gauss. We have tested these on a steel beam running through the offices and found that they will take more than 170lbs (77kgs) in weight before being pulled off. With keeper. £21.95 REF MAG77

New transmitter, receiver and camera kit. £69.00
Kit contains four channel switchable camera with built in audio, six IR leds and transmitter, four channel switchable receiver, 2 power supplies, cables, connectors and mounting bracket. £69.00 Wireless Transmitter Black and white camera (75x50x55mm) Builtin 4 channel transmitter (switchable) Audio built in 6 IR Leds Bracket/ stand Power supply 30 m range **Wireless Receiver** 4 channel (switchable) Audio/video leads and scart adapter Power supply and Manual £69.00 ref COP24

This miniature **Stirling Cycle Engine** measures 7" x 4-1/4" and comes complete with built-in alcohol burner. Red flywheels and chassis mounted on a green base, these all-metal beauties silently running at speeds in excess of 1,000 RPM attract attention and create awe wherever displayed. This model comes completely assembled and ready to run. £106.70 REF SOL1

High-power modules using 125mm square multi-crystal silicon solar cells with bypass diode Anti reflection coating and BSF structure to improve cell conversion efficiency: 14%. Using white tempered glass, EVA resin, and a weatherproof film along with an aluminum frame for extended outdoor use. system Lead wire with waterproof connector. 80 watt 12v 500x1200 £315.17, 123w 12vdc 1499x662x46 £482.90
165 w 24v 1575x826x46mm £652.30

Ultra-compact, lightweight, easy to use and comfortable to hold, the new NVMT is unique for a night scope in offering a tactile, suregrip plastic bodyshell and, for extra protection/grip, partial rubber armouring. Currently the top of the range model, the NVMT G2+ features a 'commercial grade' Gen 2+ Image Intensifier Tube (IIT). The NVMT has a built-in, powerful Infrared (IR) Illuminator for use in very low light/total darkness. Power for the scope and IR is provided by 1 x 3V Lithium CR123A battery (not supplied). A green LED next to the viewfinder indicates when the Image Intensifier Tube is switched on while a red LED indicates when the IR Illuminator is switched on.Type Gen Weight Size Lens Mag 2x, Weight 400g, 125x82x35mm angle of view 30 deg, built in infra red, rang 3 - 400m, supplied with batteries £849 ref COB24023.

55 - 200 WATT INFRA RED TORCHS

Search guard 1 infrared torch Plastic bodied waterproof infrared rechargeable lamp. 100mm diameter lens, 200mm body length, 55 watt bulb, 1,000,000 candle power (used as an indication of relative power) Supplied complete with a 12v car lighter socket lead/charger and a 240v mains plug in charger. £49 REF sguard 1. Also available, 70watt @ £59, 100 watt @ £79, 200watt @ £99.

AIR RIFLES FROM £24.70

B2 AIR RIFLE Available In .177 and .22• 19" Tapered Rifled Barrel• Adjustable Rear Sight• Full Length Wooden Stock• Overall Length 43" approxBarrel Locking Lever • Also available in CARBINE Grooved for Telescopic Sight model with 14" barrel - no front sight for use with scope. Weight approximately 6lbs Extremely Powerful .22 £28.90, .177 £24.70, pellets (500) £2.55, sights 4x20 £6.80, 4x28 £15.32 Other models available up to £250 www.airpistol.co.uk

12V SOLAR PANELS AND REGULATORS
9 WATT £58.75
15 WATT £84.25
22 WATT £126.70
Regulator up to 60 watt £21.25
Regulators up to 135 watt £38.25

The combination of multi-crystal cells and a high-reliability module structure make this series of solar panels the ideal solar module. For large-scale power generation hundreds or even thousands of modules can be connected in series to meet the desired electric power requirements. They have a high output, and highly efficient, extremely reliable and designed for ease of maintenance. Separate positive negative junction boxes and dual by-pass diodes are a few examples of some of its outstanding features. Supplied with an 8 metre cable. Perfect for caravans, boats, etc. Toughened glass.

LOCK PICK SETS 16, 32 AND 60 PIECE SETS

This set is deluxe in every way! It includes a nice assortment of balls, rakes, hooks, diamonds, two double ended picks, a broken key extractor, and three tension wrenches. And just how do you top off a set like this? Package it in a top grain leather zippered case. Part: LP005 - Price £45.00

This 32 piece set includes a variety of hooks, rakes, diamonds, balls, extractors, tension tools ... and comes housed in a zippered top grain leather case. If you like choices, go for this one! Part: LP006 - Price £65.00

If your wants run toward the biggest pick set you can find, here it is. This sixty piece set includes an array of hooks, rakes, diamonds, balls, broken key extractors, tension wrenches, and even includes a warded pick set! And the zippered case is made, of course, of the finest top grain leather. First Class! Part: LP007 - Price £99.00

Mamod steam roller, supplied with fuel and everything you need (apart from water and a match!) £85 REF 1312 more models at www.mamodspares.co.uk

Mamod steam roller, supplied with fuel and everything you need (apart from water and a match!) £130 REF 1318 more models at www.mamodspares.co.uk

PEANUT RIDER STIRLING ENGINE This all metal, black and brass engine with red flywheel is mounted on a solid hardwood platform. comes complete with an alcohol fuel cell, extra wick, allen wrenches, and Owner's Manual.Specifications: Base is 5-1/4" x 5-1/4", 4" width x 9" height, 3/4" stroke, 3-1/2" flywheel £141.90

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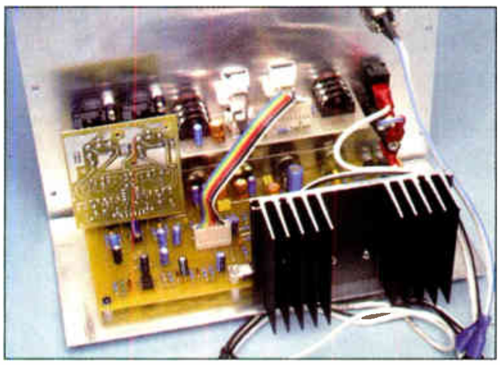

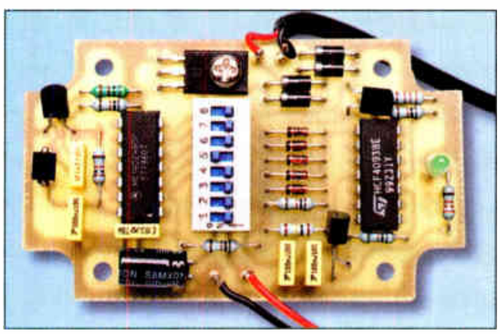

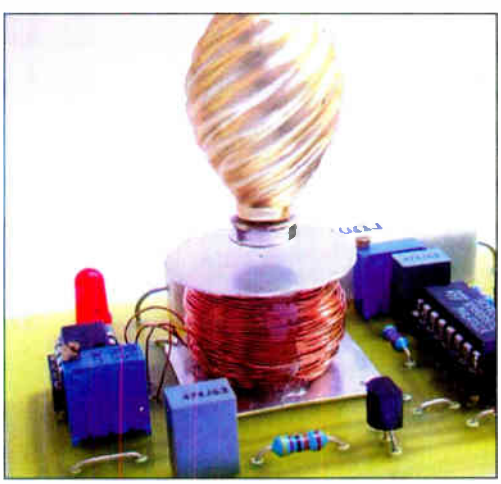

Projects and Circuits

Series and Features

Regulars and Services

Our May 2006 issue will be published on Thursday, 13 April 2006. See page 80 for details

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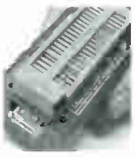
PIC & ATMEL Programmers

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

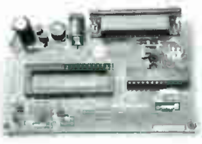
Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £15.00
18VDC Power supply (PSU010) £19.95
Leads: Parallel (LDC136) £4.95 / Serial (LDC441) £4.95 / USB (LDC644) £2.95

NEW! USB 'Flash' PIC Programmer



USB PIC programmer for most 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows Software. ZIF Socket and USB Plug A-B lead not incl.
Kit Order Code: 3128KT – **£34.95**
Assembled Order Code: AS3128 – **£39.95**

"PICALL" ISP PIC Programmer

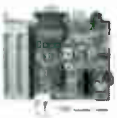


"PICALL" will program virtually all 8 to 40 pin *serial-mode** AND *parallel-mode* (PIC16C5x family)* Programmed PIC micro controllers. Free fully functional software. Blank chip auto detect for super fast bulk programming. Parallel port connection. Supply: 16-18V dc.
Assembled Order Code: AS3117 – **£24.95**

ATMEL 89xxx Programmer

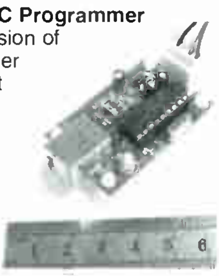
Uses serial port and any standard terminal comms program. 4 LEDs display the status. ZIF sockets not included. Supply: 16VDC.
Kit Order Code: 3123KT – **£29.95**

NEW! USB & Serial Port PIC Programmer



USB/Serial connection. Header cable for ICSP. Free Windows software. See website for PICs supported. ZIF Socket and USB Plug A-B lead extra. 18VDC.
Kit Order Code: 3149KT – **£34.95**
Assembled Order Code: AS3149 – **£49.95**

USB Flash ICSP PIC Programmer



Fully assembled version of our 3128 USB Flasher PIC Programmer but WITHOUT the pre-gramming socket. It just has 5-pin ICSP header (GND, VCC, CLK, DAT, VPP) and cable. No external PSU required. Free Windows software.
Order Code: AS3182 – **£37.95**

ABC Maxi AVR Development Board

The ABC Maxi board has an open architecture design based on Atmel's AVR AT90S8535 RISC microcontroller and is ideal for developing new designs.
Features:
8Kb of In-System Programmable Flash (1000 write/erase cycles) • 512 bytes internal SRAM • 512 bytes EEPROM • 8 analogue inputs (range 0-5V) • 4 Opto-isolated Inputs (I/Os are bi-directional with internal pull-up resistors) • Output buffers can sink 20mA current (direct l.e.d. drive) • 4 x 12A open drain MOSFET outputs • RS485 network connector • 2-16 LCD Connector • 3·5mm Speaker Phone Jack • Supply: 9-12VDC.
The ABC Maxi STARTER PACK includes one assembled Maxi Board, parallel and serial cables, and Windows software CD-ROM featuring an Assembler, BASIC compiler and in-system programmer.
Order Code ABCMAXISP – **£89.95**
The ABC Maxi boards only can also be purchased separately at £69.95 each.

Controllers & Loggers

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

Rolling Code 4-Channel UHF Remote

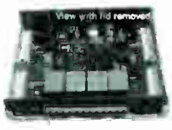
State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 TXs can be learned by one Rx (kit includes one Tx but more available separately). 4 indicator LEDs.
Rx: PCB 77x85mm, 12VDC/6mA (standby).
Two & Ten Channel versions also available.
Kit Order Code: 3180KIT – **£39.95**
Assembled Order Code: AS3180 – **£47.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Includes one DS1820 sensor and four header cables.
Kit Order Code: 3145KT – **£16.95**
Assembled Order Code: AS3145 – **£23.95**
Additional DS1820 Sensors – **£3.95 each**

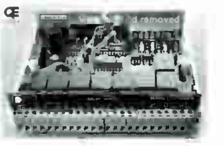
Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

NEW! DTMF Telephone Relay Switcher



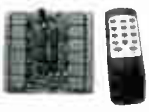
Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12VDC.
Kit Order Code: 3140KT – **£39.95**
Assembled Order Code: AS3140 – **£59.95**

Serial Port Isolated I/O Module



Computer controlled 8-channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130 x 100 x 30mm. Power: 12VDC/500mA.
Kit Order Code: 3108KT – **£49.95**
Assembled Order Code: AS3108 – **£59.95**

Infra-red RC 12-Channel Relay Board



Control 12 on-board relays with included infra-red remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12VDC/0·5A.
Kit Order Code: 3142KT – **£39.95**
Assembled Order Code: AS3142 – **£49.95**

PC Data Acquisition & Control Unit

Monitor and log a mixture of analogue and digital inputs and control external devices via the analogue and digital outputs. Monitor pressure, temperature, light intensity, weight, switch state, movement, relays, etc. with the apropriate sensors (not supplied). Data can be processed, stored and the results used to control devices such as motors, sirens, relays, servo motors (up to 11) and two stepper motors.

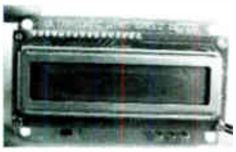
Features
- 11 Analogue Inputs – 0-5V, 10 bit (5mV/step)
- 16 Digital Inputs – 20V max. Protection 1K in series, 5·1V Zener
- 1 Analogue Output – 0-2·5V or 0-10V. 8 bit (20mV/step)
- 8 Digital Outputs – Open collector, 500mA, 33V max
- Custom box (140 x 110 x 35mm) with printed front & rear panels
- Windows software utilities (3·1 to XP) and programming examples
- Supply: 12V DC (Order Code PSU203)

Kit Order Code: 3093KT – **£64.95**
Assembled Order Code: AS3093 – **£94.95**

Hot New Kits This Summer!

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

NEW! EPE Ultrasonic Wind Speed Meter



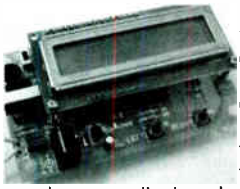
Solid-state design wind speed meter (anemometer) that uses ultrasonic techniques and has no moving parts and does not need calibrating. It is intended for sports-type activities, such as track events, sailing, hang-gliding, kites and model aircraft flying, to name but a few. It can even be used to monitor conditions in your garden. The probe is pointed in the direction from which the wind is blowing and the speed is displayed on an LCD display.

Specifications

- Units of display: metres per second, feet per second, kilometres per hour and miles per hour
- Resolution: Nearest tenth of a metre
- Range: Zero to 50mph approx.

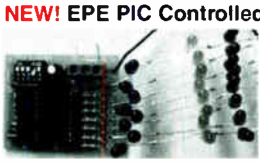
Based on the project published in Everyday Practical Electronics, Jan 2003. We have made a few minor design changes (see web site for full details). Power: 9VDC (PP3 battery or Order Code PSU345).
Main PCB: 50 x 83mm.
Kit Order Code: 3168KT – **£34.95**

NEW! Audio DTMF Decoder and Display



Detects DTMF tones via an on-board electret microphone or direct from the phone lines through the onboard audio transformer. The numbers are displayed on a 16-character, single line display as they are received Up to 32 numbers can be displayed by scrolling the display left and right. There is also a serial output for sending the detected tones to a PC via the serial port. The unit will not detect numbers dialled using pulse dialling. Circuit is microcontroller based.
Supply: 9-12V DC (Order Code PSU345).
Main PCB: 55 x 95mm.
Kit Order Code: 3153KT – **£17.95**
Assembled Order Code: AS3153 – **£29.95**

NEW! EPE PIC Controlled LED Flasher



This versatile PIC-based LED or filament bulb flasher can be used to flash from 1 to 160 LEDs. The user arranges the LEDs in any pattern they wish. The kit comes with 8 superbright red LEDs and 8 green LEDs. Based on the Versatile PIC Flasher by Steve Challinor, *EPE* Magazine Dec '02. See website for full details. Board Supply: 9-12V DC. LED supply: 9-45V DC (depending on number of LED used). PCB: 43 x 54mm.
Kit Order Code: 3169KT – **£11.95**

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

FM Bugs & Transmitters

Our extensive range goes from discreet surveillance bugs to powerful FM broadcast transmitters. Here are a few examples. All can be received on a standard FM radio and have adjustable transmitting frequency.

MMTX' Micro-Miniature 9V FM Room Bug

Our best selling bug! Good performance. Just 25 x 15mm. Sold to detective agencies worldwide. Small enough to hide just about anywhere. Operates at the 'less busy' top end of the commercial FM waveband and also up into the more private Air band. Range: 500m. Supply: PP3 battery.
Kit Order Code: 3051KT – **£8.95**
Assembled Order Code: AS3051 – **£14.95**

HPTX' High Power FM Room Bug

Our most powerful room bug. Very Impressive performance. Clear and stable output signal thanks to the extra circuitry employed. Range: 1000m @ 9V. Supply: 6-12V DC (9V PP3 battery clip suppied). 70 x 15mm.
Kit Order Code: 3032KT – **£9.95**
Assembled Order Code: AS3032 – **£17.95**

MTTX' Miniature Telephone Transmitter

Attach anywhere along phone line. Tune a radio into the signal and hear exactly what both parties are saying. Transmits only when phone is used. Clear, stable signal. Powered from phone line so completely maintenance free once installed. Requires no aerial wire – uses phone line as antenna. Suitable for any phone system worldwide. Range: 300m. 20 x 45mm.
Kit Order Code: 3016KT – **£7.95**
Assembled Order Code: AS3016 – **£13.95**

3 Watt FM Transmitter

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Kit Order Code: 1028KT – **£23.95**
Assembled Order Code: AS1028 – **£31.95**

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World Radio History

EPE EVERYDAY PRACTICAL ELECTRONICS

THE UK's No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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Front Covers

I hope you like our new style front covers – the feedback we have had is very encouraging but one or two readers still prefer the earlier ones. Our problem is usually to find suitable photos to use at a reasonable price. We try to select background photos from stock items that represent the content of the magazine – obviously this month the cover is related to the *'Smart' Slave Flash Trigger* and finding a photo with a clean background to allow all the lettering to stand was fairly easy.

Years ago when we did this it meant scanning through piles of catalogues to find something – which could take the best part of a day. Now we have thousands of stock images available and searchable from a number of sites on the web. They can also be downloaded "instantly" and tried out on-screen with the other photos and lettering. This soon throws up any problems and sometimes what seems to be an ideal photo looks poor once it is part of the cover – at least we can quickly choose another and try it without a large charge and a wait for a transparency to arrive in the post.

The Internet is great for some things – like searching for component suppliers, locating data sheets, or circuits etc. – and a pain for others like spam emails, viruses etc. Nothing seems to come without some sort of penalty!

Standing Out

We do endeavour to make the covers stand out on the newagents' shelves but with up to 2000 other magazines all vying for space in the larger stores it is not always easy. We know what it is like trying to find *EPE* in some stores but all UK newsagents can get copies so please ask if you can't see our logo on the shelf – sometimes magazines get hidden or not replenished when copies are sold – hopefully you will get your copy without too much trouble. Alternatively there is always that Internet to download an issue (**www.epemag.com**) or order a subscription, back issue, book, CD-ROM, PCB etc. (**www.epemag.co.uk**), happy hunting!

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just $15.99US (approx £9.50) per year available from **www.epemag.com**

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Online subscriptions, for downloading the magazine via the Internet, $15.99US (approx £9.50) for one year available from **www.epemag.com**.

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BINDERS

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

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READERS' TECHNICAL ENQUIRIES

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

PROJECTS AND CIRCUITS

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

COMPONENT SUPPLIES

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

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TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

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

News . . .

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

DIGIMEMO

Captures and digitises handwriting and diagrams

Selwyn Electronics has recently announced a brilliant new product called the DigiMemo. This design digitally captures and stores everything you write or draw on paper, which you can then view, edit and organise in Windows.

DigiMemo allows handwritten notes to be saved in digital format using the internal flash memory or a CF card (if fitted). Up to 66 full pages can be stored in the internal memory. Using the supplied pen, everything you write on standard A5 paper is stored into the DigiMemo's memory. Organise and edit your notes using the supplied DigiMemo Manager software. Create an e-book, add, amend and email your notes. Connection is via a standard USB port.

Using the optional and very clever Handwriting Recognition Feature you can convert your handwriting to text and automatically open Word with your text and drawings included. The design's features include:

- Digitally capture and store everything you write with ink on ordinary paper
- Portable and compact, a stand alone device with storage capability
- Built-in 8MB memory holds 66 pages
- Easily add and erase the page files in the Digimemo
- Low power consumption (over 100hrs continuous use)
- View, edit and organise page files in Windows
- Pen refills, batteries and paper available from normal stationary stores

The DigiMemo has been designed for business or home use and would be great for the medical profession. In fact the DigiMemo is ideal for anyone who needs to take notes or keep their immediate ideas, sketches, thoughts and flow charts wherever they go and whenever they want.

It can store up to 999 pages (with a CF card fitted), is lightweight and looks great.

DigiMemo is available from Selwyn Electronics for £75 (incl. VAT), at **www.selwyn.co.uk**.

Microchip C-Compiler

As though matching the needs of readers lately discussing the merits of the C language in *Readout*, Microchip have announced a C-Compiler for its 70-strong family of 16-bit controller products.

It is version 2.0 of its MPLAB C30 C compiler and the key facts are that it supports PIC24 microcontrollers and dsPIC30/dsPIC33 digital signal controllers. It includes ANSI standard C library and DSP language extensions, supports in-line assembly code and separate assembly modules, and has a free student edition. It also includes a cross-compiler, cross-assembler, linker and librarian.

The free MPLAB C30 Student Edition offers the same functionality for 60 days, after which it maintains full source-code compatibility and device support, with no memory limitations, but without additional code optimization. This is a great tool for students, colleges and universities, and also for design engineers interested in learning about Microchip's 16-bit devices and language tools.

Microchip developed the new compiler alongside the PIC24 and dsPIC33 controller families to ensure optimal C code efficiency, which can be up to 85 percent smaller than competitive 16-bit architectures. MPLAB C30 is tightly integrated into the free MPLAB Integrated Development Environment for writing code, building projects and testing using Microchip's software simulator or the MPLAB ICD2 In-Circuit Debugger. Final optimized code can be programmed into devices either with the cost-effective MPLAB ICD2 or the MPLAB PM3 production device programmer, using the same MPLAB user interface.

For more information browse **www.microchip.com/C30**.

LINKMATIK BLUETOOTH

The LinkMatik Bluetooth module from RF Solutions is a simple-to-use, plug-in device that enables designers to add wireless communications capability to their products without the need for RF and antenna design expertise. The compact module is able to transfer serial data at rates up to 50Kbits/sec full duplex, over distances of up to 100 metres.

Housed in an 18-pin DIL package, the LinkMatik module requires a 3V to 5V supply and contains all necessary RF circuitry, including an integral antenna and controller. Unlike most other Bluetooth modules, the LinkMatik is a true serial port and requires no AT commands. The module manages itself and it is not necessary to control it from a host computer.

Once implemented, the LinkMatik module can interface with many standard Bluetooth devices such as laptop computers, PDAs and mobile phones, as either a master or slave. In slave mode the new module initialises itself and waits for a remote device to connect. In master mode it looks for connections to specific devices.

It is also possible to pair two LinkMatik modules. The pair manage themselves with no external control, although Baud rate (selectable between 1200K and 1500K), device name and other details can be reconfigured from a PC via the Bluetooth connection.

Other features of the modules include Bluetooth PIN code and encryption, hardware flow control or no flow control, and a Bluetooth error correction layer. The LinkMatik Bluetooth module is FCC/CE/IC compliant and does not need re-certification if the integral antenna is used.

For more information contact R.F. Solutions Ltd, Dept *EPE*, Unit 21, Cliffe Industrial Estate, South Street, Lewes, East Sussex BN8 6JL. Tel: +44 (0) 1273 898000. Fax: +44 (0) 1273 480661. Email: sales@rfsolutions.co.uk. Web: **www.rfsolutions.co.uk**.

PLEASE TAKE NOTE

Status Monitor, Feb '06: The Receiver section should have a 5V 78L05ACZ regulator for IC3 in place of the 8·2V 78L82ACZ. To then increase the brightness of the LEDs, reduce resistor R4 to 270Ω and R3 to 220Ω. The Transmitter regulator is correct.

Mirror Weather Station

Renowned for pushing the boundaries of consumer technology, Oregon Scientific adds to its "World's First" collection with the Mirror Weather Station. This sleek model is a landscape A4 sized mirror with an integral weather station. As well as being positioned on side tables or shelving, the MR238 can be wall mounted. For added versatility its flexible arm allows for different positioning/viewing angles.

Whether you're shaving, brushing your hair or putting on make-up, say Oregon there's no need to look any futher as the MR238 can provide you with all the information you need for your day ahead.

The dual-use unit shows indoor and outdoor temperature and humidity levels. Data is captured by a remote sensor which ensures that the MR238 delivers accurate readings for weather forecasting. Information is presented clearly at the bottom of the mirror with a combination of easy to read colour illustrations and symbols. What's more the stylish mirror also displays a full segment calendar, weekday information and has a radio controlled clock.

The design sells for £129.99. Browse **www.ebooksonlineshop.com/mirror.htm**

EPE PCBs LEAD-FREE

Chiltern Circuits, who manufacture *EPE* PCBs, tell us that since November 2005 all PCBs they produce are lead free, as will be required by legislation regarding the Restriction of Hazardous Substances from 1st July 2006.

The solder they use is SN100C. This particular alloy of tin, copper and nickel was chosen due to its proven record of over four years use by some of the largest manufacturers in the world. It is an alloy that is compatible with all other solder systems and so can be used universally. The fact that it does not contain silver means that it is far less aggressive than those that do.

There are other finishes available but they were discounted, in the case of immersion tin and silver, due to potential problems of oxidation of the plated surface rendering them unsolderable over a relatively short timescale. Nickel/gold was also discounted for the majority of applications, on the grounds of cost, but is still available from Chiltern if required.

Please be reassured that, on the whole, there will not be any additional costs to you the customer as a result of this changeover. This applies to all *EPE* PCBs from the December '05 issue and older ones as we replace the stock.

RoHS at Farnell

Farnell InOne, who claim to be the number one source for RoHS compliant products and information, tell us that they are able to assure a market leading number of compliant products due to its unique approach to RoHS and its stringent policy of changing part numbers to clearly segregate compliant and non-compliant stock, even where the manufacturer hasn't changed them.

A certificate of compliance is offered for each RoHS compliant product made available after an exhaustive due diligence process. A complete audit trail for each product, rigorous risk assessments for suppliers, random product testing, and the request for independent test results from higher-risk suppliers mean that customers can be confident that every individual component will have been through a stringent and rigorous process to confirm it is RoHS compliant.

Gary Nevison, Head of Product Market Strategy at Farnell InOne, explains: "Farnell InOne believes that going the extra mile is essential so that we can put our customers' minds at rest. Our commitment to RoHS compliance goes way beyond the industry standard".

Browse **www.farnellinone.co.uk** for more information.

WATER LEVEL RECORDER

A new, highly accurate water level recorder for tanks, vessels, ponds and lakes, is being introduced by MadgeTech.

The Level 2000 Water Level Recorder measures and records water levels down to 30 feet deep over a user-selectable time period from two seconds to 12 hours for up to 12 months. Featuring a battery-powered stainless steel recorder and probe connected by a cable, it operates by measuring pressure and is atmospheric pressure compensated to assure 0·02 resolution.

Capable of accurately recording what happened to a water level over time, anywhere it can be hung, the recorder includes software that provides customizable engineering units, real-time recording and alarming, including signaling and email notification, overlaid graphs, and data and annotations that can be exported to MS Excel.

For more information and the MadgeTech distributor nearest you, contact MadgeTech Inc., Dept *EPE*, 201 Route 103 West, PO Box 50, Warner NH 03278, USA. Tel: (603) 456-2011. Fax: (603) 456-2012. Email: stephanie@madgetech.com. Web: **www.madgetech.com**.

EOCS Magazine

The latest copy of the *Electronic Organ Magazine* has been received from the EOCS, the Electronic Organ Constructors Society. This is a worthwhile club to belong to if electronic organs and such are your interest.

The Secretary's position is currently vacant, so in the meantime contact the EOM Editor, Don Bray at 34 Etherton Way, Seaford, Sussex BN25 3QB. Tel: 01323 894909. Email: editor@eocs.org.co.uk

MERG NEWSLETTER

MERG, the Model Electronic Railway Group, have sent their latest newsletter. As usual, it details some of the Group's recent exhibitions held around the UK, along with items of general interest to those involved with this hobby. They also give the latest news on kits and other products they sell to their members. They have extended their range of Babani books, for example, to include three new titles.

They say their kit sales are on the up with particular demand centred on the DCC range and specifically accessory decoders. Also in this issue, there's a proposal for a new kit, a DCC Train Detector, sometimes called a TOTI or Block Occupancy Detector. The new design enables train detection circuitry to be electrically isolated from traction current by means of inductance coils and therefore is specifically aimed at DCC systems.

The MERG committee aim to air proposals in the next months for a 4-channel servo driver kit, for points, signals (and any other moving object that inventive people can contrive!), and a DCC Auto Reverse Unit that will fill the current hole in the MERG DCC range. For their DC-oriented members, superBloc reigns supreme in this field and there is every intention to maintain the range of BC3 kits and test tools. There are lots of exciting things ahead with MERG.

If you are interested in model electronic railways, browse MERG's website at **www.merg.org.uk**.

A programmable continuity tester

No matter how high-falutin' is your involvement with electronics, one of the most common bench tests is for continuity. You can always rake out the multimeter but this little tester does a better job, with selectable resistances. It makes an ideal Go/No Go Tester.

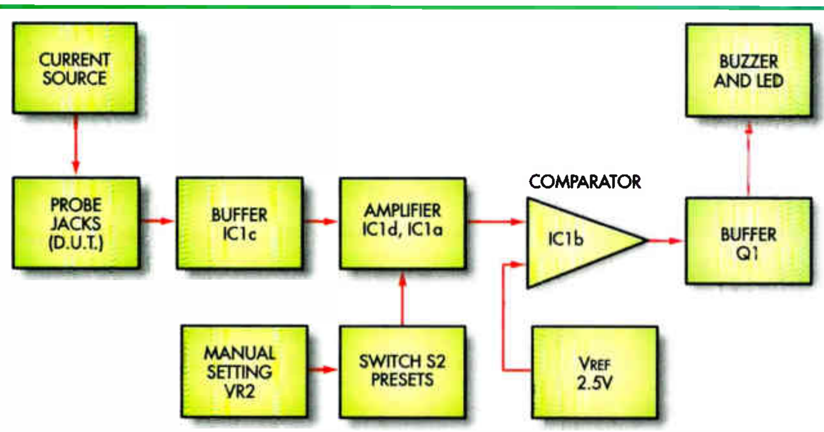


Fig.1: the block diagram of the Programmable Continuity Tester. It feeds a current through the device under test (DUT) and the resulting signal is then buffered, amplified and compared with a reference voltage.

LET'S FACE IT, almost every analogue and digital multimeter does have built-in capabilities for testing continuity. However, this function is somewhat limited. Most DMMs are preset to beep that little miniature buzzer inside when the continuity is below about 40Ω or so.

Wouldn't it be nice to have a device that allows you to set this minimum continuity to anywhere between 1Ω and 100Ω? Well, that is exactly what this project does. It is accurate, reliable and works very well.

It can be used to check the resistance of all sorts of low resistance devices: lamp filaments, motor windings, relays, switches, transformers, speakers,

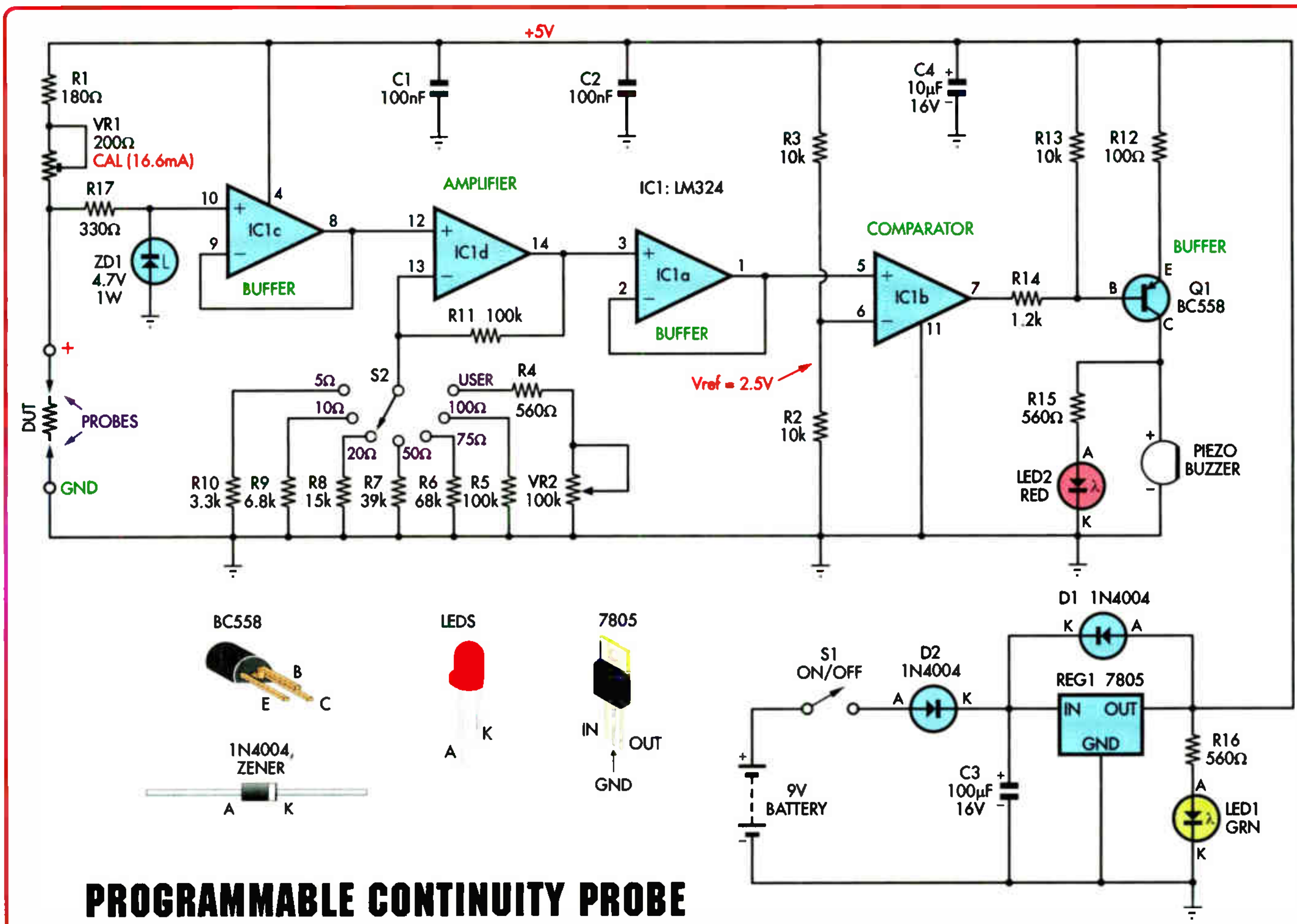


Fig.2: most of the circuit functions are performed by a single LM324 quad op amp IC. These initially buffer and amplify the signal from the DUT, after which the signal is compared against a fixed voltage reference in IC1b. The output of IC1b then drives a buzzer and indicator LED via transistor Q1.

wiring harnesses or you name it. It's ideal for auto electrical work and a host of other applications.

Features

The unit features six preset resistance levels: 5Ω, 10Ω, 20Ω, 50Ω, 75Ω and 100Ω, selected by a rotary switch. Now if any resistance that you measure is less than the preset value, the buzzer sounds and a red LED lights. In addition, there is provision for presetting any resistance value over the range of 1Ω to 100Ω. Provided the resistance you measure is less than your preset value, the buzzer sounds and the red LED lights.

How it works

The circuit uses just one low-cost op amp package, a 3-terminal regulator and not much else. Fig.1 shows the block diagram of the circuit and while it shows a lot of boxes, the concept is really quite straightforward. There is a current source to feed the device under test (DUT), three op amps used as buffer and amplifier stages, a comparator and buffer, and the LED and buzzer.

Fig.2 shows the circuit diagram and as you see, it uses just one LM324 quad op amp to do most of the circuit functions. A 3-terminal regulator (REG1) derives a fixed 5V from the 9V battery. The fixed 5V is required because the current source and comparator rely on having precise voltage levels.

Resistor R1 and trimpot VR1 set the maximum current (into a short circuit) for the device under test (DUT) at 16·6mA. The voltage developed across the DUT is then fed to IC1c via a 330Ω resistor which, together with ZD1, provides transient input protection.

IC1c is connected as a unity gain voltage follower and acts as a buffer stage. This is followed by op amp IC1d which has its gain set by one of seven switched resistors (trimpot VR2 included).

The output of IC1d goes to another unity buffer (IC1a) and is then fed to pin 5 of IC1b which is connected (no feedback) as a comparator. Pin 6 is connected to a voltage divider which means its level is +2·5V. Now if pin 5 is less than the +2·5V at pin 6, the output of the comparator goes low to turn on transistor Q1, the buzzer and LED2.

Half-supply reference

The key fact about this circuit is the +2·5V at pin 6 of IC1b; everything relies on this.

Now we'll backtrack a bit, to see how the circuit functions when testing an actual resistance. Let's say that you want to check continuity (ie, resistance) of less than 5Ω, so you set that with the rotary switch. That done, you

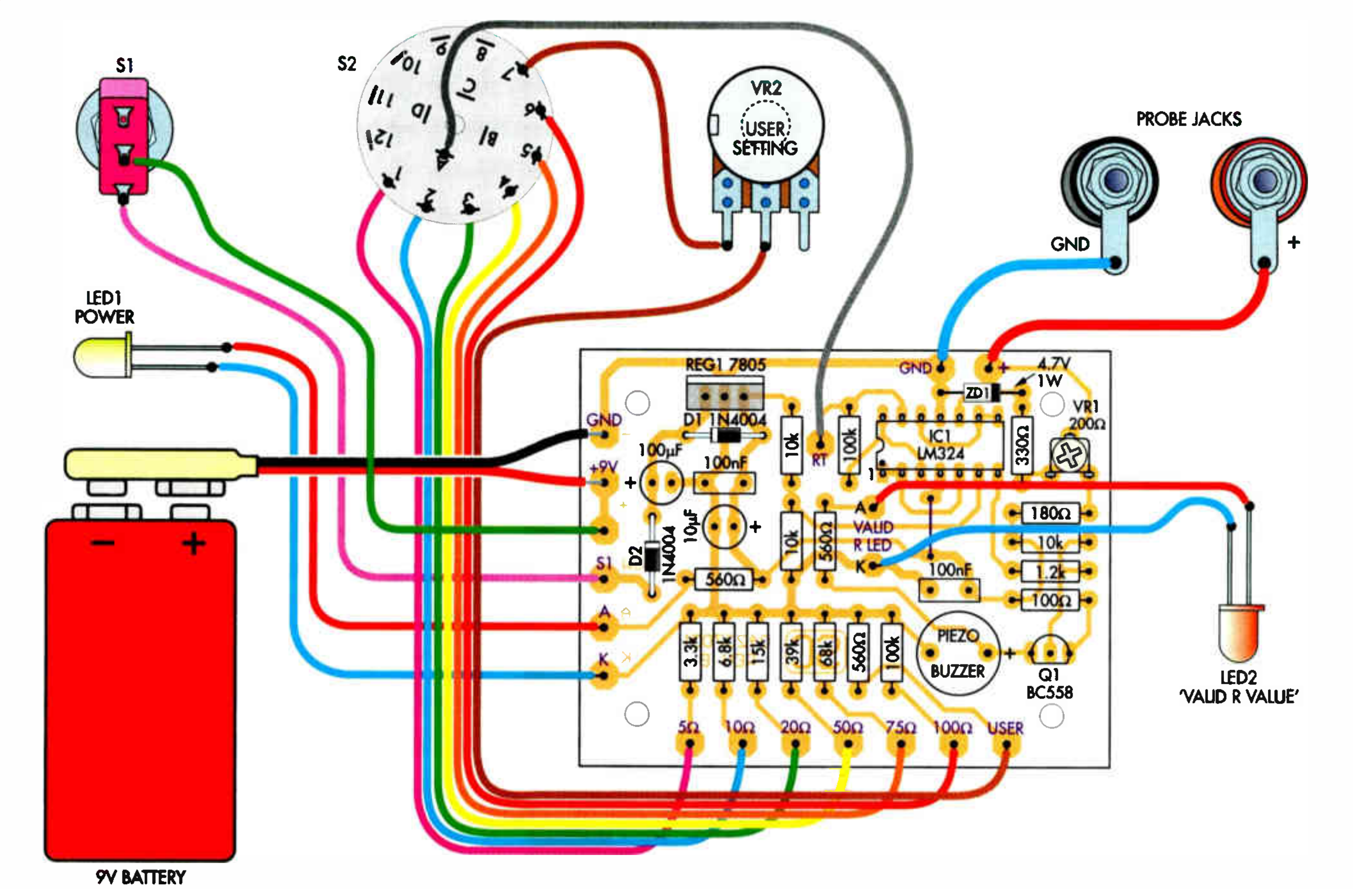


Fig.3: the assembly is straightforward but take care with the switch wiring, as it's easy to make a mistake with the connections. Take care also when installing the semiconductors, as these can easily be damaged if mounted the wrong way around on the PC board.

connect a 4·7Ω resistor across the test terminals.

As previously noted, VR1 is set to provide a maximum current into the DUT of 16·6mA. Now because the DUT is 4·7Ω, the voltage developed across it will be 4·7 x 0·0166 = 78mV.

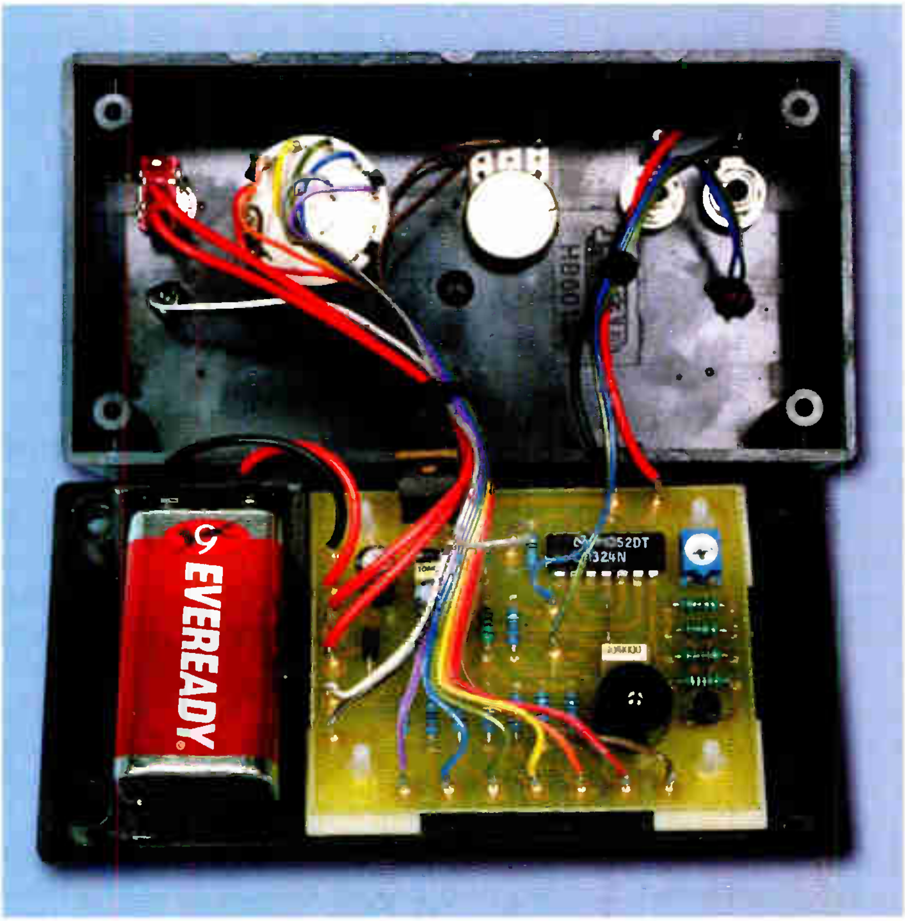
This is passed through the unity gain buffer unchanged (that's what a unity gain buffer does!) and fed to IC1d, where it will be amplified by a factor of 31·3, as set by resistors R11 and R10. So the voltage at the output of IC1d will be 0·078 x 31·3 = 2·44V. This is less than the +2·5V at pin 6 of IC1b and so Q1 will be turned on to sound the buzzer and light LED2.

The same process happens with the other resistance ranges. The gain of IC1d is changed via the switchable resistors to suit the selected threshold resistance.

Now some readers won't be happy with the above description. "Hang on a minute" they'll say. "The current set by trimpot VR1 is nowhere near

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	68kΩ	blue grey orange brown	blue grey black red brown
❑	1	39kΩ	orange white orange brown	orange white black red brown
❑	1	15kΩ	brown green orange brown	brown green black red brown
❑	3	10kΩ	brown black orange brown	brown black black red brown
❑	1	6·8kΩ	blue grey red brown	blue grey 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
❑	3	560Ω	green blue brown brown	green blue black black brown
❑	1	330Ω	orange orange brown brown	orange orange black black brown
❑	1	180Ω	brown grey brown brown	brown grey black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown



The PC board and battery holder are mounted on the lid of the case, as shown in this photo (see text). Use several cable ties to keep the wiring neat and tidy but leave enough slack in the wiring so that the lid can be opened out.

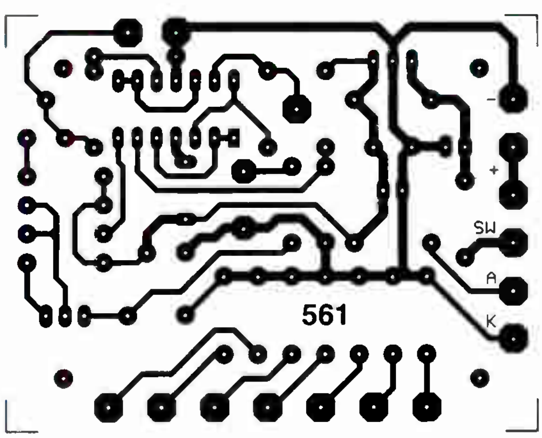


Fig.4: check your PC board against this full-size etching pattern before installing any of the parts.

Parts List

1 PC board, 70 x 55mm, coded 561 available from the *EPE PCB Service*.
1 plastic utility box, 130 x 67 x 44mm
1 label to suit box
2 knobs to suit rotary switch and potentiometer
1 SPST toggle switch (S1)
2 5mm LED bezels
2 panel mount banana sockets, one red, one black
1 9V battery
1 9V battery holder
4 adhesive PC board standoffs
1 1-pole 12-position rotary switch (S2)
1 self-oscillating piezo buzzer;
2 cable ties
Rainbow cable
1 200Ω horizontal mount trimpot (VR1)
1 100kΩ linear potentiometer (VR2)

Semiconductors
1 LM324 quad op amp (IC1)
1 7805 3-terminal regulator (REG1)
1 BC558 PNP transistor (Q1)
1 5mm green LED (LED1)
1 5mm red LED (LED2)
2 1N4004 silicon diodes (D1, D2)
1 4.7V 1W Zener diode (ZD1)

Capacitors
1 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
2 100nF (0·1µF) MKT polyester or monolithic

Resistors (1%, 0·25W)

2 100kΩ	1 3·3kΩ
1 68kΩ	1 1·2kΩ
1 39kΩ	3 560Ω
1 15kΩ	1 330Ω
3 10kΩ	1 180Ω
1 6·8kΩ	1 100Ω

constant and will be quite a bit less for higher resistances around 100Ω than for low resistance values". And they will be right. But that does not alter the validity of the circuit, because the gain resistors selected by the rotary switch have been selected with this factor in mind.

If you have trouble accepting this, let's try another example, this time using the 100Ω range. And this time, let's make the device under test (DUT) a resistance of 95Ω. We said before that trimpot VR1 is adjusted to give a maximum test current (into a short circuit) of 16·6mA. By the magic of Ohm's Law and the specified 5V supply, this means that the total resistance of R1 and trimpot VR1 is 300Ω. Try it: 5V/300Ω = 16·6mA.

Therefore, when we connect 95Ω across the DUT terminals, the total current flowing will be 5V/395Ω = 12·7mA (we never said the test current was fixed!). The resulting voltage across the 95Ω resistance is 1·2V and this is amplified in IC1d by a factor of 2, giving 2·4V at pin 5 of comparator IC1b. Once again, the output of IC1b will be low, Q1 will turn on and the buzzer will sound.

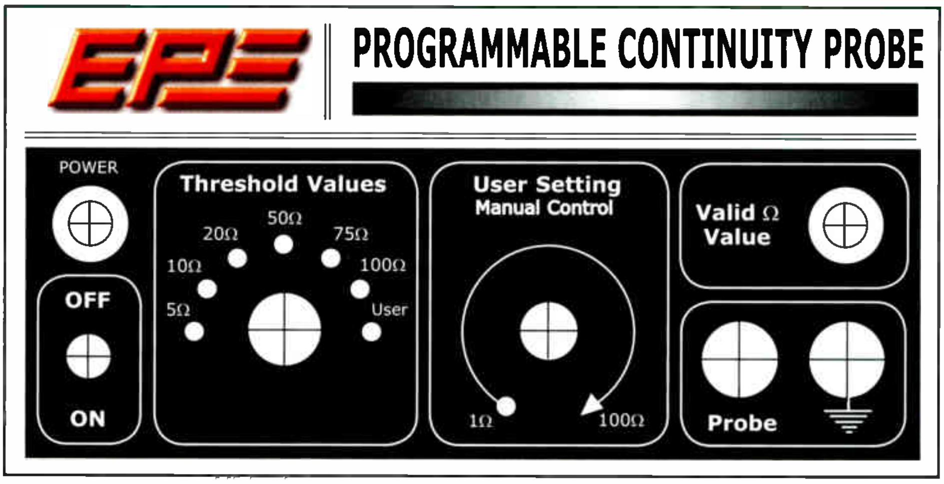


Fig.5: this full-size artwork can be used as a drilling template for the front panel. Note that it's best to make the larger holes by drilling small pilot holes first and then carefully enlarging them to size using a tapered reamer.

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We'll leave it to you to confirm the principle on other ranges but don't worry, it does. In fact, in theory, trimpot VR1 could have been omitted and R1 specified as 300Ω and the circuit would work identically. Trimpot VR1 is really only required to cope with slight tolerance variations in the circuit components.

Putting it together

All the circuit components, with the exception of the rotary switch and potentiometer VR2, are mounted on a PC board measuring 70 × 55mm and coded 561 (available from the *EPE PCB Service*). The parts overlay and wiring diagram is shown in Fig.3.

Assembly is very straightforward. Mount all the PC pins (18 required) first, followed by the resistors and diodes. Make sure the diodes are in the right way around and the same comment applies to the two electrolytic capacitors. Then mount the polarised piezo buzzer, the transistor, 3-terminal regulator and the LM324 IC.

The finished PC board mounts on the lid of the case using four adhesive standoffs. The battery holder is mounted on the lid with a dab of hot-melt glue or you could use double-sided foam tape. All front panel components are mounted on the base of the case so you can fit the label to the case and use it as a drilling template for the on/off switch, two LED bezels, rotary switch, potentiometer (VR2) and the two banana plug sockets.

Rotary switch setup

The rotary switch needs to be set to provide seven positions before it is mounted in the case: pull off the indexing washer and set it back on the threaded bush to give the right number of positions. Try it by hand before you mount it in position.

Once the case hardware is mounted, complete all the wiring as shown in Fig.3. When all is complete, carefully check your work and then fit a 9V battery and switch on. The green LED should light.

Now switch your multimeter to the 200mA range and connect it across the test terminals. Adjust VR1 for a current of 16mA.

That done, switch down to the 20mA range and readjust VR1 to obtain a reading of 16·6mA.

Now do a series of checks to see that each range gives the correct buzzer result (and with the red LED lit), using suitable test resistors for each range. That's it: make up a pair of banana plug test leads and you now have a very useful Programmable Continuity Tester. ***EPE***


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TECHNO-TALK MARK NELSON

FUNNY FACTS ABOUT THE MAINS

Another change to mains wiring colour codes?

WE'RE talking funny peculiar, not funny ha-ha, even though you might find the latest proposals to change electric wiring colours risible. The meddling is not as mad as it appears, however, and will help clear up a fascinating farrago of conflicting standards in the field of mains electricity distribution.

"Standards are vital. That's why we support so many of them". So said the regulators in the age-old joke. But when you look at electrical wiring, mains pluggery and socketry or even power distribution, it's clear that standardisation is by no means complete, either world-wide or even within Europe, where we'd be forgiven for assuming everything is now harmonised.

Assumptions are in fact dangerous. Many electrical appliances are made for international use, and international connectors and colour codes for wiring could easily mislead us into thinking the power itself is the same everywhere. It isn't, of course, and varies in voltage, frequency and phase. Let's return to this later and check out first the imminent changes in wiring colours.

Rigid Regulation

From 31st March any new installation of AC or DC power wiring in Europe must conform to the new scheme. This applies to any company placing products on the market within the European Union, so it has global implications too. Appliance cords are not affected in any way so the mains leads from the plug to your kettle, soldering iron or hi-fi will not change in any way. But fixed wiring will, with the regulations applying both to the cabling between the fusebox and your mains sockets and also to cable looms within equipment cabinets. The rules apply only to new jobs of course; existing installations are unaffected.

The newly amended regulations, known as Cenelec HD308 and BS7671, apply to what are technically known as "rigid" or fixed cables and you can find a summary at **www.iee.org/publish/wireregs/impact_2004.pdf**. Safety of life is one of the key drivers for the change and reading this document it's immediately clear that the present arrangements pose risks for DIY enthusiasts in Britain.

That's because although we have been using pan-European colours for flexible cables (blue, brown and green-yellow) for more than three decades, we never changed the traditional colours for fixed cabling. The colour scheme for fixed installations in the UK is red, white, blue (or three reds) for the Phases, black for Neutral and green-yellow for the Protective Conductor. When wiring is carried out by trained electricians, no problems should arise, but a conflict arises when amateurs wire ceiling pendants and find the colours don't match.

Employing the same colours throughout Europe for wiring installations would not only eliminate this safety risk but also cut costs by reducing the number of cable colours manufactured and facilitating competition. For *domestic* installations Phase, Neutral and Earth will now use brown, blue and green-yellow wires, the same as flexible cables.

In three-phase installations the present red, yellow and blue for three Phases and black for Neutral will be replaced by brown, black and grey for the Phases and blue for Neutral. Cable marking will change too, using L1, L2, L3 for the Phase conductors, N for the Neutral and P for the protective (earth) conductor. On DC systems L+, M and L– will be used for Positive, Earth and Negative respectively (M is the initial letter of *masse*, used already in France and Germany.

Colour Confusion

Included in the IEE document just referred to is a coloured chart showing the wide variation in colour coding for fixed wiring inside Europe that will be harmonised by the new scheme. Flexible cords (mains leads) are now largely colour-coordinated around the world, but this was not the case thirty years ago or so. Just look at the confusion in these examples (in each case the colour codes are given in the order L, N, E or Line (live), Neutral and Earth (ground).

Belgium: Red, yellow or blue, Grey, Black.
Germany: Usually Grey, Black, Red.
Great Britain: Red, Black, Green.
Netherlands: Any colour but grey or red, Red, Grey.
Russia: Red, Grey, Black.
Switzerland: Red, Grey, Yellow or yellow /red.
USA, Canada: Black, White, Green (if you think of the "Black Death" you won't go far wrong!).

From this it's obvious that there's nothing universally obvious in selecting green for Earth. Making it striped to distinguish it from the other conductors in the new scheme was an inspired choice. In fact the choice of colours for the new worldwide system was by no means an arbitrary affair. The two colours for Line and Neutral had to be clearly distinguishable, even by people who suffer from colour-blindness, and blue and brown were judged the most clearly different shades by experts in this field. These colours had the additional virtue of not being widely used in any existing scheme.

More Muddle

Unfortunately, the harmonisation achieved by this colour coordination was not matched by similar progress for AC mains voltage and frequency. Japan had two standards, 100V in the Kansai region and 220V in the Kanto region. Europe had both 110V and 220V, whilst the North American was on 117V. Great Britain settled for 240V, although 210V and 230V survived in a few areas into the 1970s at least.

Mains frequency varied far more widely than is generally recognized too. The "traction" frequency of 25Hz applied in a few locations in Britain served by industrial rather than commercial supplies until the early 1950s, in parts of the USA, also in Ontario, Canada. Ontario Hydro changed to 60Hz during the 1950s and before this many radios and other appliances were made for 25Hz supplies, which causes some problems when vintage radio enthusiasts plug a 25Hz set into 60Hz today! I'm told that North Vietnam still has some 25Hz mains supplies.

The unusual frequency of 40Hz was used quite widely in north-east England and to some extent in Australia (e.g. Perth). The geographically most widely used frequency is 50Hz, used throughout Europe, Africa, much of Asia, Australasia, parts of Japan (Kansai region) and formerly by California Edison in the USA. Finally we have 60Hz, employed in North America and parts of Japan (the Kanto region).

Puzzle No More

Incidentally, the reason for 50Hz and 60Hz standards appears to be very simple and down to the different rotational speed of the generators used. In Britain and Europe the rotational speed of these generators (1,000 rpm) ended up producing 50Hz. I suspect (but also guessing) that the USA settled on 1,200rpm.

You may be wondering also why the voltages for high tension AC are always divisible by 11. I was told by the archivist of one of Britain's power companies that this stems from engineers' love of safety margins; in other words they always added 10% for luck and 110V, 220V, 440V, 11kV and 33kV all derive from this superstition!

He also explained that nearly all domestic supplies around the world were originally fixed at 100V (or 110V for luck!), since this pressure was sufficiently high to perform useful work, yet not usually lethal. But as demand for electric lighting and power grew, the supply companies needed to deliver more power without investing fortunes in additional distribution cables. Their solution was to double the voltage, which halved the current and allowed them to use the same cables and so defer the need for investment. Believe this if you wish!

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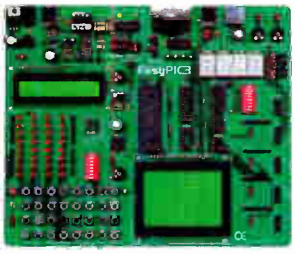

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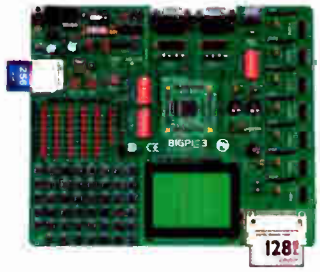

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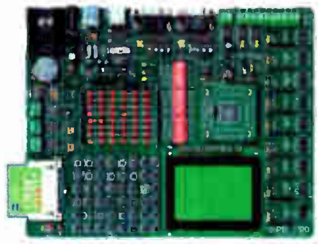

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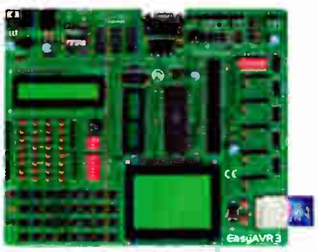

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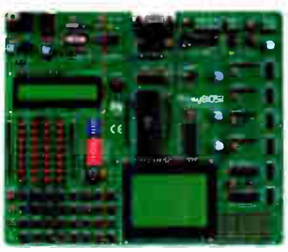

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Omni Pendulum

Bobbing back and forth incessantly – a fun design to entertain you!

By THOMAS SCARBOROUGH

OMNI is short for *omnidirectional.* The simplest of pendulums swing only through a single plane – a well known example being the pendulum clock. In this case, the period of the swing is entirely predictable, and this is easy to convert to an electronic design.

If a magnet is mounted on the pendulum, a regular electromagnetic pulse in close proximity to the magnet will keep the pendulum swinging – on condition that the pulse is more or less tuned to the period of the pendulum. However, things get considerably more complicated when a pendulum swings in all directions – that is, if it is omnidirectional.

The pendulum may begin to swing in an ellipse, or it may gyrate – and in the process may fail to pass over the electromagnet when it pulses, thus losing vital momentum. In short, a regular electromagnetic pulse may fail to impel such a pendulum any more, and in a worst case, may virtually stop it dead in its tracks.

What is required, therefore, is something far more flexible than a regular electromagnetic pulse. Ideally, the electromagnet will pulse only when the pendulum passes over the electromagnet – timed to within milliseconds. This is in fact what the present circuit accomplishes.

Omni Pendulum

The Omni Pendulum is one of those projects that "keeps on giving", since it offers a highly visible display of one's electronic skills. Note, also, that the circuit need not only impel a pendulum. It may also impel a wheel, or a roundabout, or a so-called "boinger" (an upside-down pendulum), or a hanging spring, or a see-saw on a fulcrum. As just one idea, although its implementation would take time and care, a model boxer could punch at a punchbag that has an irregular swing.

In Concept

The electromagnet used in this design has no iron core, as would normally be the case. This is because the pendulum contains a neodymium magnet. These are so powerful that a pendulum might easily jump to the electromagnet's core and stick to it if a slightly springy line were used. In this design the electromagnet comprises *two* coils – a 500-turn electromagnet to impel the pendulum, and a 100-turn coil on top of this, to detect the pendulum's motion. The complete circuit diagram of the system is shown in Fig.2.

In order to impel an omnidirectional pendulum, the circuit needs to accomplish a relatively complex sequence (see Fig.1). First, the Omni Pendulum detects the incoming pendulum before it crosses the electromagnet, which it does by means of the 100-turn coil and the circuit around IC1. Red l.e.d. D1 indicates when IC1 has been activated.

Second, the pendulum needs to be impelled by the electromagnet only at or after it reaches its centre of gravity. Failing this, it would be repelled before passing over the electromagnet – causing it to jump or gyrate, or even stop swinging. Therefore a short delay needs to be introduced immediately after detection, and this is accomplished by means of IC2a.

Depending on how this delay is adjusted by means of preset VR2, the pendulum may swing either energetically or lethargically. Thirdly, after an appropriate delay following detection (about 30ms, or one-thirtieth of a second), the electromagnet needs to be energised, to repel the pendulum – which is impelled by repulsion.

A surprisingly short pulse is required for this purpose, and the pulse employed here (about 50ms) is more than enough to impel almost any

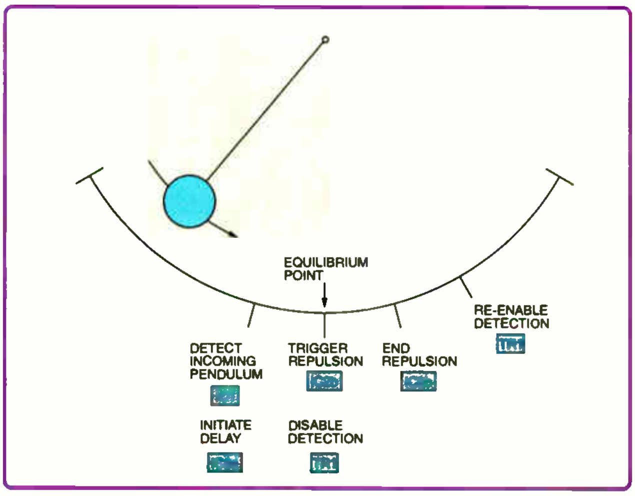


Fig.1. Pendulum sequence

pendulum (if you wish to experiment, the period of IC2b could probably be reduced to half). At this point, the Omni Pendulum is almost ready for service; though not quite.

There are two remaining problems that need to be addressed. First, the two coils are wound on top of one another. This means that they will act as a transformer, causing the larger coil to induce a voltage (about 1.3V) in the smaller coil when the larger coil pulses. This in turn will cause IC1 to imagine that it has detected the pendulum a second time (and a third and a fourth time, and so on), just after it has detected it for the first time.

Second, if the pendulum should begin to stall or gyrate, this could trigger the electromagnet almost continually, leading to a loss of purposeful pulsing. Perhaps most seriously, this could cause an enormous squandering of power, and overheating both in the circuit and the power supply. Both of these problems are solved by disabling timer IC2a through transistor TR1 for about 100ms until the circuit has settled after pulsing the electromagnet.

In this way, there is no spurious triggering through inductive coupling of the coils, nor is there any continual pulsing of the electromagnet if the pendulum should lose its stridency of swing. It is possible to adjust the Omni Pendulum to be more or less self-starting. If it is not adjusted for too vigorous a swing, and if IC1 is not adjusted either too sensitively or too "bluntly", there is a balance at which the Omni Pendulum is almost sure not to stall, but always to recover its motion.

However, this is not finally guaranteed, since there does come a point where there is not sufficient linear motion to trigger IC1, particularly if the pendulum should settle into an ever reducing circular swing.

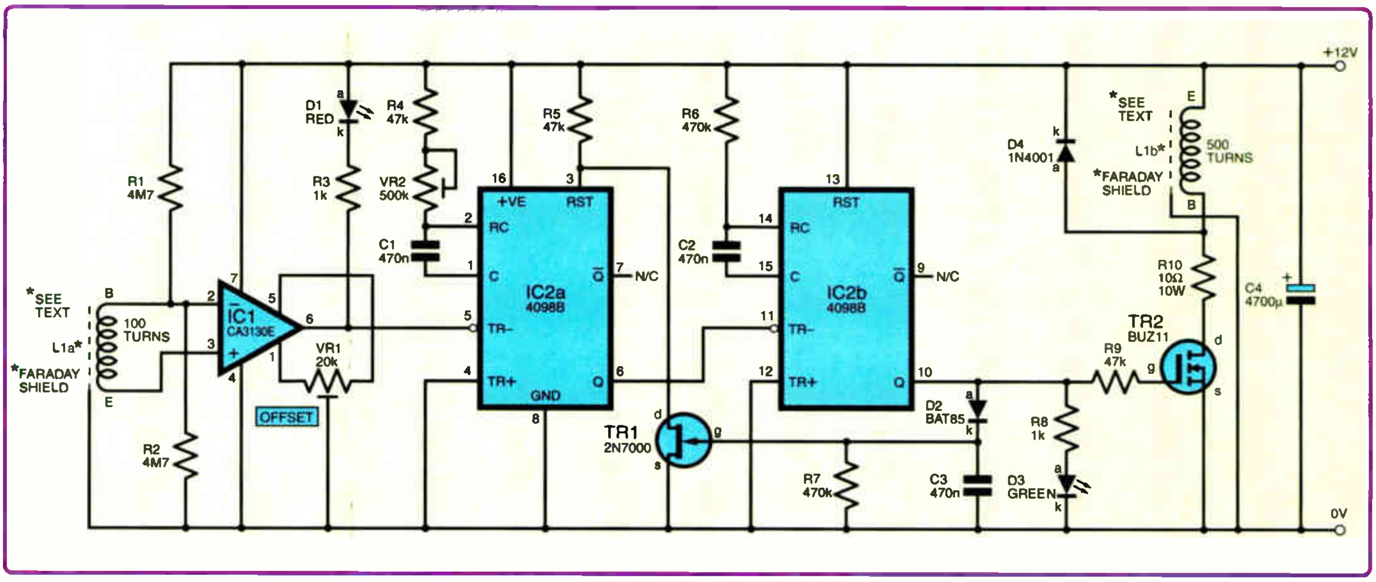
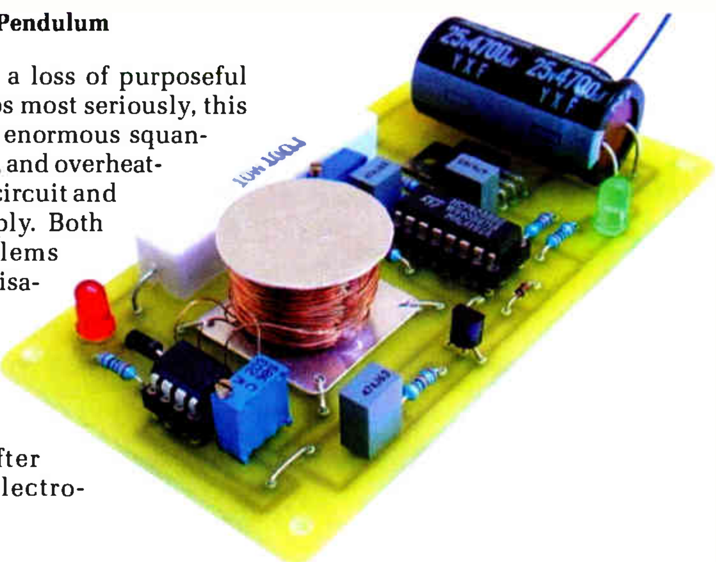


Fig.2. Complete circuit diagram for the Omni Pendulum



When the Omni Pendulum is inactive, it draws virtually zero current. It should instantly re-start simply by flicking it into action. The Omni Pendulum draws more than 10W peak power, but with the use of a 4700μF capacitor for C4, an unregulated 12V 250mA d.c. supply should prove adequate. Ideally, a regulated 0·5A or 1A power supply would be used.

Circuit Diagram

The circuit diagram shown in Fig.2 begins with IC1, which is essentially wired as a comparator. This detects the swinging pendulum as it approaches its equilibrium point. As the pendulum's magnet approaches the 100-turn coil L1a, so a small voltage is induced in the coil, causing the output of IC1 to go "low", thus illuminating l.e.d. D1.

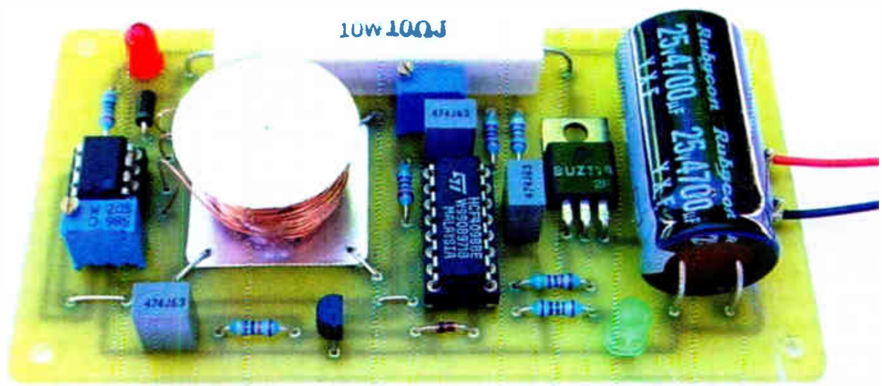
The sensitivity of IC1 is adjusted by means of Offset adjust control VR1. In the original prototype, which is pictured in the photographs, resistors R1 and R2 were omitted, with the circuit relying on IC1's 5pA internal biasing. However, with sustained testing under various conditions, the adjustment occasionally drifted over time, so that D1 began to gently glow, then fully illuminate, effectively stopping the pendulum. To obviate this problem, resistors R1 and R2 are used to add a light external bias (about 1μA) to the inverting input of IC1.

Delayed Trigger

IC2a is a trailing edge triggered retriggerable monostable (a timer). That is, it triggers on the trailing edge of a pulse from IC1. Its purpose is to insert a delay between detection of the pendulum and pulsing it, as described above. Preset potentiometer VR2 sets the period of the timer, which effectively controls the "vigour" of the pendulum. IC2b is again a trailing edge triggered retriggerable monostable, which pulses the 500-turn electromagnet.

Resistor R9 is included for safety purposes. If transistor TR2 should fail, a large current could flow through the transistor's gate, and destroy the rest of the circuit. With R9 in place, the rest of the circuit should be safe.

Almost any power MOSFET should work in place of TR2, on condition that it is rated 15W or higher. The purpose of resistor R10 is to protect both transistor TR2 and coil L1b by limiting the current flow. It will be seen that R10 is slightly under-rated at 10W (peak current through R10 is just over 14W). However, the pulse through the electromagnet is so short that this should not present a problem. During use, R10 just slightly warms.



Component layout on the Prototype Pendulum circuit board. Note biasing resistors R1 and R2 have been included in the final version

No Going Back

Green l.e.d. D3 indicates when electromagnet L1b is activated. Diode D4 suppresses back e.m.f. In order to prevent a pulse from "going back through the circuit" through coil L1a, f.e.t. TR1 is employed to disable timer IC2a for a

Parts List – Omni Pendulum

1 PC board, code 566, 113 x 60mm, available from the *EPE PCB Service*
1 8-pin d.i.l. socket
1 16-pin d.i.l. socket
1 suitably rated power supply or batteries (ideally 12V 0·5A)
1 battery holder or clip (if required)
1 electromagnet (L1 two coils – see text): 40 metres 30s.w.g. (0·315mm) enamelled copper wire; thin, stiff aluminium sheet, 25 x 25mm (2 off); 15mm length of 5mm dia. wood dowel
4 PC nylon self-adhesive stand-offs, link wire, glue, solder pins, solder etc

Semiconductors
1 5mm red l.e.d.
1 5mm green l.e.d.
1 BAT85 signal diode
1 1N4001 50V 1A rectifier diode
1 2N7000 *n*-channel f.e.t.
1 BUZ11A *n*-channel power MOSFET or rough equivalent
1 CA3130E CMOS bipolar op.amp
1 4098B CMOS dual retriggerable monostable

Capacitors
3 470n polyester, 5mm pitch
1 4700µ radial elect. 16V

Resistors (0·25W, 5%, except where indicated)
2 1k
3 47k
2 470k
2 4M7
1 10Ω 10W minimum

Potentiometers
1 20k multiturn (25-turn) preset
1 500k multiturn preset

Pendulum
1 neodymium magnet (approx. 8mm dia. 2·5mm thick)
thin nylon line or thread, pendulum "bob" and superstructure – see text

brief moment while the circuit settles after impelling the pendulum.

This further serves the purpose of preventing the electromagnet, under certain conditions, from pulsing continually and thus overloading the circuit and power supply.

When the electromagnet is activated, capacitor C3 instantly charges through diode D2, thus causing TR1 to conduct, holding IC2a's reset pin 3 "low".

Note that the circuit has no reverse polarity protection diode in the positive power supply line. This is because the attendant voltage drop could compromise the performance of the Omni Pendulum. Care needs to be taken, therefore, not to reverse the battery or power supply connections, since this would destroy the circuit.

Capacitor C4 serves mainly to take up slack from the power supply to power the electromagnet. If this capacitor were omitted, one would need a fairly "meaty" power supply to power the circuit.

Electromagnet Construction

The electromagnet is custom made. It is easily constructed, and the most critical aspect of the operation is to keep track of the beginning and end wires of the two coils. A square aluminium base is used (see Fig.3), measuring 25mm on each side. This is cut from a thin, yet stiff, sheet of aluminium. Holes are drilled in the four corners, for anchoring it to the printed circuit board. This will also ground the electromagnet electrically, which is important.

An early prototype employed no Faraday shield. However, the pulsing of coil L1b caused slight charges to build up on both coils, which were not quickly enough dissipated after pulsing, causing the output of IC1 to drift slightly. This was obviated by the use of the custom-made shield, which serves to remove excess charge from the coils. It is not crucial that aluminium be used here, but this should be a non-magnetic metal.

Bare wires are used to anchor the plate to the p.c.b. A 5mm diameter wood dowel, 15mm in length, is glued to the centre of the square aluminium base with strong glue, to stand vertically, like the stump of a tree. A circular aluminium "roof" is glued on top of the dowel, being 25mm in diameter. A bare length of wire, as shown in Fig.3, makes

Electromagnet Construction and Coil Winding

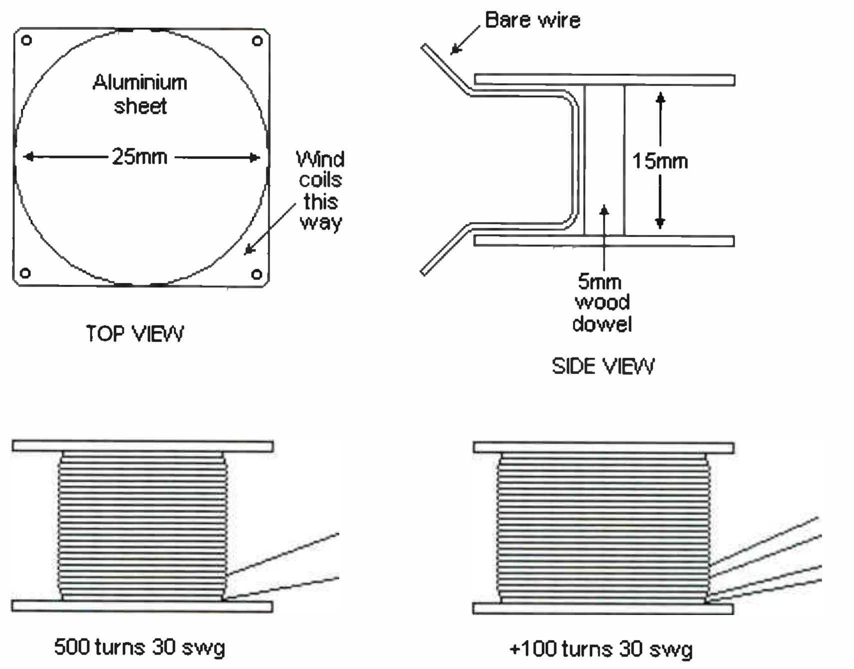


Fig.3. Construction of the electromagnet, coils L1a and L1b

electrical contact between the lower (square) and upper (circular) aluminium pieces. The two coils are wound over this wire, pressing it into place.

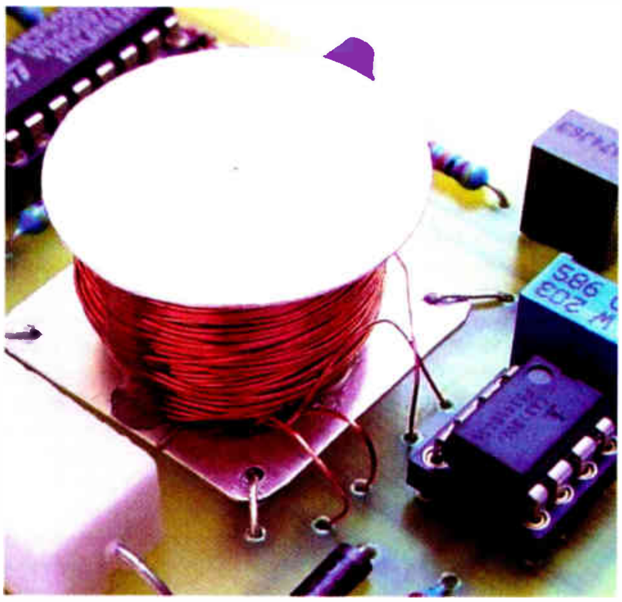
The two metal pieces do not need to be made of aluminium, but it is important that they should be non-magnetic. Begin by winding the electromagnet with 500 turns of approximately 30s.w.g. (0·315mm) enamelled copper wire. The number of turns and the wire gauge are not critical.

Seen from above (looking down onto the circular "roof"), the wire is wound in a clockwise direction. Take careful note of the beginning wire (B) and end wire (E). Then wind the detection coil on top of this, covering the whole of the coil beneath it, with 100 turns of the same wire gauge, also in a clockwise direction, and again taking careful note of the beginning wire (B) and end wire (E). The coils may finally be held in place with some glue.

Without losing track of which are the beginning and end wires, snip the four wires to suitable lengths for inserting in the p.c.b., and scrape the enamel off their ends for soldering. Take care, when these are soldered into place, that they do not touch each other and cause a short circuit.

P.C.B. Assembly

The printed circuit board component and track layout details are shown



Close-up of the electromagnet showing the aluminium "shield" and coil windings

Pendulum Circuit Board

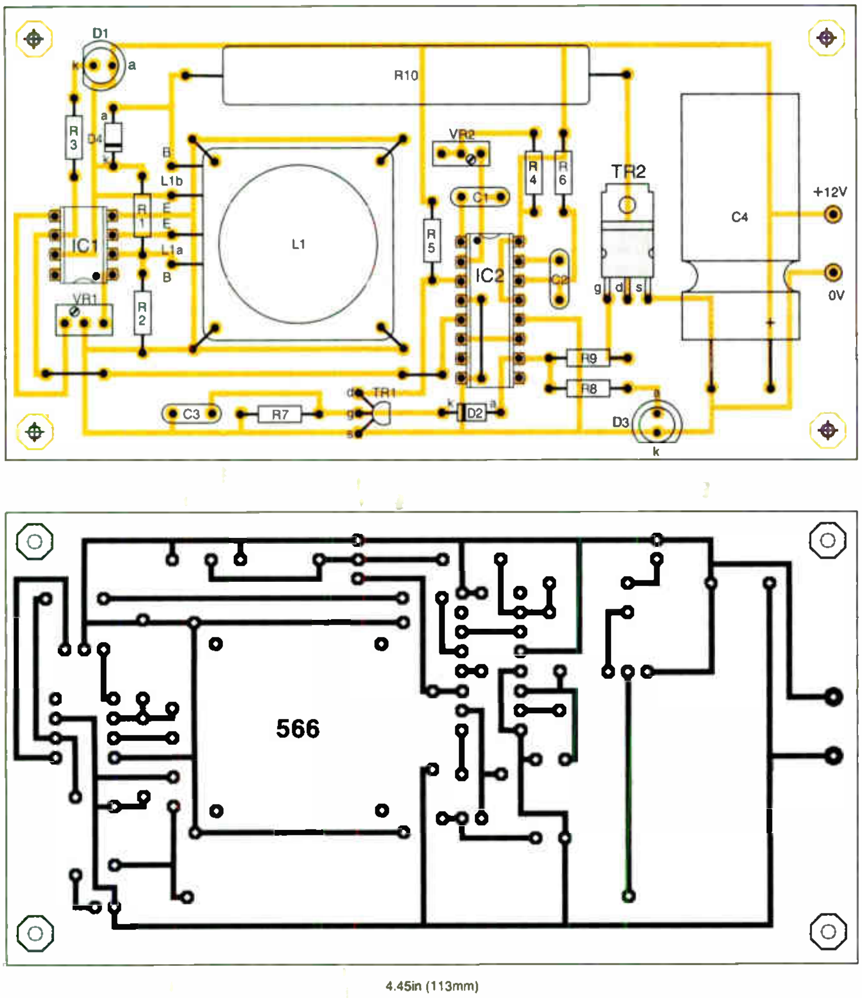


Fig.4. Printed circuit board component layout and full-size copper foil master pattern for the Omni Pendulum

in Fig.4. This board is available from the *EPE PCB Service*, code 566.

Since the integrated circuits are CMOS devices, dual-in-line (d.i.l.) i.c. sockets are recommended, and normal anti-static precautions are advised (in particular, discharge your body to earth before handling these i.c.s).

Begin assembly by soldering the three link wires (the four "anchor" wires for the electromagnet will be added shortly). Note that one of the link wires is situated underneath the socket for IC2. Solder the two solder pins, and the two d.i.l. sockets – observing the correct orientation of their "polarity" notches.

Continue with the resistors, the two multi-turn preset potentiometers (observing their orientation), the capacitors (note the polarity of C4), the diodes, including the l.e.d.s, and the transistors (also observing the correct orientation of these devices).

The coil assembly is lowered into place and anchored by means of four bare wires at its corners, which are soldered to the p.c.b. Then the four wires from coils L1a and L1b are soldered into place, taking careful note of the beginning (B) and end (E) wires – not to mention remembering which coil is which!

The solder pins are taken to a suitable battery clip or power socket, taking careful note again of polarity. Finally, after fully checking your assembly for component positioning and soldering errors, insert IC1 and IC2 in their d.i.l. sockets, ensuring that these are inserted the right way round.

Pendulum

The pendulum may be any fairly lightweight object beneath which a powerful neodymium magnet is attached. The author used a neodymium magnet 8mm in diameter and 2·5mm thick, but there is room for much variation. The magnet's North pole faces downwards as the pendulum swings. Ideally, the length of the pendulum's line will be about 20cm, although here, too, there is room for much variation.

The magnet will swing about 7mm above the top of the electromagnet – again there is room for experimentation. An easy way to determine the polarity of the neodymium magnet is to power up the circuit, and pass it across the electromagnet. If it is repelled, its North pole is facing the electromagnet, as it should be. Alternatively, if a neodymium magnet is placed on a very smooth surface, its North pole will turn to face the Earth's North pole.

In Use

Attach a suitably rated 12V battery or d.c. power supply (250mA minimum), taking care of the correct polarity. If red l.e.d. D1 illuminates, preset potentiometer VR1 needs to be turned back (anti-clockwise). Alternatively, it needs to be turned up (clockwise).

Once the point has been found at which D1 illuminates, turn back VR1 one full turn, by which it will extinguish. Preset VR1 adjusts the sensitivity of detection. Finer adjustments can be made later.

Pull the pendulum back about 10cm from the electromagnet, and let it go – to swing towards the electromagnet. As it crosses the electromagnet, red l.e.d. D1 should illuminate, with the green l.e.d. D3 following so speedily that it will be hard to discern the time lapse. If the pendulum jumps or "bounces" at the electromagnet, preset VR2 needs to be turned back (anti-clockwise) until it is able to pass easily across it.

If, on the other hand, the pendulum swings too lethargically, or is unable to sustain its swing, VR2 needs to be turned up (clockwise). Preset VR2 can be adjusted for a very vigorous swing. However, if the pendulum loses speed, perhaps through falling into an elliptical swing, this can cause it to stall. A more natural swing is far more likely to keep the pendulum swinging indefinitely without interruption. With the correct adjustments of VR1 and VR2, the Omni Pendulum will be virtually self-starting with a small initial movement. *EPE*

Consumer Electronics Show

Barry Fox reports on the 2006 annual CES show in Las Vegas

THE *Consumer Electronics Show*, held every January in Las Vegas, just keeps on getting bigger because the computer industry has scrapped its *Comdex* show and climbed onboard the CE bandwagon. Keynote speeches at CES are now given by IT industry leaders, including Bill Gates of Microsoft and Larry Page of Google.

Blue Laser Discs

All eyes were on Vegas this year as the launchpad for blue laser HDTV disc recording. But failure of the electronics companies to agree on a single standard has split industry support between two incompatible systems, Blu-ray and HD-DVD.

The split has widened because Sony will build Blu-ray into PlayStation 3 and Microsoft will sell an external HD-DVD drive for Xbox 360. The games industry traditionally sells hardware cheap and makes money on software. PS3 is expected to cost $499. At CES Toshiba announced that it will launch an HD-DVD player for the same $499 price. But Pioneer was quoting $1800 for a Blu-ray player.

Said Rudy Provoost, Philips CE CEO: "If PS3 sells at $499 then that is because the games companies can afford to subsidise players to sell games. We are still in the process of evaluating price. We will only introduce a player if we can do it in a competitive way."

An industry insider whose company supplies key technology to both blue laser formats, summed up the industry's problem: "The hardware manufacturers cannot go on making $2 profit on players. They want to earn it from intellectual property rights. But players will be made in China and when they talk to the Chinese about patents, the Chinese will just say: what patents?

"Consumers will no longer take part in a format war. The studios don't want to kill DVD sales. We saw this with DVD-Audio and SACD. Who won that standards battle? Apple's iPod won it. Now we'll see people turn their backs on Blu-ray and HD-DVD, saying 'you guys fight it out'. Consumers will just download movies onto hard drives or video iPods instead of blue laser disc".

Internet Downloads

Sure enough CES became the launchpad for a whole raft of new systems that make it easier to download entertainment onto hard disc from the Internet. Some use an Internet PC; others rely on a consumer recorder with hidden computer intelligence to make the Internet connection. Microsoft's Vista, the upcoming new version of Windows XP Media Center, will make it easier to search through large libraries of downloaded music and movies by automatically labeling them with high quality artwork that mimics disc retail packaging.

Although Hewlett Packard sells Media Center PCs, the company is hedging bets with a new large screen LCD HDTV which has built-in Ethernet and WiFi networking connectors. The TV has no keyboard, just a near-normal remote; computer intelligence in firmware lets the TV connect by wire or wirelessly to any type of PC, whether Windows, Linux, or Apple. The PC will download and store movies, then "serve" them to the TV.

French giant Thomson, owner of RCA, is moving multimedia even further away from the computer model, with an 80GB hard disc video recorder that holds around a hundred hours of video programmes that it has sucked on demand from the Internet. Thomson has done deals with Akimbo and Movielink, two companies which "aggregate" TV and movie rights and then sell the material on line with Digital Rights Management to prevent copying.

Google's Plans

Google's latest plan to change the world – after the ubiquitous Google search engine and new Google Earth digital bird's eye view of the world – is the Google Video Store. This will give PC users the chance to buy premium TV entertainment online, for instance $2 per episode of popular CBS TV programmes or sports events. CBS will also make archive TV shows available by Google pay-per-view. Hollywood movie sales look likely to follow suit (**http://video.google.com/**).

Google's rival Yahoo plans a similar service, called Yahoo Go, mainly for mobile phones and TVs that connect to the Internet through a PC – like HP's.

Viewing Options

Apple is expanding the video options for iTunes. Sony showed an intriguing new system which will let holidaymakers – and business travellers – use a laptop PC to watch what's on TV back home, switch channels on the home TV and record too.

Locationfree TV, due for launch this month in the US and Japan and in Europe later, relies on a home box (the size of a paperback novel) with its own IP address that connects to the Internet by a conventional Ethernet DSL broadband cable. The box also connects to any home TV tuner or satellite or cable receiver, converting the TV signal to an MPEG-4 digital stream, encrypting the signal for privacy and streaming it out over the Internet at around 300kbps.

When a laptop PC is loaded with Sony's control software, it can connect to the Internet anywhere in the world, and go to the home box "home page" and display whatever programme the home box is getting from the home TV. The remote PC also displays a panel on screen which acts as a TV remote control.

If the viewer is going out for the evening, the PC can record the home TV programme on its hard drive, for viewing later. As a bonus for gamers who own one of Sony's PSP portables, the Locationfree box also has a WiFi transmitter which streams the TV programme round the home or garden. All PSPs have a built-in WiFi receiver, so the PSP becomes a portable pocket TV. The Locationfree box and software will cost around $350.

Driving Music

Sony also launched a neat gadget for car-drivers. Many car radios now have a removable front panel, to deter thieves. The new Gigapanel, which will cost around $350, is a car stereo with a USB socket and 1GB of flash memory built into its removable panel.

When the panel is connected to a PC the owner can download a library of MP3 music tracks – which then play in the car through the radio.

Clever Cams

First prize for cleverest gadget at CES must surely go to the new vest pocket digital camera from Kodak that uses two lenses instead of one. The V570 has one very wide-angle 23mm lens alongside a conventional 39mm to 117mm zoom lens. Moving the zoom control switches seamlessly between the two lenses to give a much greater zoom range, 23mm to 117mm, than normally possible with a slim vest pocket camera.

In panorama mode the camera takes a series of three wide angle shots, one after the other, as the user steps the camera through a 180 degree pan. The camera then electronically stitches the three shots into one 180 degree view. As each new picture is taken the viewfinder overlays some of last shot. All the photographer has to do is align the overlapping picture content in each shot. The result is a scenic view that is wider than human vision, with no visible joins.

Over-Optimistic Gates?

Bill Gates boasted at CES that 6·5 million people are now using Media Center PCs, and 130 manufacturers are selling them in 33 countries. It is uncertain though how many of these MPCs will be able to deliver the mouth-watering performance that Gates demonstrated at CES from a Media Center PC with Vista (**www.microsoft.com/events/executives/billgates.mspx**).

Representatives of Microsoft, Intel, Dell and HP all said that it would be mid-2006 before Microsoft releases a recommended hardware specification for Vista. When we checked several of the PCs that Microsoft was using on the show floor – for much more limited demonstrations than Gates' grandstanding – they all had at least 1GB of RAM and a 3GHz Pentium processor. Dell reckoned Vista will need "nothing less than 1GB, ideally 2GB". Intel said "we'll be recommending a dual-core processor – absolutely!"

Although owners of existing MPCs can add more memory, it is not practical to swap a conventional Pentium for a dual-core processor that works like two Pentiums ganged together. So many existing owners of Media Centers, and people buying new ones over the next few months, may find them unable to match what Gates was demonstrating at CES.

PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Experimenting With Overclocking PICs

THERE is an old saying that goes "Scientists build to learn, while engineers learn to build". This month we will be following the scientists' path of building some circuits to learn more about an unusual topic, that of overclocking microcontrollers.

Overclocking is a principle that may be familiar to die-hard PC gaming fans. It refers to the process of raising the speed at which a processor is running, above the limit specified by the manufacturer (Intel or AMD normally) and just below the point where it stops working altogether.

Overclockers go to considerable lengths to push their processors to unbelievable speeds, by carefully controlling the voltage they run at and improving the cooling technology – sometimes even using cryogenic techniques to keep the device from melt down! All in the name of faster gaming.

PIC Games

So how about our humble PIC? They are processors too, so can we overclock them?

We first need to consider what the clock signal does, and how device speed is limited. In common with most processors the PIC is a synchronous device; changes that occur within the device occur when a clock signal changes level.

So for instance, when two numbers are being added together, the individual signals that make up each "bit" in the numbers will arrive at the adder circuit at slightly different times (because they travel through different length paths on the chip) but the addition only occurs once, when the clock signal changes. The clock causes events to occur at the same time.

As signals pass though various gates within the CPU, capacitance causes minor delays in the rising and falling edges. This is referred to as *propagation delay*, and the more of it you have, the slower the clock must be. If you clock the bits arriving for an addition too quickly, some of the signals may have been so delayed that they "miss" the clock edge, and some old data gets used.

Careful Testing

The delays in the chip characterise the performance, and ultimately the speed of the device. Many factors affect the speed characteristics, and therefore careful and wide ranging testing is performed by manufacturers to determine what category each part will fall into. As faster devices command a higher price, it's in the manufacturer's interest to identify the better ones.

Intel, for example, test every processor that comes off their production line. Parts from the same production process will be categorised into one of three speed classifications. Typically, the test parameters would include the propagation time for a signal traveling through the longest path in the chip; the resulting time will determine into which speed classification the device will fall. Maintaining historic data on past performance, high temperature testing on a sample basis and a lot of statistics determine how those speed classifications are determined.

Even across a single die wafer, processors can vary by up to 20% in performance. One must remember that chip manufacturing involves many chemical processes, the speed of the device depends on the quality of the crystalline structures laid down during each process step. The slightest imperfections will cause the signal carrying electrons to move merely fast, rather than very fast!

PIC Emulation

So why should PIC users try to emulate the PC overclockers? First off, by examining the performance of PICs under varying clock speeds, we gain an insight into how critical device parameters such as power consumption and temperature are affected – and this is very useful when you are trying to leverage the optimum use of a device. If the true maximum clock speed is significantly higher, you might be able to use a lower specified device rather than a more expensive one. Or perhaps avoid having to move to a higher performance technology altogether. There are caveats to this, which we will pick up on later.

One of the questions that most likely springs to mind is "Is it safe?" Overclocking on a PC is potentially dangerous because the core of the processor is running at very high temperatures. Increasing the clock speed raises the temperature and the resulting stress on the die can lead to catastrophic failure and even a real risk of fire.

The PIC, however, runs at a sufficiently slow enough speed that the increase in temperature is only marginal, and well within the thermal dissipation ability of the package. The worst that can happen is that the software will malfunction; reducing the clock speed will return the device to normality. As a side point, raising the voltage at which the device runs at is likely to cause permanent damage, so all our tests are carried out at 5.0V

So what device are we testing? A PIC16F873 rated at 20MHz, a PIC18F2620 and two PIC18F2520s. These devices have been chosen because they have the same pinout and can therefore use the same "test jig". We have gone with the DIL package and use a quality turned pin IC socket to simplify swapping parts. The software used in the tests is available on the *EPE* website under Downloads in the *PicN'Mix* area.

Test Setup

The test setup is a very minimal working system with just an LED connected on PORTB,1 to provide feedback during start-up. The power input is fed from a variable bench supply and decoupled by a 10μF and a 0.1μF capacitor. Since we want to vary the oscillator frequency over a wide range, we do not want to use fixed value crystals and instead the circuit is fed from an external signal generator. This signal should come in on a BNC socket and be fed through a logic gate to buffer the signal into the OSC1 pin. OSC2 is left unconnected.

As we are (hopefully!) going to be using clock frequencies above 40MHz all leads should be kept short and the IC decoupled by a $0.1\mu f$ capacitor in close proximity.

A 10Ω resistor should be included in the supply to the PIC to make measurements of current consumption easier. You can place a digital voltmeter across it and apply Ohm's law to determine the current, and then use the same DVM to measure the supply voltage to the PIC, all without interrupting the operation of the circuit. An additional benefit is that you can if you wish place an oscilloscope across the resistor and see how the current consumption varies with time – very handy for testing current consumption of individual peripherals in the IC during "real" operation.

The test setup includes a small temperature probe on the top of the chip. With the probe in place we had to wait several minutes for the chip to settle back to ambient – even handling the device for a few seconds raised the temperature by several degrees.

Test Procedure

The test procedure consisted of increasing the clock speed, adjusting the PSU to give exactly 5.0V at the input to the PIC, measuring the current consumption and then waiting for the temperature to settle. The current consumption settled almost immediately, while the temperature, due to the thermal mass of the device, took over one minute to settle. We recorded current consumption and temperature rise at each step.

To confirm that the device is actually running correctly during these tests, the software performs two tasks. First, for five seconds during startup, it flashes an LED connected on PORTB,1. After five seconds the LED is turned off and the code runs

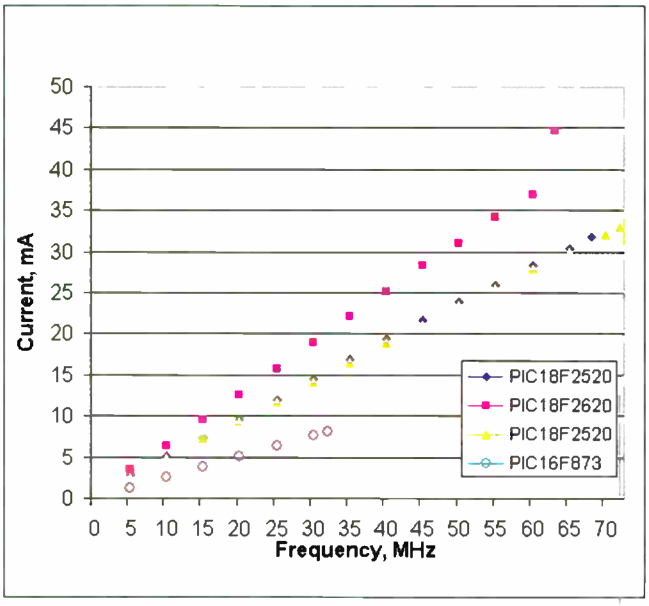


Fig.1. Current Consumption versus frequency

the LED is turned off and the code runs through a loop, toggling I/O pin PORTB,0 to which no load is connected.

This way we can monitor the CPU activity using an oscilloscope without having an external load (such as an LED) confuse the current consumption figures. Abnormal activity such as changes in the flow of instructions show up as "jitter" on the otherwise steady waveform.

We are not exercising all the logic paths within the chip with this code, and it is possible that subtle CPU errors may occur at some of the speeds at which we have been running. But this is intended to be an exploration of overclocking, not an attempt to recategorise Microchip's products!

Device Tests

In the case of the PIC18F devices, these tests were run without the use of the internal clock multiplying phase-locked loop. It was found that the PLL quickly throttled any speed increase when the input clock was raised above the specified limit, and despite accepting an input clock above 10MHz (which generates an internal clock of 40MHz) the multiplier fails to increase the speed much above 40MHz.

The current consumption results for the four devices are shown in Fig.1. The PIC16F873 is a 20MHz rated part, so of course it fails earlier than the 40MHz rated PIC18F parts. The results are quite astonishing – an average increase of 60% – and have to be tempered by the knowledge that not all logic paths are being tested, but there is obviously quite a bit of headroom for experimentation.

Performance Per Watt

What of the other important parameter, temperature rise? This is shown in Fig.2. Although there is a clear increase in temperature with increase in clock speed, the effect is minimal. The IC package is able to dissipate the additional heat easily.

Going back to the current consumption curves in Fig.1, it's interesting to see how the "performance per Watt" metric changes. This is a very useful parameter when designing low power consumption products. From the measurements, the MIPS/Watt increase by 15% over the range of 5MHz to 40MHz. Clearly you get more done for less power if you run the device fast; this is probably due to the contribution of background quiescent current at the lower speeds.

Conclusion

So, clearly we can run faster than the specified limit, and there is a demonstrated increase in the performance versus current consumption, but should we do it?

The simple answer is *no*. Unlike general purpose PCs that can be rebooted when they go wrong, PICs are placed in embedded circuits where the circuit is designed to do one thing, and do that thing very well. Reliability is extremely important and is not worth risking in a production system.

If you are building a system for yourself, however, the risks may well be tolerable in which case a small increase beyond the specified limit might be acceptable. Experimentation is not going to damage anything.

The results certainly show that at higher clock frequencies within the specified limits there are power consumption benefits to be had if your design can use it. For example, if you are processing a periodic event, it would be better to run fast and then put the processor to sleep, than to run constantly at a slow speed.

Reliability in microcontroller circuits is vital and we will be giving practical advice on this in the next issue.

Acknowledgement

The author would like to thank Bill Riley, formerly of Intel, for sharing his knowledge of the Intel manufacturing process with him.

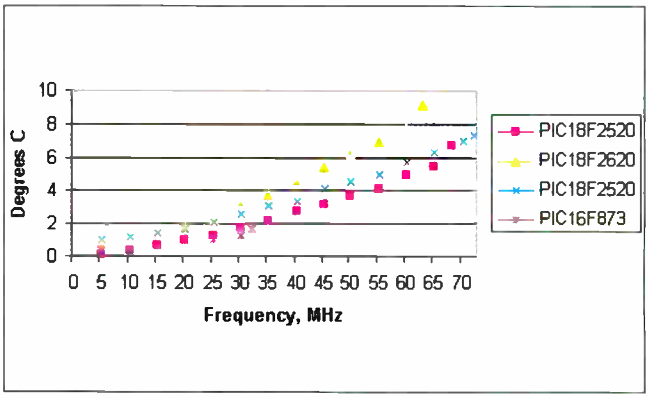


Fig.2. Temperature rise versus frequency

Circuit Surgery

Ian Bell

More on extending PIC output capabilities

FOLLOWING on from the question posed by ***Paul Goodson*** (via the *EPE Chatzone*) last month regarding extending the output capabilities of PICs with the aid of shift registers, we finish with the merits of using an additional parallel register.

Additional Registers

There is a problem with using a simple shift register to extend microcontroller outputs. When you shift new data through, all the ouputs change on each clock pulse. In some cases you might get away with this, but often these unwanted intermediate values will cause havoc with your circuit. The problem is easily overcome using an additional parallel register as shown in Fig.7. This approach can use many more bits than the four shown.

In this circuit, data is first clocked into the shift register via the SDI input by pulsing the Shift Clk input four times. A single clock is then applied to the Set Outputs input, which loads the data from the shift register into the output register.

Using this approach, a single bit of the "extended outputs" from the microcontroller can easily be changed, while keeping all the other outputs static. If then the output register is clocked, the value in the shift register is the same as the value currently in the output register, so no change will be seen in the external circuit.

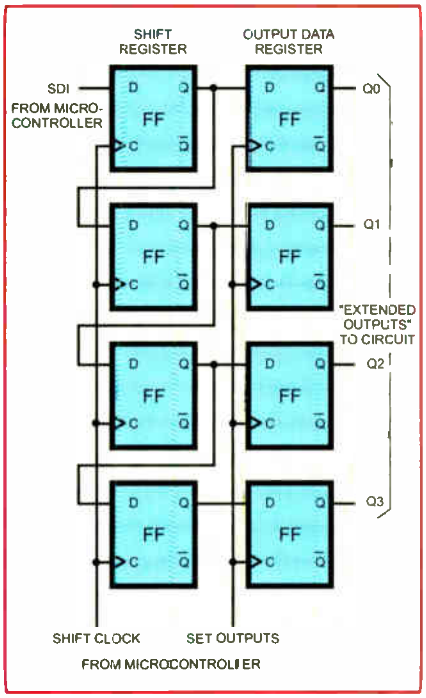


Fig.7. Use of a parallel output register to manage updating of output signals when a shift register is used to extend microcontroller outputs

Pin Value Storage

The software in the microcontroller keeps all the "extended pin" values in a memory register location. When one or more of these pins need to be changed, the "extended pin register" is updated as appropriate. The extended pin register contents are then shifted into the circuit using two microcontroller pins, SDI and Shift Clk in Fig.7.

A third microntroller pin is used to clock Set Outputs once the data shift is complete. The update rate for the extended pins is, of course, slower than for the microcontroller's own pins as more than one instruction is required to update them. However, as long as the speed is acceptable, extended pins can be used for techniques such as Pulse Width Modulation, as was suggested in Paul's question.

LED Drivers

The NLSF595 Serial (SPI) Tri-Colour LED Driver from On Semiconductor (**http://onsemi.com**) may be close to what Paul is looking for. This device is based on the 74HCT595, but has different output circuitry to make it more suitable for LED driving. The basic stucture of the circuit is similar to that in Fig.7, but the outputs are overvoltage-protected open drain drivers.

The supply voltage may be between 2·0V and 5·5V, but the output driver voltage level may be independent of the supply voltage and range from 0V to 7·0V. The outputs can sink up to 12mA, but they may be paralleled for increased drive output.

In Fig.8 is shown a circuit taken from the NLSF595 data sheet. It is capable of driving five tri-colour displays from either an SPI (data, clock, enable) bus or simply from three digital output pins of a microcontroller (MCU). If there are more SPI devices, the only pin compeltely dedicated to the NLSF595 is the EN pin, which is a negative-edge output latch, equivalent to the Set Outputs pin in Fig.7. The other two SPI lines can also be used to control other SPI peripherals when the NLSF595 is not enabled. The microcontroller SPI interface (if used) should be in the MISO mode (Master In Slave Out) – the NLSF595 is a slave peripheral. You do not have to use SPI, any three I/O lines of the microcontroller may be used.

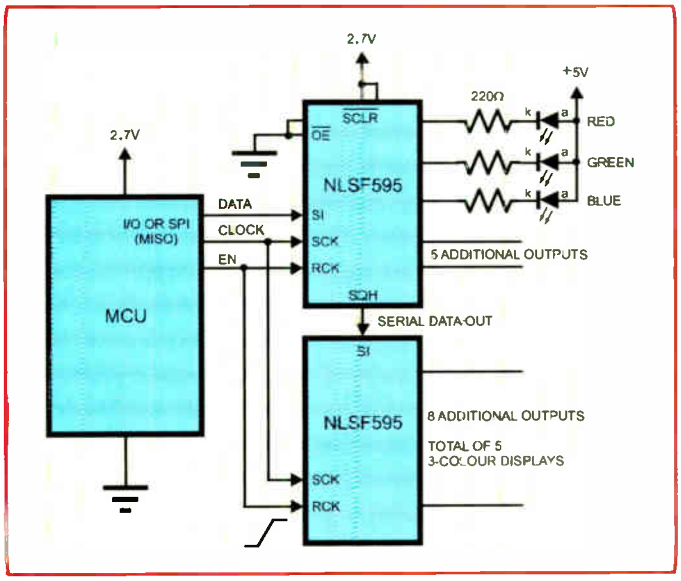


Fig.8. Using an NLSF595 to drive LEDs from a microcontroller (circuit taken from On Semicondutor's Data Sheet)

In Fig.8, two NLSF595 devices are cascaded to provide more outputs than are available from a single device. The SQH (serial data out) pin feeds the SI (serial in) pin of the second device.

Next month we take up the task of driving large numbers of LEDs when used together.

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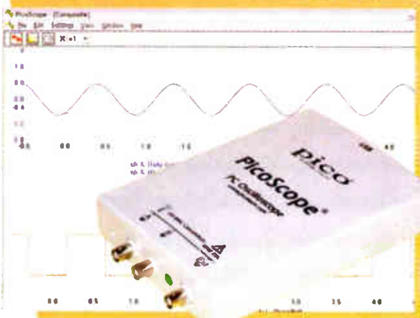

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC-based oscilloscope could be yours. Every 12 months, Pico Technology will be awarding a PicoScope 3205 digital storage oscilloscope for the best IU submission. In addition a DrDAQ Data Logger/Scope worth £59 will be presented to the runner up.

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!**

Sound Effects Generator – *Fun Noises Abound*

HERE'S a circuit that provides great fun for kids. It can generate a European police-car siren, bird noises, spaceship sounds, etc. In addition, it can be put to serious use as a doorbell or an alarm. It's easy to build, and is inexpensive.

The circuit consists of four parts: a binary counter, a digital to analogue converter (DAC), a voltage controlled oscillator (VCO), and an audio output amplifier. The speed at which the counter counts depends on the frequency of the output of the VCO, which in turn is determined by the output of the counter. This feedback loop is what gives this circuit its characteristic output.

Referring to the complete circuit diagram in Fig.1, the initial frequency of the oscillator, basically formed around IC2a and IC2b, is determined by potentiometer VR1 and capacitor C1. It first oscillates at a relatively low frequency, and gradually picks up speed as the control voltage supplied by the DAC increases.

The DAC converter is simply the group of resistors R1 to R8, fed by the digital outputs of counter IC1, providing base current into transistor TR1. When none of IC1's outputs are active, little current will flow into the base of transistor TR1, so the VCO's control voltage will be low. As more and more counter outputs become active, base current increases, and thereby so does the VCO's frequency of oscillation.

The VCO itself is composed of IC2a, IC2b, TR1, and the network comprising diodes D2 to D5, C1, R10 and VR1. The diode bridge functions basically as a voltage controlled resistor.

The buffer amplifier is made up of the four remaining gates from IC2, all wired in parallel, capacitively driving loudspeaker LS1. The volume is sufficient for experimental purposes, but you could add an amplifier module instead.

Use any convenient means of wiring the circuit. Layout is not critical, but be sure to connect the power supply to the i.c.s correctly. Pressing pushbutton switch S1, the sound you get will depend on the setting of VR1. To vary the effect, try tapping on S1.

Craig Kendrick Sellen, Carbondale, PA, USA

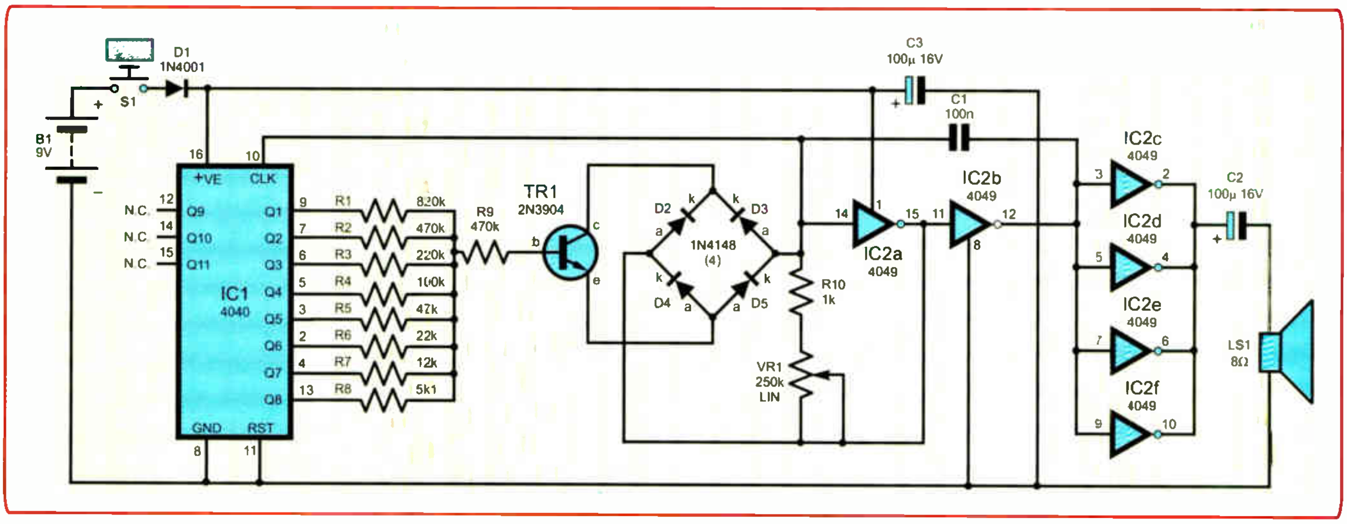

Fig. Full circuit diagram for the Sound Effects Generator


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Building The

Our state-of-the-art portable public

Last month, we introduced this compact and powerful portable PA amplifier based on the Philips TDA1562Q 70W class-H power IC. This month, we conclude with the description of the power supply, cabinet and PC board construction and the parts list.

AS NOTED last month, the power supply is effectively a battery charger with the 7 amp-hour SLA (sealed lead-acid) battery permanently connected.

Since the charger has other uses and could be used in any situation where a float charger is required, we are describing its circuit operation and construction separately.

We're also detailing the box construction separately. While we give detailed dimensions, this is not the only approach possible. We're sure some readers will come up with completely different ideas for the enclosures.

Construction

The PortaPAL PA Amplifier is housed in a timber cabinet measuring 480 × 280 × 240mm which is covered in speaker carpet. Corner protectors, a speaker grille, a speaker stand socket and a handle are included.

The electronics is accommodated on four PC boards: the microphone PC board coded 562 (64 × 73mm), the auxiliary PC board coded 563 (109 × 35mm) and the main PC board coded 564 (199 × 90mm) – all available from the *EPE PCB Service*. These are mounted on an L-shaped metal bracket, the reverse of which becomes the front panel.

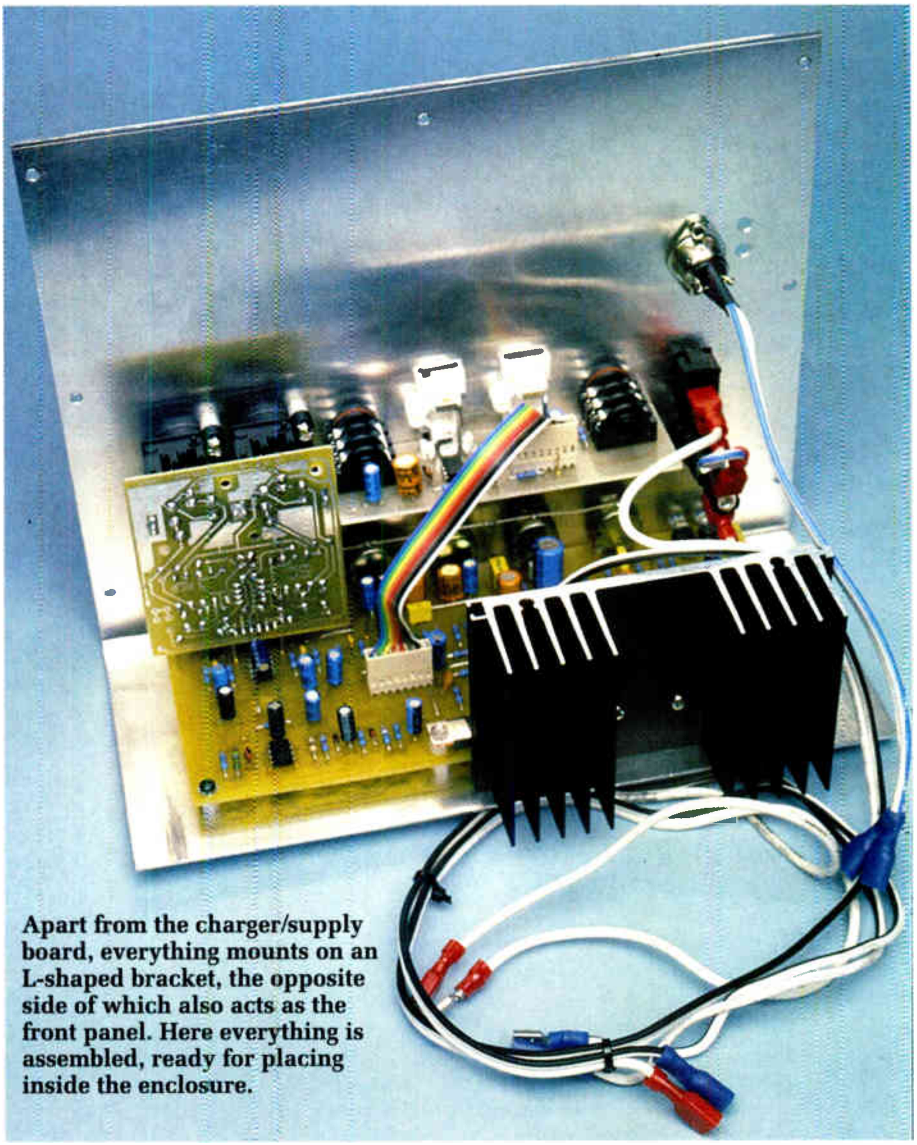
The charger PC board coded 565 (132 × 66mm) mounts on the side of the box with its indicating LEDs protruding through the front panel.

You can begin construction by checking the PC boards for shorted tracks or any breaks in the copper patterns. Also check that the holes are drilled to suit the components. In particular, check the corner mounting hole sizes and the holes for the

FEATURE PROJECT

PortaPAL address amplifier

PART 2:
BY JOHN CLARKE & LEO SIMPSON



Apart from the charger/supply board, everything mounts on an L-shaped bracket, the opposite side of which also acts as the front panel. Here everything is assembled, ready for placing inside the enclosure.

pots, RCA, 6·35mm jack and XLR sockets.

Microphone board

Assembling the microphone PC board is simple, as shown in Fig.1. Begin by installing the LM833 op amp (IC1), together with all the resistors and capacitors.

Use the resistor colour code and capacitor code tables to guide you in selecting the correct values, and/or check the resistor values with a digital multimeter. Also, the electrolytic capacitors need to be oriented with the polarity shown.

Note that the 10kΩ resistors and 10µF capacitor marked with an asterisk (*) are optional for powering electret microphones. These components are not needed for dynamic microphones but will not do any harm to a dynamic mic if you regularly swap microphones.

There are a couple of PC stakes required to be installed for test points TP1 and TP2.

Next, insert the 90° 6-way pin header into the PC board as shown.

Before mounting the two XLR sockets, screw the M3 × 10mm screws into the mounting pillars from the back of the socket and then secure the M3 tapped 6mm long spacers from the front side of the sockets. Then mount the XLR sockets directly into the PC board holes provided.

Main PC board

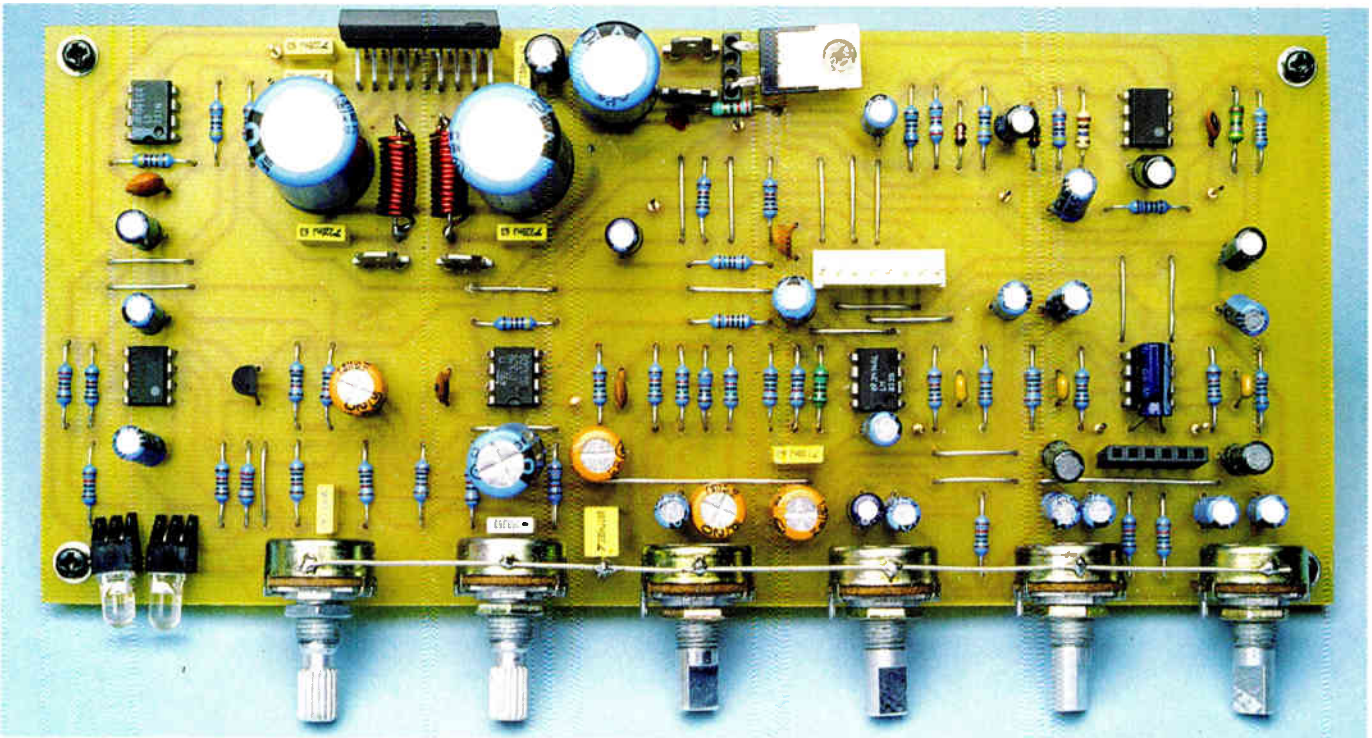
The main PC board accommodates all the potentiometers and the TDA-1562Q power amplifier module. Its component layout is shown in Fig.2. You can start its assembly by installing all the links, the resistors and then the ICs but not the TDA1562Q.

The 2·2Ω 1W resistors need to have an over-wind of 16 turns of 0·5mm diameter enamelled copper wire. These windings are shown on the circuit published last month, as L1 & L2.

Start with a short length of 0·5mm copper wire, strip and tin one end and solder it to one end of the 2·2Ω resistor. Then wind on 16 turns. Strip and tin the other end and solder it to the other end of the resistor. Repeat the process for the second 2·2Ω resistor. Then solder each resistor into the PC board.

Insert all the PC stakes used for the test points and also the PC-mount spade connectors. Mount the capacitors as shown with the electrolytics marked as polarised with the correct orientation.

Electrolytics marked BP (ie. non-polarised) can be inserted either way.



The main PC board shown here without the heatsink attached. Note the inductors wound over the resistors (near IC9).

Note also that the 10µF capacitor near IC2 must be bent over the top of IC2. This is to allow clearance when the microphone PC board is plugged into the header socket.

Insert the 6-way and 8-way headers, as shown. Transistor Q1, diodes D1 and D2 and the power amplifier (IC9) can be inserted. IC9 is positioned with the centre-line of its mounting holes exactly 12mm above the top face of the PC board. Be sure to solder all the pins of the amplifier and take care not to have any of the pins shorted.

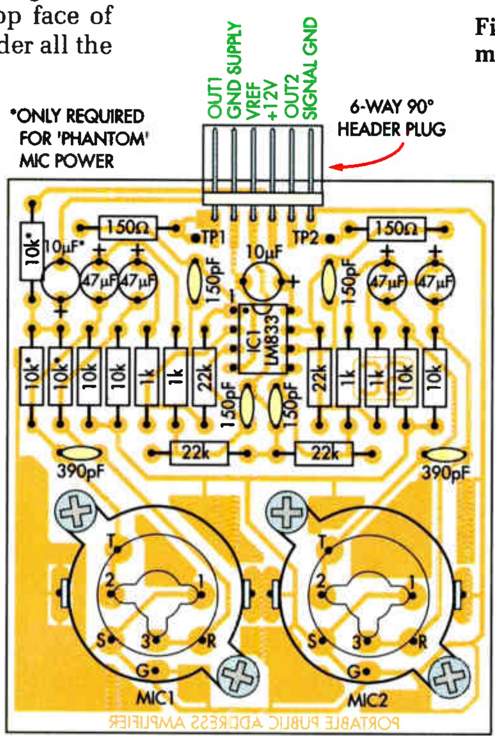
Diode D3 is mounted onto a 6mm spacer and secured with a nylon screw and another 6mm tapped spacer on the underside of the PC board.

The nylon screw is required to prevent the tab of the diode shorting to the metal panel when it is finally assembled.

The two LEDs are mounted using LED mounts. The LEDs are inserted into the mounts from the front and the leads bent over at 90° within the mount before being inserted into the PC board. Be sure that the orientation is correct before bending the leads.

Finally, the potentiometers can be installed – take care to place each one in its correct position. The potentiometer bodies are all tied together with a length of 0·8mm tinned copper wire soldered to the top of each body. It is difficult to solder to the passivated metal, so you will need to scrape away the passivation coating (with a knife or screwdriver) before soldering the wire. The wire is then connected to the PC stake adjacent to the 330nF earthing capacitor.

Place a dab of red paint or nail polish next to the positive spade lug near the 22Ω resistor and the TP GND PC stake.



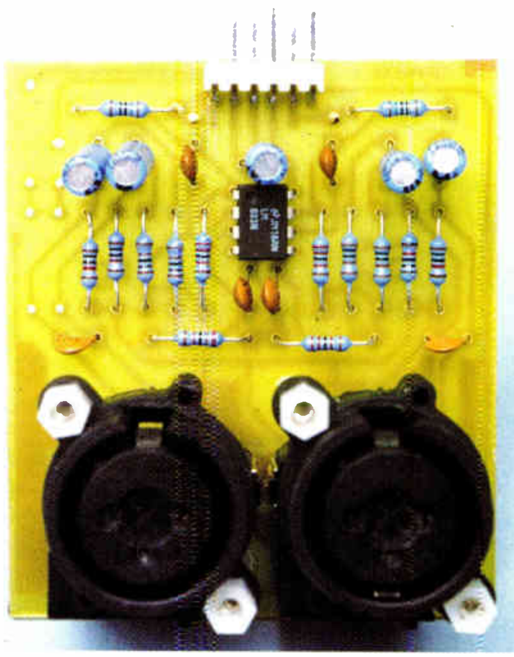


Fig.1: PC board overlay and same-size photo of the microphone input board.

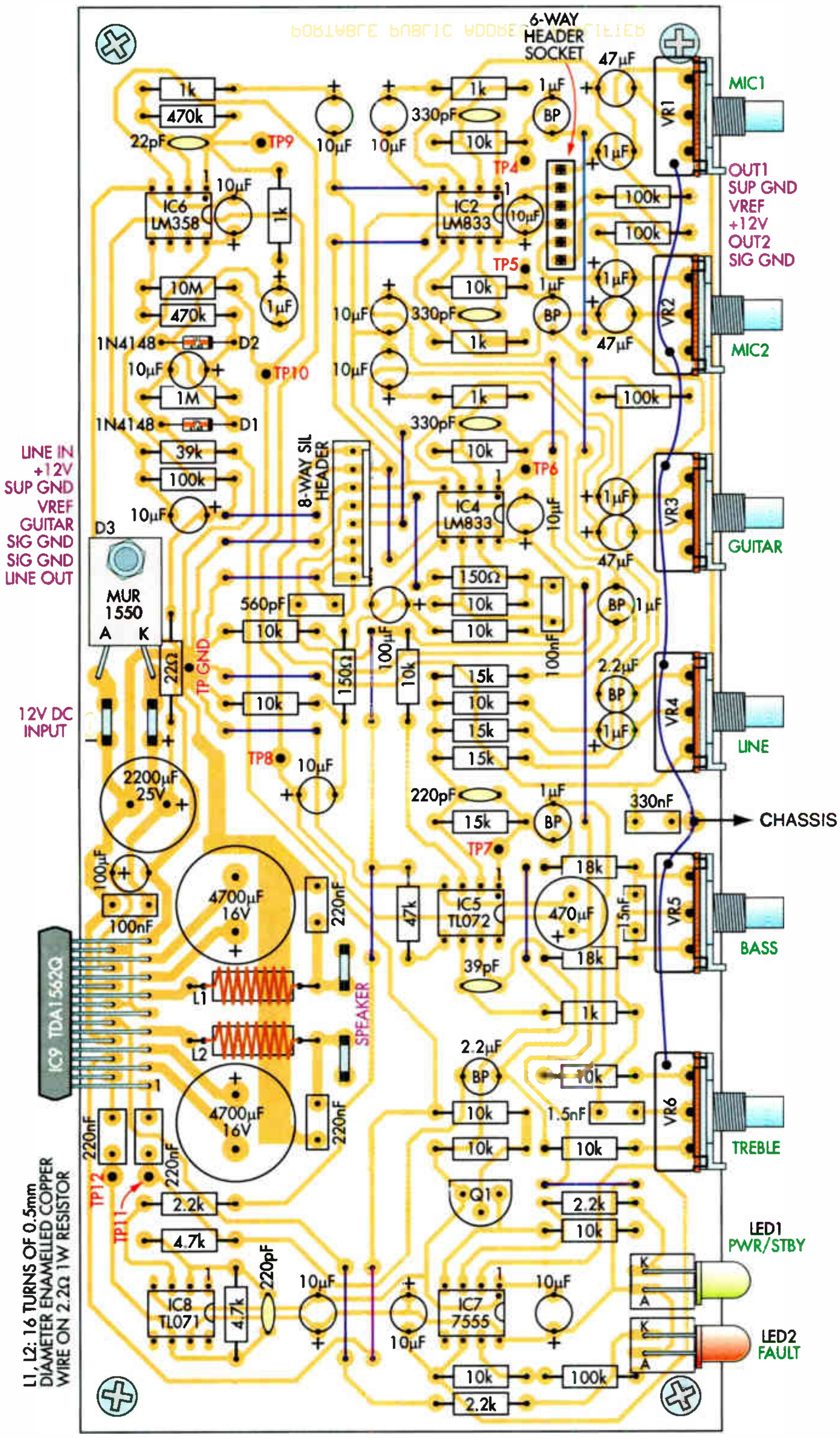


Fig.2: install the parts on the PC board as shown on this wiring diagram. Note how the potentiometer bodies are linked together and earthed at a single point.

This is for easy identification when connecting the supply wires.

Auxiliary board

The auxiliary PC board carries the four RCA sockets and the jack sockets. Its component layout is shown in Fig.3. First, install all the resistors and the TL071 (IC3) op amp. Then insert the capacitors, again taking care with the polarity of the electrolytic capacitors. The 6·35mm jack sockets and the stereo RCA sockets are directly mounted onto the PC board. An 8-way pin header is mounted with the orientation shown.

Finally, install the PC stake for the test point, TP3.

Support bracket

The bracket which supports the amplifier also doubles as the front panel. It is made from 195 × 240 × 1·5mm aluminium, bent at 90° to form an L-shape.

The dimensions of the panel, hole positioning and sizes are shown in Fig.4. The panel can be drilled and the larger holes cut before the panel is bent and the label attached.

We expect that if you purchase a kit, the panel will already be drilled and bent and will come screen printed. Those building from scratch will need to prepare the panel as shown.

The dress panel artwork (like the PC board artwork) can be downloaded from the *EPE* website, **www.epemag.co.uk** and printed, then glued to the aluminium panel.

Place nuts on all the pot bushes for the main board and then mount the board on M3 tapped 6mm standoffs, with M3 × 6mm screws and star washers. The standoff beneath D1 is secured in place with an M3 nut and star washer. Secure the pots with nuts on the outside of the panel.

The holes in the main heatsink can be drilled as shown in Fig.6. Apply a smear of heatsink compound on the face of the power amplifier and attach the heatsink to the baseplate with M6 screws into the heatsink mounting screw points. Then attach the amplifier to the heatsink with two M3 × 15mm screws, two flat washers and two nuts.

Attach the auxiliary board to the front panel by first fitting fibre washers onto the 6·35mm jack socket bushes and then mating them up to the relevant panel holes; secure with the nuts. The RCA stereo sockets are secured with M3 × 6mm screws tapped into the plastic mounting pillars.

Plug the microphone board pin header into the control PC board socket and push the sockets into the front panel holes. Secure with M3 × 6mm screws into the 6mm standoffs already attached to the XLR sockets.

Make up a lead that connects the 8-way pin header sockets using 8-way coloured rainbow cable. This connects the auxiliary board to the main board. Make sure the orientation is correct, with no twist in the wiring.

Power switch S1, the fuseholder and the 3-pin DIN power/charger socket

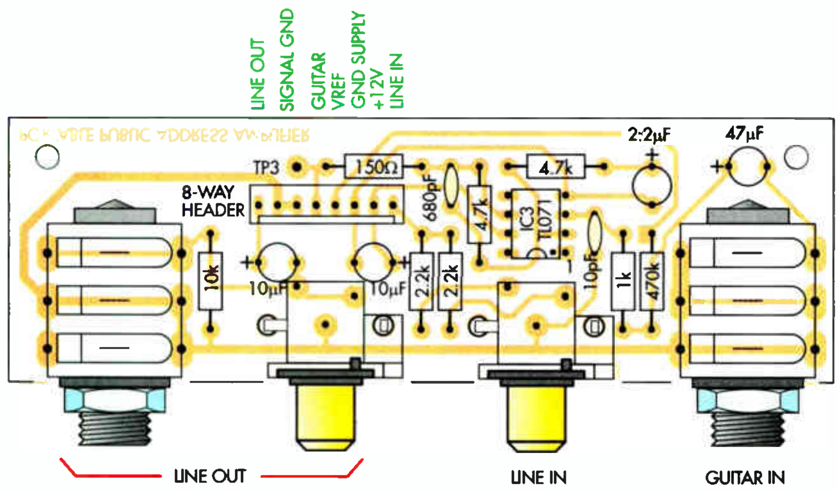
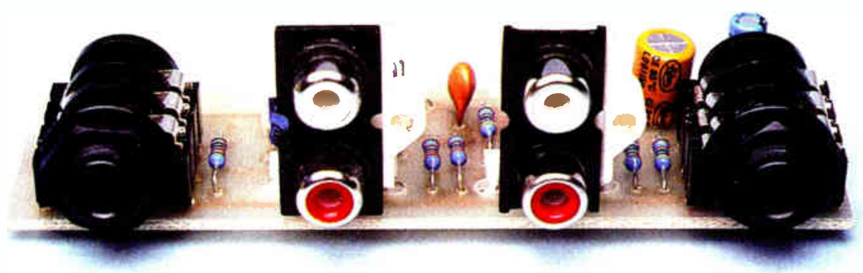


Fig.3: the auxiliary PC board has the line in/out and guitar input sockets – it connects to the main board via the 8-way header.



can now be attached. The DIN socket is secured with M3 x 6mm screws, star washers and nuts.

Connecting the boards

Fig.5 shows the wiring to the boards, battery and speaker. The battery and speaker connections are run in 7·5A figure-8 wire and crimp plugs. Use the lengths detailed on the diagrams for the charger and Fig.5.

Be sure to use blue crimp connectors for the negative lead connections and red connectors for the positive leads. That way, there is less chance of wrong polarity connections.

Also note that the amplifier power leads should be connected to piggy-back connectors for the battery terminals, so that the charger leads can also be connected to the battery.

Making the cabinet

The box is made using 16mm Medium Density Fibre board (MDF) and 16 × 16mm batten for the corner in-fills. Because many home constructors may not have precision woodworking equipment (nor skills!) we have described the box construction in detail later.

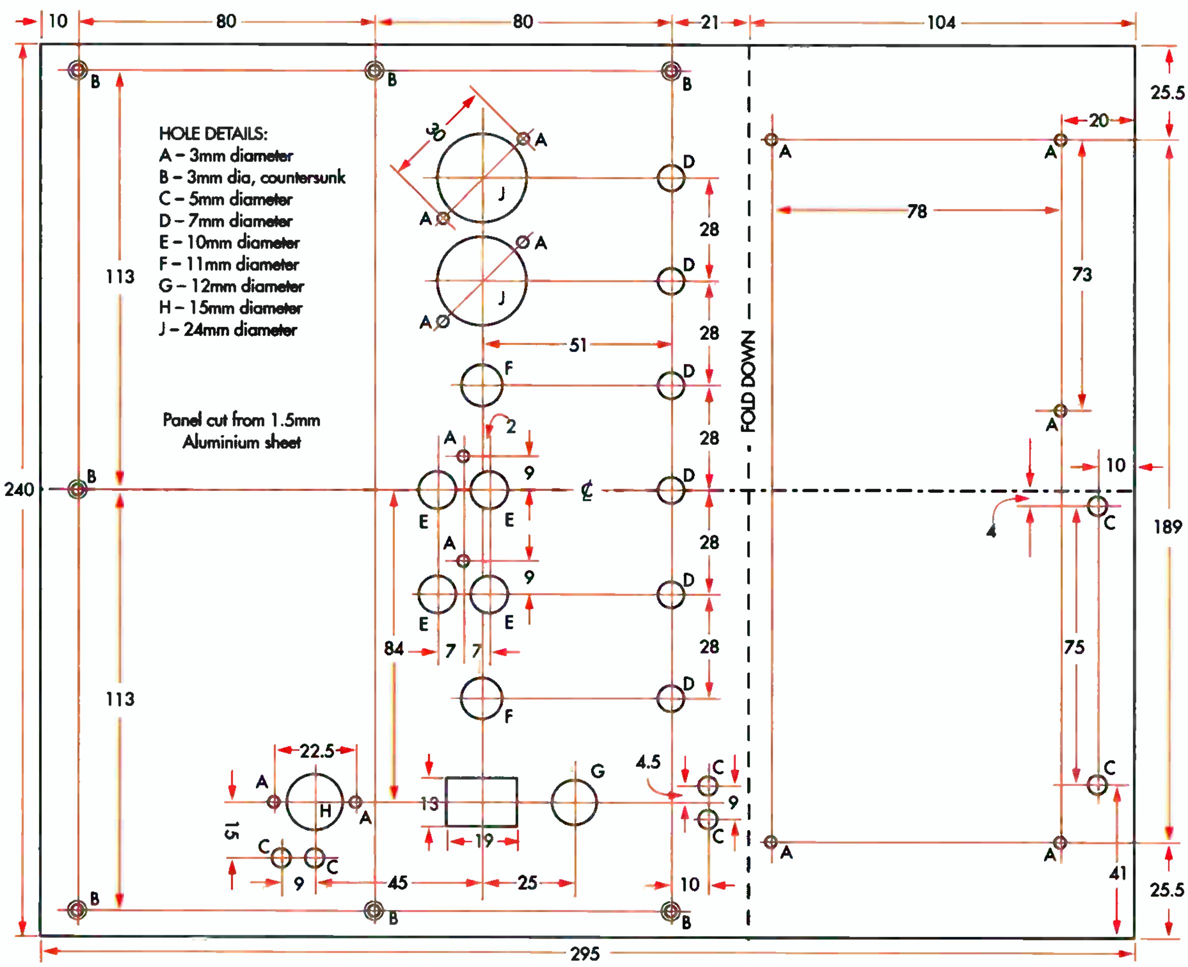


Fig. 4: this drilling guide should help you with the front panel/amplifier bracket.

Parts List – PortaPAL PA (Main Section)

1 mic input PC board, code 562, 64 x 73mm
1 auxiliary input PC board, code 563, 109 x 35mm
1 control PC board, code 564, 199 x 90mm. All available from the *EPE PCB Service*
2 450 x 900 x 16mm sheets of MDF
1 4m length of 12 x 12mm batten
1 195 x 240mm sheet of 1·5mm aluminium for panel
1 aluminium vent strip, 240mm long 15 x 12mm channel with holes or slots (eg, slotted shelf support strip)
1 SP-202E 202mm (8in) 50W, 4Ω loudspeaker (Wilmslow Audio – see text)
8 speaker box corners, 55 x 35 x 35mm
1 speaker box "top hat" stand socket
1 200mm speaker grille
1 strap handle
1 1m x 1·8m length of speaker box carpet
1 heavy duty heatsink 110 x 33 x 72mm
1 M205 fuseholder
1 7·5A M205 fuse (F1)
4 blue knobs
2 grey knobs
3 16mm PC-mount 10kΩ log pots (VR1-VR3)
1 16mm PC-mount 5kΩ log pot (VR4)
2 16mm PC-mount 100kΩ linear pots (VR5,VR6)
1 SPST 6A rocker switch (S1)
2 6·35mm PC-mount jack sockets
2 stereo PC-mount RCA sockets
2 PC-mount XLR/6·35mm jack socket without locking tab
1 6-way header connector with 90° bend pins (2·54mm spacing)
2 8-way header connectors with straight pins (2·54mm spacing)
2 8-way header sockets (2·54mm spacing)
1 6-way PC-mount header socket (2·54mm spacing)
2 piggy-back 6·3mm crimp connectors
7 red female 6·3mm spade lug crimp connectors
5 blue female 6·3mm spade lug crimp connectors
4 6·3mm spade PC board connectors with 5mm pitch PC lugs
10 6mm tapped standoffs
10 M3 shakeproof washers
2 M3 flat washers
3 M3 nuts
10 M3 x 6mm screws
2 M3 x 15mm screws (for amplifier to heatsink connection)
4 M3 x 10mm screws (for 6mm standoffs on XLR sockets)
1 M3 x 20mm nylon screw (for diode D3 mounting and PC board mounting point)
2 M6 x 15mm screws (to secure heatsink to baseplate)
6 4G x 16mm countersunk wood screws for securing control panel and charger PC board
4 6G x 10mm cheese-head wood screws for mounting loudspeaker
4 6G x 20mm to mount speaker stand socket
3 6G x 30mm countersunk wood screws to secure MDF battery cover
2 8G x 25mm cheese-head wood screws to mount handle
32 4G x 16mm countersunk wood screws to mount corner protectors
2 5G x 20mm countersunk wood screws to mount aluminium vent strip
1 500mm length of 0·5mm enamel copper wire
1 2m length of 7·5A rated figure-8 wire
1 500mm length of 0·8mm tinned copper wire
1 120mm length of 8-way rainbow cable

Semiconductors
3 LM833 op amps (IC1,IC2&IC4)
1 TL072 op amp (IC5)
2 TL071 op amps (IC3,IC8)
1 LM358 op amp (IC6)
1 7555 CMOS timer (IC7)
1 TDA1562Q power amplifier (IC9)
1 BC337 transistor (Q1)
2 1N914, 1N4148 diodes (D1,D2)
1 15A diode (MUR1550 or similar TO-220 package) (D3)
2 5mm high brightness red LEDs (LED1,LED2)
2 PC board LED mounts

Capacitors
2 4700µF 16V PC electrolytic
1 2200µF 25V PC electrolytic
2 100µF 16V PC electrolytic
8 47µF 16V PC electrolytic
14 10µF 16V PC electrolytic
2 2·2µF BP* electrolytic
1 2·2µF 16V PC electrolytic
4 1µF 16V PC electrolytic
5 1µF BP* electrolytic
1 330nF MKT polyester
4 220nF MKT polyester
1 100nF MKT polyester
2 15nF MKT polyester
2 1·5nF MKT polyester
1 680pF ceramic
1 560pF ceramic
2 390pF ceramic
3 330pF ceramic
2 220pF ceramic
4 150pF ceramic
1 39pF ceramic
1 22pF ceramic
1 10pF ceramic

** BP (bipolar) capacitors are also known as NP (non-polarised)*

Resistors (0.25W, 1% except where shown)

1 10MΩ	1 1MΩ	3 470kΩ	5 100kΩ
1 47kΩ	1 39kΩ	2 22kΩ	2 18kΩ
4 15kΩ	21 10kΩ	4 4·7kΩ	5 2·2kΩ
8 1kΩ	5 150Ω	2 2·2Ω 1W	

Miscellaneous
PVA (timber) adhesive, contact adhesive, black paint, Bag of TEK particle board screws (for box assembly)
Optional: 3-pin mains socket, panel mounting – not connected but mounts inside bottom of box to act as a storage holder for plugpack when not in use.

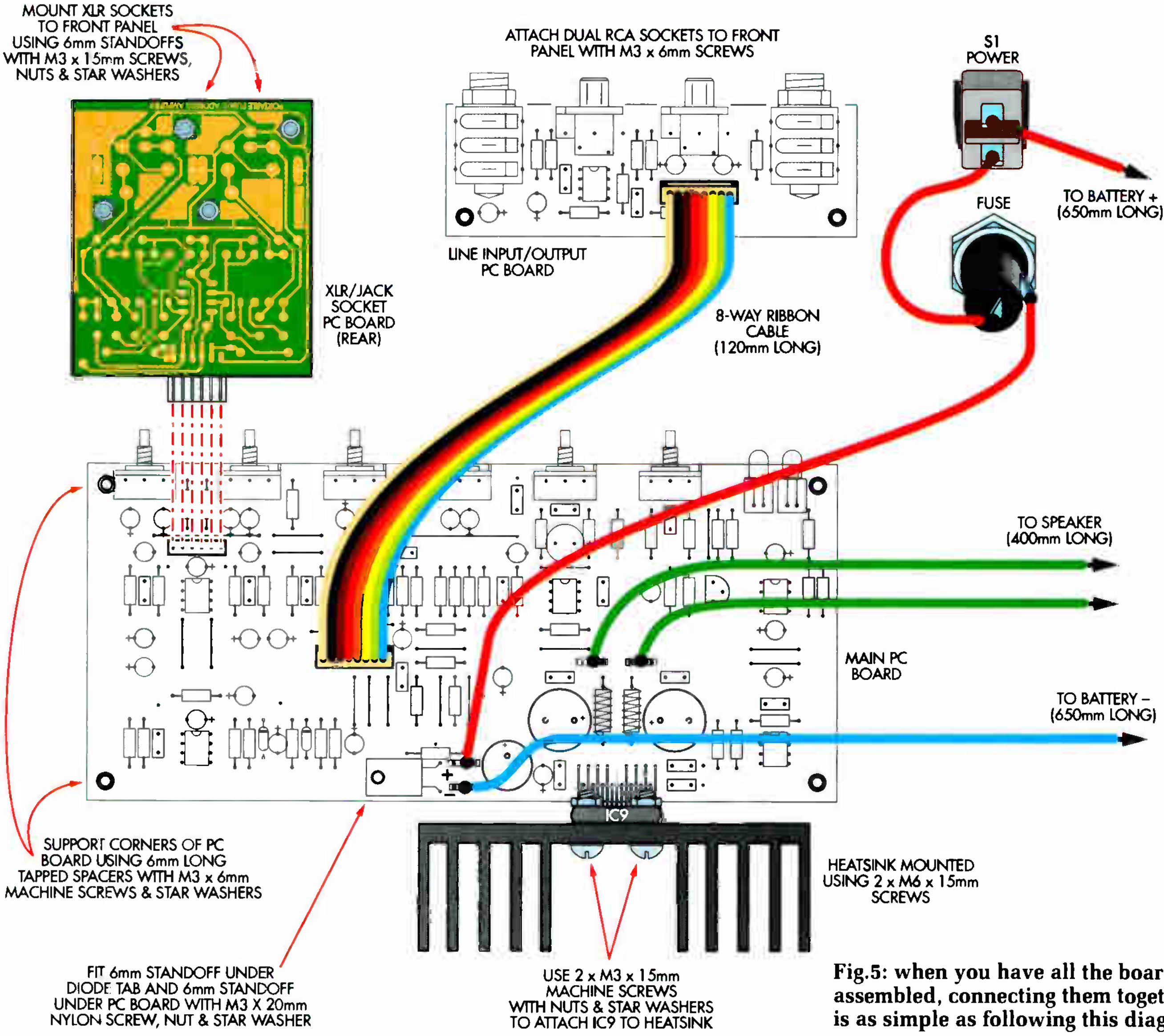


Fig.5: when you have all the boards assembled, connecting them together is as simple as following this diagram.

Parts List – PortaPAL SLA Float Charger

1 SLA battery charger PC board coded 565 Available from the *EPE PCB Service*, 133 x 66mm
1 16VAC 1·5A plugpack 3-wire earthed type
1 PC board finned heatsink 84 x 24 x 28mm
1 12V relay with 6A contacts (RELAY1)
1 3-pin 180° DIN plug
1 3-pin 180° DIN chassis socket
2 5mm high brightness red LEDs (LED3, 4)
2 PC board LED mounts
4 6·3mm spade PC board connectors with 5mm pitch PC lugs
2 M3 x 6mm screws (for DIN socket)
2 M3 x 10mm screws (for heatsink)
4 M3 nuts
4 3mm star washers
1 50mm length of 0·8mm tinned copper wire
4 4G x 16mm countersunk wood screws for securing charger PC board

Semiconductors
1 LM317T regulator (REG1)
2 BC337 transistors (Q2,Q3)
9 1N4004 1A diodes (D4-D12)

Capacitors
1 4700µF 25V PC electrolytic
1 4700µF 16V PC electrolytic
1 470µF 25V PC electrolytic
2 10µF 16V PC electrolytic

Resistors (0.25W, 1%, except where shown)
2 2·2kΩ 3 1kΩ 3 470Ω 1 120Ω
1 220Ω 0.5W, 5%
1 1Ω 5W wirewound
1 500Ω horizontal trimpot (VR7)

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❐	1	10MΩ	brown black blue brown	brown black black green brown
❐	1	1MΩ	brown black green brown	brown black black yellow brown
❐	3	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❐	5	100kΩ	brown black yellow brown	brown black black orange brown
❐	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❐	1	39kΩ	orange white orange brown	orange white black red brown
❐	2	22kΩ	red red orange brown	red red black red brown
❐	2	18kΩ	brown grey orange brown	brown grey black red brown
❐	4	15kΩ	brown green orange brown	brown green black red brown
❐	21	10kΩ	brown black orange brown	brown black black red brown
❐	4	4·7kΩ	yellow violet red brown	yellow violet black brown brown
❐	7	2·2kΩ	red red red brown	red red black brown brown
❐	11	1kΩ	brown black red brown	brown black black brown brown
❐	3	470Ω	yellow violet brown brown	yellow violet black black brown
❐	1	220Ω	red red brown brown	red red black black brown
❐	5	150Ω	brown green brown brown	brown green black black brown
❐	1	120Ω	brown red brown brown	brown red black black brown
❐	2	2·2Ω	red red gold brown	red red black silver brown

Capacitor Codes

Value	IEC Code	EIA Code
330nF	330n	334
220nF	220n	224
100nF	100n	104
15nF	15n	153
1·5nF	1n5	152
680pF	680p	681
560pF	560p	561
390pF	390p	391
330pF	330p	331
220pF	220p	221
150pF	150p	151
39pF	39p	39
22pF	22p	22
10pF	10p	10

Once the box is completed you can install the speaker in its rebated hole in the front panel. We used some self-adhesive foam tape underneath the speaker to make it an airtight seal.

Fit the speaker grille over the front of the speaker and screw in the four mounting screws. The grille may seem like overkill because the speaker cone is so far back from the front panel – but if you don't fit one it won't be long before you wished you did!

The specified speaker is a 4Ω. 50W speaker with a wide frequency response. It is available from Wilmslow Audio price £25 each including VAT, – add £10 for UK postage for any quantity (Tel: 01455 286603, www.wilmslow-audio.co.uk).

Testing

Before installing the assembly into the box, you can test the circuit by applying power using the battery.

At switch-on, the power LED should flash at a one-second rate. Check that there is power to the op amps by testing for 12V between pins 4 and 8 of the LM833, TL072 and LM358 op amps (IC1, IC2, IC4, IC5, IC6) and at pins 4 and 7 for the TL071 op amps (IC3, IC8). IC7 should have 12V between pins 1 and 8.

The output of IC4b (pin 7) should be at half supply, at around +6V. Similarly, the outputs of IC1a (pin 1), IC1b (pin 7), IC2a (pin 1), IC2b (pin 7), IC3 (pin 6), IC4a (pin 1), IC5a (pin 1), IC5b (pin 7) and IC8 (pin 6) should also be at about +6V.

Check that the circuit works by connecting the loudspeaker and applying an audio signal to one of the inputs. Turn up the volume and the speaker should begin to produce sound. The power LED should light continuously when not muted.

Check operation of the charger by connecting the output leads to the piggyback battery terminals (make sure the polarity is correct) and connecting the DIN socket to the AC input on the charger.

Switch on power to the plugpack and the charger LED should light and possibly the charging LED will light depending on battery charge.

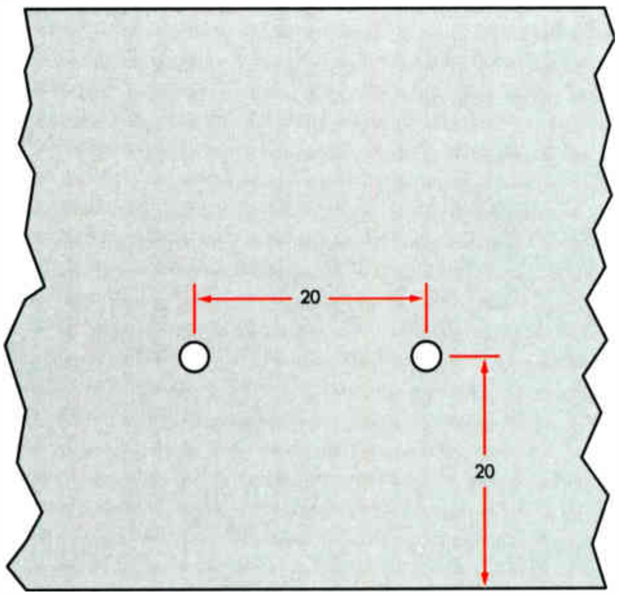
Mount the charger board on the inside of the cabinet, making sure that the two LEDs align and protrude through their respective holes in the control panel.

Use 4G × 16mm screws to attach it in place. We used a small rubber grommet cut in half to lift the two front mountings of the PC board off the in-fills by about 1mm.

The L-shaped amplifier bracket/panel is installed into the box by sliding it into the 2mm gap and securing it to the cleat frame with 4G × 16mm long screws. The battery leads for the amplifier and charger pass through from the rear of the battery compartment .

The battery cover is secured with three 6G × 30mm countersunk screws. With the dimensions shown, the battery should be a snug fit but if necessary, pack some pieces of foam into the compartment to stop it moving around in transit.

Finally, a chassis-mounting 3-pin mains socket, screwed to the inside bottom of the case but not connected to anything makes an ideal plugpack holder when the plugpack is not being used to charge or power the PortaPAL.



(BOTH HOLES 3mm IN DIAMETER)

Fig.6: this guide can be used to ensure your drill holes on the heatsink are in exactly the right place!

MAKING THE BOX

One of the areas where home constructors come unstuck is in the cutting-out of speaker box panels. It is essential that the edges are not only straight and square but opposite panels also need to be exactly the same size – otherwise the box may be crooked or there may be air gaps.

For a typical part-time woodworker using typical home workshop tools (as distinct from a pro who does it all the time!), achieving perfectly straight, smooth and square cuts with a hand saw or any type of hand-held power saw is difficult. Yes, it can be done – but it is difficult.

However, there is a delightfully easy way to ensure that at least three sides of each panel have perfectly straight and parallel sides/right angles – and that is to use sheets of pre-cut board. (If the manufacturers can't get it straight and square then we are all in trouble!)

For this reason, we have elected to use two sheets of 16mm, 450 x 900mm MDF. We have made the three vertical panels (ie front and both sides) 450mm high. Originally we had planned to use a single sheet of 900 x 900mm board but fortunately couldn't find any in our local hardware store. So we purchased two 450mm wide sheets and suddenly realised what an advantage that was!

Cut the two sides (240mm wide) from the top of each sheet and the front (247mm wide) from the bottom of one of the sheets (as shown on the cutting diagram) and you'll have three edges on each panel perfectly square. The fourth edge depends on how accurately you cut.

The identical top and bottom pieces (240 x 280mm) and the various bits and pieces which form the battery holder, etc, can be cut from what is left over.

The vertical panels sit between (ie, inside) the top and bottom pieces, making the overall height of the box 482mm (450+16+16). One reason for placing the vertical panels inside the top and bottom, rather than vice-versa, is for strength. As made, the box will easily handle someone using it as a seat (as will inevitably happen).

The front panel and the various rear pieces are recessed – the front back far enough to accommodate the speaker grille, while the rear is even further recessed. Recessing both front and back will allow the box to fall over and not break or damage the speaker itself, pot knobs or other controls.

It might appear that 247mm is wrong for the front panel: if the base is 280mm wide and the two sides are 16mm wide, surely it should be 248mm (280-16-16)? That extra 1mm off allows the front panel to be a snug, but not too tight fit.

We cut suitable lengths of 16 x 16mm pine batten (which we happened to have on hand – just about any softwood will be OK) for the in-fills – all around the front inside of the box for the box front (speaker baffle) to attach to and in strategic locations on the rear inside as shown by our drawings.

Before assembling the box proper, we glued'n'screwed the battens in position.

The "L"-shaped aluminium plate holding most of the amplifier electronics screws to these battens.

After the battens were done, the top, bottom and two side box panels were glued and clamped together, and allowed to dry overnight. The (unglued) front panel was placed in position as formwork to keep the whole thing square,

When dry, we pushed out the front panel and on it marked and cut (with a jigsaw) a circle (size to fit the speaker used) right in the centre. Naturally enough, this is where the speaker mounts – but first, the hole needs a 7mm deep, 10mm rebate all around from the front (using a router) to allow the speaker to sit flush.

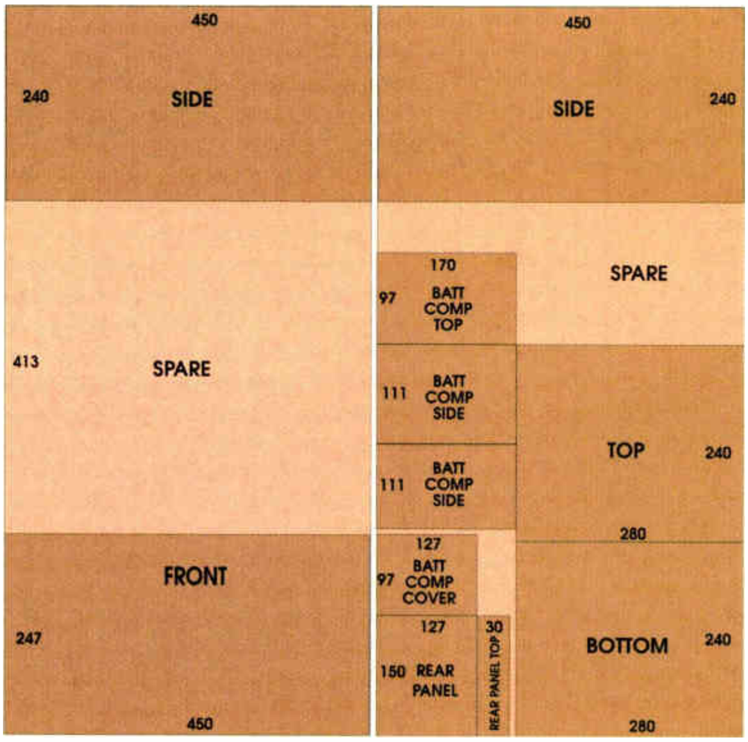
A 200mm metal speaker grille goes over the speaker later on to protect it.

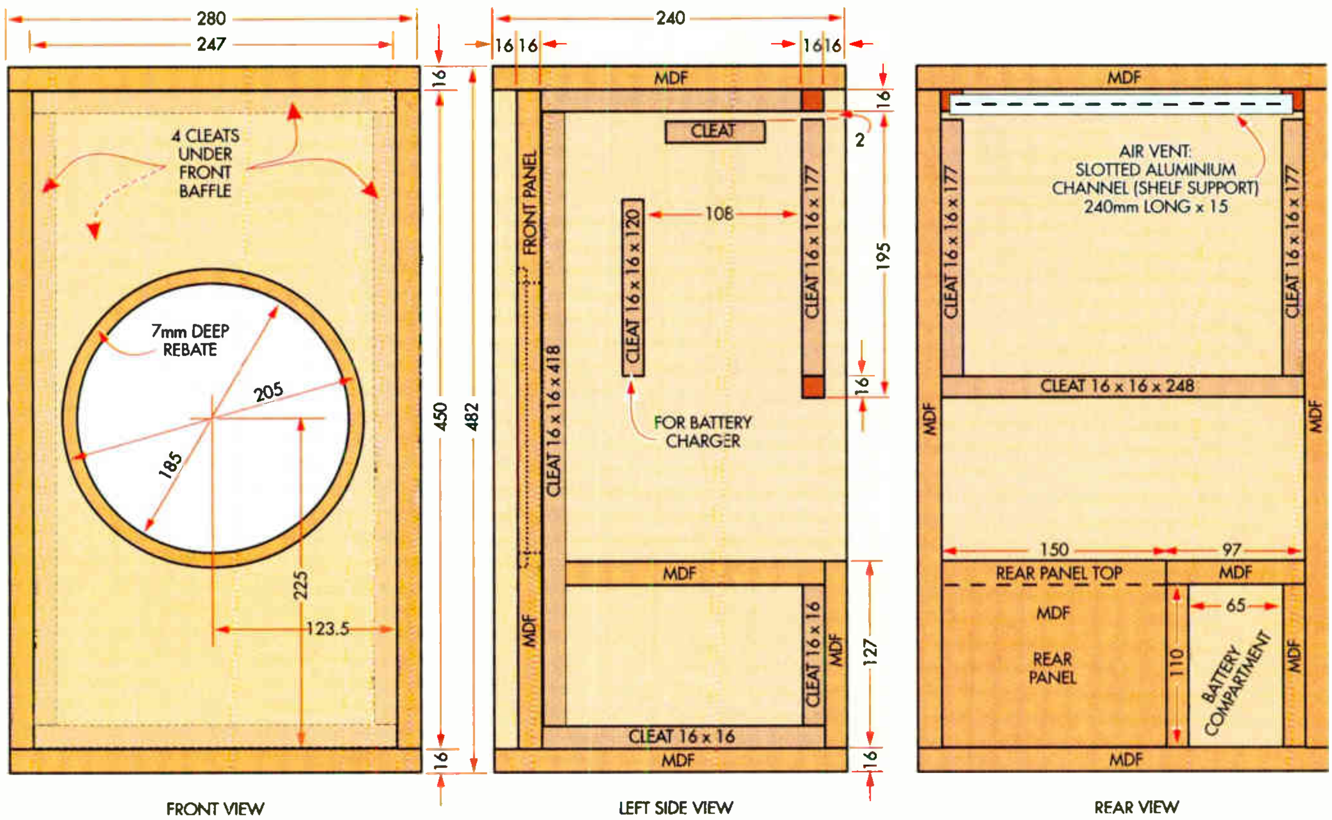
The final bit of woodwork is the mounting of the various bits of MDF which hold the battery and other components in place. These mount as shown in our detailed drawing opposite.

The finished box, measuring 280(w) x 240(d) x 482mm(h), can be painted, veneered, or as we have done, covered in speaker "carpet". A lot of pro audio gear is covered in this stuff because it helps it absorb knocks and scrapes on the job or in transit. It also hides any "sins" you might have created along the way.

The carpet is glued on with contact adhesive, making sure it is stretched nice and tight over and around the box. Edges are trimmed with a sharp knife and also glued.

We also completely covered the inside of the box (and even the back of the speaker magnet) with the carpet to act as a sound deadening and resonance-reducing agent. It looks





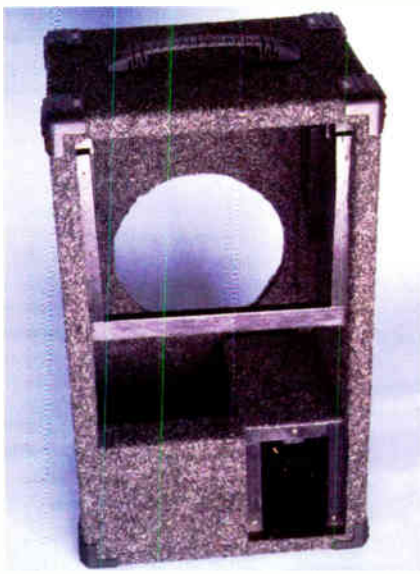
FRONT VIEW LEFT SIDE VIEW REAR VIEW

good, too! All these pieces need to be cut to the appropriate size before gluing in place.

Eight plastic speaker box corners were fitted on all corners (top and bottom) to protect them from damage. For ease of transportation we added a flexible carry handle. As we mentioned before, a metal speaker grille is fitted over the front of the speaker cone to protect it.

In perhaps a bit of overkill, we added a "top hat" stand mount to the bottom of the box. This allows the box to be mounted "up high" on a standard 35mm speaker stand (or even a length of water pipe driven into the ground). Raising the box above the heads of an audience dramatically improves the sound "throw", allowing greater coverage without the use of a second box or extension.

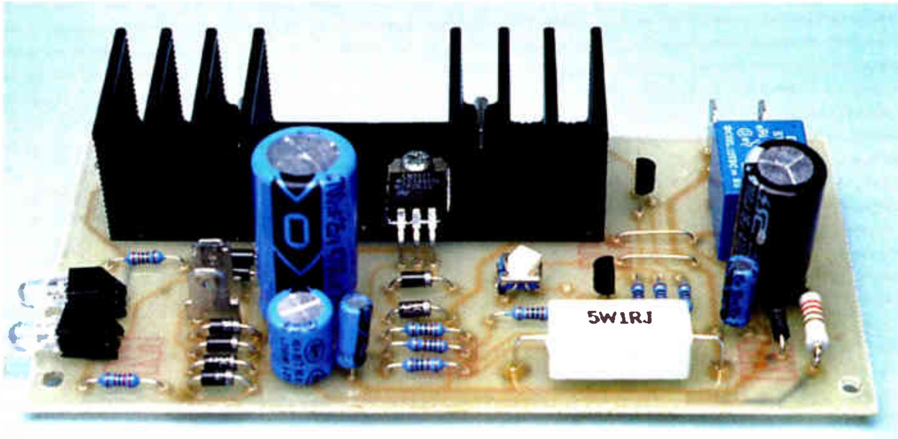
Finally, the "aluminium air vent" shown above is simply an offcut from a length of U-shaped slotted aluminium channel used for shelf support verticals (the kind brackets clip into to hold shelves) which should be available at any hardware store. It even comes with the slots pre-cut for you!


These three shots, along with the diagram above, give a pretty good idea of how we constructed our box. Of course, other approaches may be just as valid – and because it *is* for PA (not hifi) use, dimensions are not particularly critical with the exception of the speaker cutout, battery compartment and, of course, the amplifier mounting arrangement.

12V SLA BATTERY FLOAT CHARGER

This specially designed float battery charger feeds pure DC to the battery and is disconnected from the battery when the AC input is removed. With no input power and the PA amplifier also switched off, there is no current drain from the battery and it should have a shelf life of many months, if not years.

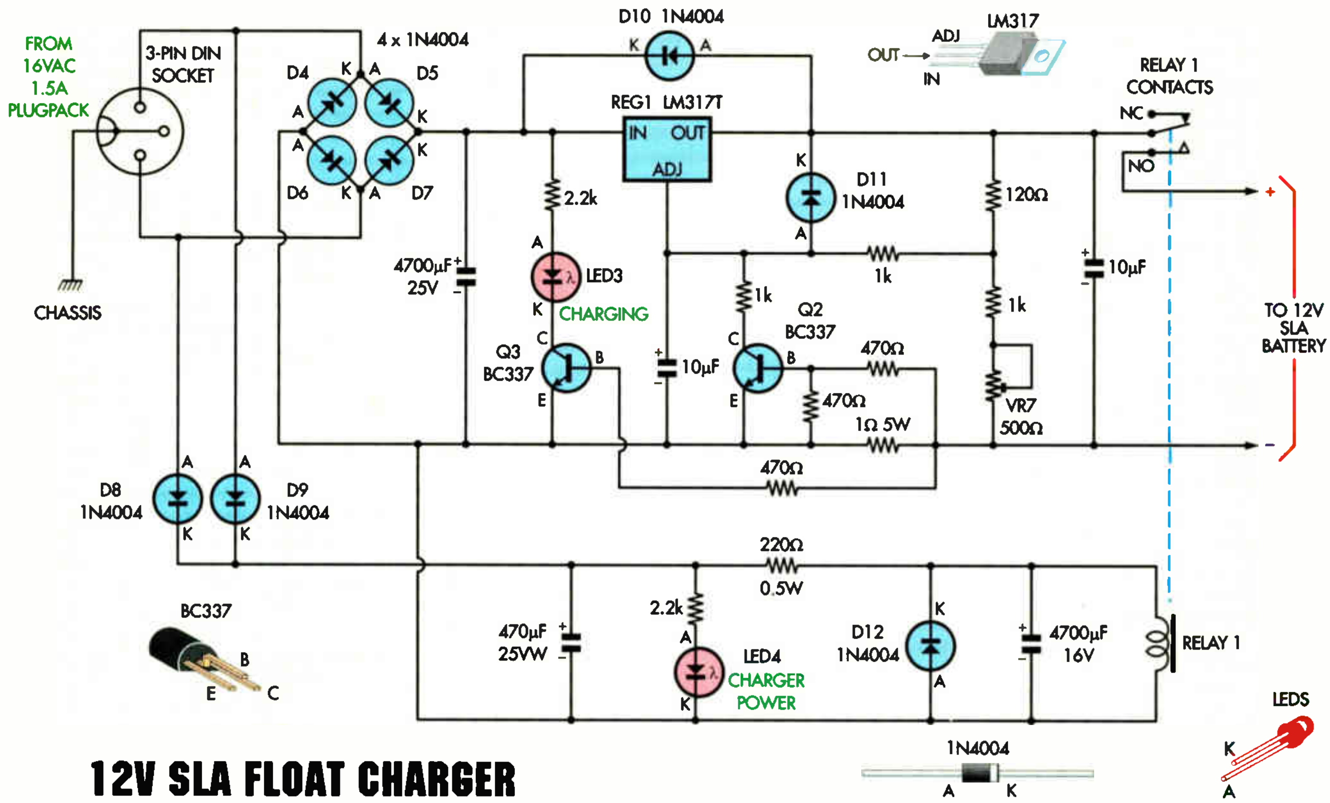


Circuit Diagram

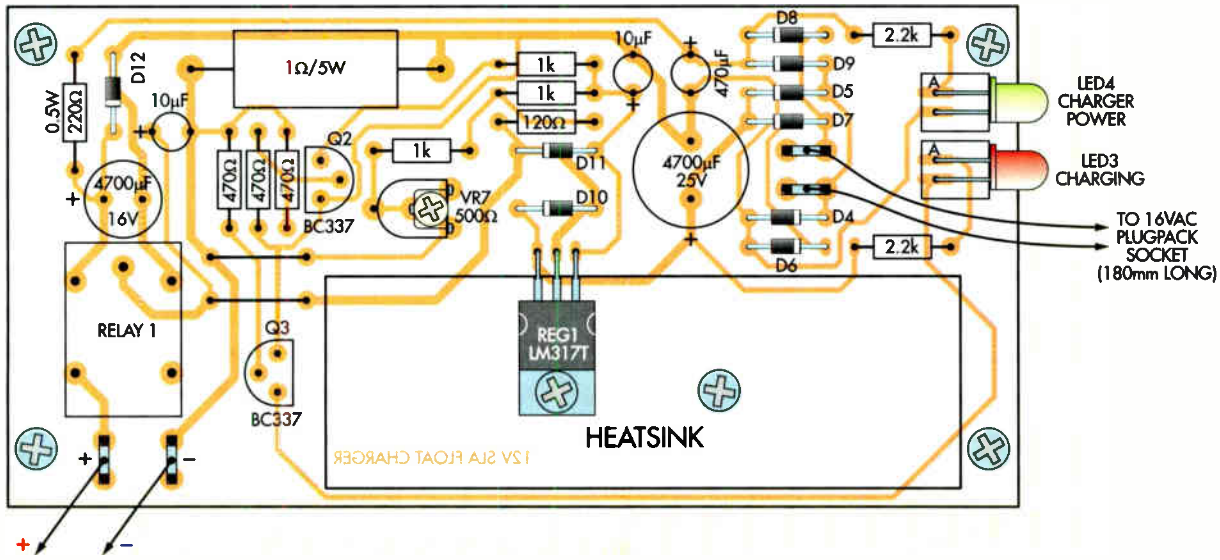
The charger circuit is shown below. As mentioned before, this also makes a perfect general-purpose 12V Sealed Lead Acid (SLA) battery float charger.

Power for the charger circuit comes from a 16V 1·5A AC plugpack which feeds diodes D4-D9 to produce two DC supplies. The main supply comes from diodes D4-D6 and the 4700µF capacitor. The capacitor is necessary to ensure that the battery is charged with DC that is free from ripple. Any ripple would be heard in the amplifier's output.

A 3-terminal regulator, REG1, sets the maximum battery charge voltage to 13·8V. It operates as follows. The voltage between its output and adjust (ADJ) pin is fixed at 1·25V and this voltage is applied across the 120Ω resistor (neglecting the small current drawn by the ADJ pin). The resulting 10mA through the 120Ω resistor flows through the 1k resistor and series 500Ω



12V SLA FLOAT CHARGER



trimpot VR7 to provide a voltage across them, effectively jacking up the regulator voltage. Trimpot VR7 is adjusted for an output of 13·8V.

Current limiting

A 1Ω 5W wirewound resistor is used to monitor the charging current. The voltage developed across it is monitored by transistor Q2. When the voltage across the 1Ω resistor reaches 1V, corresponding to a charging current of 1A, the base voltage of Q2 reaches about 0·5V and it begins to conduct, pulling the ADJ pin of REG1 lower to reduce the output voltage of REG1. This limits the charging current to 1A.

Transistor Q3 also monitors the voltage across the 1Ω resistor. Q3 turns on whenever the resistor voltage is above about 0·5V to drive LED3, the charging indicator. So provided the charging current is more than about 500mA, LED3 will be alight.

Once the battery voltage reaches 13·8V, the charging current drops to zero and the battery is effectively "on float".

When power to the charger is switched off, the battery could be drained back via the resistors across REG1. To stop that, we added the relay circuit, to disconnect the battery from the charger if no mains power is present.

Diodes D8 & D9, in conjunction with diodes D4 & D6, produce a separate supply from the 16VAC plugpack. This is filtered with a 470µF capacitor and then fed through a 220Ω resistor so that the relay is driven with 12V. The 4700µF capacitor across the relay coil delays the relay switch-on until the 4700µF capacitor for REG1 is fully charged. Without this delay, the initial switch-on of the charger would cause a loud hum in the loudspeaker until the 4700µF capacitor for REG1 was fully charged. LED4 provides power ON indication.

Charger board assembly

The 12V SLA float charger is assembled on a PC board measuring 133 x 66mm, coded 565, available from the *EPE PCB Service*. It has a single-sided heatsink for the regulator (REG1) measuring 84 x 24 x 28mm. The component overlay is shown above.

Once you have checked the board for obvious defects such as open-circuit tracks, shorts and undrilled holes, install the small components such as diodes and resistors first. Watch the polarity of the diodes. That done, install the two transistors, 500Ω trimpot, the electrolytic capacitors and the relay. Again, watch the polarity of the electrolytics.

When mounting the 1Ω 5W wirewound resistor, make sure there is about 1mm clearance between the resistor body and the PC board. This improves cooling for the resistor.

The two high brightness LEDs are mount-ed in right-angle PC mounts. These enable the LEDs to mate precisely with the control panel of the amplifier.

The 3-terminal REG1 is mounted on the heatsink with its leads bent, inserted and soldered into the PC board holes. The heatsink and regulator tab are then secured to the PC board with two M3 x 10mm screws. Nuts and star washers are used on the underside of the PC board.

Four spade lugs are inserted and soldered into the PC board for the input and output connections. The positive spade lug output near the relay should be marked with red paint or nail polish, to ensure correct connection to the battery.

Testing

Before you can test the charger board, you will need to wire up the 16VAC plugpack.

The cable is wired to a 3-pin DIN plug. The earth wire must go to the centre pin of the DIN plug while the other two wires go to the remaining pins. You will then need to temporarily wire up a DIN socket with the two AC wires going to pins 1 & 2 (not the centre pin) of the socket. These wires then should be fitted with spade connectors to fit the spade lug inputs on the charger board.

Switch on the plugpack and the charger LED should light and possibly the charging LED will light depending on battery charge.

Disconnect the battery and then set the trimpot for an output of 13·8V, using a digital multimeter. The charger is now ready to go. ***EPE***

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The circuit board may measure just 2"(L) x 11/16(W), but it can transmit signals over half a mile in the open. It has flexible power requirements, with 6 to 12VDC input voltage (so a 9V battery would be suitable). It is quick to build, and fun to use.

- Kit supplied with circuit board, electronic components, and clear English instructions.

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Get the video quality you paid for.

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Caution. During signal conditioning, this unit removes copyright protection. Piracy is a crime & Jaycar Electronics takes no responsibility for its potential for unlawful use.

Requires 9VAC wall adaptor (Maplin #GU09K £9.99).

Lead-Acid Battery Zapper Kit

KC-5414 £11.75 + post & packing

This simple circuit is designed to produce bursts of high-energy pulses to help reverse the damaging effects of sulphation in wet lead acid cells. This is particularly useful when a battery has been sitting for a period of time without use. The effects are dependant of the battery's condition and type, but the results can be quite good indeed.

- Kit supplied with case, silk screened lid, leads, inductors, all electronic components, and clear English instructions

Universal High Energy Ignition Kit

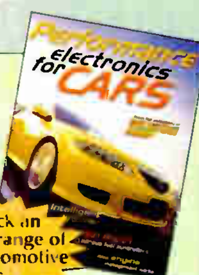
KC-5419 £27.75 + post & packing

A high energy 0.9ms spark burns fuel faster and more efficiently to give you more power! This versatile kit can be connected to conventional points twin points or reluctor ignition systems. Includes PCB, case and all electronic components with clear english instructions.

High Performance Electronic Projects for Cars

BS-5080 £7.00 + post & packing

Australia's leading electronics magazine Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers. The book includes all instructions, components lists, colour pictures, and circuit layouts. There are also chapters on engine management, advanced systems and DIY modifications. Over 150 pages! All the projects are available in kit form, exclusively to Jaycar. Check out our website for all the details.



We stock an extensive range of quality automotive kits

Universal Voltage Switch

KC-5377 £9.95 + post & packing

This is a universal module which can be adapted to suit a range of different applications. It will trip a relay when a preset voltage is reached. It can be configured to trip with a rising or falling voltage, so it is suitable for a wide variety of voltage output devices eg., throttle position sensor, air flow sensor, EGO sensor. You could even use it to trigger an extra fuel pump under high boost, anti-lag wastegate shutoff, and much more. Kit supplied with PCB, and all electronic components.

Recommended box UB5 (HB-6015) £1.05 each

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

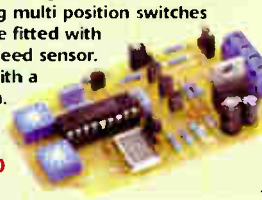
Digital Speedo Corrector

KC-5380 £14.75 + post & packing

If you upgrade your gearbox, change diff ratios or even change to a larger circumference tyre, you could be plagued with an inaccurate speedo. It alters the speedo signal up or down from 0% to 99% of the original signal. The adjustment is easy to dial in using multi position switches

- Requires car to be fitted with electronic type speed sensor. It will not work with a cable type system.

Recommended box UB5 (HB-6015) £1.05 each



Add on Intercooler Water Spray Controller for Fuel Mixture 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.

Picture shows Spray Controller fitted to the Display Kit.

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

Speaker Bass Extender Kit

KC-5411 £6.00 + post & packing

Most audiophiles know that loudspeaker enclosures have a natural frequency rolloff which is inherent in their design.

The Bass Extender kit boosts the level of the bass to counteract the natural rolloff of the enclosure, producing rich, natural bass. It gives an extra octave of response, and is sure to please even the most avid audiophiles.

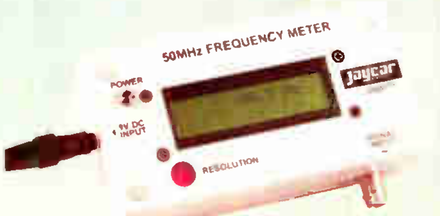
- Kit supplied with PCB, and all electronic components.

50MHz Frequency Meter Kit

KC-5369 £22.50 + post & packing

This compact 50MHz Frequency Meter is invaluable for servicing and diagnostics. Its autoranging and displays the frequency in either Hz, kHz, or MHz. Its compact (130 x 67 x 44mm) size features, an 8-digit LCD display, high and low resolution modes, and can be powered by a 9V battery or a 9-12VDC wall adapter.

- 0.1Hz resolution up to 150Hz, 1Hz resolution maximum up to 150Hz and 10Hz resolution resolution above 16MHz.



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

STOP PRESS STOP PRESS

EPE are publishing a series of popular projects by Silicon Chip Magazine, Australia. The projects are well designed, 'bullet proof' and already tested down under. Watch out for these projects in future Jaycar advertisements.

Tiptronic Style Gear Indicator Kit

KC-5344 £20.30 + post & packing

This display indicates up to 9 gears, neutral and reverse. The unit is calibrated in setup, so it will work with almost any vehicle. Using a PIC Microcontroller, it calculates the gear via the engine RPM and speed. Gear indication is displayed on a 7 segment LED display, and features an automatic dimmer for night driving. Supplied with case, pre-punched silk screened front panel, PCB and all electronic components. Hall Effect Sensor Included!

- As published in Everyday Practical Electronics Magazine (January)

AC/DC Current Clamp Meter Kit for DMM's

KC-5368 £8.75 + post & packing

A great low cost alternative. It uses a simple hall effect sensor, an iron ring core and connects to your digital multimeter. It will measure AC and DC current and has a calibration dial to allow for any magnetising of the core. Kit supplied with PCB, clamp, case with silk screened front panel and all electronic components.

- As published in Everyday Practical Electronics January 2006

AV Booster Kit

KC-5350 £31.95 + post & packing

This kit will boost your video and audio signals preserving them for the highest quality transmission to your projector or large screen TV. It boosts composite, S-Video, and stereo audio signals. Kit includes case, PCB, silk screened & punched panels and all electronic components.

- As published in Everyday Practical Electronics Magazine (January)

Requires 9VAC wall adaptor (Maplin #GU09K £9.99).

Programmable Continuity Tester Kit

KC-5362 £8.70 + post & packing

This unit will test for continuity from 1-100ohms, making it ideal for measuring low resistance devices. It is accurate, reliable, and works extremely well. kit supplied with PCB, case with silk screened panel and all electronic components.

Featured in this month's Everyday Practical Electronics magazine

"Clock Watchers" LED Clock Kits

KC-5404 £41.75 + post & packing
KC-5416 £55.25 + post & packing

THESE CLOCKS ARE HYPNOTIC!

They consist of an AVR driven clock circuit, that also produces a dazzling display with the 60 LEDs around the perimeter. It looks amazing, but can't be properly explained here. We have filmed it in action so you can see for yourself on our website! Kit supplied with double sided silk screened plated through hole PCB and all board components as well as the special clock housing! Available in Red (KC-5404) and Blue (KC-5416).

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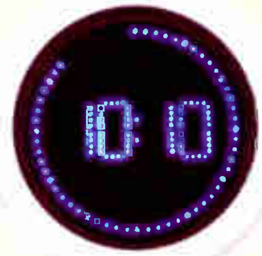

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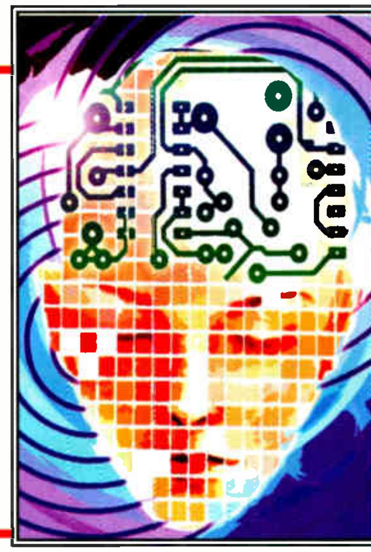

Part Six – Transistors: types, operation, and characteristics. Basic concepts of amplifiers: gain, frequency response and bandwidth. Some practical amplifier circuits.

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 investigate transistors and amplifiers.

Transistors

Transistors fall into two main categories: *bipolar junction transistors (BJT)* and *field-effect transistors (FET)*. They can also be classified according to their field of application (e.g. general purpose, switching, high-frequency, etc.) and the semiconductor material employed (silicon or germanium).

However, due to its superior characteristics (particularly in relation to leakage current and the effects of temperature) silicon is now used almost exclusively in the manufacture of transistors and germanium devices are considered obsolete.

Bipolar Junction Transistors (BJT)

Bipolar junction transistors generally comprise *npn* or *pnp* junctions of either silicon (Si) or germanium (Ge) material (see Figs.6.1 and 6.2).

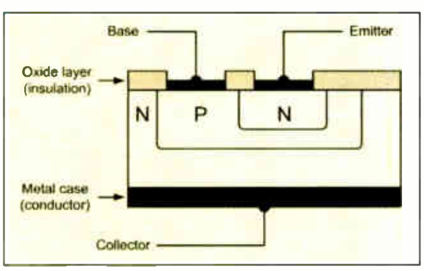

Fig.6.1. Construction of an npn *silicon transistor*

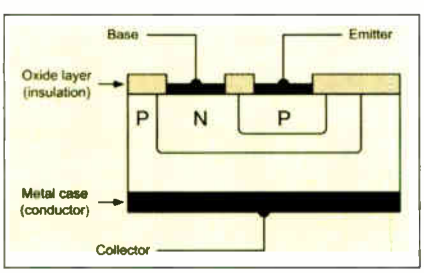

Fig.6.2. Construction of a pnp *silicon transistor*

The junctions are extremely small and they are produced in a single slice of silicon by diffusing impurities (see Part 4) through a photographically reduced mask. Silicon transistors are superior when compared with germanium transistors in the vast majority of applications (particularly at high temperatures) and thus germanium devices are rarely, if ever, used nowadays.

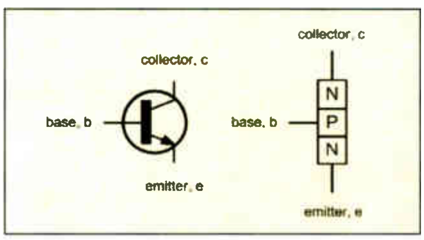

Fig.6.3. Symbol and simplified model of an npn *silicon transistor*

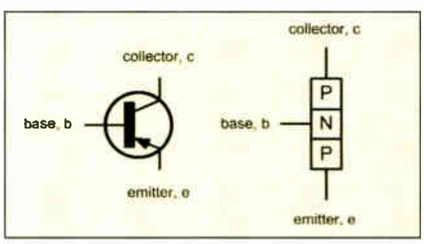

Fig.6.4. Symbol and simplified model of a pnp *silicon transistor*

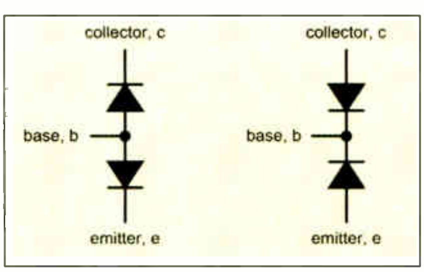

Fig.6.5. Diode models of npn *(left) and* pnp *(right) transistors*

Simplified representations of *npn* and *pnp* transistors are shown, together with their symbols, in Figs.6.3 and 6.4. The connections to the semiconductor material are labelled *collector(c)*, *base(b)* and *emitter(e)*. An important point to note about these models is that each junction within the transistor, whether it be collector-base or base-emitter, constitutes a *p-n* junction, as shown in Fig.6.5.

Respectively, Figs.6.6a and 6.6b show the normal bias voltages applied to *npn* and *pnp* transistors and the current flow within the device. It is important to note that the base-emitter junction is *forward biased* and the collector-base junction is *reverse biased*. The base region is, however, made very narrow so that current carriers leaving the emitter are swept across it into the collector and only a relatively small

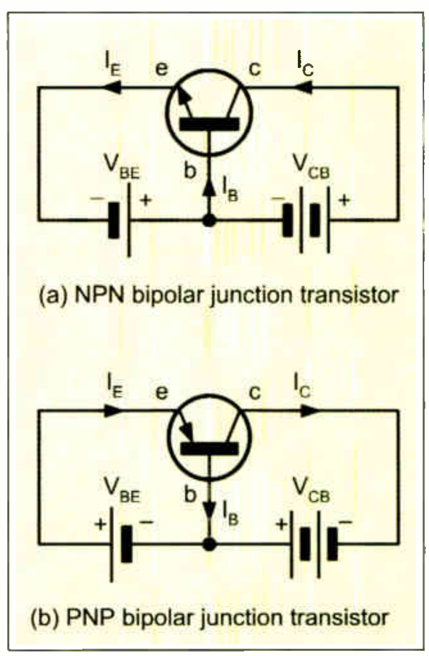

Fig.6.6. Bias voltages and currents for npn *and* pnp *transistors*

number appear at the base. To put this into context, the current flowing in the emitter circuit is typically 100 times greater than that flowing in the base.

The direction of conventional current flow is from emitter to collector in the case of a *pnp* transistor, and collector to emitter in the case of an *npn* device. By applying Kirchhoff's Current Law to Fig.6.6, we arrive at the following relationship between the currents flowing in the transistor:

$$I_E = I_B + I_C$$

where I_E is the emitter current, I_B is the base current, and I_C is the collector current (all expressed in the same units).

Example 6.1

A transistor operates with I_E = 10mA and I_B = 100μA. Determine the value of I_C.

The value of I_E can be calculated by re-arranging the equation $I_E = I_B + I_C$ to make I_C the subject, as follows:

$$I_C = I_E - I_B = 10 - 0{\cdot}1 = 9{\cdot}9\text{mA}$$

Check Point 6.1

Bipolar junction transistors (BJT) can be either *npn* or *pnp* types. The connections to a BJT are labelled emitter(e), base(b) and collector(c).

Field-Effect Transistors (FET)

Field effect transistors (FET) comprise a channel of *p*-type or *n*-type material surrounded by material of the opposite polarity. The ends of the channel (in which conduction takes place) form electrodes known as the *source* and *drain*. The effective width of the channel (in which conduction takes place) is controlled by a charge placed on the third (*gate*) electrode. The effective resistance between the source and drain is thus determined by the voltage present at the gate.

Field effect transistors are available in two basic forms; *junction gate* and *insulated gate*. The gate source junction of a junction gate field effect transistor (JFET) is effectively a reverse-biased *p-n* junction. The gate connection of an insulated gate field effect transistor (IGFET), on the other hand, is insulated from the channel and charge is capacitively coupled to the channel. To keep things simple, we will consider only JFET devices in this *Teach-In* series (IGFET devices are described in most electronic text books).

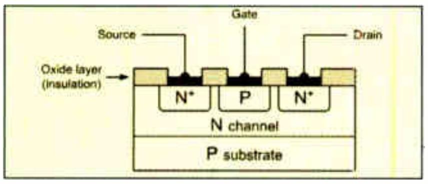

Fig.6.7. Construction of an n-channel JFET

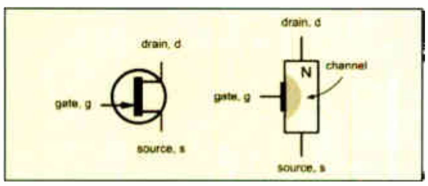

Fig.6.8. Symbol and simplified model of an n-channel JFET

The basic construction of an *n*-channel JFET is shown in Fig.6.7, whilst Fig.6.8 shows its symbol and simplified model.

It is important to note that JFETs offer a *very* much higher input resistance when compared with bipolar transistors. For example, the input resistance of a bipolar transistor operating in common-emitter mode (see later) is usually around 2·5kΩ whereas a JFET device operating in equivalent common-source mode would typically exhibit an input resistance of 100MΩ. This feature makes JFET devices ideal for use in applications where a very high input resistance is desirable.

In Fig.6.9 are shown the normal bias voltages applied to an *n*-channel JFET (a similar arrangement is used for a *p*-channel JFET but with the voltages and currents reversed). Note that the gate-source junction is reverse biased and that the current flowing from drain to source is determined by the voltage that appears between the gate and source (unlike the BJT which is essentially a device that is controlled by current).

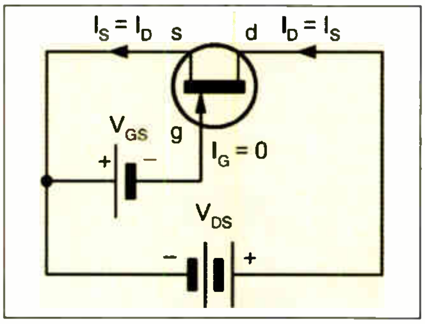

Fig.6.9. Bias voltages and currents for an n-channel JFET

Operating Modes

Regardless of what type of transistor is employed, three basic circuit configurations are used. These three circuit configurations depend upon which one of the three transistor connections is made common to both the input and the output. In the case of bipolar transistors, the configurations are known as *common emitter, common collector* (or *emitter follower*) and *common base* (see Fig.6.10).

Where field effect transistors are used, the corresponding configurations are *common source, common drain* (or *source follower*) and *common gate* (see Fig.6.11).

The three basic circuit configurations shown in Figs 6.10 and 6.11 exhibit quite different performance characteristics, as shown in Tables 6.1 and 6.2 (typical values are given in brackets).

Check Point 6.2

Junction gate field effect transistors (JFET) can be either *n*-channel or *p*-channel types. The connections to a JFET are labelled source(s), gate(g) and drain(d).

BJT Characteristics

The characteristics of a transistor are often presented in the form of a set of graphs that show the relationship that exists between the voltages and currents present at a transistor's terminals. These characteristics usually include:

Input characteristic (base current plotted against base-emitter voltage with the collector-emitter voltage held constant)

Output characteristic (collector current plotted against collector-emitter voltage with the base current held constant)

Transfer characteristic (collector current plotted against base current with collector-emitter voltage held constant)

A typical input characteristic (I_B plotted against V_{BE}) for a small-signal general-purpose *npn* transistor operating in common-emitter mode is shown in Fig.6.12. This characteristic shows that very little base current flows until the base-emitter voltage (V_{BE}) exceeds 0·6V. Thereafter, the base current

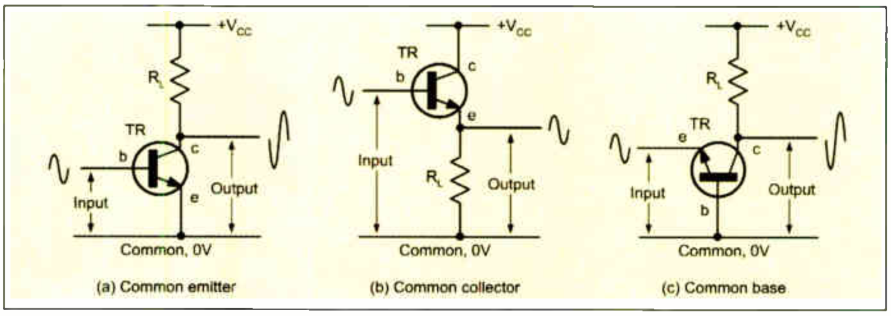

Fig.6.10. Operating modes for a BJT

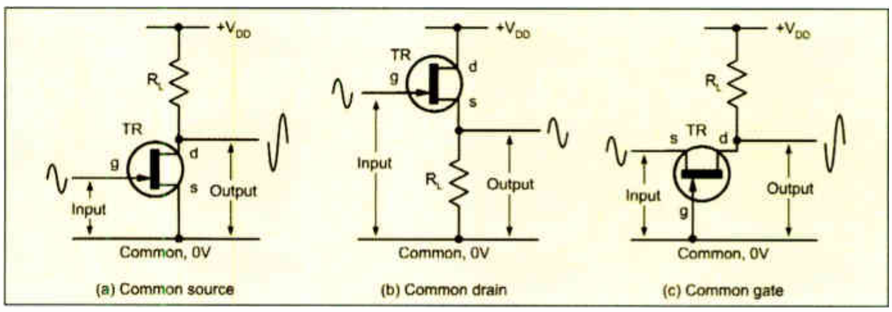

Fig.6.11. Operating modes for a JFET

Table 6.1 BJT configurations

Mode of operation	Parameter: Voltage gain	Current gain	Power gain	Input resistance	Output resistance	Phase shift	Typical applications
Common emitter Fig.5.10(a)	medium/high (40 to 80)	high (200)	very high (8000)	medium (2·5kΩ)	medium/high (20kΩ)	180°	General purpose AF and RF amplifiers
Common collector Fig.5.10(b)	unity (1)	high (200)	high (200)	high (100kΩ)	low (100Ω)	0°	Impedance matching; input and output stages
Common base Fig.5.10(c)	high (200)	unity (1)	high (200)	low (200Ω)	high (50kΩ)	0°	VHF/UHF amplifiers

Table 6.2 JFET configurations

Mode of operation	Parameter: Voltage gain	Current gain	Power gain	Input resistance	Output resistance	Phase shift	Typical applications
Common source Fig.5.11(a)	medium/high (20 to 50)	very high (200,000)	very high (200,000)	very high (2MΩ)	medium/high (50kΩ)	180°	General purpose AF and RF amplifiers
Common drain Fig.5.11(b)	unity (1)	very high (200,000)	very high (200,000)	very high (20MΩ)	low (200Ω)	0°	Impedance matching; input and output stages
Common gate Fig.5.11(c)	high (250)	unity (1)	high (250)	low (500Ω)	high (100kΩ)	0°	VHF/UHF amplifiers

increases rapidly (this characteristic bears a close resemblance to the forward part of the characteristic for a silicon diode (see Part 4).

A typical set of *output characteristics* (I_C plotted against V_{CE}) for a small-signal general purpose *npn* transistor operating in common-emitter mode is shown in Fig.6.13. Note that this characteristic comprises a family of curves, each relating to a different value of base current (I_B). It is important to note the "knee" that occurs at values of V_{CE} of about 2V. This suggests that, for linear operation, we should ensure that the collector-emitter voltage does not fall below 2V. Also, note how the curves become flattened above the knee such that the collector current (I_C) remains reasonably constant over a very wide range of collector- emitter voltage (V_{CE}).

Finally, a typical *transfer characteristic* (I_C plotted against I_B) for a small-signal general purpose *npn* transistor operating in common-emitter mode (see later) is shown in Fig.6.14. This characteristic shows an almost linear relationship between collector current and base current (i.e. doubling the value of base current produces double the value of collector current, and so on). This characteristic is reasonably independent of the value of collector-emitter voltage (V_{CE}) and thus only a single curve is normally shown.

Current gain

The current gain offered by a BJT is a measure of its effectiveness as an amplifying device. The most commonly quoted parameter is that which relates to *common-emitter mode*. In this mode, the input current is applied to the base and the output current appears in the collector (the emitter is effectively common to both the input and output circuits, as shown in Fig.6.10a).

The common-emitter current gain is given by:

$$h_{FE} = \frac{I_C}{I_B}$$

where h_{FE} is the *hybrid parameter* which represents *large signal (DC) forward current gain*, I_C is the collector current, and I_B is the base current. When small (rather than large) signal operation is considered, the values of I_C and I_B are

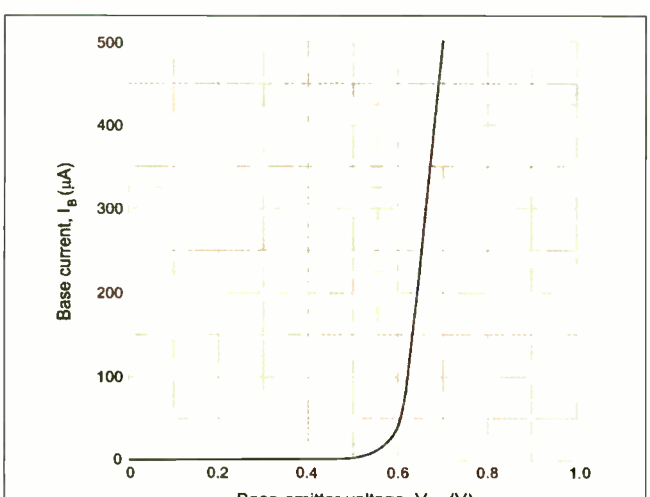

Fig.6.12. Typical input characteristic for a BJT

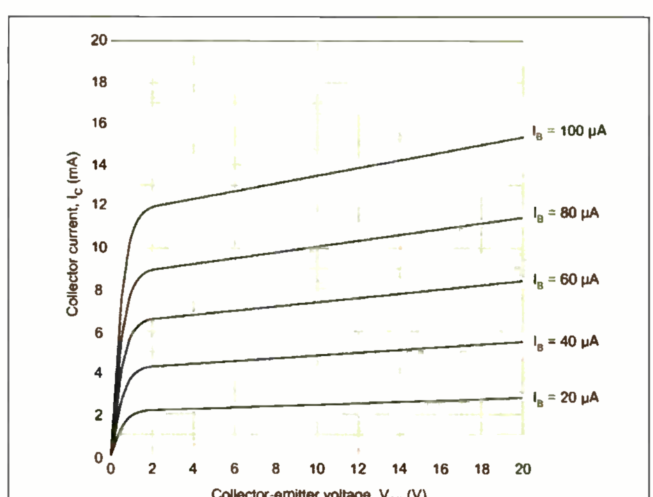

Fig.6.13. Typical output characteristics for a BJT

Table 6.3 Selected BJT data

Device	Type	I_C max.	V_{CEO} max.	V_{CBO} max.	P_t max.	h_{fe} typ.	at I_C	$f_t$typ	Application
BC108	NPN	100mA	20V	30V	300mW	125	2mA	250MHz	General purpose
BCY70	PNP	200mA	–40V	–50V	360mW	150	2mA	200MHz	General purpose
BD131	NPN	3A	45V	70V	15W	50	250mA	60MHz	AF power
BD132	PNP	3A	–45V	–45V	15W	50	250mA	60MHz	AF power
BF180	NPN	20mA	20V	20V	150mW	100	10mA	650MHz	RF amplifier
2N3053	NPN	700mA	40V	60V	800mW	150	50mA	100MHz	Driver
2N3055	NPN	15A	60V	100V	115W	50	500mA	1MHz	LF power
2N3904	NPN	200mA	40V	60V	310mW	150	50mA	300MHz	Switching

incremental (i.e. small changes rather than static values). The current gain is then given by:

$$h_{fe} = \frac{\Delta I_C}{\Delta I_B}$$

where h_{fe} is the *hybrid parameter* which represents small signal (AC) forward current gain, ΔI_C is the change in collector current which results from a corresponding change in base current, ΔI_B.

Values of h_{FE} and h_{fe} can be obtained from the transfer characteristic (I_C plotted against I_B) shown in Fig.6.14. Note that h_{FE} is found from corresponding *static values* while h_{fe} is found by measuring the slope of the graph. Also note that, if the transfer characteristic is linear, there is little (if any) difference between h_{FE} and h_{fe}.

It is worth noting that current gain (h_{fe}) varies with collector current. For most small-signal transistors, h_{fe} is a maximum at a collector current in the range 1mA and 10mA. Furthermore, current gain falls to very low values for power transistors when operating at very high values of collector current. Another point worth remembering is that most transistor parameters (particularly common-emitter current gain, h_{fe}) are liable to wide variation from one device to the next. It is, therefore, important to design circuits on the basis of the *minimum value* for h_{fe} in order to ensure successful operation with a variety of different devices.

Some parameters for a representative selection of BJT and JFET devices are shown in Tables 6.3 and 6.4. Some common transistors are shown in Photo 6.1.

Table 6.4 Selected JFET data

Device	Type	I_D max.	V_{DS} max.	P_D max.	g_{fs} min.	Application
2N3819	N-channel	10mA	25V	200mW	4mS	General purpose
BF244A	N-channel	100mA	30V	360mW	3mS	RF amplifier
2N3820	P-channel	–15mA	20V	200mW	0·8mS	General purpose
2N5461	P-channel	–9mA	40V	310mW	1·5mS	Audio amplifiers
J310	N-channel	30mA	25V	350mW	8mS	VHF/UHF amplifier

Example 6.2

A transistor operates with I_C = 20mA and I_B = 500μA. Determine the value of I_E and h_{FE}.

The value of I_E can be calculated from $I_C + I_B$, thus:

I_E = 20 + 0·5 = 20·5mA

The value of h_{FE} can be found from $h_{FE} = I_C/I_B$ thus:

$h_{FE} = I_C/I_B$ = 20/0·5 = 40

Example 6.3

A transistor operates with a collector current of 97mA and an emitter current of 98mA. Determine the value of base current and common emitter current gain.

Since $I_E = I_C + I_B$, the base current will be given by:

$I_B = I_E - I_C$ = 98 – 97 = 1mA

The common-emitter current gain (h_{FE}) will be given by:

$$h_{FE} = \frac{I_C}{I_B} = \frac{97}{1} = 97$$

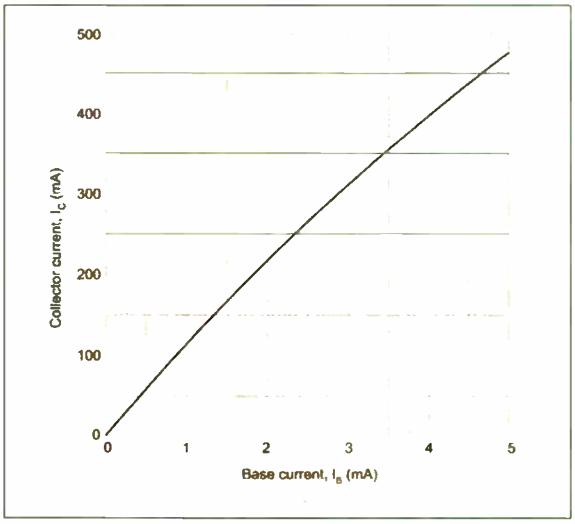

Fig.6.14. Typical transfer characteristic

Amplifiers

Apart from the obvious requirement of making a signal voltage or current larger, an important requirement of most amplifiers is that the output signal should be a faithful copy of the input signal, albeit somewhat larger in amplitude. We describe these as *linear amplifiers* and the need for

Questions 6.1

Q6.1. An *npn* transistor is to be used in a regulator circuit in which a collector current of 1·5A is to be controlled by a base current of 5mA. What value of h_{FE} will be required?

Q6.2. If the device is to be operated with V_{CE} = 6V, which transistor selected from Table 6.3 would be appropriate for this application and why?

See later for the solutions to these questions.

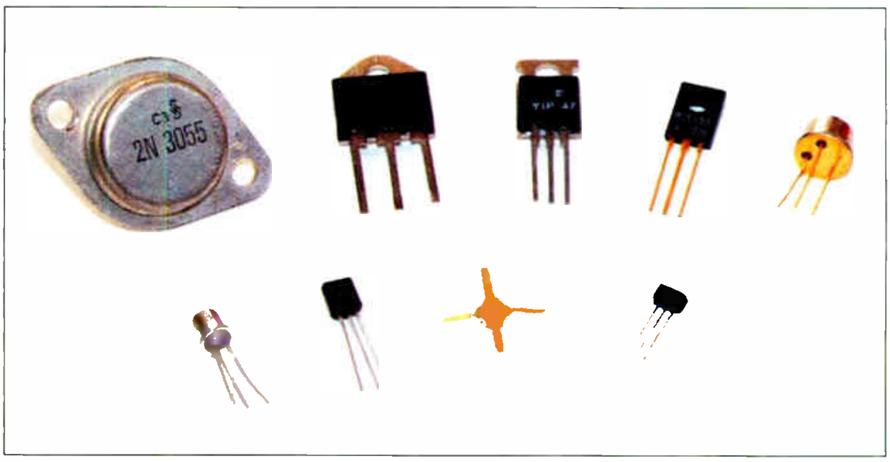

Photo.6.1. Various transistors (including power, switching, and small-signal types)

linearity is an important consideration in their design.

Some other types of amplifier are *non-linear*, in which case their input and output waveforms will not necessarily be identical. In practice, the degree of linearity provided by an amplifier can be affected by a number of factors, including the amount of bias applied (see later) and the amplitude of the input signal. It is also worth noting that a linear amplifier will become non-linear when the applied input signal exceeds a threshold value. Beyond this value the amplifier is said to be *overdriven* and the output will become increasingly distorted if the input signal is further increased.

Amplifiers are usually designed to be operated with a particular value of bias supplied to the active devices (see later). For linear operation, the active device(s) must be operated in the linear part of their *transfer characteristic*. This form of operation is known as *Class A* and the *bias point* is adjusted to the mid-point of the linear part of the transfer characteristic.

Note also that collector (or drain) current will flow in the transistors used in a Class A amplifier during a complete cycle of the signal waveform. At no time will the current fall to *zero*.

Amplifier Parameters

Important parameters of most amplifiers include:

Voltage gain

The voltage gain of an amplifier is simply the ratio of output voltage to input voltage. Since voltage gain may vary at different frequencies, the voltage gain of an amplifier is usually quoted in the *mid-band* (often 1kHz for most audio amplifiers).

Output power

Output power is the power delivered by an amplifier under a specified set of conditions (such as load resistance, distortion, and frequency). This parameter is normally only meaningful for amplifiers that are designed to produce an appreciable level of output power (such as an amplifier that is designed to feed a loudspeaker).

Input resistance

Input resistance is the ratio of input voltage to input current expressed in ohms. The input of an amplifier is normally purely resistive (i.e. any reactive component is negligible) in the middle of its working frequency range (i.e. the *mid-band*). In some cases, the reactance of the input may become appreciable (e.g. if a large value of stray capacitance appears in parallel with the input resistance). In such cases we would refer to *input impedance* rather than input resistance.

Output resistance

Output resistance is the ratio of open-circuit output voltage to short-circuit output current and is measured in ohms. Note that this resistance is internal to the amplifier and should not be confused with the resistance of a load connected externally.

As with input resistance, the output of an amplifier is normally purely resistive and we can safely ignore any reactive component. If this is not the case, we would once again need refer to *output impedance* rather than output resistance.

Finally, it is important to note that, although these resistances are meaningful in terms of the signals present, they cannot be measured using a conventional meter!

Frequency response

The frequency response of an amplifier is usually specified in terms of the upper and lower *cut-off frequencies* of the amplifier. These frequencies are those at which the output power has dropped to 50% (otherwise known as the *–3dB points*) or where the voltage gain has dropped to 70·7% of its mid-band value (see Fig.6.15). Note that frequency response graphs are usually plotted on *logarithmic* graph paper.

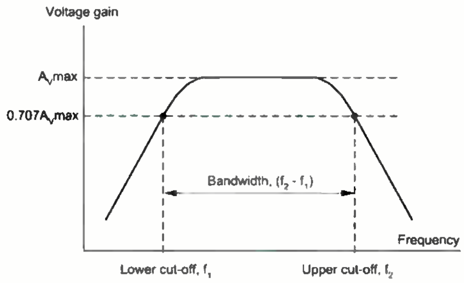

Fig.6.15. Frequency response and bandwidth

Bandwidth

The bandwidth of an amplifier is usually taken as the difference between the upper and lower cut-off frequencies (i.e. $f_2 - f_1$ in Fig.6.15). The bandwidth of an amplifier must be sufficient to accommodate the range of frequencies present within the signals that it is to be presented with. Many signals contain *harmonic components* (i.e. signals at *2f, 3f, 4f*, etc where *f* is the frequency of the *fundamental* signal).

To reproduce a square wave, for example, requires an amplifier with a very wide bandwidth (note that a square wave comprises an infinite series of harmonics). Clearly it is not possible to *perfectly* reproduce such a wave but it does explain why it can be desirable for an amplifier's bandwidth to greatly exceed the highest signal frequency that it is required to handle!

Phase shift

Phase shift is the phase angle between the input and output signal voltages measured in degrees. The measurement is usually carried out in the mid-band where, for most amplifiers, the phase shift remains relatively constant. Note also that conventional single-stage transistor amplifiers provide phase shifts of either 180° or 360°.

> **Questions 6.2**
>
> Q6.3. Determine the mid-band voltage gain and upper and lower cut-off frequencies for the amplifier whose frequency response is shown in Fig.6.16.
>
> See later for the solutions to this questions.

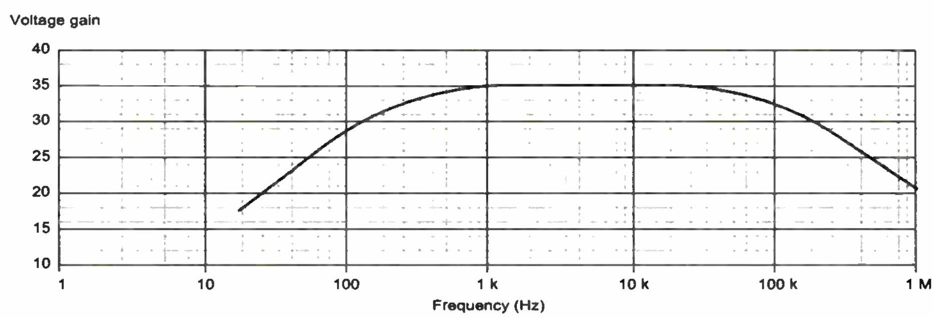

Fig.6.16. See question Q6.3

Practical Amplifier Circuits

We stated earlier that the optimum value of bias for a Class A (linear) amplifier is that value which ensures that the active devices are operated at the midpoint of their transfer characteristics. In practice, this means that a static value of collector current will flow even when there is no signal present. Furthermore, the collector current will flow throughout the complete cycle of an input signal (i.e. conduction will take place over an angle of 360°). At no stage will the transistor be *saturated* nor should it be *cut-off* (i.e. the state should not be reached at which *no* collector current flows).

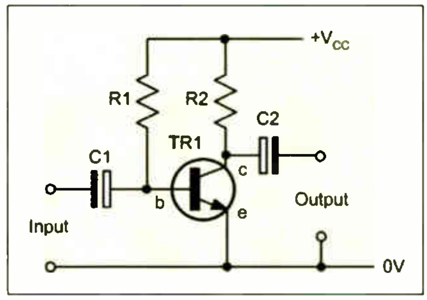

Fig.6.17. Basic Class A common-emitter amplifier

In order to ensure that a static value of collector current flows in a transistor, a small current must therefore be applied to the base of the transistor. This current can be derived from the same voltage rail that supplies the collector circuit (via the load). Fig.6.17 shows a simple Class A common emitter amplifier circuit in which the base bias resistor, R1, and collector load resistor, R2, are connected to a common positive supply rail.

The signal is applied to the base terminal of the transistor via a coupling capacitor, C1. This capacitor removes the DC component of any signal applied to the input terminals and ensures that the base bias current delivered by

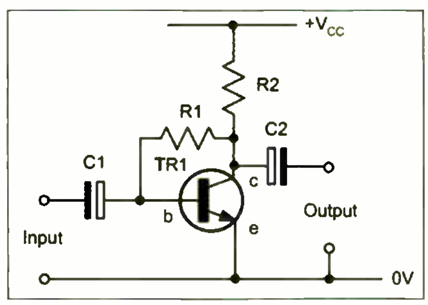

Fig.6.18. Improvement on the circuit shown in Fig.6.17 (using negative feedback to bias the transistor)

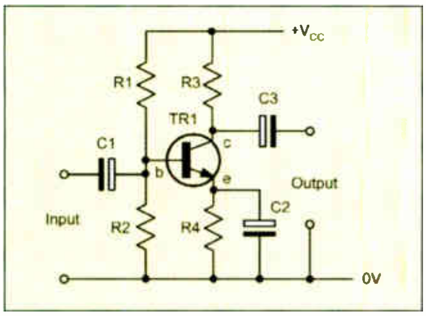

Fig.6.19. A common-emitter amplifier stage with effective bias stabilization

R1 is unaffected by any device connected to the input. Capacitor C2 couples the signal out of the stage and also prevents DC potentials appearing at the output terminals.

In order to stabilize the operating conditions for the stage and to compensate for variations in transistor parameters, base bias current for the transistor can be derived from the voltage at the collector (see Fig.6.18).

This voltage is dependent on the collector current which, in turn, depends upon the base current. The result of this *negative feedback* is a degree of self-regulation; if the collector current increases, the collector voltage will fall and the base current will be reduced. The reduction in base current will produce a corresponding reduction in collector current to offset the original change.

Conversely, if the collector current falls, the collector voltage will rise and the base current will increase. This, in turn, will produce a corresponding increase in collector current to offset the original change.

The circuit in Fig.6.19 shows an improved form of transistor amplifier in which DC negative feedback is used to stabilize the stage and compensate for variations in transistor parameters, component values and temperature changes. Resistors R1 and R2 form a potential divider that determines the DC base potential, V_B. The base-emitter voltage (V_{BE}) is the difference between the potentials present at the base (V_B) and emitter (V_E).

The potential at the emitter is governed by the emitter current (I_E). If this current increases, the emitter voltage (V_E) will increase and, as a consequence V_{BE} will fall. This, in turn, produces a reduction in emitter current which largely offsets the original change. Conversely, if the emitter current decreases, the emitter voltage (V_E) will decrease and V_{BE} will increase (remember that V_B remains constant). The increase in bias results in an increase in emitter current compensating for the original change.

In practice the simple common-emitter amplifier stages shown in Figs 6.17 to 6.19 provide a modest voltage gain (80 to 120 typical) with an input resistance of approximately 1·5kΩ and an output resistance of around 20kΩ. The frequency response can be made to extend from a few hertz to several hundred kilohertz.

Practical Investigation 6.1

Objective: To investigate the transfer characteristic of a transistor.

Components and materials: Breadboard, digital or analogue meter with DC current ranges, 9V DC power supply (or battery), 47kΩ resistor, 10kΩ variable resistor (potentiometer), two different *npn* transistors (e.g. BC108 and BC548), test leads, connecting wire.

Circuit diagram(s): See Fig.6.20

Wiring diagram: See Fig.6.21 and 6.22

Procedure: The required breadboard wiring is shown in Table 6.5.

1. Connect the circuit in Fig.6.20a as shown in breadboard Fig.6.21 and Table 6.6. Before switching on the supply (or connecting the battery), set the meter to the DC 2mA range and the variable resistor VR1 to minimum position (i.e. fully anticlockwise).

2. Switch on (or connect the battery) and slowly increase the base current (by adjusting the variable resistor) until it reaches 0·01mA (10μA).

3. Switch off (or disconnect the battery) and reconnect the circuit as shown in Fig.6.20b, Fig.6.22 and Table 6.7. Set the meter to the DC 20mA range.

4. Switch on (or connect the battery) and then measure and record the collector current (without disturbing the setting on the variable resistor) in Table 6.8.

5. Repeat steps 2 to 4 for base currents in steps of 0·01mA up to a maximum 0·1mA (100μA), at each stage measuring and recording the corresponding value of collector current and recording each measured value in Table 6.8.

6. Repeat the investigation with a different type of transistor (e.g. BC548).

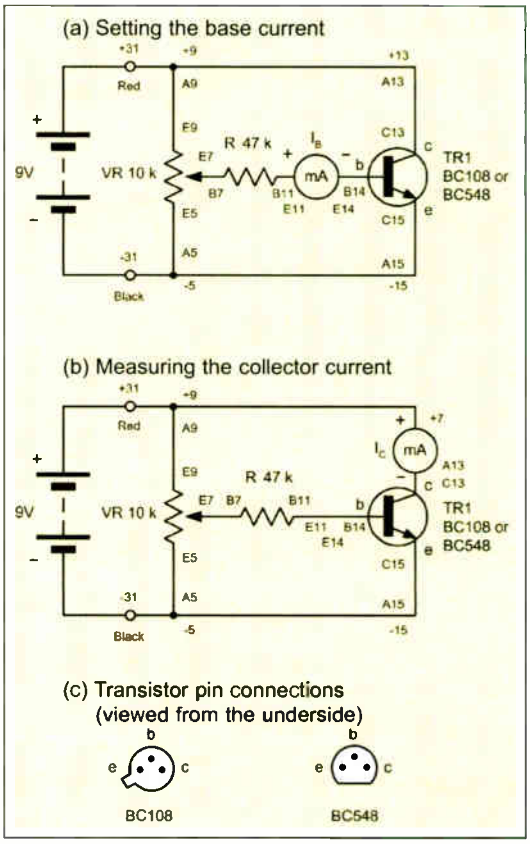

Fig.6.20. Circuit diagram for Practical Investigation 6.1

Graph and Calculations: For each transistor, having recorded your results in Table 6.8 showing corresponding values of I_C and I_B, plot graphs showing I_C plotted against I_B (i.e. the transfer characteristic) using the graph sheet shown in Fig.6.23, which you may enlarge on a photocopier.

Finally, calculate the value of h_{FE} for each transistor at I_C = 2mA. Compare your calculated results and characteristic graphs with manufacturer's data.

Conclusion: Comment on the shape of each graph. Is this what you would expect? Is the graph linear? If not, what will this imply about

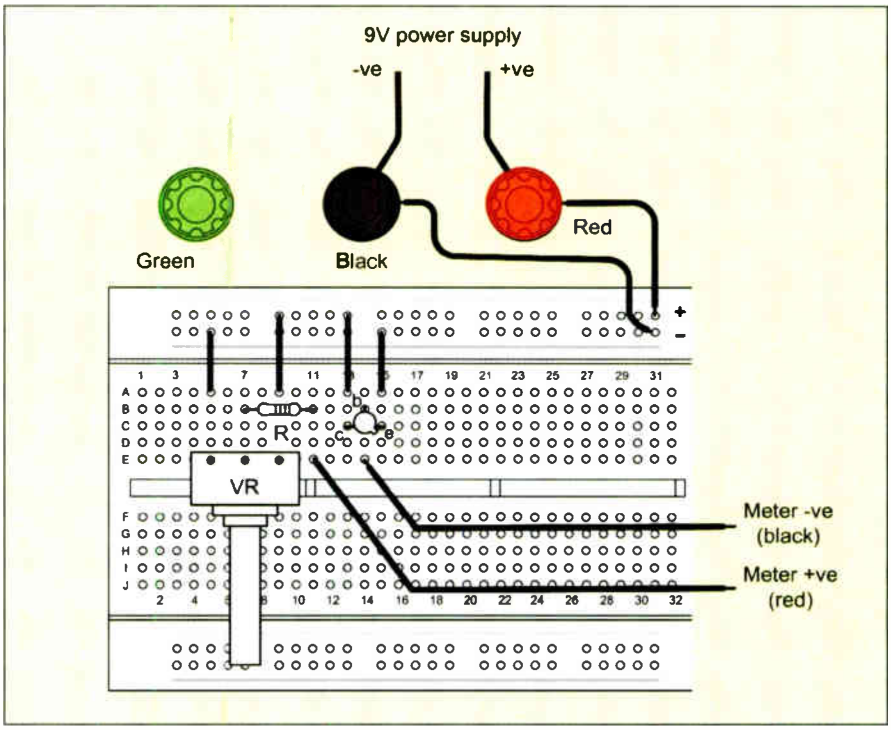

Fig.6.21. Wiring diagram for setting the base current in Practical Investigation 6.1

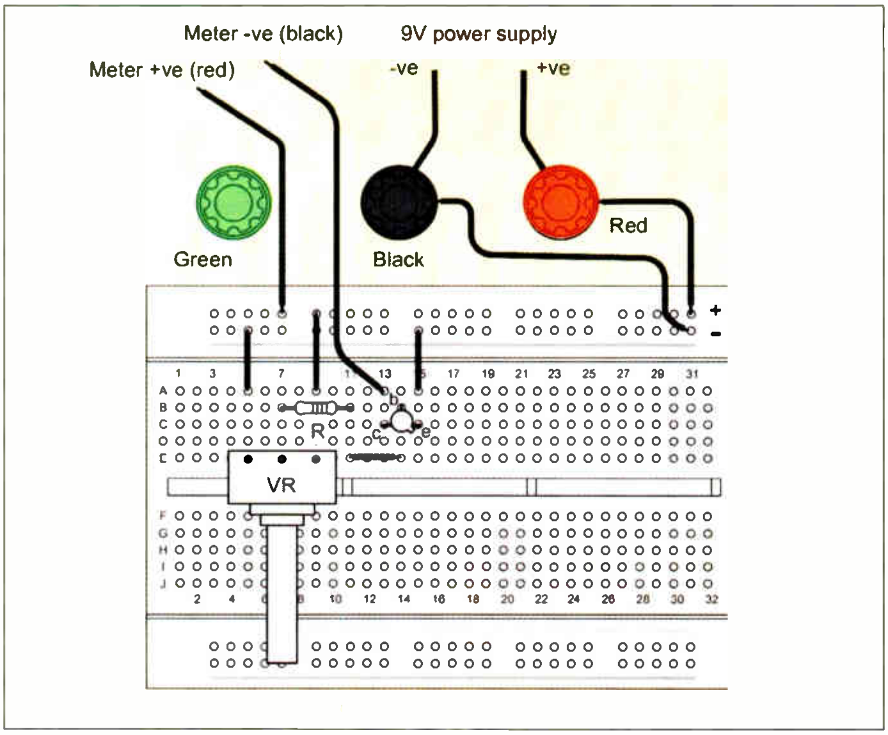

Fig.6.22. Wiring diagram for measuring the collector current in Practical Investigation 6.1

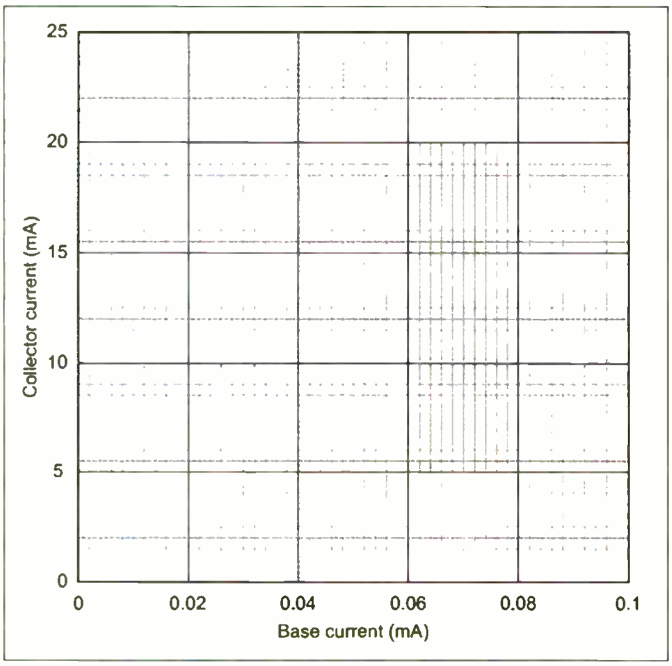

Fig.6.23. Graph sheet for plotting the results of Practical Investigation 6.1

the static and small-signal values of current gain? What was the calculated value of h_{FE}? Was this what you expected? Which of the transistors had the highest value of current gain?

Answers To Questions

Q6.1. The required current gain can be found from:

$h_{FE} = I_C/I_B = 1{\cdot}5A/50mA = 1{\cdot}5 / 0{\cdot}05 = 30$

Q6.2. The most appropriate device would be the BD131. The only other device capable of operating at a collector current of 1·5A would be a 2N3055. The collector power dissipation will be given by:

$P_C = I_C \times V_{CE} = 1{\cdot}5 \times 6V = 9W$

However, the 2N3055 is rated at 115W maximum total power dissipation and this is more than ten times the power required.

Q6.3. The mid-band voltage gain corresponds with the flat part of the frequency response characteristic. At the point the voltage gain reaches a maximum of 35, the voltage gain at the two cut-off frequencies can be calculated from:

Av cut-off $= 0{\cdot}707 \times Av_{max} = 0{\cdot}707 \times 35 = 24{\cdot}7$

This value of gain intercepts the frequency response graph at f_1 = 57Hz and f_2 = 590kHz (see Fig.6.16).

Next Month

In Part 6, next month, we shall be introducing testing and measurement techniques. In the meantime you might like to see how you get on with our on-line quiz for Part 6. You will find this at: **www.miketooley.info/teach-in/quiz6.htm**

Table 6.6 To set the base current in Fig.6.21

Step	Connection, link or component	From	To
15	Link	A13	+13
16	Meter positive	A(Red)	E11
17	Meter negative	COM (Black)	E14

Table 6.7 To measure collector current in Fig.6.22

Step	Connection, link or component	From	To
18	Link	E11	E14
19	Meter positive	A(Red)	+7
20	Meter negative	COM (Black)	A13

Table 6.5. Breadboard wiring for Practical Investigation 6.1

Step	Connection, link or component	From	To
1	-9V supply	-9V	Black terminal
2	+9V supply	+9V	Red terminal
3	Black wire	Black terminal	-31
4	Red wire	Red terminal	+31
5	TR1 BC108 emitter	C15	
6	TR1 BC108 base	B14	
7	TR1 BC108 collector	C13	
8	R 47k	B7	B11
9	VR 10k	E5	
10	VR 10k	E7	
11	VR 10k	E9	
12	Link	A5	-5
13	Link	A9	+9
14	Link	A15	-15

Table 6.8 Results table for Practical Investigation 6.1

Base Current (mA)	Collector Current (mA)
0·01	
0·02	
0·03	
0·04	
0·05	
0·06	
0·07	
0·08	
0·09	
0·10	

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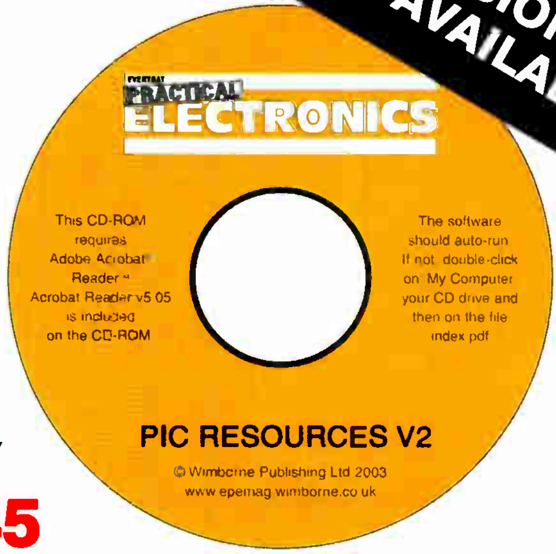

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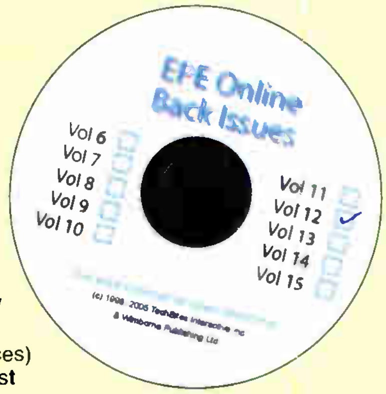

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INTERFACE

Robert Penfold

BOOSTING OUTPUT CURRENTS

THE previous *Interface* articles considered a simple digital-to-analogue converter for a PC, together with signal processing circuits to enable the converter to do something useful. This month's article continues in the same vein with an output stage for the level shifting and amplifying circuits described in the previous *Interface* article.

These circuits provide high resolution outputs that cover a relatively small voltage range, such as 10V to 12·55V, with a resolution of 10 millivolts (0·01 volts). However, they can only provide output currents of a few milliamps or less. Many practical applications require an output current of a few amps rather than milliamps.

Big Following

In order to boost the output current of these circuits it is merely necessary to add a buffer stage at the output, or a voltage follower as this type of circuit is also known. In other words, a circuit where the output voltage is the same as the input voltage, but a much higher output current can be provided.

Probably the most common method of providing a voltage follower is to use a common collector amplifier. This type of amplifier is also known as an "emitter follower". A massive amount of current gain is normally required in order to supply very high output currents, so practical output stages often use two transistors connected as what is often described as a "Darlington pair". In Fig.1 this is the configuration shown on the left.

A circuit of this type gives a total current gain that is equal to the product of the gains of the individual transistors. In practice the combined current gain is usually several thousand or more, which enables an input current of a few milliamps to control an output that can supply a few amps. One slight drawback of this configuration is that there is a relatively large voltage drop from the input to the output. With large output currents the output is typically about 1·5V less than the input voltage.

This voltage drop is not a problem in terms of setting accurate output potentials. The output stage is normally included in the negative feedback loop of a high gain amplifier that compensates for and effectively removes the voltage drop. It does reduce the efficiency of the circuit though, since the supply potential has to be about 1·5V more than the maximum output voltage that will be needed.

In practice the supply voltage often has to be even higher than this in order to compensate for inefficiencies elsewhere in the circuit. For example, the output stage is often driven from an op.amp (operational amplifier), and these typically have a maximum positive output potential that is about 1·5V to 2·5V less than the supply voltage. Together with the drop through the output stage, this requires the supply to be three to four volts higher than the maximum output voltage.

Getting Heated

With low power circuits an inefficient output stage is unlikely to be of any great consequence. However, it is undesirable with high power circuits because it necessitates a larger and more expensive power supply. It also results in the generation of more heat in the output stage, making it necessary to use a larger heatsink in order to keep the output transistor reasonably cool.

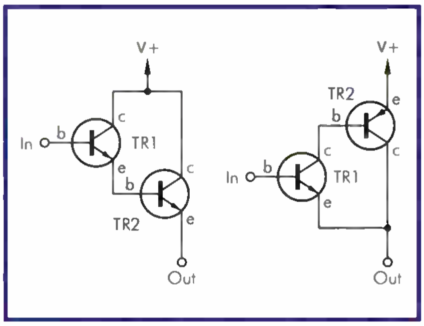

Fig.1. The common collector output stage (left) works quite well, but is less efficient than using two common emitter amplifiers (right)

A simple way of obtaining increased efficiency is to use two common emitter amplifiers in the output stage. The circuit on the right in Fig.1 shows two transistors in this configuration. The input transistor (TR1) is an *npn* type and the output device (TR2) is a *pnp* type.

Although common emitter transistors normally provide high voltage gain and little current amplification, this configuration has 100 percent negative feedback from the collector of TR2 to the emitter of TR1. Consequently, there is unity voltage gain through the circuit but a high level of current amplification. In other words, it has similar characteristics to a Darlington pair used as a common collector amplifier, but with a slightly lower voltage drop between the input and the output.

This still leaves the problem of the inefficiencies of the driving circuit, but one way around it is to modify the output stage to provide a small amount of voltage gain. In Fig.2 the purpose of resistors R1 and R2 is to act as a potential divider that reduces the amount of feedback between the collector of TR2 and the emitter of TR1. In practice the values of the feedback resistors are chosen to provide only a small amount of voltage gain. With the output of the op.amp (IC1) nearing its maximum possible voltage, this is all that is needed in order to take the output of the circuit a couple of volts higher and avoid a large voltage drop through the output stage.

Note that there is 100 percent negative feedback from the output of the circuit to the non-inverting (–) input of IC1. Thus the overall voltage gain of the circuit is unity, and there is no significant voltage offset between the input and the output.

Switching

It is probably with a PWM (pulse width modulation) controller that an output stage having a low dropout voltage is most beneficial. The circuit shown in Fig.3 is essentially the same as the one featured in a recent *Interface* article, and it is for a PWM controller that provides an average output voltage of between zero and about 12 volts. A controller of this type provides a pulsed output signal, and the average output voltage is varied by altering the mark-space ratio of the pulse train. It is of no use in applications that require a normal DC signal, but it works well with loads that respond to the average supply potential, such as DC electric motors, LEDs, and filament bulbs.

The main point of using a PWM controller is that it produces little power loss and heat generation in the output transistor. When the output device is switched off there is no significant current flow or heat dissipation. There is a large current flow when it is switched on, but the voltage drop through the output transistor is quite low. With the original design the actual voltage drop was about 3V or so at high output currents, giving dissipations of just over 3W and 6W with respective output currents of 1A and 2A.

In the original circuit a Darlington power device was used as a common collector output stage. The modified circuit featured here has an output stage that is a practical version of the theoretical circuit of Fig.2. Like the rest of the controller circuit, the output stage is designed to operate using a

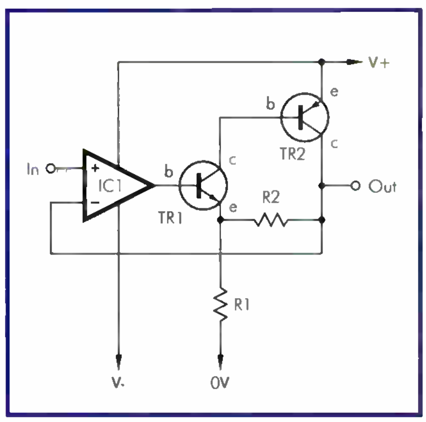

Fig.2. Resistors R1 and R2 reduce the amount of negative feedback applied to TR1 and TR2 so that they provide a small amount of voltage gain. However, the overall voltage gain of the circuit is unity

single supply. This is only possible if a suitable op.amp is used for IC6. Using anything other than the specified devices for this circuit is definitely not recommended.

The voltage drop through output transistor TR2 is typically a little over one volt at high output currents. Using dual 15V supplies an average output potential of 12V is easily achieved. With the original design an output potential of 12V required the output device to be switched on continuously. The more efficient output stage used here requires the output transistor to be switched on for substantially less than 100 percent of the time in order to

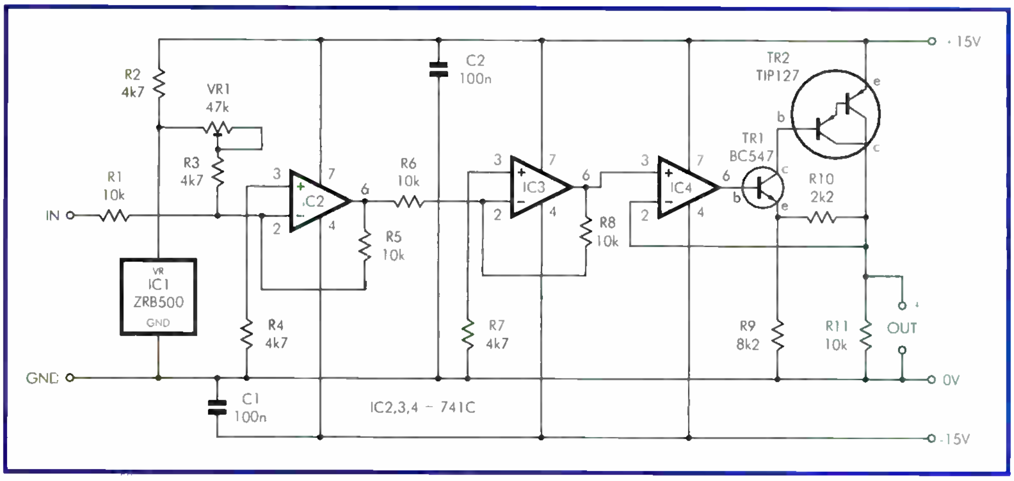

Fig.4. Here the high effiiency output stage has been added to the voltage shifter circuit featured in the previous Interface article. Output currents of up to 2A can be accommodated

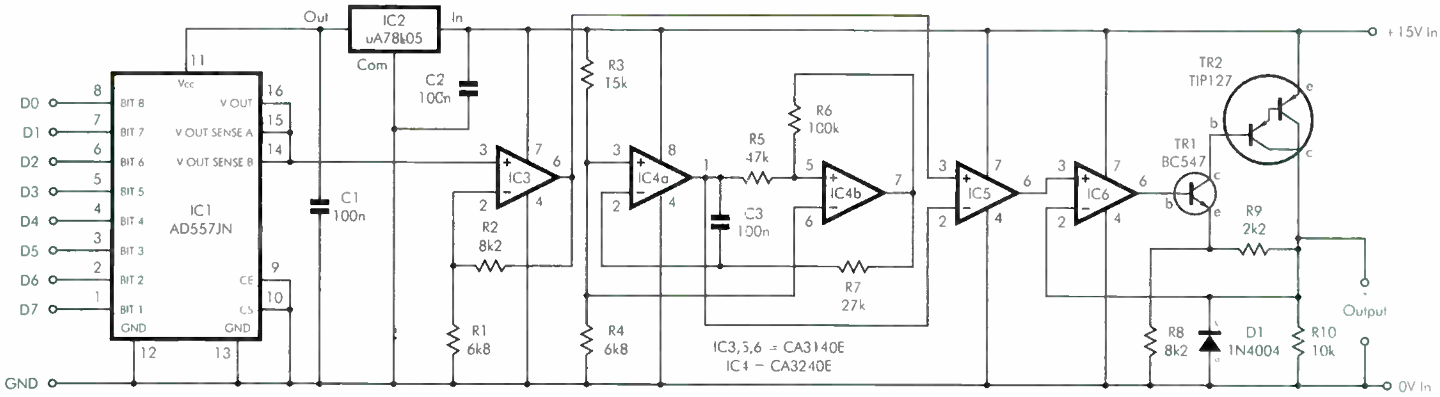

Fig.3. This modified PWM controller circuit can provide a higher maximum output potential and has reduced dissipation in the output Darlington transistor (TR2)

produce 12V at the output. As a result, the dissipation in TR2 is typically a little under 1W and 2W at respective output currents of 1A and 2A. In both cases a small clip-on heatsink should be sufficient to ensure that TR2 runs reasonably cool.

Power Supply

The circuit diagram of Fig.4 is a modified version of a power supply circuit that was described in the previous *Interface* article (Feb '06). It is designed to be used in conjunction with a digital-to-analogue converter that is the same as the one used in the PWM controller circuit of Fig.3. The zero to 2·55V output range of the converter is given a positive offset that can be varied from a little under one volt to just over 10V by means of preset VR1. With the original version of the circuit it was possible to use an offset of 10V to obtain an output voltage range of 10V to 12·55V, but the circuit would struggle to provide an output potential of around 12·5V at high output currents.

```
Example program

Private Sub Form_Load()

End Sub

Private Sub HScroll1_Change()
Out &H378, HScroll1.Value
Voltage = (HScroll1.Value / 100) + 10
Label1.Caption = Voltage & " VOLTS"
End Sub
```

The modified version of the circuit has the low voltage drop output stage and this provides more "headroom". It can easily handle a maximum output potential of 12·55V at high currents, and would probably just about handle an 11V offset and a maximum output of 13·55V.

Raising the supply voltages is an alternative method of achieving the same ends, but this method is better. It avoids increasing the dissipation in the output transistor and keeps the op.amps well within their recommended maximum supply potential.

Software

A minimal Visual BASIC program is all that is required in order to control the power supply circuit. The example program is shown in action in Fig.5, and is has a horizontal scrollbar to control the output voltage. A label component acts as a digital readout that displays the output voltage. The scrollbar has the required output range of 0 to 255 set via its properties window, so changes in value can be written direct to the printer port address. Of course, the program needs the support of **inpout32.dll** in order to get the OUT instruction to work.

The value from the scrollbar needs a small amount of mathematical manipulation in order to produce a corresponding output voltage that can be displayed on the label component. Dividing the value by one hundred gives a value that is equal to the output voltage from the converter. The offset voltage is then added to this. A value of 10 is used in the example program, but this must be changed to suit the particular offset used. The final value plus "VOLTS" is written to the label component.

Next time the subject of writing control programs using Visual BASIC will be considered in more detail.

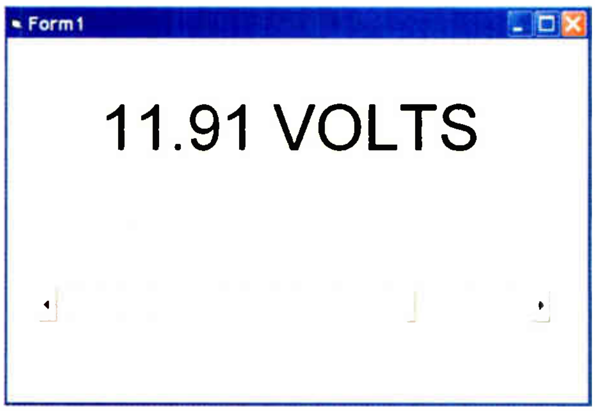

Fig.5. The example control program in operation. It is designed to operate with an off-set potential of +10 volts

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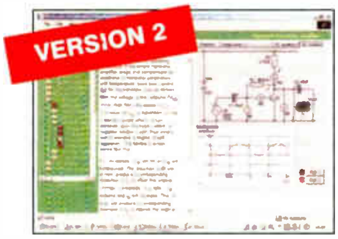

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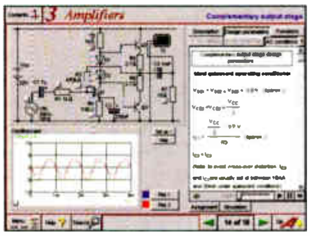

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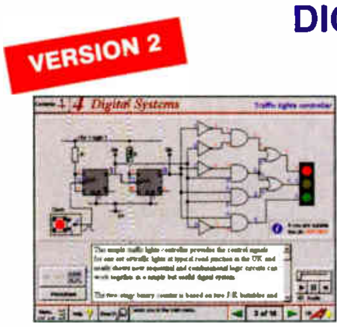

Virtual laboratory – Traffic Lights

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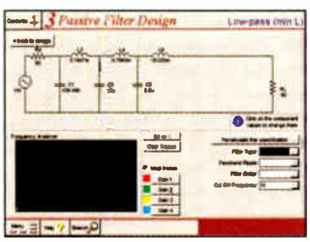

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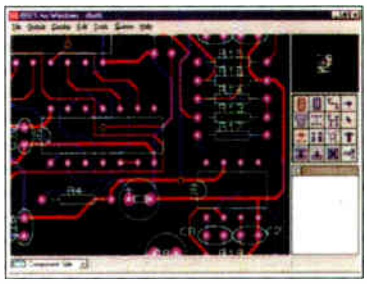

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(Formerly PICtutor)

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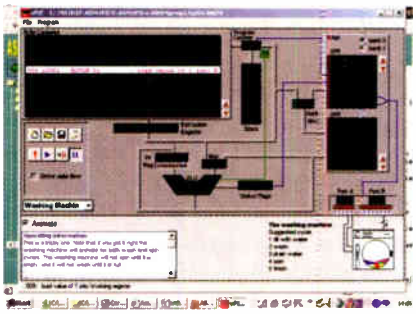

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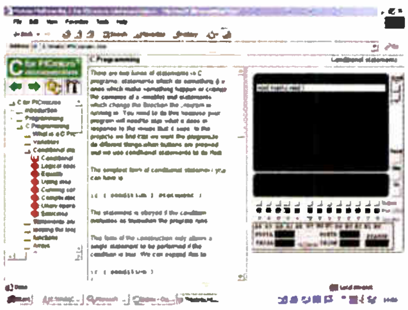

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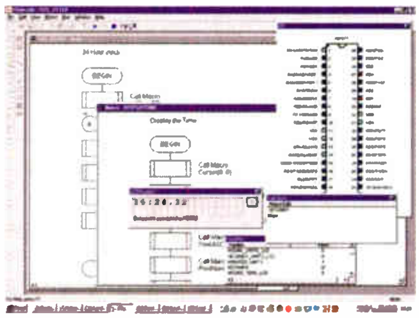

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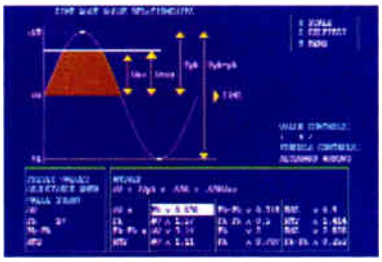

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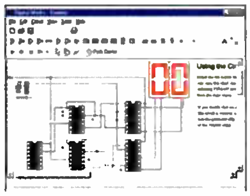

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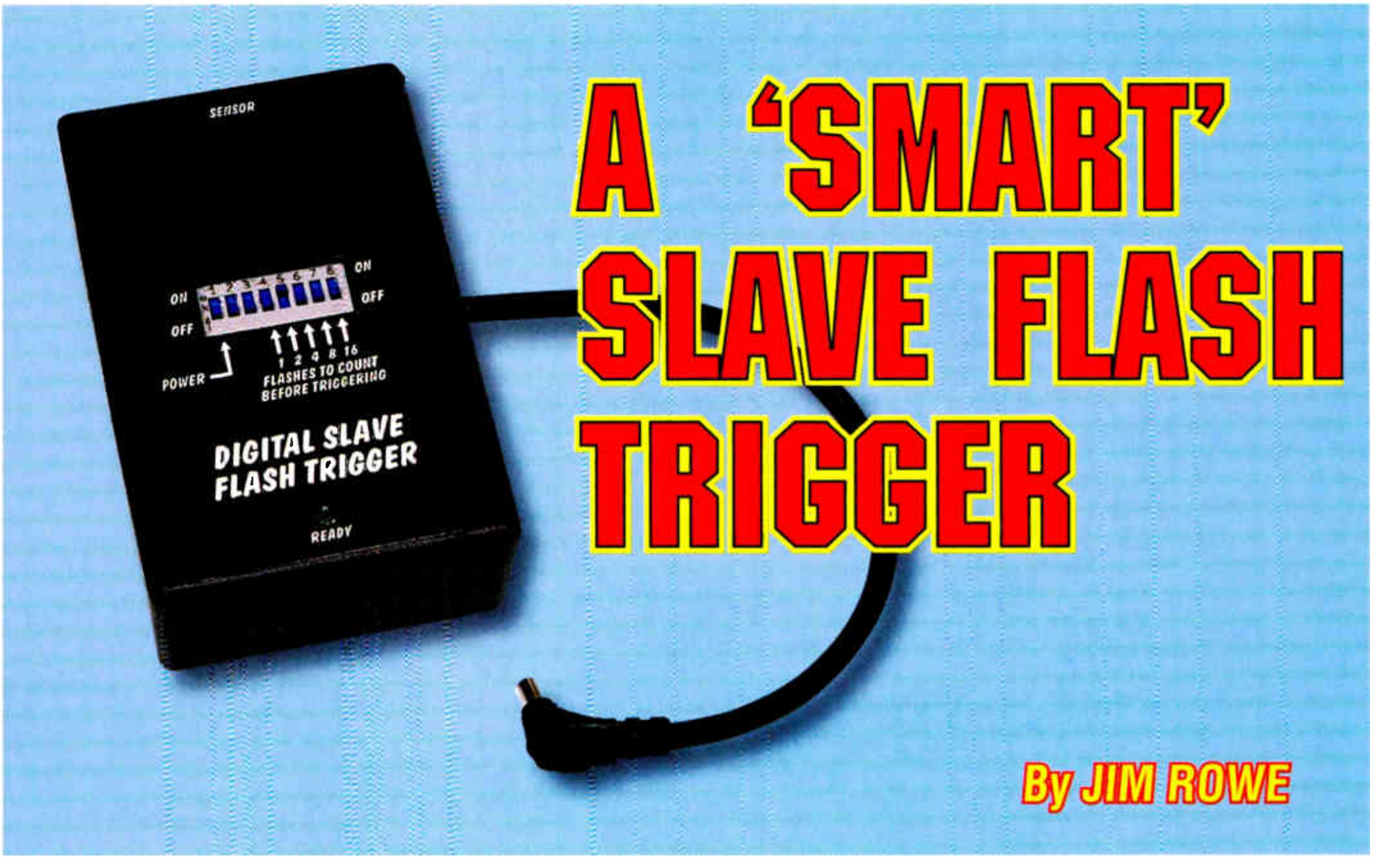


A 'SMART' SLAVE FLASH TRIGGER

By JIM ROWE

Want to use an external flash unit with your new hi-res digital or film camera but it doesn't have a trigger socket or "hot shoe"? Cheer up, this new slave flash trigger will let you do it and it will cope with those cameras which only work in multiple-flash "red-eye reduction" mode. You can build it for a fraction of the cost of similar "smart" trigger units, too.

MOST OF THE LATEST digital still and film cameras have a built-in electronic flash, which at first glance seems great. The trouble is that it's almost impossible to take a good professional photo with only a single flash. They're OK for "happy snaps" but that fixed flash, right next to the lens and pointing in the same direction is a big problem. It gives very "flat" lighting and very dark shadows.

For much better modelling and control of shadows, you really need at least one additional source of light and/or a system of light diffusion. But neither of these options is easy with most digital cameras, not only because of their fixed forward-facing internal flash but because they generally don't have a "hot shoe" or conventional flash contact socket to trigger an external flash.

So the only way to trigger a second flash with these cameras is to use a slave flash trigger unit. This has an optical sensor which detects when the camera's own flash operates, to trigger an external "slave" flash.

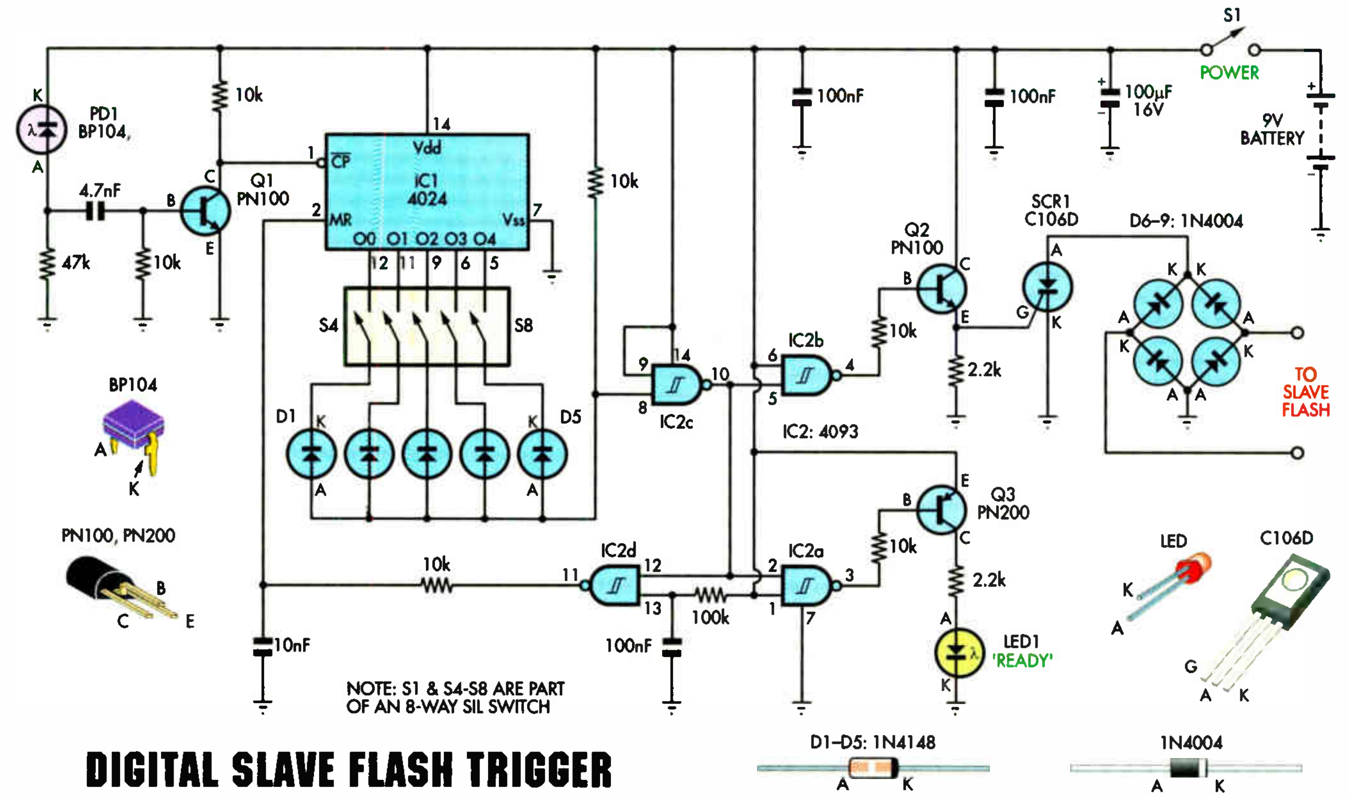
But there is a further complication with many new digital cameras. Their internal flash often operates only in "red-eye reduction" mode, where the flash gives not just one single pulse of light but multiple flashes. There may be one, two or even a bunch of short pre-flashes shortly before the main flash.

This is done so that when you're taking portraits, the irises in your subjects' eyes are made to "stop down" before the main flash. This reduces the reflection of light from their retinas (the cause of that annoying red-eye effect).

It's nice that the camera makers do provide this feature to minimise the red-eye effect. But if you can't turn off red-eye reduction, it makes it impossible to use a conventional slave flash trigger. That's because the first pre-flash will trigger the slave flash unit, long before the camera takes the actual shot!

What's needed is a "smart" slave flash trigger unit which can ignore the red-eye reduction pre-flashes and only trigger the external flash when the camera's main flash occurs. That is exactly what this new trigger unit is designed to do.

This compact, low-cost unit counts up the camera flash pulses and only



DIGITAL SLAVE FLASH TRIGGER

Fig.1: the camera flash is picked up by photodiode PD1 and this drives transistor Q1 which in turn clocks IC1. IC1 is wired as a programmable counter and the output of gate IC2c (pin 10) will go low only when the right number of pulses have been counted. IC2c then triggers SCR1 (via IC2b & Q2) to trigger the slave flash unit.

triggers an external flash unit when the last flash is detected. It operates from a standard 9V battery and everything fits in one of the smallest jiffy boxes (UB5 size).

How it works

At first sight, the circuit of Fig.1 may look a little complex but there is not a lot to it.

PD1 is the photodiode which senses the camera flashes. For PD1 we're using a BP104 device. Actually this has an inbuilt IR (infrared) filter but still has more than adequate response to visible light to do the job here.

PD1 is connected in series with a 47kΩ load resistor across the 9V supply, as a reverse-biased light detector. To make the sensor insensitive to ambient lighting levels, we AC-couple its output to the base of transistor Q1 via a 4·7nF capacitor. As the base is pulled to ground via a 10kΩ resistor, Q1 is normally off; it only conducts briefly when the photodiode detects a flash of light. But during that time Q1 is switched on fully, so that a negative-going pulse of very close to 9V peak appears at its collector.

In other words, the combination of PD1, Q1 and the associated surrounding components forms a sensitive light-to-voltage pulse converter.

The pulses from Q1's collector are fed directly to the clock input of IC1, a 4024 binary counter which is connected as a programmable counter. To make IC1 programmable, we've added logic circuitry involving DIL switches S4-S8, diodes D1-D5 and gates IC2c & IC2d. The two gates are part of IC2, a 4093 quad Schmitt NAND device.

Programmable counter

The programmable counter works as follows. The cathodes of diodes D1-D5 are each connected to one of the five counter outputs O0-O4 via one of the DIL switches. The anodes of all five diodes are connected together and to +9V via a 10kΩ pull-up resistor.

This diode arrangement functions as a five-input AND gate, because the output (the junction of the five diode anodes and the 10kΩ resistor) can only be pulled up to +9V (logic high) when all five diode cathodes are also at logic high. If any diode cathode is pulled low, it pulls the output low as well.

So if we close switches S4 and S5, this means that the gate output can only go high when IC1 has counted three pulses (so that its outputs O0 and O1 both go high). We can therefore program the counter for any desired pulse count, simply by setting the DIL switches for the binary equivalent of that number. The switches can be set for a total pulse count between 1 and 31 – more than enough for our needs.

The output of the diode AND gate is connected to pin 8 of IC2c, used here as an inverter. And IC2c's output (pin 10) is connected to pin 12 of IC2d, which is again used as an inverter. Pin 11 of IC2d is connected to the master reset input (pin 2) of counter IC1 via a small RC delay circuit (series 10kΩ resistor and 10nF bypass capacitor). This means that shortly after the programmed count is reached, the counter is reset, ready for the next sequence of flashes.

By the way, the 100kΩ resistor and 100nF capacitor connected to the second input of IC2d (pin 13) form a simple power-up reset circuit, to ensure that the counter is reset to zero when power is first turned on.

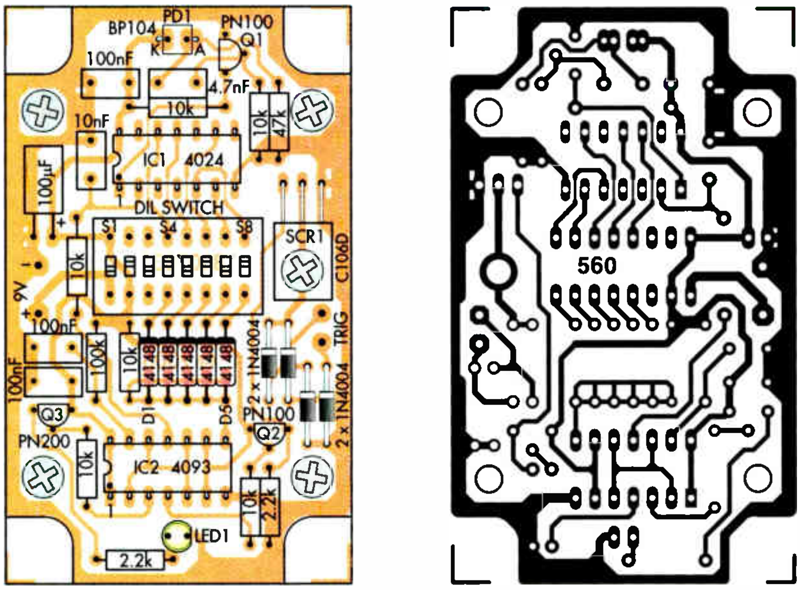


Fig.2: here's how to install the parts on the PC board. Note that the 100µF capacitor must be mounted on its side, while transistors Q1-Q3 must all be bent over so that they sit close to the board surface (see text). The full-size etching pattern for the PC board is at right.

Summarising the action so far, we now have a light pulse sensor and counter which can be programmed using the DIL switches so that the output of IC2c (pin 10) will go low only when the right number of pulses have been counted. It also goes low only briefly (about 75µs), because of the way the counter is then quickly reset via IC2d.

This narrow pulse from IC2c is used to trigger the slave flash. It is inverted by IC2b which drives transistor Q2. The resulting narrow pulse at the emitter of Q2 is then used to switch on SCR1, which acts as the triggering "contacts" for our slave flash unit.

SCR1 is a 400V-rated C106D silicon-controlled rectifier, which is connected to the slave flash trigger input via the bridge formed by diodes D6-D9. The bridge ensures that the voltage applied across SCR1 from the flash unit is always of the right polarity (ie, positive to the anode), regardless of the circuitry inside your flash unit.

So that's how the main part of the trigger circuitry works. The only part left to explain is the purpose of gate IC2a, transistor Q3 and LED1. These provide a simple power-on indicator, as well as indicating that the counter circuit is reset and ready for the next flash pulse sequence.

Gate IC2a is again connected as a simple inverter, so that when the counter is reset and waiting for pulses, output pin 3 is held low (because pins 10, 2, 1 and 12 are high). This turns on PNP transistor Q3, which allows a low current (about 3·5mA) to pass through LED1. The LED therefore glows weakly, showing both that the power is turned on and that the counter has been correctly reset. The LED goes out for the duration of the slave flash trigger pulse but it comes back on again as soon as the counter resets.

The complete circuit draws only about 4mA from the 9V battery, which should therefore give a very long service life.

Construction

As can be seen from the photos, all of the slave flash trigger's circuitry fits on a small PC board which measures 76 × 45mm and is coded 560 (available from the *EPE PCB Service*). The board has cutouts in each corner so it fits snugly inside a standard UB5-size plastic jiffy box, with the battery underneath.

Programming switches S4-S8 and power switch S1 are actually all part of an 8-way DIL switch, making it cheap and compact. This is mounted in the centre of the board. The left-most switch is the power switch (S1), while the five nearest the right-hand end are used for programming (S4-S8). The two remaining switches (S2 & S3) are not used.

Photodiode PD1 is mounted at the top of the board (Fig.2). A pair of PC board terminal pins and the diode's very short leads soldered to the pins so that the top surface of the diode is 6mm above the board.

The complete PC board assembly is mounted behind the lid of the jiffy box, using four M3 tapped Nylon spacers 6·3mm long. The spacers are attached to the lid using four 6mm × M3 machine screws with countersink heads, while the board is fitted to the spacers using four round head 6mm × M3 machine screws with lock washers.

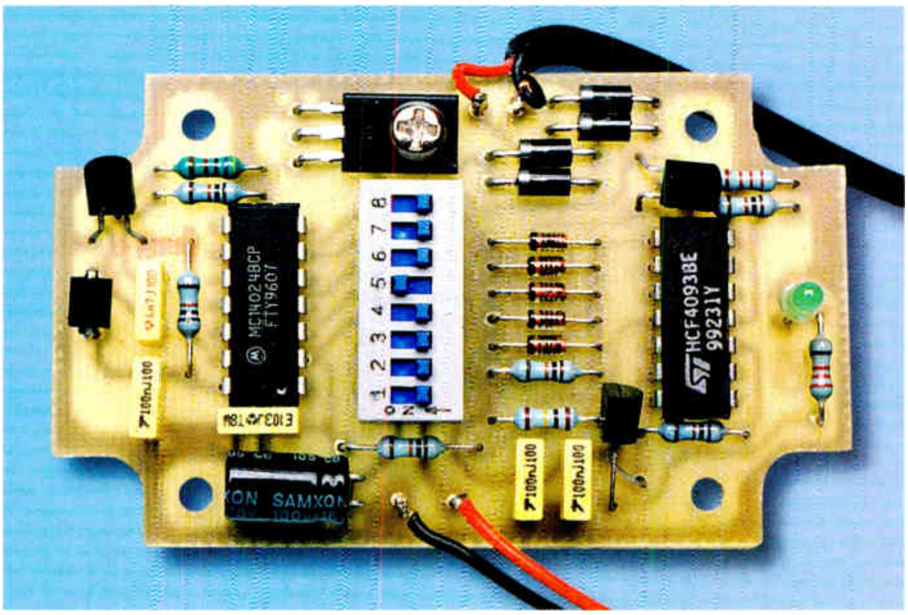
The lid has a central rectangular cutout to allow easy access to the switches and small circular holes top and bottom – one to allow light to reach PD1 and the other to allow LED1 to protrude through and be seen.

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0·1µF	100n	104
10nF	(0·01µF)	10n	103
4·7nF	(0·0047µF)	4n7	472

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	6	10kΩ	brown black orange brown	brown black black red brown
❑	2	2·2kΩ	red red red brown	red red black brown brown



This is the fully-assembled PC board, ready for mounting inside the case. The DIL switch sets the number of flashes from the main flash unit before the slave is triggered (see text).

The board mounting details should be fairly clear from Fig.3.

By mounting the board assembly only 6·3mm behind the box lid, we provide just enough room inside the box to fit the 9V battery – plus a sheet of thin plastic to ensure that the battery case can't short out any of the board wiring.

Assembling the board

The location of all of the parts on the PC board is shown in Fig.2. Note that because the board must be mounted only 6·3mm behind the case lid, some of the taller parts have to bent over so that they fit into this space.

We suggest you begin assembling the board by fitting the PC board terminal pins. There are two on the left side of the board for battery connections and another two on the right for the flash trigger output lead connections. Plus two more pins at the top centre for the BP104. If the tops of all six pins are longer than 6·3mm, cut them so that they are only about 5mm long.

Now you can fit the resistors, which all mount flat down against the board. This is also the case with the diodes, which all mount with their cathode ends towards the top the board.

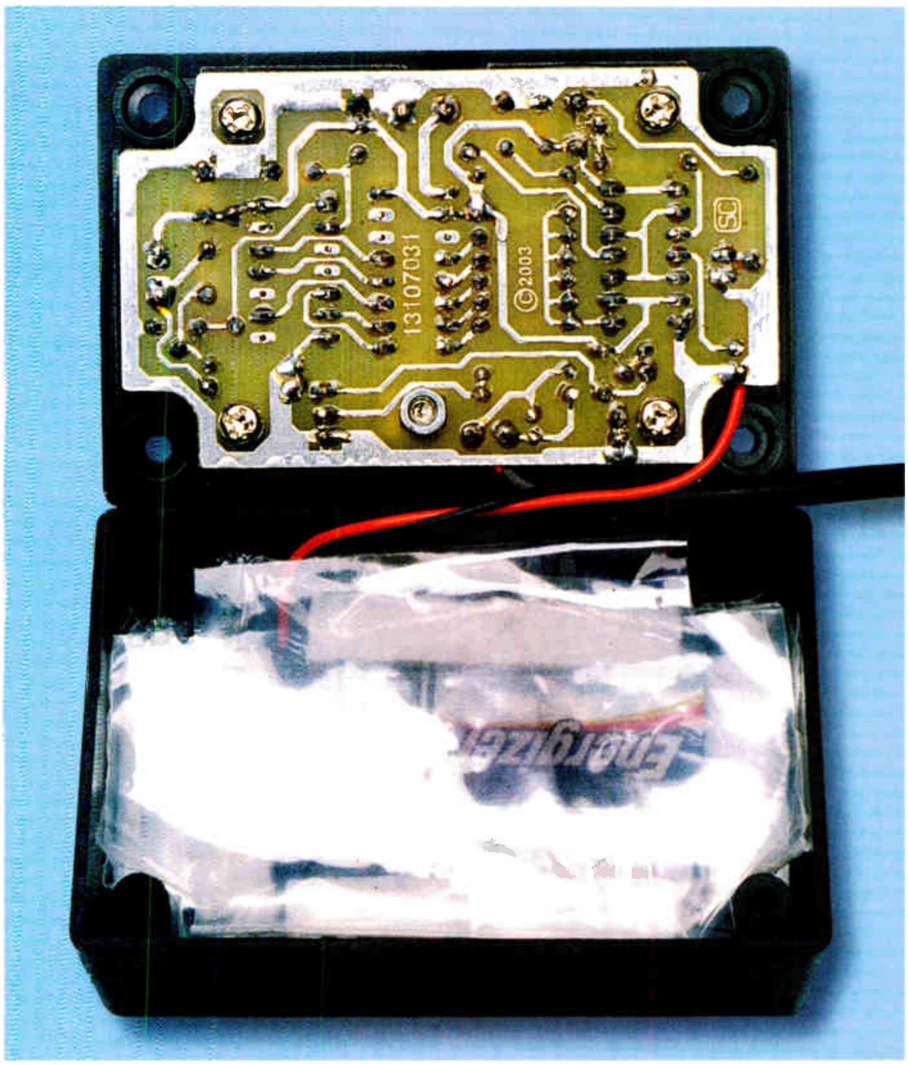
The capacitors can all be fitted next. Note that the 100µF electrolytic mounts on its side as shown and make sure you get the polarity right.

Next, fit the SCR. It mounts with its "metal insert" face down against the board. All three leads are bent down at 90° at a distance of 5mm from the body, so they pass through the board holes. The device itself is held down using a 6mm x M3 machine screw and nut.

IC1 and IC2 can be fitted next, taking care to fit them the correct way around. Observe the usual precautions to avoid damage due to static charge, too – remember that both devices are CMOS types.

Now fit the three transistors. These all have to be mounted leaning over so they will allow the board assembly to be fitted only 6·3mm behind the case lid.

For the two PN100 devices, this is achieved by carefully bending their three leads so the centre base lead is about 3mm shorter than the other two when they are passed down through the board holes. In other words these transistors have their leads bent so



The 9V battery sits in the bottom of the case and is wedged in position using pieces of foam. A sheet of plastic is then fitted over the top of the battery, to prevent it shorting against the bottom of the PC board.

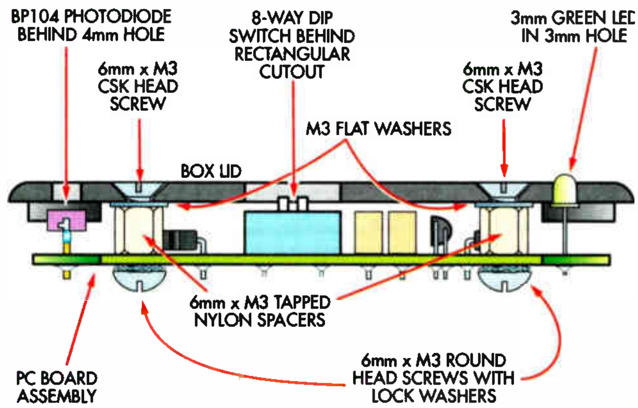


Fig.3: the PC board is attached to the lid of the case on 6.3mm spacers and secured using machine screws, nuts and washers.

The close-up view shows the completed assembly, just before it is fitted to the case. The flash trigger lead emerges through a small semicircular notch near the top centre of one side of the jiffy box.

they are mounted leaning back, with the short base lead underneath and the two longer leads bending down at about 60°.

There isn't space to mount the PN200 transistor Q3 in this way, because it's quite close to one of the Nylon mounting spacers. So Q3 has all three leads bent at 90° towards the emitter side, so it can be mounted "side on" with its body between IC2 and the 100kΩ resistor. The flat side of the body is towards the 100kΩ resistor, with the emitter lead lowest and the collector lead uppermost.

The 8-way DIL switch is fitted next, taking care to fit it with the 'ON' side of the switches towards IC1. Also make sure when you're soldering its pins to the board pads that you don't accidentally link the pads with fine solder bridges.

Now fit photodiode PD1; cut off both PC board pins at a point 3mm above the board. Then very carefully bend the leads of the BP104 down at right angles about 1mm from the body and solder them to the PC board pins. The flat top of the diode should be horizontal and just 6mm above the top of the board. Make sure you solder the diode's cathode lead (the one with the small side tag) to the pin furthest from transistor Q1.

With the photodiode fitted, only two steps remain to complete the PC board assembly. One is to fit the 3mm Ready LED, making sure that the longer anode lead is nearest to the 2·2kΩ series resistor and the "flat" side of the body is towards the 10kΩ resistor. Also take care that you solder the leads with the LED and its leads truly vertical, and with the bottom of the LED's body just 5mm above the board.

The final step is to connect the 9V battery clip lead, the wires of which connect to the PC board terminal pins over on the lefthand side. Note that the red wire connects to the lower pin (ie, the one nearer the two 100nF capacitors), while the black wire connects to the upper pin (nearer the 100µF electrolytic).

Preparing the case

Your board assembly should now be complete, and you can put it aside while you prepare the box lid. If you're building the project from scratch, this will involve drilling and cutting the required holes using the drilling template of Fig.4 as a guide.

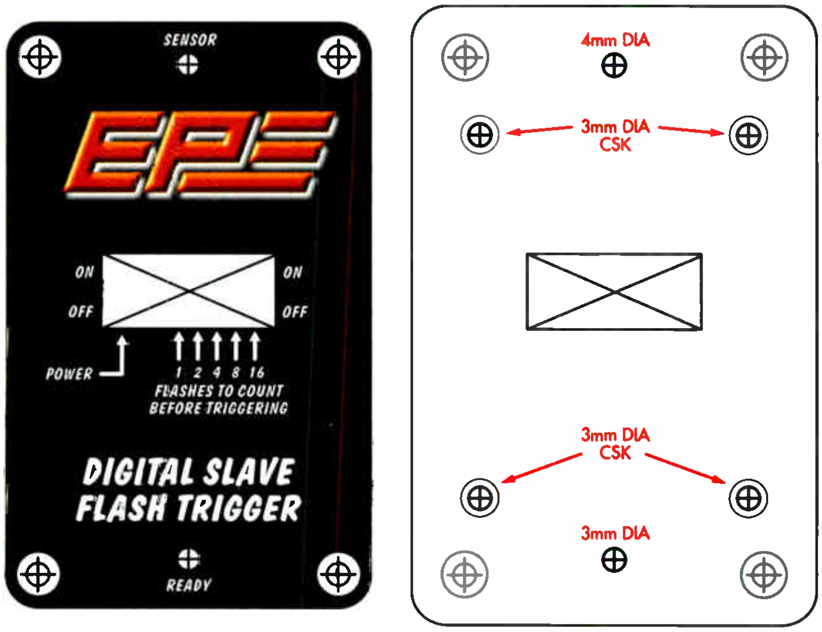
Note that the four 3mm holes for the board mounting spacer screws are countersunk at the top, so that the tops of the screws will be flush with the lid's upper surface. This allows them to be hidden beneath a stick-on front panel if one is used.

Once the lid is prepared, you can attach the four 6·3mm tapped Nylon spacers to it using four 6mm × M3 countersink-head machine screws plus four M3 flat washers (see Fig.3). Then you should be able to mount the PC board assembly on the four spacers in turn, using four 6mm × M3 round-head screws and lockwashers.

There's only one remaining step before you can test the trigger unit and finish its assembly. This is to fit a suitable output lead, to connect to the external flash unit it will be triggering. The main requirement here is that this lead will need to be fitted at the far end with a connector to suit the trigger input of the flash unit.

If the flash unit has a conventional 3mm concentric connector, your best approach is probably to buy a short flash extension lead from a photographic store and cut off the unwanted connector so the wires at the free end can be soldered to the output pins on the trigger unit board.

On the other hand, if your flash unit is only fitted with a "hot foot" connector, you will have to either salvage a matching "hot shoe" connector from a junked camera or make one yourself. This could be done with some pieces of blank PC board laminate or some 1mm sheet brass and a piece of insulating material. That done, the hot shoe connections can be wired to the trigger unit's output pins with a length of shielded audio cable.



FRONT PANEL

LID DRILLING TEMPLATE

Fig.4: here are the full-size artworks for the front panel and the drilling template for the case lid.

Parts List

1 PC board, code 560, available from the *EPE PCB Service*, 45 x 76mm
1 Jiffy box, UB5 size (83 x 54 x 28mm)
1 8-way DIL switch (S1, S4-S8)
1 9V alkaline battery, 916/PP3 type
1 battery clip lead to suit
6 PC board terminal pins
4 6·3mm M3 tapped spacers (Nylon)
4 6mm x M3 screws, countersink head
4 6mm x M3 screws, round head
1 6mm x M3 machine screw & M3 nut
4 M3 flat washers
1 flash trigger lead with connector

Semiconductors
1 4024 binary counter (IC1)
1 4093 quad Schmitt NAND (IC2)
1 C106D 400V SCR (SCR1)
2 PN100 NPN transistors (Q1,Q2)
1 PN200 PNP transistor (Q3)
1 BP104 or photodiode (PD1)
1 3mm green LED (LED1)
5 1N4148 diodes (D1-D5)
4 1N4004 diodes (D6-D9)

Capacitors
1 100µF 16V electrolytic
3 100nF (0·1µF) MKT polyester
1 10nF (0·01µF) MKT polyester
1 4·7nF (0·0047µF) MKT polyester

Resistors (0·25W, 1%)

1 100kΩ	6 10kΩ
1 47kΩ	2 2·2kΩ

Checkout time

Ready to roll? Make sure that all the DIL switches are set to Off (down) and connect a 9V battery to the clip lead. That done, switch on S1, set timing switch S4 to On (leave S5-S8 Off) and check that the green Ready LED lights.

Now connect your slave flash unit to the trigger unit's output lead and turn on its own power switch so the flash capacitor becomes charged and ready for action. Also get your camera ready and set it for flash operation.

To check out the trigger unit's basic operation, set timing switch S4 only to the On position and then press the shutter release of the camera to produce a flash (or more than one, if it's only capable of working in red-eye reduction mode). You don't need to aim the camera flash at the trigger unit's sensor – aiming it at the ceiling should be fine.

As soon as the camera's flash (or first flash) occurs, you should also see the slave flash fire. Assuming this is the case, your trigger unit is probably working correctly.

If not, you may have made a wiring mistake somewhere. Perhaps you've connected a component the wrong way around or bridged a couple of tracks on the board with a whisker of solder. So turn off the flash unit and disconnect it from the trigger unit, then unclip the trigger unit's 9V battery and look for the problem.

Once the trigger unit is operating correctly, you can then set the DIL switches so that the trigger unit only operates the slave flash in response to the camera's main flash. Of course, if the camera is able to be operated in normal single-flash mode, there's nothing further to be done.

Setting the flash count

You've already set the trigger unit to respond to the first camera flash, by turning on only DIL switch S4. As you've probably realised by now this is the correct setting for cameras that can operate in this mode.

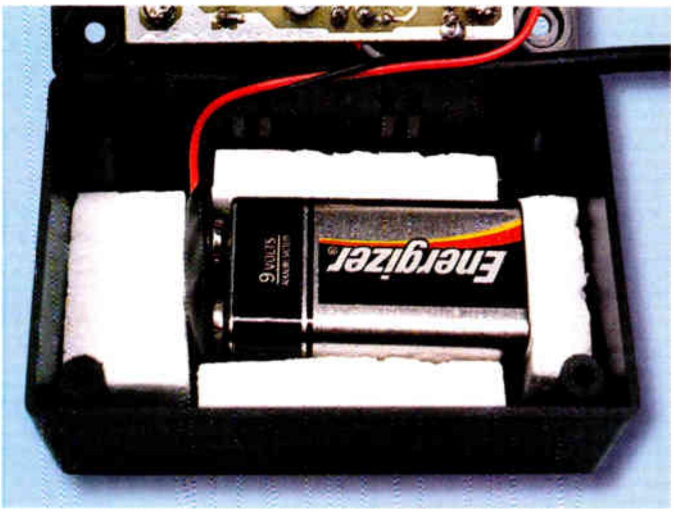
Even if your camera can only operate in multi-flash red-eye reduction mode, it's still quite easy to find the correct switch setting. You don't have to count exactly how many flashes the camera does produce for each shot. Just have a guess and set the trigger unit's switches initially to that figure.

For example, if you think it produces five flashes in all (four pre-flashes and the main flash), turn on switches S4 (1) and S6 (4). Then press the camera's shutter release to take a 'shot', and see if the slave flash is triggered.

If it does fire, you've either guessed the total number of camera flashes correctly or you have underestimated.

To find out which, increase the switch setting by one (ie, S4 off, and S5 and S6 on, for 2 + 4 = 6) and try again. If the slave flash still operates, you did underestimate the number of camera flashes the first time – so increase the setting by one more and try again.

Conversely, if the slave flash doesn't fire this second time, your previous guess must have been correct. In this case, return the switches to their previous setting and your trigger unit is correctly set up.



This view shows how the 9V battery is wedged in position using polystyrene foam. Note the semi-circular groove in the back of the case for the flash trigger lead.

In short, the correct setting for the trigger unit's flash count programming switches is the highest count that still results in the slave flash being triggered for each flash shot – because it's being triggered on the last and 'main' camera flash.

Final assembly

Once you've completed this check-out and setting up procedure, your trigger unit is ready for final assembly. Just before doing this, though, you'll need to file a small semicircular notch near the top centre of one side of the jiffy box, to allow the output trigger lead to exit the box when it's assembled.

To work out exactly where the notch should be located, offer the lid and PC board assembly up to the top of the box, and mark the position where the lead will need to exit for minimum strain on the lead and the connections. Then file the notch with a rat-tail file, making it only just large enough for the lead – so that when the lid is screwed to the box, the lead will be securely clamped.

Now place the 9V battery (still connected to the trigger board via the clip lead) in the centre of the box and cut four small pieces of expanded polystyrene foam to go around it and hold it in position. That done, cut a piece of thin sheet plastic to the same size and shape as the trigger unit PC board, to provide an insulating layer above the battery.

You can now fit the lid/board assembly to the box, winding the battery lead carefully around so it doesn't get caught between the edge of the lid and the box rim. The final step is to fit the four screws provided with the box, to hold everything together firmly.

Your Slave Flash Trigger unit is now ready for action. *EPE*

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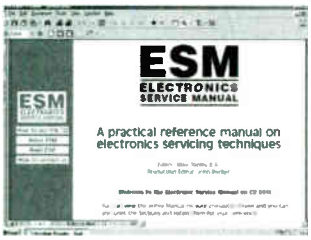

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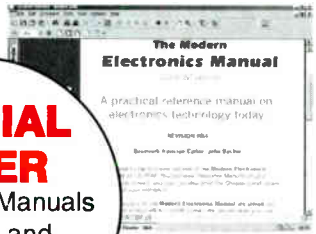

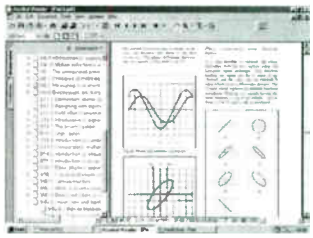

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eChip Review

By ROBERT PENFOLD

IT IS difficult to categorise the eChip training system. Although it is an educational system based on PIC microcontrollers, it is not intended as a means of learning about PICs. Strangely perhaps, it is designed to teach the user how to utilize conventional logic circuits to build practical devices.

These days most students learn about logic circuits by either using computer-based circuit simulators, or by reading about them in textbooks. Hands-on experience is strictly limited due to time and cost considerations. The purpose of this system is to provide a form of hands-on experience, but more cheaply and quickly than using the "real thing".

Basic idea

The basic idea is to design a logic circuit and produced the circuit diagram using a computer-based system. Next the circuit is compiled into PIC code, and transferred to the hardware. The latter is, of course, a simple PIC based circuit, which is then used to emulate the logic circuit. The PIC microcontroller version of the circuit avoids the substantial amount of time it would take to solder together the real thing. On the other hand, it does provide something more tangible than a simulation. Although you have what is still essentially a form of simulation, it does at least have real switches, lights, or whatever.

The real thing?

Unfortunately, despite its advantages, there is no getting away from the fact that the hardware side of this system is not quite the real thing. It does have inputs and outputs that behave in the appropriate fashion. However, any inputs and outputs that are purely internal parts of the circuit cannot be accessed and checked because they do not even exist in virtual form. It is the overall action of the circuit that is simulated and not the individual building blocks.

You certainly avoid the time taken up designing circuit boards and soldering everything together, but you also lose the experience that this provides. No doubt some will consider that this lack of practical experience renders the system invalid, but it is certainly one step closer to the real thing than using a system that is solely based on a computer simulation. You have to make up your own mind as to whether the eChip system represents a worthwhile compromise.

Whatever your feelings about its other merits, a big plus point for this system is that it is very easy to make changes to circuits. In many cases it is just a matter of reprogramming the PIC chip, with no actual hardware changes being required. It is also possible to "build" and to test a wide range of systems in a short space of time. It is probably possible to cover almost as much ground as using a pure simulation, but with the eChip system you have a degree of practical experience.

How it works

That is the rationale behind the system, but how well does it actually work in practice? The software is provided on a mini CD-ROM, which auto-runs and produces a Welcome screen. This provides some general information about the system, and links that are used to install the software in standard Windows fashion.

The software is not particularly demanding in terms of the required hardware, and the system should work perfectly well with any PC that is capable of running a modern version of Windows. As with any system that involves drawing on-screen circuit diagrams, a high-resolution screen is a decided asset.

Hardware

The hardware side of the system connects to the PC via a standard nine-pin serial port. For most users this is a good choice, because most PCs have a spare serial port these days. Unfortunately, it is increasingly common for new PCs to lack a serial port. In most cases the serial port hardware is actually present on the motherboard, but the sockets and leads to make the connections to the outside world are not always included as standard.

Due to a lack of serial ports on my newly acquired PC I had to revert to an older PC for this review, although I did eventually mange to get hold of the optional serial port back-plate and leads for the new PC. Using a USB connection for this system would have provided better future-proofing.

The system supplied for review consists of two main parts, one of which is an RS232C Interface board (Photo.1). This really just acts as a level shifter that enables the second unit to handle the nominal plus and minus 12V signal levels of an RS232C serial port.

The second PIC Prototyping board (Photo.2) contains the PIC chip, and the latter handles the serial encoding and decoding as well as providing the hardware circuit simulation. This board has a prototyping area that measures about 40mm by 40mm. This area can be used to accommodate LED displays, switches, or whatever, so that the simulated circuit can be tested. Both boards are nicely made, but they are constructed from a very thin grade of copper laminate board. Something a bit tougher might have been a better choice for the PIC board.

Connections

The supplied lead provides the connection from the 9-pin serial port to the 3-way connector of the Interface board, but it is a bit short at only about 0·5 metres in length. A lead two or three times longer would be more convenient in use. A simple three-way lead interconnects the interface and PIC boards.

The Interface board requires a PP3 battery or six AA size cells in a holder. A separate supply is required for the PIC board, which can be four AA size cells in a holder. Of course, an addition supply or supplies might be needed if the unit is used to control motors, solenoids, etc.

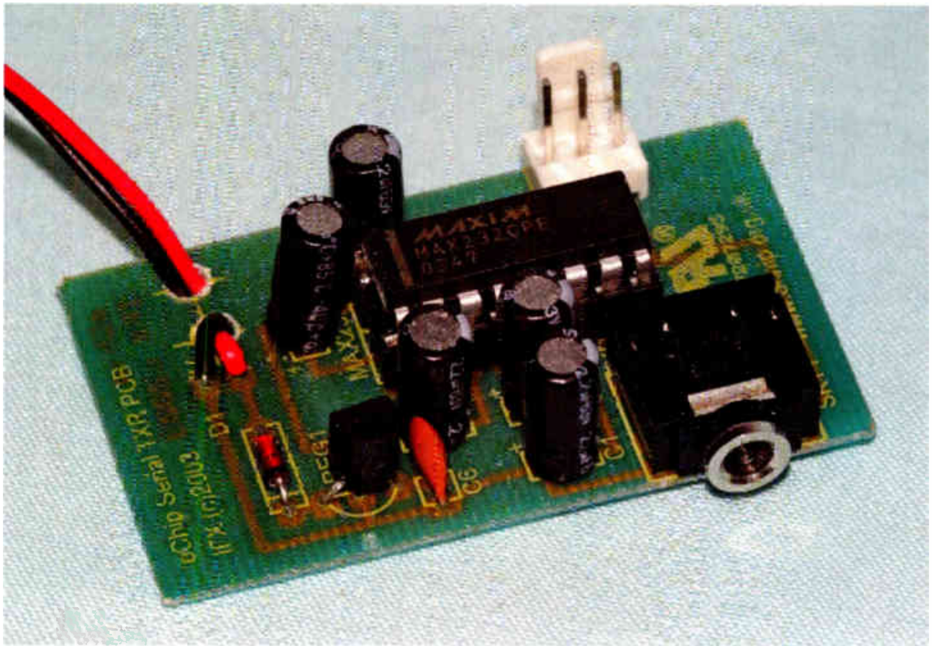

Photo 1. The main RS232 Interface printed circuit board for the eChip training system

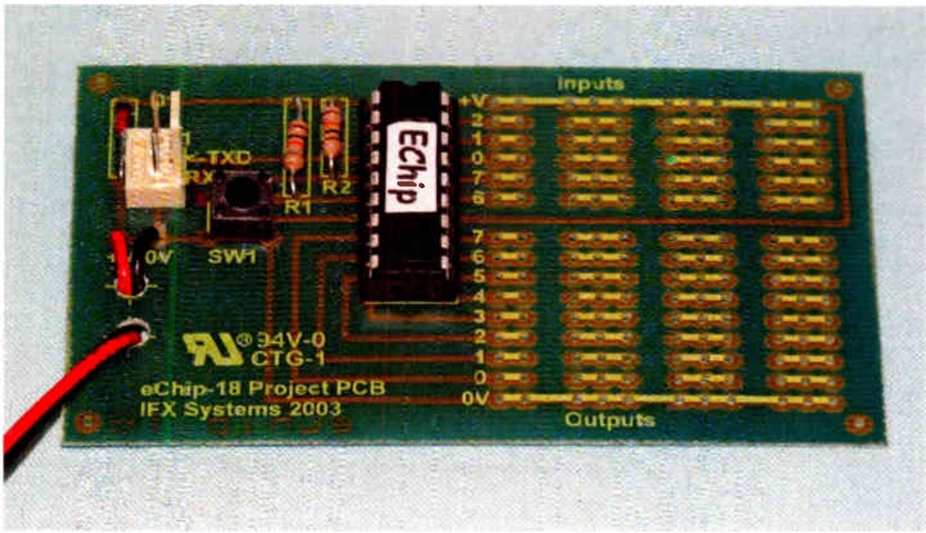

Photo 2. The PIC printed circuit board has a prototyping area and requires a separate voltage supply

Programming

Although eChip is PIC-based, there is no associated programming language. The system needs a circuit to emulate, but this is produced by drawing the circuit using the eChip program (Photo.3). The program generates the appropriate code for each circuit produced. The user can therefore concentrate on the logic circuit side of things, and largely ignore the fact that the final hardware is PIC based.

The eChip program has the usual menu bar at the top with a toolbar beneath. There are four moveable and resizable windows in the main screen area, and one of these is used to produce the circuit diagram. Another has a scrollable palette containing the various logic building blocks. These include such things as gates, latches, and an astable, plus input and output ports so that the circuit can be connected to the outside world. The third window acts as a status area for system messages, and the fourth contains the ICE (in-circuit emulator). This provides direct control of the eChip outputs and is used for faultfinding and testing.

In order to produce a circuit diagram it is first a matter of dragging some logic blocks from the palette window into the drawing area. The connections between the various circuit elements are produced by left-clicking at each start

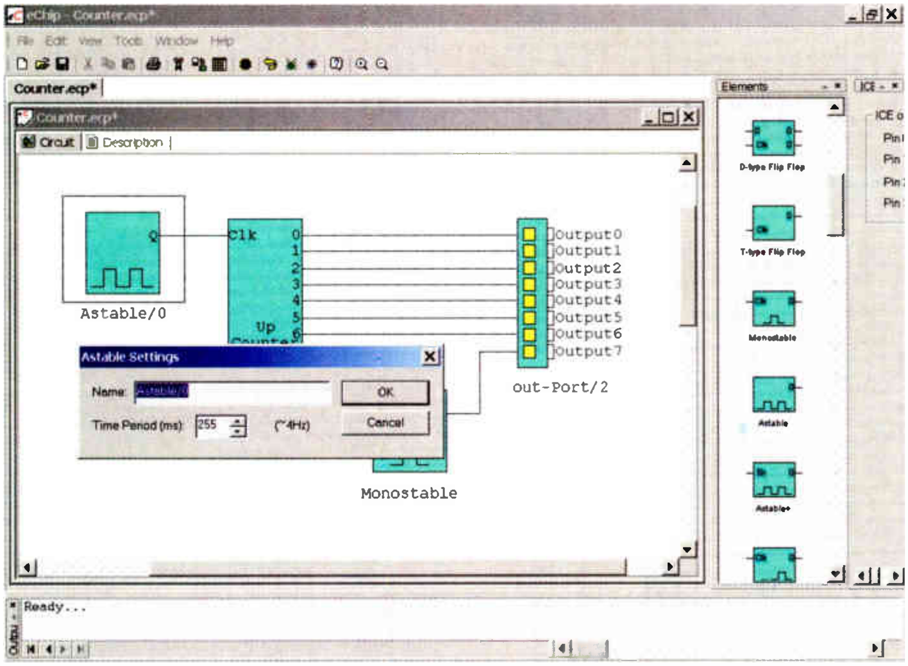

Photo 3. A circuit drawn using the eChip program. The dialogue box shown is for an Astable

point and dragging a line to the finish point. If a mistake is made or a circuit has to be modified it is easy to delete a line or change its start and finish points. In other respects the routing facilities are very basic, but as this system would not be used to produce complex circuits they should be adequate.

Adjustable parameters

Some of the circuit blocks have parameters that can be adjusted. With an astable for example, the frequency can be altered. Where appropriate, double-clicking a symbol in the drawing area brings up a dialogue box that enables any adjustable parameters to be set to the required figures. In the example of Photo.3, the dialogue box is for an astable. The period of one cycle can be set between one and 250 milliseconds, and the corresponding frequency is shown in the dialogue box.

Having produced a circuit it is then just a matter of using the Compile function to produce the corresponding program and upload it to the PIC board via the Interface board. It is only necessary to have the PIC board connected to the rest of the system when communication with the PC is required. In other words, when using the ICE facility, programming the PIC, or something similar.

The PIC board can be disconnected from the Interface board once the program for a circuit has been uploaded. It then provides a standalone simulation of the circuit. A small pushbutton switch on the PIC board enables the circuit to be reset.

Manuals

The documentation is in the form of several Adobe PDF files rather than printed matter. The Adobe Acrobat Reader program is needed in order to view these files, but most PCs will already have this software installed. For those that do not already use this program it is included on the mini CD-ROM. If you prefer manuals of the paper variety it is easy to print the files via the reader program.

The "manuals" are brief and to the point, but they are clear, well written, and tell you everything you need to know to set up and use the system. There are a few simple examples to help test the system and get the user underway, but the eChip system is not intended to be used on its own as a system to teach students all about logic circuits. It is designed to be used as part of a course, and to operate in conjunction with suitable course material.

Conclusion

This system works well enough and "does what it says on the can". If you are happy with the concept of the eChip system then you will almost certainly find it well worth the money. It provides plenty of scope to "do your own thing", which is important for any system that will be used in a learning environment. It is firmly aimed at educational establishments, where the potential time and cost savings will be important. The eChip system would seem to have limited appeal for individuals wishing to learn about conventional logic circuits, as they would presumably opt for the real thing.

There were one or two minor causes for concern when testing the review system. The choice of a serial interface for communication with the PC is less than ideal. PC game ports are now long-gone, and serial ports seem to be next on the "hit list". As things stand, most PCs have at least one serial port, but they are becoming rare on new PCs. This could make it difficult to keep the system in use for years to come.

There were a few strange problems with start-up errors when testing the system with three different PCs. For example, the program will not start if no printer is installed, or if the default printer is offline. Making the software a little less pernickety would make it quicker and easier to get the system "up and running".

Availability

The eChip system is available from IFX Systems, 15 Willow Tree Close, Keighley, BD21 4RZ, and also from Rapid Electronics. Further details can be obtained at **www.echip,org.uk**.

The kit containing the software, both boards, and the two leads costs £40 plus VAT. Various individual components are also available. ***EPE***

READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

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★ LETTER OF THE MONTH ★

Digital Terrestrial TV

Dear EPE,

May I thank David Sharp (*Readout*, Dec '05) for his kind remarks, and George Chatley for a balancing view. Typical, is it not, for Londoners to think that what's good for them is also best for everyone else!

David adds some very interesting and educational information to the debate, but unfortunately can be interpreted as an advocate for analogue switch off. With the analogue channels out of the way, the power can be turned up on the digital channels and all the problems will largely disappear – digital is digital after all, and fairly robust until the bitstream dies completely.

However, only recently has the ex-boss of *Channel 5* gone public with his opinion of the extraordinary cost of analogue switch off. With the steamroller apparently unstoppable, I have begun considering how it can be lived with – not so much for myself, I can find other things to do – but for those around me.

I have a grandmother in her 90s, and a close relationship with a lady in her 80s, so I have first hand experience of how badly elderly people react to things that change.

First of all, my grandmother's TV doesn't have a SCART socket, so just plugging in a Freeview box is a non-runner. Even if it was, and some kind person (me!) sets it up so that button "1" gives you BBC 1 etc, just press the wrong button by accident and the menus that come up will cause no end of confusion and trouble. Before that, of course, the TV itself would need switching to the AV input. Will a TV with built-in Freeview be any easier to operate? Who is going to pay for it?

My 80 year old has a number of TVs around the house, only one of which has SCART (neither of my own TVs have SCART, and neither is in imminent need of replacement). The aerial system is fed around the house with a series of splitters and distribution amplifiers, having first "visited" the VCR so she can watch video playback (and the security camera) anywhere in the house. If the non-SCART TVs were replaced, and digiboxes fitted everywhere (at what cost?), would the aerial distribution be up to the job? I don't think this scenario can be all that rare.

I have a solution, not cheap, but it would address the problems and make analogue switch off a relatively smooth and trouble free process. The answer is to mass-produce a box that takes a digital aerial feed at one end, decodes the bitstream into the four terrestrial channels (or five if you insist!), and outputs them simultaneously on separate UHF channels for direct connection to the aerial input of a normal TV/VCR. It should do this from power-up without user intervention, and even better if it can be configured to output on the same frequencies that are used in the area (saves retuning TVs, but not an essential). TVs etc would then work just the same, with no need for retraining the users, except maybe the lack of Teletext, Nicam stereo, or PDC.

I reckon I can do this (more or less) using four Freeview boxes and four UHF modulators, but surely such a box could be manufactured for the cost of, say, two Freeview boxes. These boxes should then be available for sale, and issued free to households that get winter fuel allowance or free TV licensing. It may also be of interest to hotels with distribution amplifiers feeding hundreds of rooms. I would buy one!

Ken Wood, via email

I do agree with you Ken – I too have one of the many varieties of a Freeview box and am constantly left with the feeling that there must be better ways of doing things. But I must add that I do periodically welcome the additional channels that I can get.

I also have the problem that the remote control with the Freeview does not seem to have the range that I've become used to with other remotes around the house, and in a largish lounge it does mean that the set has to be maintained in a more constant position than other equipment that I have.

No doubt having a combined unit would be useful, but then I dare say that I shall eventually update the analogue TV to one suited to digital. I'm left with the feeling, though, that following on from what Mark Nelson reported in Techno Talk *Dec '05, the time is not yet ripe for that. So I guess I'll live with the situation for the time-being.*

Teach-In 2006 Feedback

Dear EPE,

Referring to the December '05 issue, I am delighted to see the *Teach-In 2006* electronics course (have been really interested in electronics but never put in a lot of effort and was quite reluctant to tackle mathematic calculations in this domain).

Unfortunately, I think I have spotted an error: on page 844 in Fig.2.10, the current *I1* should be 0·33A and not 0·53A as specified.

Emmanuel, via email

Mike Tooley replied:

Hello Emmanuel, many thanks for getting in touch. This isn't an error in the text – it's just that your calculations are not quite right! Let me see if I can explain:

In Fig.2.10 there are two branches – one to the left (through R1) and one to the right (through R2). The current flowing in B1 is the *sum* of the these two currents. The current in B2 is the same as the current in the right branch. Are you happy with that? Hope so!

So, let's calculate the current in the left branch:

The voltage delivered by B1 is 9V. The resistance in the left branch of the circuit is 27 ohms. The current in this branch (let's call it *I1*) is then given by:

$I1 = B1 / R1 = 9V / 27\,ohms = 1/3A = 0{\cdot}33A$.

In the right hand branch we can calculate the current, *I2*, from:

$I2 = (B1 - B2) / 15 = (9 - 6) / 15 = 3 / 15 = 1 / 5 = 0{\cdot}2A$.

So, to the left we have 0·33A flowing and to the right we have 0·2A flowing. The current in B2 is thus just 0·2A (flowing upwards – i.e. this battery is being charged) whilst the current in B1 is (0·33 + 0·2) = 0·53A (flowing downwards – i.e. this battery is being discharged).

I hope this makes sense! Your input is much appreciated and I do hope that you enjoy the *Teach-In* series!

Mike Tooley

Avast Anti-Virus Nightmare

Dear EPE,

I have read your articles with great interest and downloaded the Avast anti-virus software that Alan rates so highly in *Net Work*.

The nightmare begins! This software attempted to take over my entire PC. I was unable to surf the Net. It broke my connection with my hardware Firewall/Router. When I eventually managed to disable it to enable myself to get to the Web, it still scanned every web page and slowed my ADSL to a crawl. It is the worst piece of software I have ever used. There was seemingly no way to uninstall it via Windows XP and it had no uninstall of its own. I eventually managed to boot to DOS and manually remove nearly all of its files. Still it managed to screw up my system.

So I had to relent and reformatted my entire 200GB SATA drive and reinstall all my programs. What a nice Christmas present this East European software was! Well, I have learnt my lesson. I used to use Norton 2005 but decided to try "free", and wow did I really pay!

You get what you pay for in computing. I reinstalled Zone alarm Pro and AVG anti-virus and now the system is working perfectly.

Phil, via email

Alan replied direct to Phil:

I was sorry to hear of your problems Phil, though you are the only one to have reported any negative feedback. There is never enough magazine space to publish comprehensive review details, so what you read in half a page may be the result of months of work beforehand.

Prior to recommending Avast software to readers, I tested it for many months on five machines under Windows 98SE, ME, XP Home Edition and then on two XP Professional "production" machines. I found that Avast installed perfectly each time, it updated itself immediately and continues to update frequently, and it detected resident infected files that other products had missed. Today it catches some 200 incoming virus emails a day.

Avast is a well established but modestly-publicised product that enjoys a good reputation. As always, I stand behind everything that I write, I test out all products thoroughly before recommending them (or I include caveats as necessary). I rely on the Internet for a living so I don't make recommendations lightly. Details of other independent testimonials are at **www.avast.com/eng/awards.html** and there are nearly 100 user reviews at **www.snapfiles.com/get/avast.html**.

I am surprised if it was felt necessary to go to the extreme of reformatting a hard drive. Windows ME and Windows XP have a System Restore function allowing users to "wind the clock back" to an earlier Restore point, to overcome any perceived installation problems. (see Start/Programs/Accessories/System Tools). Avast has an uninstaller that is accessible via the Control Panel. It appears that your software installation wasn't successfully completed to begin with, if you were unable to access the Uninstaller in the normal way.

Without seeing the system I would only speculate that Avast tried to reach out to update itself after installation, and this action may have been blocked by your third party firewall software. Or, your machine was already pre-infected with an outbound worm, which has saturated your outbound traffic. Of course, the AVG software you are using is free as well. I recommended it in the *Net Work* article as an alternative choice. If nothing else, at least we agree that free anti-virus products can outperform better known paid-for packages.

Alan Winstanley

More C Feedback

We continue to receive a fair bit of response to the letters from David Parkins and Dr Jim Arlow in the Jan '06 issue, both as direct mail, and via our Chat Zone (access via **www.epemag.co.uk***). As said in* Readout *last month, we are taking active steps to bring you a general feature on "Using C for PICs" later this year. Here is a further selection of the feedback:*

I think programmers using assembler produce some exceptional projects and results. I find assembler difficult and in past years used to program my Sinclair spectrum and BBC computers using Basic. I have little knowledge of C.

One of the sad things that has happened to our hobby is the replacement of specialised chips with microcontrollers. I remember scouring through magazines and studying circuit diagrams to find ideas to adapt to my own projects. The satisfaction of producing one's own unique project is unsurpassed! Those days have gone and now if micros are used I have to construct a project as published or not bother.

Most of us have busy lives and little time to devote to our hobbies, many of the high level language compilers appear to do a lot of the background assembly for you making the task of programming and moving between devices and different families of microcontrollers easier. I for one would like to see more in the magazine about high level languages and their merits and if possible tutorials rather like the *EPE Teach-Ins*.

Programming is a means to an end and as long as a project functions as desired the easiest and simplest route must be the goal of most readers, you wouldn't throw away an op.amp and replace it with transistors. I am not saying abandon assembler or that one programming method is better than another, but give us some informed choices and an insight into other programming methods so we can choose our own paths to meet our programming needs.

Dave Larner, Caister On Sea

Like David Parkins and Dr Jim Arlow, I think that ideally, no-one outside the manufacturing companies like Sun, Microsoft, or Microchip should write anything in assembler. Like the editors of *EPE*, I accept that the real world is far from ideal.

While I want to agree with Jim's enthusiasm for you to "lead the way to a high level future", I think it would be very brave of you to attempt that. I think that emphasis on PICAXE projects rather than on raw PIC projects is about as close an approximation as you can achieve.

At the risk of admitting to be a fool, I think that the following statements are both true: only a fool would write in assembler; I write in assembler. There are many reasons I don't use C – or some other high level language.

The most important reason is that I can't find a suitable development system that I can afford. Although the free development system from Microchip is great value for money rather than great, economical alternatives seem to be significantly inferior.

For the systems I have examined, including one that I bought, I find that if my application is sufficiently trivial that the system can handle it, then it is so trivial that it is easier to do in assembler. Conversely, if my application is sufficiently complicated that it would be very useful to implement it in C, then it is impossible to implement in any C system that I can afford, and assembler is the only option available.

This might be an opportunity for you to do some reviews of available systems. I would be very interested to discover the systems that Jim has found to be "so readily available".

A second reason is implied by my use of the word "system" above, rather than the word "language". My experience is that the choice of language is relatively unimportant. The important criterion is the total time from initial idea to delivering it to the customer, and issues like debugging tools and in-circuit programming become more important than issues like language.

I think that this is why the PIC has been so successful and why it would be a brave move to develop projects for other processors. I think that this is an issue where it is reasonable to expect the suppliers, not you, to take the initiative. If companies other than Microchip want to sell their gadgets, then they need to develop suitable projects and submit them for you to publish.

A third reason is implied by the list of high level languages Jim mentions. Particularly for a hobby magazine, it is highly likely that some dialect of BASIC would be more appropriate than C; which brings me back to the PICAXE. Probably, "more PICAXE projects" would be a more popular and safer strategy than "more projects using raw PICs programmed in C".

It is of course useful to remember that electronics is about a lot more than microprocessors, and "more projects with no microprocessors" is also certain to be popular with many readers.

Keith Anderson, Tasmania, Australia

Net Work

Alan Winstanley

It's Good To Talk

In this month's *Net Work* – the Internet column, I summarise some of the current trends in Internet telephony for the home user: how to use the Internet to converse in real time with other users.

A number of peer-to-peer (P2P) services are available that allow Internet users to converse with each other. Which one to use depends on what your friends use themselves, and whether your needs are basic or more demanding. For years, ICQ ("I Seek You") has been the trendsetter for communicating with other Internet users. A small applet (the buddy list) runs on the PC, Mac or PDA and contains your contact list. A status indicator shows who's online, and you take it from there: message them, chat or talk, or exchange files (P2P file transfer). It is worth mentioning that P2P anti-virus protection is worthwhile, which my preferred choice of Avast! offers in the form of P2P Shield (**www.avast.com**).

ICQ has evolved into an elaborate package with very many features, including voice calls, instant messaging, video, file transfer, terminal-style chat and PTT (push-to-talk walkie talkie style speech communications with other users). Even over a 56k dialup link it is possible to have some fun with interactive ICQ chat, typing messages into a screen that appears at the recipient's window: make sounds play at their end, by pressing a keystroke, and more.

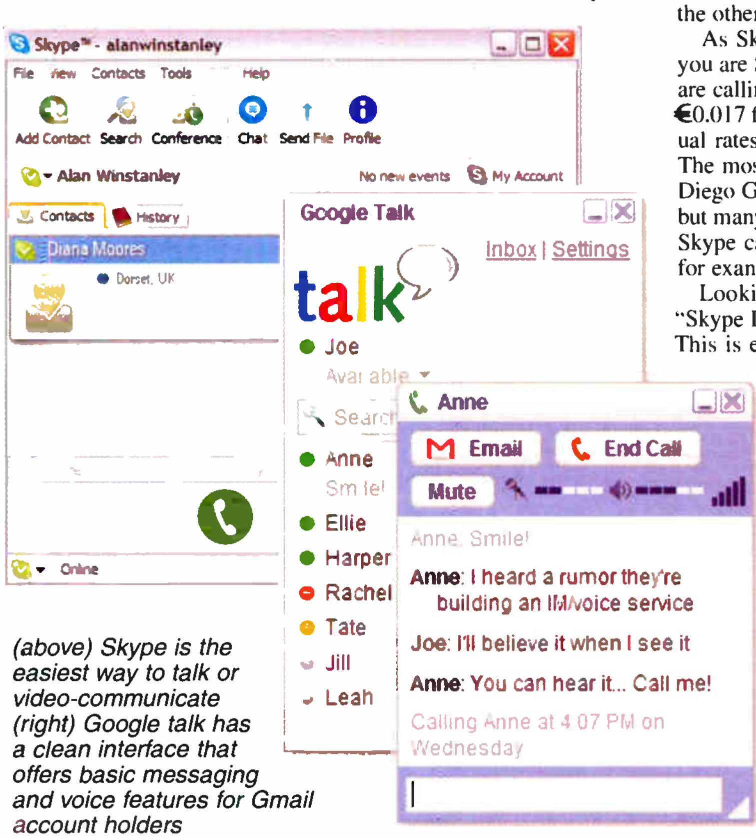
The current version ICQ5 software can be downloaded free in a number of language versions from **www.icq.com**. Other similar services to consider include AIM (AOL Instant Messenger) at **www.aim.com** (you don't need an AOL account) or Google Talk, discussed next.

Voice On The Net

Improvements in broadband access are opening up new territories in higher-speed "streaming" communications in place of simple static messaging. Instead of relying on copper wires and fibre optics to carry analogue speech from end to end, the future trend is towards VoIP (Voice over Internet Protocol) – speech converted into packets of data that are transmitted over a network. Broadband releases the handbrake on more user interaction, including running decent quality web cams and voice transmissions.

Google has launched its own Internet speech service called *Google Talk*. Just like the eponymous search engine itself, Google Talk has a simplicity of use that will be attractive to many users not needing the complexities of ICQ. It has a simple clean interface designed to let you IM (Instant Message) or chat (teletype-style), or physically talk to users contained on your contact list. Google Talk has the added benefit, for some, of directly checking their GMail account.

The service is in beta and some trials by the writer using a microphone and headset were encouraging over a 1Mbps broadband connection. A GMail account must be opened before you can fetch Google Talk from **http://www.google.com/talk**.



(above) Skype is the easiest way to talk or video-communicate (right) Google talk has a clean interface that offers basic messaging and voice features for Gmail account holders

Simply Skype

After Google Talk, ***Skype*** is the simplest and neatest introduction to voice communications via the Internet and is rapidly becoming the defacto mass market service of choice for small businesses and consumers. Skype (**www.skype.com**) is a hugely popular VoIP service recently bought by eBay, who is not slow to recognise a trend or two. Users can enjoy both voice and video communications over a broadband connection. The free video calling of Skype 2.0 means that friends or contacts can now video-communicate in real time, anywhere in the world: and of course, it costs nothing on top of a flat-rate broadband subscription. They claim there have been 250 million downloads and there can be four million users or more online at a time.

It doesn't stop there: what if you want to talk to someone halfway around the globe but they don't have a Skype account? Or Internet access even? Skype offers "Skype Out" that enables subscribers to call traditional landlines or mobiles. You talk "into" the Skype network via a computer but an ordinary landline voicecall is placed at the other end, for a small tariff.

As Skype says, it doesn't matter where you are Skyping out from, only where you are calling to. A "global rate" is offered of €0.017 for major destinations, and individual rates are available for other countries. The most expensive country found was to Diego Garcia at €1.512 + VAT per minute, but many countries cost just a few cents. A Skype call to a typical UK mobile phone, for example, costs €0.205.

Looking ahead, Skype is trialling "Skype In" to a small number of countries. This is equivalent to giving out your own personal Skype telephone number. When friends who don't have Skype call the number on their traditional phone line, you receive the call on your computer: it's POTS (Plain Old Telephone Service) to VoIP conversion. Conference calls can also be set up, and a Skype toolbar for MSIE and Firefox will let you call Skype numbers in web pages directly, with a mouse click.

Next month: starting with Skype for the first time, and some tips to checkout if buying a webcam for video communicating. You can Email the writer at **alan@epemag.demon.co.uk**

FREE *Electronics Hobbyist Compendium* book with Teach-In 2000 CD-ROM

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Robotics

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

288 pages – large format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

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

For a further selection of books see the next two issues of *EPE*.

Radio

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

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

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

263 pages **Order code NE30** **£18.99**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

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

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

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

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

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

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

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

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Morris Rosenthal
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Through 150 crisp photographs and clear but minimal text, readers will confidentiy absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format **Order code MGH2** **£20.99**

PIC YOUR PERSONAL INTRODUCTORY COURSE
SECOND EDITION John Morton
Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

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

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

The revised second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

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Cherry Nixon
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eBay presents an opportunity for everyone, the trick is to master it. This book shows you how to start trading on eBay UK. It also offers advice on getting organised and tips to put you ahead.

The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaning eBay and how to trade on it there are sections on Paypal, producing pictures of your sale items, fees and accounts, safety and security including what to do when things go wrong and what protection is provided.

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Clive (Max) Maxfield

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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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CD-ROM
Clive (Max) Maxfield and Alvin Brown

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R. A. Penfold

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

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

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Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

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Suitable for PC and Mac users, the book is full of tips, "how to do" topics and illustrations. It's the perfect answer to the question "How do I use my computer to produce my own CD?"

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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 orogram your own sounds and effects, this practical and well-illustrated book tells you what you need to know.

60 pages **Order code PC118** **£7.45**

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
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:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages **Order code PC119** **£7.45**

ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

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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.

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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.

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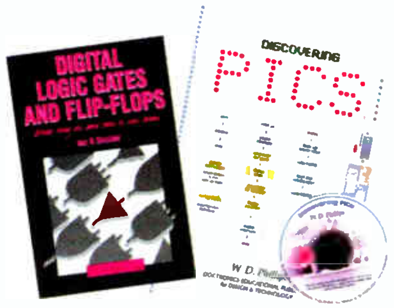

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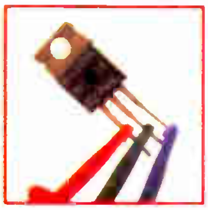

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