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World Radio History

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

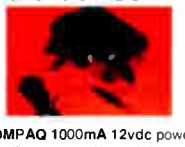
Fully cased **IR light source** suitable for CCTV applications. The unit measures 10x10x150mm. is mains operated and contains 54 infra red LEDs. Designed to mount on a standard CCTV camera bracket The unit also contains a daylight sensor that will only activate the infra red lamp when the light level 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 FF11

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

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

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



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

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

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

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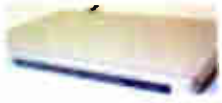
1.3AH 12V @ £5.50 GT1213
3.4AH 12V @ £8.80 GT1234
7AH 12V @ £8.80 GT127
17AH 12V @ £19.80 GT1217
All new and boxed, bargain prices. Good quality sealed lead acid batteries



1.2ghz wireless receiver Fully cased audio and video 1.2ghz wirelessreceiver190x140x30mm, 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 intertere 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 Pertect 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 2.2 gauss 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 Engin** measures 7" x 4-1/4" and comes complet with built-in alcohol burner. Red flywheel and chassis mounted on a green base, thes 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 t run. £106.70 REF SOL1

High-power modules using 125mm square multi crystal silicon solar cells with bypass diode Ant reflection coating and BSF structure to improv cell conversion efficiency: 14%. Using white tempered glass, EVA resin, and a weatherproo 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, partialrubber 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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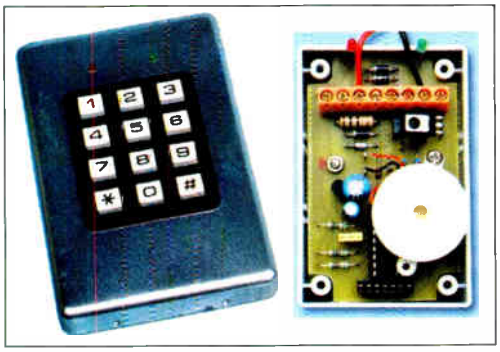

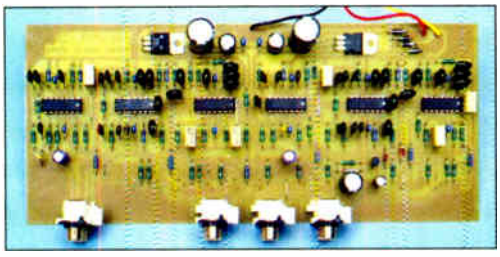

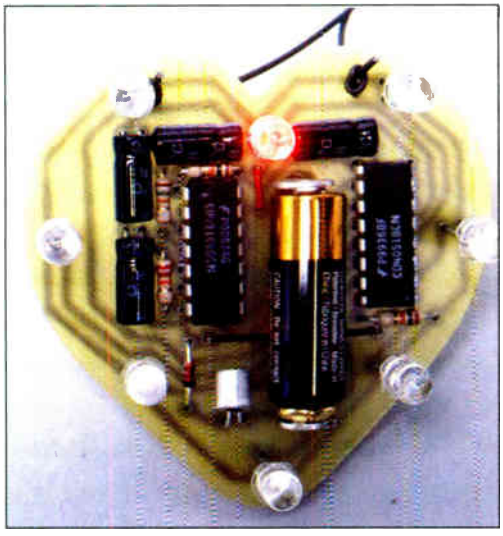

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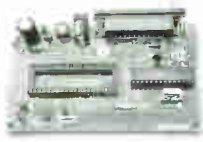
We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

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 web-site 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

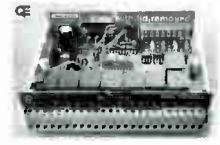
Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Includes one DS1820 sensor and four header cables.
Kit Order Code: 3145KT – **£16.95**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

World Radio History

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

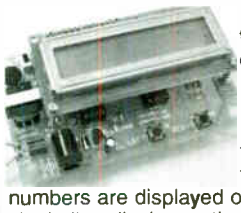
Solid-state design wind speed meter (anemometer) that uses ultrasonic techniques and has no moving parts and does not need calibrating. It is intended for sports-type activities, such as track events, sailing, hang-gliding, kites and model aircraft flying, to name but a few. It can even be used to monitor 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.

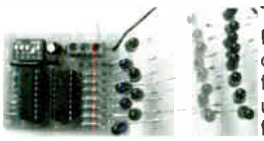
Based on the project published in Everyday Practical Electronics, Jan 2003. We have made a few minor design changes (see web site for full details). Power: 9VDC (PP3 battery or Order Code PSU345).
Main PCB: 50 x 83mm.
Kit Order Code: 3168KT – **£34.95**

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

Small, powerful FM transmitter. Audio preamp stage and three RF stages deliver 3 watts of RF power. Can be used with the electret microphone supplied or any line level audio source (e.g. CD or tape OUT, mixer, sound card, etc). Aerial can be an open dipole or Ground Plane. Ideal project for the novice wishing to get started in the fascinating world of FM broadcasting. 45 x 145mm.
Kit Order Code: 1028KT – **£23.95**
Assembled Order Code: AS1028 – **£31.95**

25 Watt FM Transmitter

Four transistor based stages with a Philips BLY89 (or equivalent) in the final stage. Delivers a mighty 25 Watts of RF power. Accepts any line level audio source (input sensitivity is adjustable). Antenna can be an open dipole, ground plane, 5/8, J, or YAGI configuration. Supply 12-14V DC, 5A. Supplied fully assembled and aligned – just connect the aerial, power and audio input. 70 x 220mm.
Order Code: AS1031 – **£134.95**

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Electronic Project Labs

Great introduction to the world of electronics. Ideal gift for budding electronics expert!

500-in-1 Electronic Project Lab

This is the top of the range and is a complete electronics course taking you from beginner to 'A' level standard and beyond! It contains all the parts and instructions to assemble 500 projects. You get three comprehensive course books (total 368 pages) – *Hardware Entry Course, Hardware Advanced Course* and a microcomputer based *Software Programming Course*. Each book has individual circuit explanations, schematic and assembly diagrams. Suitable for age 12 and above.
Order Code EPL500 – **£149.95**
30, 130, 200 and 300-in-1 project labs also available – see website for details.

Number 1 for Kits!

With over 300 projects in our range we are the UK's number 1 electronic kit specialist. Here are a few other kits from our range.

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3143KT – 10W Stereo Amplifier £10.95
1011-12KT – Motorbike Alarm £12.95
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3126KT – Sound-Activated Relay £8.95
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3033KT – Telephone Recording Adpt £8.95
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3118KT – 12-bit Data Acquisition Unit £49.95
3101KT – 20MHz Function Generator £69.95

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EPE PROJECT PICS

Programmed PICs for *EPE Projects
12C508/9 – £3.90; 16F627/8 – £4.90
16C84/16F84/16C71 – £5.90
16F876/877 – £10.00
All inc. VAT and Postage
(*Some projects are copyright)

EPE MICROCONTROLLER P.I. TREASURE HUNTER

The latest MAGENTA DESIGN – highly stable & sensitive – with I.C. control of all timing functions and advanced pulse separation techniques.

- High stability drift cancelling
- Easy to build & use
- No ground effect, works in seawater

- Detects gold, silver, ferrous & non-ferrous metals
- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware

KIT 847 .....£63.95

68000 DEVELOPMENT TRAINING KIT

- NEW PCB DESIGN
- 8MHz 68000 16-BIT BUS
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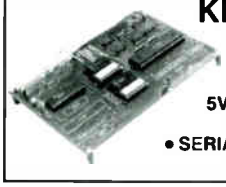
- 2 SERIAL PORTS
- PIT AND I/O PORT OPTIONS
- 12C PORT OPTIONS



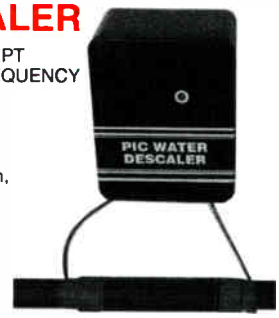
KIT 621 £99.95
• ON BOARD 5V REGULATOR
• PSU £6.99
• SERIAL LEAD £3.99

Stepping Motors

MD100..Std 100 step..£9.99
MD200...200 step...£12.99
MD24...Large 200 step...£22.95

PIC PIPE DESCALER

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



An affordable circuit which sweeps the incoming water supply with variable frequency electromagnetic signals. May reduce scale formation, dissolve existing scale and improve lathering ability by altering the way salts in the water behave.
Kit includes case, P.C.B., coupling coil and all components.
High coil current ensures maximum effect. L.E.D. monitor.

KIT 868 ..... £22.95 **POWER UNIT.....£3.99**

MICRO PEsT SCARER

Our latest design – The ultimate scarer for the garden. Uses special microchip to give random delay and pulse time. Easy to build reliable circuit. Keeps pets/pests away from newly sown areas, play areas, etc. uses power source from 9 to 24 volts.

- **RANDOM PULSES**
- **HIGH POWER**
- **DUAL OPTION**

Plug-in power supply £4.99

KIT 867.....£19.99
KIT + SLAVE UNIT.....£32.50

WINDICATOR

A novel wind speed indicator with LED readout. Kit comes complete with sensor cups, and weatherproof sensing head. Mains power unit £5.99 extra.

KIT 856.....£28.00

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

As featured in March '97 issue.

Set of 4 spare electrodes £6.50

Magenta have prepared a FULL KIT for this. excellent new project. All components, PCB, hardware and electrodes are included. Designed for simple assembly and testing and providing high level dual output drive.

KIT 866. . Full kit including four electrodes £32.90

1000V & 500V INSULATION TESTER

Superb new design. Regulated output, efficient circuit. Dual-scale meter, compact case. Reads up to 200 Megohms.
Kit includes wound coil, cut-out case, meter scale, PCB & ALL components.

KIT 848.....£32.95

EPE TEACH-IN 2000

Full set of top quality *NEW* components for this educational series. All parts as specified by *EPE*. Kit includes breadboard, wire, croc clips, pins and all components for experiments, as listed in introduction to Part 1.
**Batteries and tools not included.*

TEACH-IN 2000 -

KIT 879 £44.95
MULTIMETER £14.45

SPACEWRITER

NOW WITH PIC16C84 EEPROM CHIP & SOFTWARE DISK

An innovative and exciting project. Wave the wand through the air and your message appears. Programmable to hold any message up to 16 digits long. Comes pre-loaded with "MERRY XMAS". Kit includes PCB, all components & tube plus instructions for message loading.

KIT 849 .....£16.99

12V EPROM ERASER

A safe low cost eraser for up to 4 EPROMS at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work - updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

KIT 790 .....£29.90

SUPER BAT DETECTOR

1 WATT O/P, BUILT IN SPEAKER, COMPACT CASE
20kHz-140kHz
NEW DESIGN WITH 40kHz MIC.

A new circuit using a 'full-bridge' audio amplifier i.c., internal speaker, *and* headphone/tape socket. The latest sensitive transducer, and 'double balanced mixer' give a stable, high performance superheterodyne design.

KIT 861 .....£34.99
ALSO AVAILABLE Built & Tested. . . £48.99

MOSFET MkII VARIABLE BENCH POWER SUPPLY 0-25V 2·5A

Based on our Mk1 design and preserving all the features, but now with switching pre-regulator for much higher efficiency. Panel meters indicate Volts and Amps. Fully variable down to zero. Toroidal mains transformer. Kit includes punched and printed case and all parts. As featured in April 1994 *EPE*. An essential piece of equipment.

Kit No. 845 .....£64.95

ULTRASONIC PEsT SCARER

Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.

- KIT INCLUDES ALL COMPONENTS, PCB & CASE
- EFFICIENT 100V TRANSDUCER OUTPUT
- COMPLETELY INAUDIBLE TO HUMANS
- UP TO 4 METRES RANGE
- LOW CURRENT DRAIN

KIT 812.....£15.00

SIMPLE PIC PROGRAMMER

KIT 857... £12.99

Includes PIC16F84 chip disk, lead, plug, p.c.b., all components and instructions

Extra 16F84 chips £3.84
Power Supply £3.99

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PIC LCD DISPLAY DRIVER

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

- Learn how to drive the display and write your own code.
- Ideal development base for meters, calculators, counters, timers — just waiting for your application!
- **Top quality display** with industry standard driver, data and instructions

KIT 860.....£19.99

PIC STEPPING MOTOR DRIVER

PCB with components and PIC16F84 programmed with demonstration software to drive any 4 phase unipolar motor up to 24 Volts at 1 Amp. **Kit includes 100 Step Hybrid Stepping Motor** Full software source code supplied on disc.

Use this project to develop your own applications. PCB allows 'simple PIC programmer' 'SEND' software to be used to reprogram chip.

KIT 863.....£18.99

8 CHANNEL DATA LOGGER

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

KIT 877.....£49.95

PIC16F84 MAINS POWER CONTROLLER & 4 CHANNEL LIGHT CHASER / DIMMER

- Zero Volt Switching
- Opto-Isolated 5 Amp **HARD FIRED** TRIACS
- 12 Way keypad Control
- With program source code disk.
- Chase Speed and dimming potentiometer controls.
- Reprogram for other applications

KIT 855.....£39.95

PIC TUTOR 1

EPE MARCH APRIL MAY '98 PIC16F84 STARTER SERIES

The original PIC16F84 series by John Becker. Magenta's Tutor board has individual switches and leds on all portA and PortB lines, plus connectors for optional 4 digit seven segment led display, and 16 x 2 intelligent lcd. Written for newcomers to PICs this series. Disk has over 20 tutorial programs. Connect to a PC parallel port, send, run, and experiment by modifying test programs - Then Write and Program your Own

KIT 870... £27.95, Built...£42.95

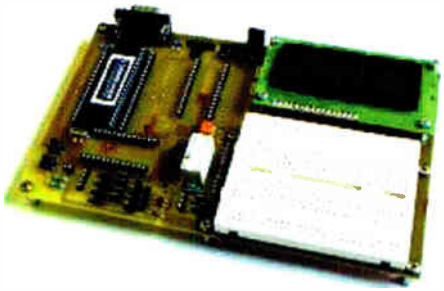
16x2 LCD..£7.99. LED display..£6.99. 12VPSU..£3.99

SUPER PIC PROGRAMMER

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

KIT 862... £29.99 Power Supply £3.99

ICEBREAKER



PIC Real Time In-Circuit Emulator

- ICEbreaker uses PIC16F877 in-circuit debugger.
- Links to standard PC **Serial** port (lead supplied).
- Windows (95 to XP) Software included
- Works with MPASM assembler

16 x 2 LCD display, Breadboard, Relay, I/O devices and patch leads.

Featured in *EPE* **Mar'00** Ideal for beginners & experienced users.

Programs can be written, downloaded, and then tested by single-stepping, running to breakpoints, or free run at up to 20Mhz.

Full emulation means that all ports respond immediately - reading and driving external hardware.

Features include: Run; set Breakpoint; View & change registers, EEPROM, and program memory; load program; 'watch window' registers.

KIT 900...£34.99 **With serial lead & software disk, PCB, Breadboard, PIC16F877, LCD, all components and patch leads.**

POWER SUPPLY - **£3.99** STEPPING MOTOR 100 Step **£9.99**

20W Amp. Module

EPE May '05 -- Superb Magenta Stereo/Mono Module

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

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

Stable Reliable design

Latest Technology IC with local feedback gives very high performance.

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

Magenta BrainiBorg

A super walking programmable robot with eyes that sense obstacles and daylight. **BrainiBorg** comes with superb PC software CD *(WIN95+ & XP)* and can be programmed to walk and respond to light and obstacles on any smooth surface.

CD contains illustrated constructional details, operating principles, circuits and a superb **Educational Programming Tutorial**.

Test routines give real-time 'scope traces of sensor and motor signals. Connects to PC via **SERIAL** port with the lead supplied.

Kit includes all hardware, components, 3 motor/gearboxes. Uses 4 AA batteries *(not supplied)*. *An Ideal Present!*

KIT 912 Complete Kit with CD rom & serial lead **£49.99**

KIT 913 As 912 but built & tested circuit board **£58.95**

EPE PIC Tutorial

***EPE* Apr/May/Jun '03 and PIC Resources CD**

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

KIT 880 (with 16F84) **£34.99,** built & tested **£49.99**

KIT 880 (with 16F877) **£39.99,** built & tested **£55.99**

EPE TEACH-IN 2004

THE LATEST NOV 03 SERIES

All parts to follow this new Educational Electronics Course. Inc. Breadboard, and wire, as listed on p752 Nov. Issue.

KIT 920.....£29.99

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

Reprints: £1.00 per part.

KIT921.....£12.99

MAGENTA BRAINIBOT I & II

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

KIT 910....£16.99 **KIT 911....£24.99**

MAGENTA

All prices include VAT. Add **£3.00** p&p. Next day **£6.99**

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BC548A	£0.08
BC548B	£0.09
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BC549B	£0.09
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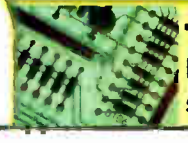

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World Radio History

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Debate

It's good to see that there is a lively debate on various aspects of the magazine going on via our *Readout* pages and on the *Chat Zone*. In particular the opinions on the use of high-level languages, like "C", in programming PIC microcontrollers is bringing up some interesting and varied pointers and we are following it with interest.

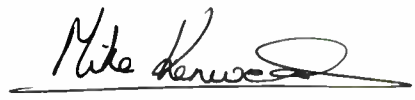
The comments on soldering are also interesting and no doubt helpful to other readers. Although I must say that there seems to be a fear of lead free soldering. Our article in the May 2004 issue explored this subject and is well worth reading, especially for those that are worried about the change. You can order back issues from the shop on our UK web-site or see page 64.

Everyone's views are of interest to us and we do note your comments on the *Chat Zone*, the telephone, in emails, letters and subscription renewals etc. They all help us to keep the magazine on track. I should, however, point out that if you require a response from the Editorial team then you must email us (see the email address on the top right of this page) and not post your request to the *Chat Zone*.

A Nice Chat

Unfortunately there has been some "misuse" of the *Chat Zone* recently and our administrator Alan Winstanley has had to edit or delete various postings where readers have been, shall we say, "overcritical" of others. We will keep strict control of the *Chat Zone*, which is an "extension" of the magazine and will not allow any postings which we consider in any way inappropriate. Some posters see this as censorship and I suppose, in a way, that is what it is – it will continue in order for the *Chat Zone* to remain a "safe" and friendly place for *everyone*, young or old – see this month's *Network* for more information.

There are plenty of places on the Web where those that wish to can conduct slanging matches or indulge in bad language etc., our *Chat Zone* is not, and will not be, one of them.



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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.**

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News . . .

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

PATENTLY CLEVER

Barry Fox reports on some recent patents filed

Toy Story – The Musical

A series of patents filed by the Disney empire reveal a neat idea for making electronic toys cheaper and cleverer (US 2004/0081078). Disney is adding a new twist to the old idea of making a toy animal move in time with audio trigger signals coming from a loudspeaker.

A digital control message is broken down into several parallel data streams and each stream used to modulate a musical note by wavering its loudness. All the wavering notes are then combined into a musical chord, like the chords made by strumming all the strings of a guitar or playing a handful of piano keys.

The data chords are vaguely musical so do not sound offensive. They are also strong enough to cut through background noise in a playroom or car. So a CD played on a car stereo can make an animal perform tricks for kids in the back seat – with no need for the expense of a wireless system like Bluetooth.

Boeing Broadbands Hijackers

Boeing is patenting a clever anti-terror trick (WO 2004/025600). Sooner or later terrorists will find a way to get weapons on board a plane and into the cockpit, warns Boeing. They will also disable any system that is preset to fly the plane to a safe location. The most important thing then will be to give the ground services real time information.

By good fortune – or forward planning – more and more planes are now equipped with broadband connections, for passenger movie and web entertainment. "There would be little interest in the case of a hijack situation in surfing the Internet" says Boeing, in a classic understatement. So in an emergency the full bandwidth of the system is automatically switched to transmit a live audio and video surveillance feed, from hidden cameras and microphones. Ground services then know exactly what is going on in the air.

Personalising Your Game Play

Sony is staking a patent claim on radically new ways of enjoying computer games and home entertainment in the future (US 2004/0267118). The system builds on research work described in the *Journal of Neuroscience (Reconstruction of Natural Scenes from Ensemble Responses in the Lateral Geniculate Nucleus*, Garrett B Stanley, Sept 15, 1999) **(www.jneurosci.org/cgi/content/abstract/19/18/8036).**

Pulses of ultrasound are fired at the head, from modified hi-fi headphones, to alter the firing pattern of neurons in a localised area of the brain and create sensations of light, sound, touch, taste and smell. The effect varies from person to person so Sony's system uses a library of basic effects which users can fine-tune for themselves.

Two transducers on a headband generate the same pulse pattern, but slightly out of step, so that interference patterns focus the pulses into a tight beam – much like a phased array radar antenna focuses microwaves. The generated sensory experience is not claimed to be exact, says Sony, but that does not matter for gaming which is an unreal experience anyway.

Mobile Disguise

Mobile phone owners can already buy a gadget that plays a recording of office noise, or train delay announcements, down the line as a background to speech. So time spent in a pub or club is disguised as overtime or travel.

Patents filed recently by Lawrence Hoffman of Portland, Oregon adds a new tech twist to the idea of online deception (US 2005/0208931).

As the inventor rightly says, some phone calls just go on too long. While the caller rambles on, the other party is in a hurry to go out or have dinner, or is just plain bored. The perennial problem is how to end the call without seeming rude.

The patent describes a neat solution that takes advantage of the fact that calls to or from a mobile often drop out of their own accord. When a train goes into tunnel, a car drives through a dead cover spot, or a lift descends through a tall building, there is usually a digital burbling sound, followed by dead silence. When the battery is going flat the phone injects warning beeps just ahead of shut-down and cut-off.

So the new phone will have a library of pre-recorded warning sounds that the owner can trigger just ahead of abruptly hanging up without causing offence. The trick can be used for fixed phones as well as mobiles, because the party at the other end is so used to the sound of dropped calls from a mobile that the effect rings subconsciously true.

TOMORROW'S TV WORLD

Students are learning the next generation of TV technology in a unique new £300,000 high definition TV Lab at De Montfort University where academics are also conducting multimillion pound research to develop 3D TV. State of the art equipment in the new high definition TV lab includes a £23,000 DVB/ATSC combined encoder and multiplexer for processing multiple data streams, which is so new it's the only one in the UK.

The students at De Montfort University's Leicester Faculty of Computing Sciences and Engineering are also using real time high definition editing facilities in the new lab as well as high definition cameras which will soon be used by TV crews around the UK.

The funding is a "Network of Excellence" grant from the European Union. Networks of Excellence are designed to bring the very best researchers from across Europe together to conduct cutting-edge research into difficult or challenging fields at an internationally recognised level. The award is funding the University's Imaging and Displays Research Group which has established an international reputation for excellence in developing 3D displays.

De Montfort is also launching a unique Masters degree in Digital Television and Video Technology next September. The MSc, like existing undergraduate degrees in Media Production and Broadcast Technology, is run in conjunction with the BBC and students spend part of their course training at the BBC Wood Norton Training and Development Centre near Evesham.

Professor Musa Mihsein, Dean of the Computing Sciences and Engineering Faculty, said: "De Montfort University is now one of the leading institutions for its 3D TV research and is setting the standard for vocational teaching hand in hand with industry to produce high calibre graduates ready for work in the next generation of TV, video and other creative industries."

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StorVision miniVCR

StorVision has announced the release of the StorVision miniVCR, which aims to record direct from a TV to a Memory Stick Duo Gaming card or CF/Microdrive and playback onto handheld viewing devices such as the Sony PSP. The miniVCR is primarily targeted at Sony PSP, Epson P2000, Nintendo Gameboy Micro and iPod Viewer owners so they have the facility to easily record movies, TV programmes, sport matches and watch them anywhere on their gaming console.

The miniVCR is powered from the mains and connects with Audio/Video composite cables to a TV set, and is very easy to use via the supplied remote control. The miniVCR also lets the user playback MP3 music, as well as view JPEG photos from CF/Microdrive cards (other cards via an optional CF 5-in-1 adapter).

Although the product is not directed at the photographics market the versatility of this device makes it a useful accessory. On the digital photography side, it enables the user to view direct onto a television most types of memory cards through one unit making it easy to share photos. Also, if the user owns a Sony PSP or an Epson P2000, they will be able to easily record any movie or TV programme and watch it whenever and wherever they want.

StorVision is a newly established company specializing in portable Multimedia and backup devices for the digital technology market including Digital Photography. The miniVCR is retailing at £99.90 including VAT in the UK.

Further information is available from **http://www.stor-vision.com/miniVCR.htm**.

LEAD FREE TESTING

With lead-free soldering proving to be one of the biggest challenges currently facing the electronics industry, Farnell InOne has launched a new "test and try" campaign to ensure electronics and electrical engineers are fully equipped to deal with the changes required by the EU Restriction of the Use of Certain Hazardous Substances (RoHS) directive. This is supported by key legislative and technical information on lead-free soldering in Farnell InOne's RoHS Technical & Legislation Manual at **www.rohs.info**.

Farnell InOne is offering engineers the chance to "test and try" two-metre lengths of lead-free solder wire, costing as little as 99p, to enable them to trial the different products before coming to a full reel.

The catalogue highlights key points to consider when deciding to upgrade or change solder tools in a leaded solder process, as well as providing a useful Q&A section to answer some of the most frequently asked questions. For more information browse **www.farnellinone.co.uk**

Temperature Recorder

A new low-cost single-use temperature recorder that lets users easily monitor temperature fluctuations during the shipment or storage of goods has been introduced.

The MadgeTech TRANSITEMP-EC is a device that provides a record for up to 90 days. It can log up to 8191 measurements in a non-volatile memory, and then be connected to a PC to display the history. It has a push-button start which is date and time stamped.

Contact MadgeTech, 201 Route 103 West, PO Box 50, Warner, NH 03278, USA. Web: **www.madgetech.com**.

USB 5-in-1 Scope

Audon Electronics' Handyscope HS3 is a powerful USB computer controlled measuring system that consists of five instruments in one: multimeter, oscilloscope, spectrum analyser, transient recorder and an arbitrary waveform generator. Connected to the fast USB 2.0, the Handyscope HS3 doesn't require an external power supply, and is equally at home in the laboratory or in the field.

The Handyscope HS3 features a user selectable 12-bit, 14-bit or 16-bit resolution, 200mV to 80V full scale input range, 128K samples record length per channel and a sampling frequency up to 100MHz on both channels.

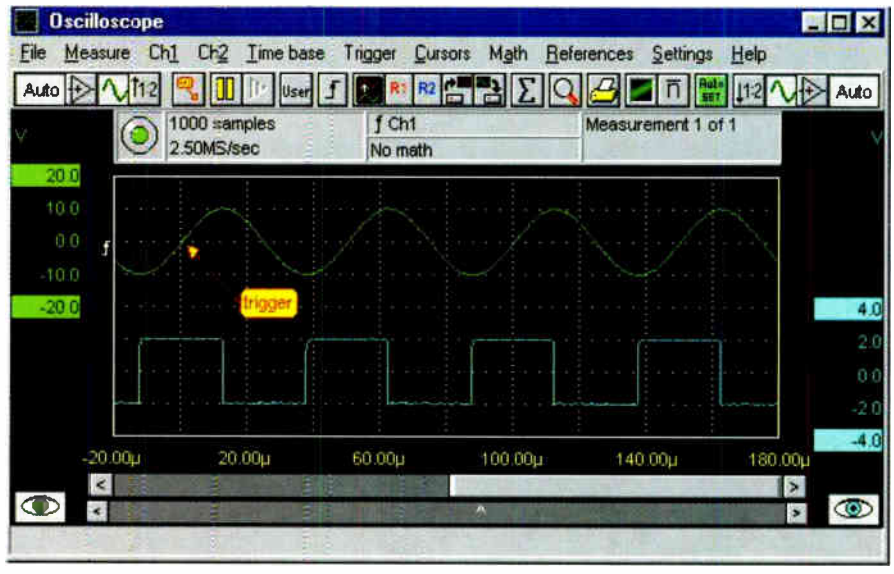
The integrated arbitrary waveform generator operates fully independent of the measuring system. It has a 50MHz sampling clock, 1024/128K samples deep waveform memory, 14-bit output resolution and a ±12V output range. The Arbitrary Waveform Generator allows you to generate test signals for your measurements in any shape you like. Several standard signal shapes are available and it is possible to regenerate previous measured signals.

The universal software turns your PC into a storage oscilloscope, a spectrum analyser, a voltmeter and a transient recorder. An intelligent auto setup allows the inexperienced user to perform measurements immediately. The software allows you to save instrument settings on disk. Later these setting files can be recalled, reducing the setup time of your instrument to an absolute minimum.

A major advantage is the ability to work with third party software tools through the use of a Windows DLL file. Examples written in LabVIEW, MatLab, VB, Delphi and C++ are supplied on the disk.

There are five models in the range: HS3-5, 5MHz, £435.00; HS3-10, 10MHz, £530.00; HS3-25, 25MHz, £610.00; HS3-50, 50MHz , £776.00; HS3-100, 100MHz, £820.00. Prices exclude VAT and delivery.

For more information contact Audon Electronics, tel: 0115 925 8412. Fax: 0115 925 9757. Email: info@audon.co.uk. Web: **www.audon.co.uk**



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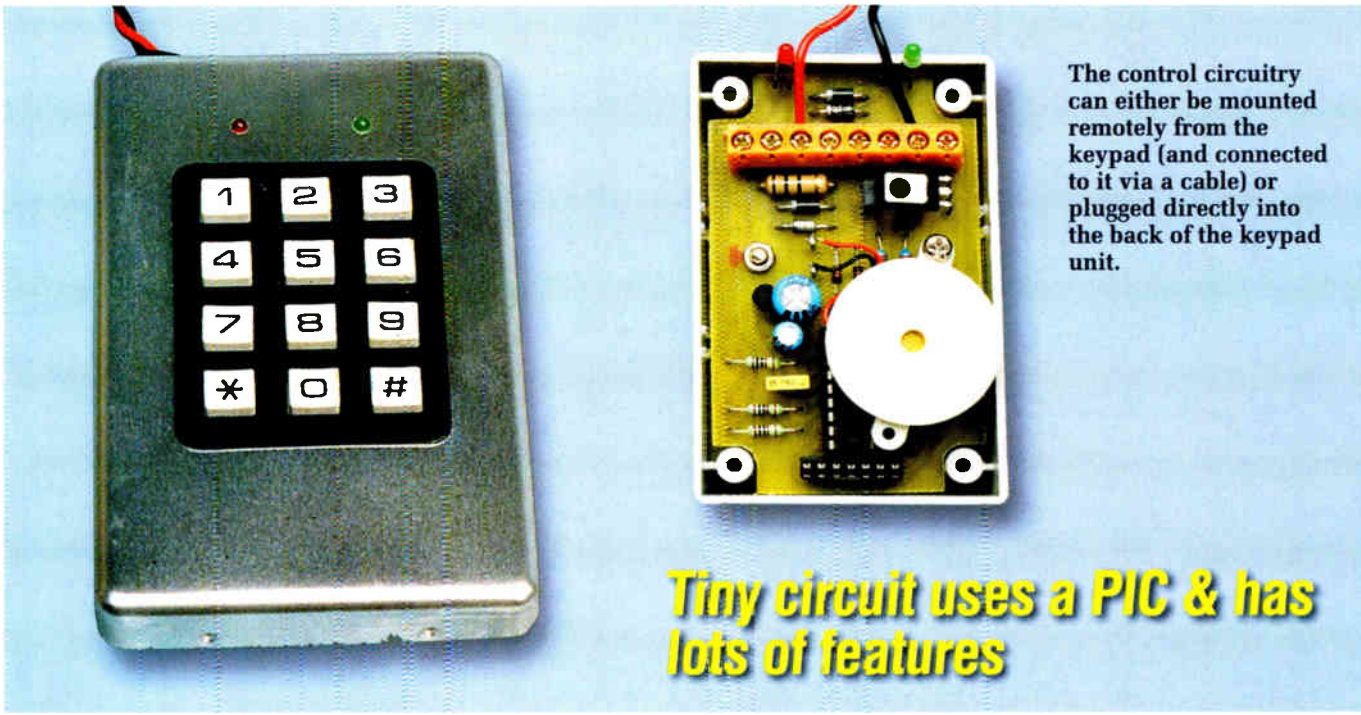

The control circuitry can either be mounted remotely from the keypad (and connected to it via a cable) or plugged directly into the back of the keypad unit.

A highly flexible keypad alarm

This versatile little alarm can be used as a stand-alone alarm system for your home, commercial premises or car and also for keypad door entry. Or it can be incorporated into a larger main alarm system if required.

By JOHN CLARKE

KEYPADS ARE OFTEN used in security systems since they avoid having to use a key or remote control, both of which can be lost or copied. Keypads are also widely used in commercial buildings to allow access through doors.

Here we are presenting a stand-alone keypad alarm system which, with the addition of a siren, a passive infrared detector and door switches, will provide a basic security system for the home, office, church or hall. Installed in a car, the keypad alarm can incorporate an engine immobiliser, as well as standard burglar alarm features.

To use the system, a number is entered in using the keypad. If the entered number is correct, the unit will respond accordingly and either arm or disarm itself and operate a door lock release, if connected. Exactly how the keypad alarm responds depends on the application and how the timer and options are set. For example, when used for keyless door entry, the unit needs to be always armed but operate the door lock release each time the correct code is entered.

Features

The list of features of this alarm is so extensive that it will take more space to briefly describe them all than to describe the circuit itself. That's because all the features are a result of the programming of the PIC microcontroller. Nevertheless, describe the features we must, so we will keep it as brief as possible.

For use as an alarm, the system needs to be armed on exit and disarmed on entry. Each application requires different operating characteristics and the alarm has a host of features which can be tailored to suit. External inputs and outputs include delayed and instant

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alarm inputs, and armed and alarm outputs.

The alarm output can only be activated by the inputs after the exit delay. Instant and delayed inputs can be a passive infrared detector and door or window switches. Alternatively, the alarm can sound when the keypad is tampered with or if a duress code has been entered.

The tamper alarm is activated if more than five incorrect attempts are made within a 90-second period. The 3-digit duress code sounds the alarm when required. In each case, the alarm is deactivated by entering the correct code.

Three separate codes are available: Master, User and Service codes. All three codes can be different but must be of the same length. Either the Master or User code can be used to arm and disarm the alarm. The two different codes are included for use when several keypads are installed to operate door lock releases on separate doors. The Master code will gain access through all keypad operated doors, while the User code only allows entry to selected doors. These codes can be anywhere from 1-12 digits long. The last three digits of the user code become the Duress code.

The Service code is provided to change the codes, the various timers and options. The Service code itself can be changed and if a new Service code is entered, it also sets the length of the User and Master codes. If, for example, the Service code is six digits, then the User and Master codes must also be six digits. Generally, a 4-digit code is sufficient to provide adequate security. With four digits, the possible combinations are more than 14,000 (using digits 0-9 plus the * key).

If the entry or Service codes for the keypad are lost or a mistake is made on changing a code and the keypad becomes inoperable, there is a way to restore operation. This involves having several inputs tied to ground when power is applied to return to the default codes and settings.

Timers

The service mode also allows the various timing delays involved with keypad and alarm operation to be changed. All time periods can be set from 1-99s in 1-second increments. The delayed and instant input timers determine the time before the alarm is sounded after being activated. This delay gives time to enter the building and switch off the alarm before it sounds and is necessary if the keypad is mounted inside. The default settings are one second for the instant input and 10 seconds for the delayed input.

Similarly, the default for the exit delay (allowing you to leave the building after arming the alarm) is 15 seconds.

In addition, the instant input can be configured as an exit input – a switch on this input will arm the keypad alarm instead of the user having to enter the code on the keypad.

A door timer sets the duration that power is applied to an electric door striker, to give sufficient time to open the door. The default value here is five seconds.

Yet another timer sets the alarm duration (the default is 60 seconds). By the way, when we speak of a "default setting", it is the setting you get if you don't program in a setting.

There is also an "alarm warning timer". This sets the time period before a small piezo transducer in the keypad sounds and serves as a warning before the main alarm. The default is five seconds. Note that the alarm time starts at the beginning of the alarm warning period. Thus, the alarm warning period reduces the main alarm duration. There is no alarm warning if the keypad is tampered with or the duress code has been entered.

Finally, there is the keypad entry timer which sets the period during which the code must be entered. The default is five seconds but may need to be extended if the code is 12 digits long

If you make a mistake when entering the code, you can either press the hash (#) key to reset the timer or wait for it to time out before trying again. If an incorrect code is entered but with the correct number of digits, the correct code can be immediately entered in again.

Arming options

Various options are also available to configure the following operations: arming, the door lock, the instant input and the armed output. For alarm installations, the unit must be armed and disarmed alternately, with each code entry. By contrast, keyless door applications will require that the unit be re-armed each time the code is entered.

Operation of the door lock will also depend on the application. For alarm use, for example, you may need to be able to arm the unit with the door lock activated – eg, so that you can exit the door when the keypad is mounted inside.

By contrast, an outside mounted keypad will need to operate the door lock on disarming, so that you can gain access. And in some cases, the door lock will need to operate on both arming and disarming. All of these options are available.

Operation of the armed output can be altered as well. The default setting is with the output transistor conducting to ground when the unit is armed. When disarmed, the output can be pulled high with a resistor to the +12V supply.

MAIN FEATURES

- 1 to 12-digit codes
- Separate Master and User codes
- Service code to alter codes and parameters
- Duress code to start alarm
- Instant and delay inputs
- Inputs triggered on change
- Optional easy exit input
- Exit delay
- Keypad tamper alarm
- Door lock output and indicator
- Armed output and indicator
- Alarm warning period
- Audible key entry acknowledge
- Key entry reset using #
- Keypad entry timeout
- All codes can be changed via keypad
- Adjustable timing parameters
- Alarm mode and keyless door entry options
- Default return facility for all codes, parameters and options
- Powers up in armed mode
- 12V operation at 15mA (ancillaries extra)

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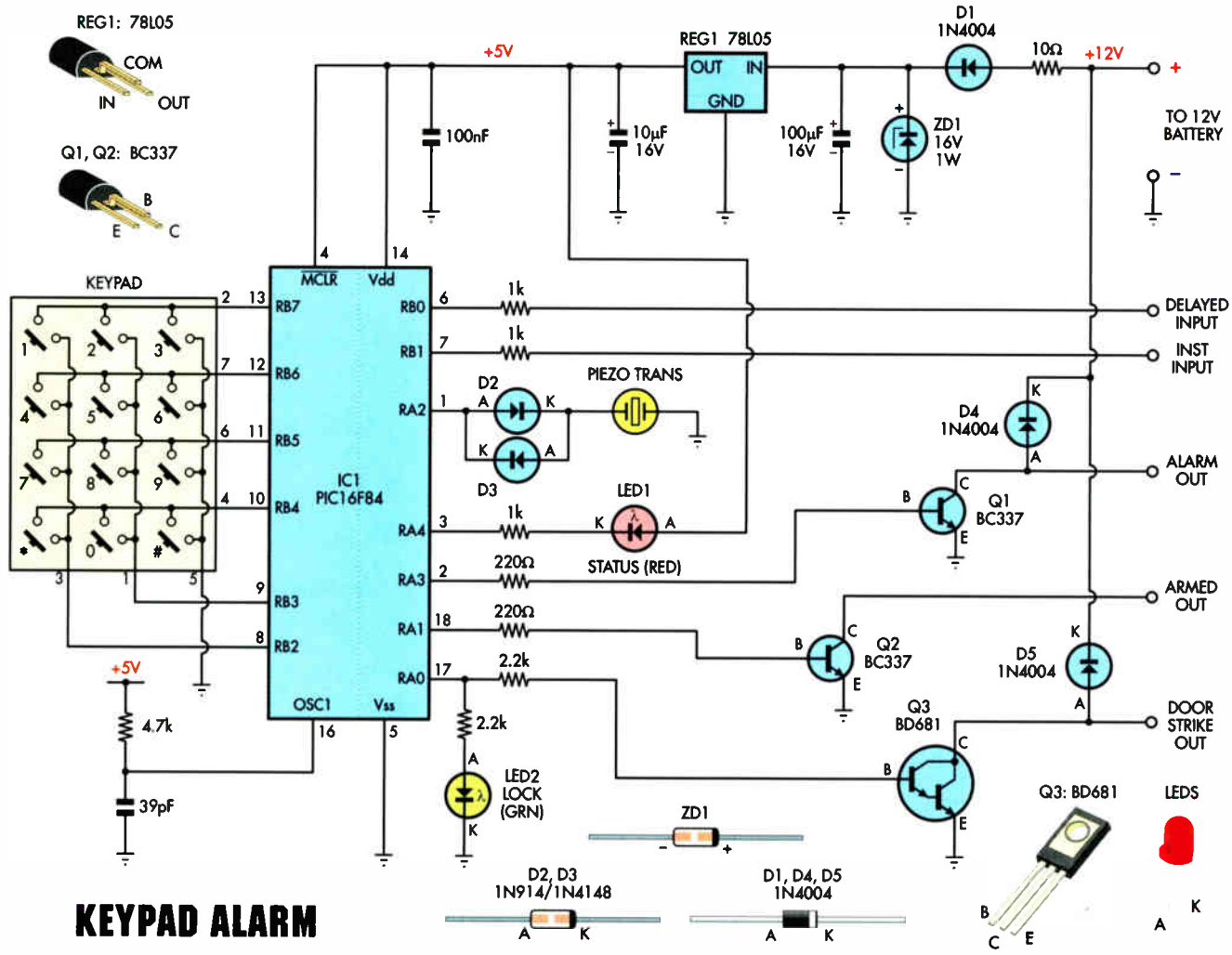

Fig.1: a PIC16F84 microcontroller (IC1) forms the heart of the circuit and is used to monitor the keypad and the delayed and instant inputs. It also controls the various outputs.

Alternatively, you can have the output transistor conducting (to ground) when the unit is disarmed and open-circuit (pulled to +12V using a resistor) when armed. The armed output can control a main alarm unit or switch on an immobiliser in a car. It generally would not be used in keypad entry applications.

Status LEDs

The armed and door lock functions are both indicated with LEDs. First, the status LED (red) flashes once a second when the unit is armed and is off when the unit is unarmed. In alarm mode, this LED also flashes at a 2Hz rate to indicate the exit delay period, reverting to the 1Hz rate afterwards. In "service mode", however, the status LED is constantly lit.

The door lock LED (green) lights only while the electric door striker plate is powered. There is no alarm indication, except for the tone that occurs during the alarm warning period.

Circuit details

The circuit for the keypad alarm is shown in Fig.1. IC1, the PIC16F84 microcontroller, is the heart of the circuit and it is used to monitor the keypad and the delayed and instant inputs. It also controls the various outputs.

The keypad is a matrix of four rows by three columns. Two of the switch column connections go to outputs RB2 and RB3 respectively, while the third column connection goes to 0V (ground). The row connections are monitored by the RB4-RB7 inputs which are normally held at +5V via internal pullup resistors within IC1.

The delayed and instant inputs at RB0 and RB1 are normally held at +5V via internal pullup resistors. However, the micro can detect changes of state of either polarity, so if these inputs are held low by normally closed switches and they are opened, this can trigger the alarm condition.

False triggering is prevented in the following way. After the micro first detects a change in level at RB0 or RB1, it then checks again, after a short delay. If the voltage remains at the new level, the micro decides that this was a genuine change in level. Conversely, if the level is different after the delay, the program then decides the original change in level was a glitch or only a very momentary change and so is ignored.

The piezo transducer is driven via a square-wave signal at the RA2 output

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of IC1 to produce a tone. It is used to acknowledge each key entry and provide the alarm warning tone. Diodes D2 and D3 are included to prevent sound in the piezo transducer when the RA2 output is nominally low (ie, at 0V). What actually happens is that switching operations at other inputs or outputs can be reflected as very small voltage excursions above 0V and these would be heard in the transducer if the diodes were not included.

Outputs at RA3, RA1 and RA0 drive the alarm out, armed out and door strike transistors respectively. When RA3 is high, the base of Q1 is driven via the 220Ω resistor to switch on the transistor. The alarm out signal at the collector can sink a nominal 600mA maximum to drive a siren and flasher. Diode D4 protects Q1 against back-EMF spikes if the siren is an inductive load.

Transistor Q2 is driven via the 220Ω base resistor at the RA1 output. This transistor can also sink up to 600mA. It can be configured to switch on when armed and off when disarmed, or switched off when armed and on when disarmed. If required, a pullup resistor can be connected between Q2's collector and the 12V supply.

Output RA0 drives Darlington transistor Q3 which is suitable for powering an electric door strike. This comprises a solenoid which releases the striker plate to allow a door to be opened. Diode D5 quenches the back-EMF caused by the inductive load of the solenoid when switched off. The transistor is set to sink a nominal 1·3A with the 2·2kΩ base resistor. Up to 4A can be handled if a 680Ω base resistor is fitted.

The door open operation is indicated with the Lock LED (LED2), driven from the same RA0 output.

IC1 uses an RC oscillator as its reference to set the various timing functions within its program. The oscillator components are the 39pF capacitor and 4·7kΩ resistor at pin 16. It runs at about 2.7MHz.

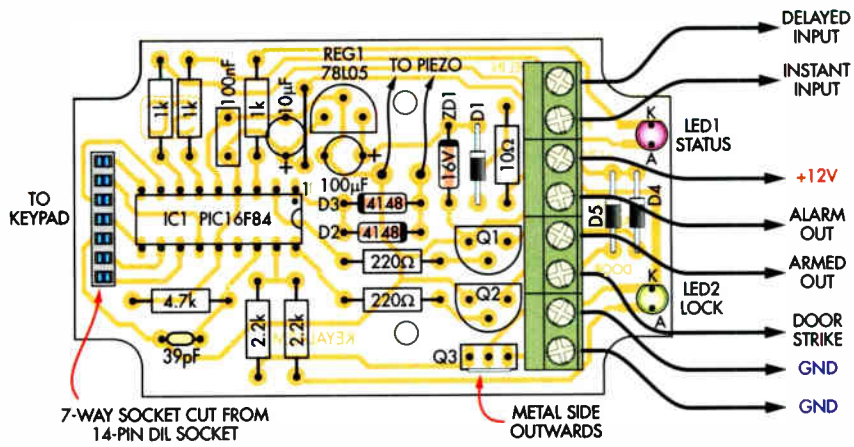

Fig.2: install the parts on the PC board as shown here. The PIC micro-controller (IC1) is installed in a socket and is left out of circuit until after the initial power supply checks have been made.

Power for the circuit is provided from a 12V SLA (sealed lead-acid) battery or car battery (when used in a car). The SLA battery is kept charged using a plugpack style SLA charger. Power is fed to the input of the regulator via a 10Ω resistor and diode D1. The diode provides polarity protection while the 10Ω resistor limits current when the 16V Zener conducts due to voltage spikes in an automotive installation.

REG1 provides the 5V supply for IC1 while the 100µF and 10µF capacitors at the input and output filter the voltage and ensure stability of the regulator.

Construction

The keypad alarm is constructed on a PC board coded 552 and measuring 78 x 48mm. It is mounted in a small plastic utility box. The keypad sits in a cutout in the front panel.

As an alternative to one-piece construction, it could be built as two separate units with the keypad remote from the circuit box and connected with 7-way cable. The component wiring diagram is shown in Fig.2. We recommend the separate construction method if the keypad is to be installed outside a building, to prevent any tampering with the electronics.

Begin construction by checking the PC board for any shorts between tracks or any breaks in the copper pattern. Check also that the holes are drilled to suit the components. The corners of the PC board also need to be shaped to clear the integral pillars inside the plastic case.

Install the resistors and wire link first. Table 1 shows the resistor colour codes. Use your multimeter to check the resistor values as well. That done, install the diodes, taking care to install the Zener in the correct place. Install and solder in the two PC stakes.

Table 2: Capacitor Codes

Value	Old Code	EIA Code	IEC Code
100nF	0.1µF	100n	104
39pF	39pF	39p	39

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	2	220Ω	red red brown brown	red red black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown

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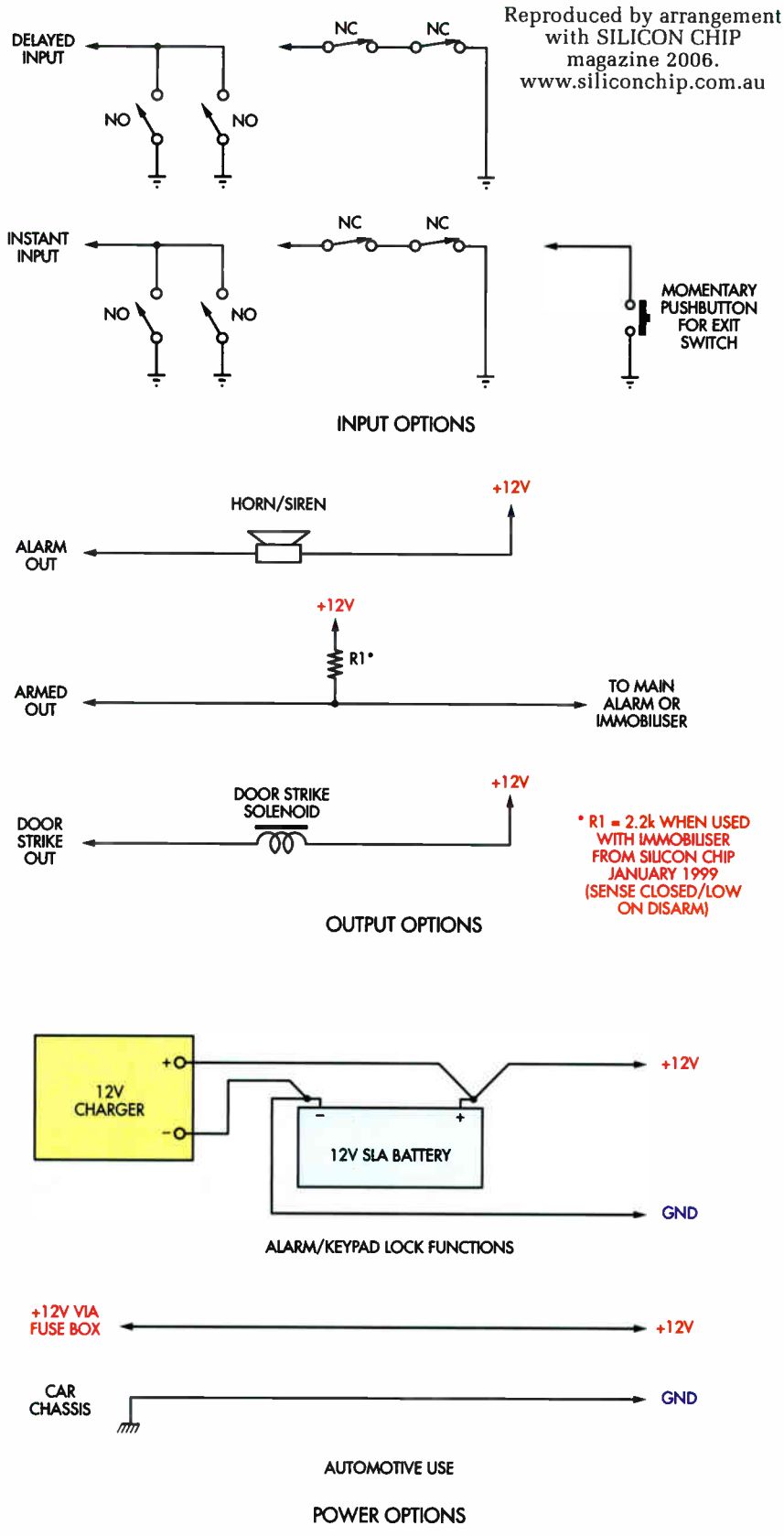

Fig.3: the input, output and power options for the keypad unit. Both the delayed and instant inputs can be connected to either normally open (NO) or normally closed (NC) switches but do not mix these two switch types on the same input.

Q1 and Q2 are both mounted with the top of the transistor body 8mm above the PC board. Transistor Q3 mounts with its leads bent over at 90º and sitting on top of Q1 and Q2. Q3 should have its metal face upwards.

Next, install the 5V regulator, the capacitors and IC socket. Take care to orient the socket and the electrolytic capacitors with the correct polarity. The keypad connection uses a 7-way socket cut from a 14-pin DIL IC socket. Cut the socket with a sharp utility knife to obtain the two socket strips. The second strip is soldered to the underside of the keypad.

The LEDs are soldered with their tops 21mm above the PC board. Finally, install the 8-way terminal strip.

Mounting the keypad

Mark out the required cutout for the keypad and cut this shape out by drilling a series of holes around the perimeter first and then knocking out the piece. File to shape afterwards.

Four holes are required for mounting the keypad. Use a 2.5mm (3/32-inch) drill.

The keypad is connected to the PC board using the IC socket strips on both the keypad and PC board, with a 7-way pin header plugged in-between these. For the separate unit version, connection is via 7-way cable plus two extra wires for the piezo transducer.

The piezo transducer can be either mounted on top of a 10mm standoff for the single-unit installation or on the back of the keypad for separate units. The piezo transducer should be loud enough with the sound coming through the keypad itself. Extra holes can be drilled if more sound level is required.

Testing

Connect power to the +12V and ground terminals and measure the voltage between pins 5 & 14 of the IC socket. This should be close to +5V. If correct, disconnect power and insert IC1.

Now reapply power with the keypad connected – the status (red) LED should be flashing at a one-second rate. Enter 1000 and the armed LED should extinguish. There should be a beep from the piezo transducer on each key press.

Enter 1000 again and the status LED should begin flashing twice per second

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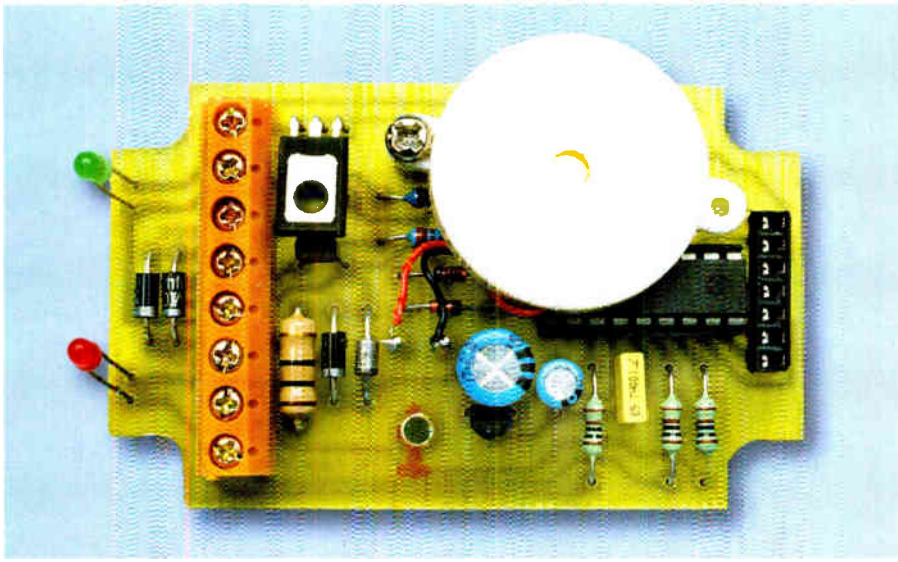


The piezo buzzer is mounted on top of a 10mm untapped spacer and secured using a 15mm machine screw and a 10mm tapped spacer which screws on from the underside of the board.

and the green (door strike) LED should light for five seconds. After 15 seconds (the default exit delay), the status LED should return to the 1-second rate.

Enter in 2000 and the same results should be available as for the 1000 code. These are the default Master and User codes. Any mistake when entering a code can be cleared with the # key. Enter 000 for the duress code and the piezo transducer should sound for around one second and the alarm output should go low. This can be checked with your multimeter switched to a low Ohms range. To cancel the alarm output, re-enter the Master or User code.

Try entering more than six incorrect codes until the alarm output goes low again. Entering a correct code will stop the alarm.

Now enter the Service code – 3000. The status LED should now light continuously. Press # to cancel.

The Service mode allows changes to be made to the codes, delays and options. These are summarised in Table 3. Changing the Master and User codes is done by entering the Service code, then a 1 for the Master code or a 2 for the User code.

Enter a new number code (maximum 12 digits). The * key can be used as part of the code. The # key exits and returns the unit to normal operation. The new code will be stored and can then be used. Changing the code again will require the same steps.

Note that the code entry length is set by the Service code and initially, with this being set at 3000, the Master and User codes can only be four digits long too. Also note that the 10th, 11th and 12th digits of the User code will set the duress alarm code if entered first. So be sure that any User, Master or Service codes do not start with these numbers, otherwise the duress alarm will sound.

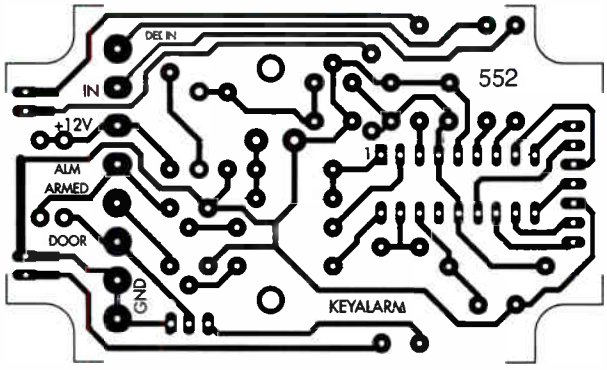


Fig.4: this is the full-size etching pattern for the PC board. Check your board carefully for defects before installing the parts.

Changing the service code

This can be done by entering the current Service code, pressing key 3 and then entering the new code. Pressing 12 keys will set all codes to 12 digits. Pressing only a few keys and then the # key will set the code at the entered length.

Note that the Master and User codes have defaults of 100000000000 and 200000000000 respectively (12 digits) and these are normally truncated to

Parts List

1 PC board, code 552, 78 x 48mm. Available from the *EPE PCB Service*
1 plastic utility box 83 x 54 x 30mm
1 12-key numeric keypad
1 8-way PC-mount screw terminal strip with 0·2" spacing
1 piezo transducer
1 14-pin DIL IC socket (cut for 2 x 7-way sockets)
1 18-pin DIP socket
1 7-way pin header 0·1" spacing
1 10mm untapped spacer
2 10mm M3 tapped spacers
2 M3 x 15mm cheese-head screws
1 M3 nut
2 PC stakes
1 50mm length of 0.8mm tinned copper wire

Semiconductors
1 PIC16F84 programmed with Keypad.hex (IC1) The software can be downloaded from the *EPE* Website at **www.epe-mag.co.uk.** Preprogrammed PICs are available from Magenta Electronics
1 78L05 3-terminal regulator (REG1)
2 BC337 NPN transistors (Q1,Q2)
1 16V 1W Zener diode (ZD1)
3 1N4004 diodes (D1,D4 & D5)
2 1N914 or 1N4148 diodes (D2,D3)
1 BD681 NPN Darlington transistor (Q3)
1 3mm red LED (LED1)
1 3mm green LED (LED2)

Capacitors
1 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
1 100nF MKT polyester
1 39pF ceramic

Resistors (0.25W 1%)
1 4.7kΩ
2 2.2kΩ
3 1kΩ
2 220Ω
1 10Ω

World Radio History

TABLE 3: PROGRAMMING THE ALARM KEYPAD

For all service operations, enter the Service code, press the designated function key and then enter the code or value. Press the # key to end each single digit entry.

Key	Codes	Range	Default
1	Master Code	0-9 and * (1-12 digits)	1000
2	User Code	0-9 and * (1-12 digits) Duress Code is last three digits of 12-digit code	2000 (User Code) 000 (Duress Code)
3	Service Code	0-9 and * (1-12 digits) - sets code length	3000

Note: for codes less than 12 digits or timer numbers less than 10 digits, press # to enter value. Do not make the first three digits the same as the Duress Code.

Key	Timers	Range (seconds)	Default (seconds)
4	Delayed Input	1-99	10
5	Instant Input	1-99	1
6	Door Lock	1-99	5
7	Exit Delay	1-99	15
8	Alarm	1-99	60
9	Alarm Warning	1-99	5
0	Keypad Entry	1-99	5

Enter Service Code & Press *	Option	Mode	Default
	0# (16)	Alarm mode, lock powered on arming, instant alarm input	0
	2# (18)	Alarm mode, lock powered on arming, exit input	0
	4# (20)	Alarm mode, lock powered on disarming, instant alarm input	0
	6# (22)	Alarm mode, lock powered on arming, exit input	0
	8# (24)	Alarm mode, lock powered on both arming and disarming, instant alarm input	0
	10 (26)	Alarm mode, lock powered on both arming and disarming, exit input	0
	1#	Keyless entry mode, lock powered on rearming, instant alarm input	0
	3#	Keyless entry mode, lock powered on rearming, exit input	0

Note: entering the first option number means that the armed output is pulled to ground when the alarm is armed. Conversely, entering a bracketed number means that the armed output is pulled to ground when the alarm is disarmed.

Resetting To Default Values	
Tie instant & delay inputs low, hold down the 3 6 9 and # keys, and power up.	Resets all codes, timing parameters & options to default values.

1000 and 2000 when the code is four digits long. So if the Service code is increased in digits, then more zeroes will need to be entered for the default Master and User codes.

If you forget the Service code, it is possible to redeem the situation. First, switch off the power and tie the instant and delayed inputs to ground. Now hold down the 3, 6, 9 and # keys simultaneously and re-apply power. The status LED will light and stay lit until power is again disconnected. All codes and settings will then be set to their default values.

The delay values can be altered using keys 0 and 4-9, after entering the Service code. The delays can be set to any time from 1-99 seconds. Entry of a single digit time period needs to be ended with #, to store the value and exit the Service mode. Entry of a 2-digit value will automatically store and exit the service mode.

Options

The options are entered in a slightly different way in that the * key is entered after the service code and then a number which matches the required operation mode is entered. The main change that can be made to the unit is from alarm operation to keypad entry mode operation. Alarm mode means that the unit is armed on entry of the Master or User code and disarmed on the second entry of the code. You can also select whether the door striker is operated on arming, disarming or both.

Input wiring

Fig.3 shows the connections that can be made to the keypad alarm. The delayed and instant alarms can be connected to normally open (NO) or normally closed (NC) switches. NO switches can be connected in parallel while NC switches are connected in series. It is not possible to mix NO and NC switches on the same input.

The switches can be set up in a doorway to detect opening or can be a part of an ancillary component such as a passive infrared detector. You can also use doormat switches, window switches and glass breakage tape, or similar.

Power options for the keypad unit are also shown in Fig.3. For automotive applications, it is simply connected between chassis for the ground supply and to +12V via the fusebox for the positive supply. The supply must be continuous 12V and not the switched supply used for ignition or accessories.

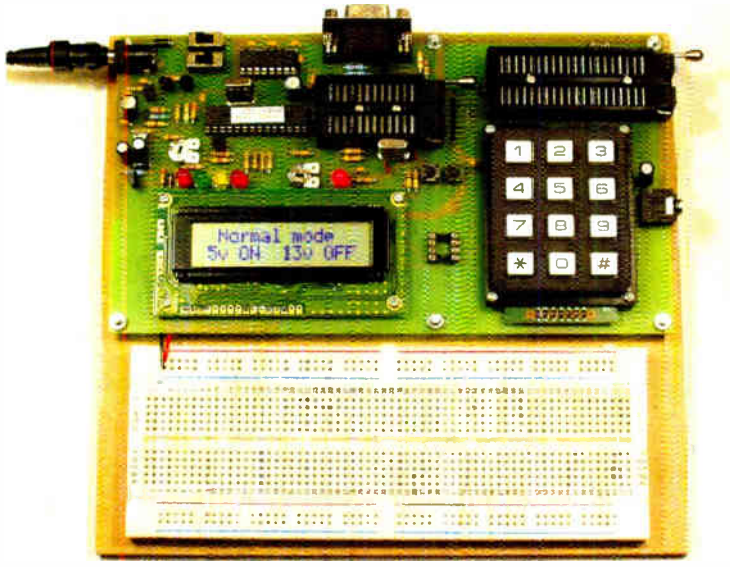
For other applications, the unit needs a 12V SLA battery rated from 1·2 to 7Ah capacity. 1·2Ah should be adequate for most applications but heavy usage of the door strike may require a larger battery.

Installation

This really depends on your application. For most installations, the keypad will be installed on a wall near the exit door. A brick wall may require the unit to be mounted onto a standoff box. ***EPE***

World Radio History

Learn About Microcontrollers



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Which Language to Learn

Everyone should start programming PICs using assembly language. That is the only way to fully understand what happens. Then there are good arguments in some applications to change over to using a high level language, but, BASIC or C? At the beginning BASIC is easy to learn while C can seen very strange, but the weakness of BASIC comes from its ease of use, while the power of C lurks in its strangeness. Once the early stages are past programmes are easier to write in C than in BASIC.

Experimenting with PIC Microcontrollers

This book introduces PIC assembly language programming using the PIC16F84, and is the best way to get started for anyone who is new to PIC programming. We begin with four easy experiments, the first of which is explained over ten and a half pages assuming no starting knowledge of PICs. Then having gained some practical experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Fur Elise*. Finally there are two projects to work through, using the PIC16F84 as a sinewave generator and investigating using the PIC16F88 (from the PIC16F877 family) to monitor the power taken by domestic appliances. In the space of 24 experiments, two projects and 56 exercises the book works through from absolute beginner to experienced engineer level.

Web site:- www.brunningsoftware.co.uk

PIC C Language

The second book *Experimenting with PIC C* starts with an easy to understand explanation of how to write simple PIC programmes in C. The first few programmes are written for a PIC16F84 to keep continuity with the first book *Experimenting with PIC Microcontrollers*. Then we see how to use the same C programmes with the PIC16F627 and the PIC16F877 family.

We study how to create programme loops using C, we experiment with the IF statement, use the 8 bit and 16 bit timers, write text, integer and floating point variables to the liquid crystal display, and use the keypad to enter numbers.

Then its time for 25 pages of pure study, which takes us much deeper into C than is directly useful with PICs as we know them - we are studying for the future as well as the present. We are not expected to understand everything that is presented in these 25 pages, the idea is to begin the learning curve for a deep understanding of C.

In chapter 9 we use C to programme the PIC to produce a siren sound and in the following chapter we create the circuit and software for a freezer thaw warning device. Through the last four chapters we experiment with using the PIC to measure temperature, create a torch light with white LEDs, control the speed of one then two motors, study how to use a PIC to switch mains voltages, and finally experiment with serial communication using the PIC's USART.

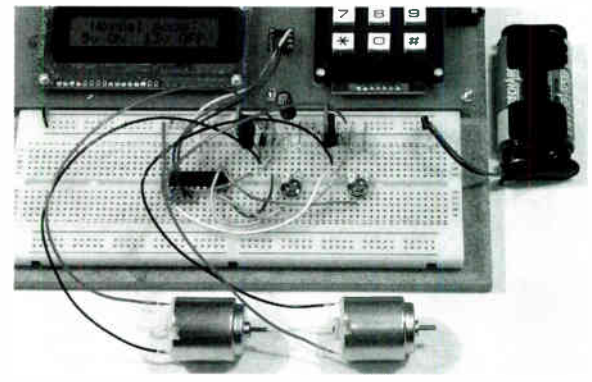
Some of the programmes towards the end of *Experimenting with PIC C* are shown in assembler and C to enable the process to be fully explained, and in the torch light experiments, due to the fast switching speed, the programmes are written only in assembler.

As you work through this book you will be pleasantly surprised how C makes light work of calculations and how easy it is to display the answers.

Ordering Information

The programmer module connects to the serial port of your PC (COM1 or COM2). All our software referred to in this advertisement will operate within Windows 98, XP, NT, 2000 etc.

Telephone with Visa, Mastercard or Switch, or send cheque/PO. All prices include VAT if applicable.



White LED and Motors

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

We use a PIC16F627 as a freezer thaw monitor, as a step up switching regulator to drive 3 ultra bright white LEDs, and to control the speed of a DC motor with maximum torque still available. A kit of parts can be purchased (£30) to build the circuits using the white LEDs and the two motors. See our web site for details.

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PRONOUNCED GUILTY WITHOUT TRIAL

The record industry seems to believe it has the right to install stealth software on our computers. Mark Nelson explains.

GEORGE Orwell's famous book *1984* describes a totalitarian society that censors and monitors everyone's behaviour, even their thoughts. Tyranny of this kind is not entirely fiction, however. The record industry believes that we are all copyright thieves and has the right to install stealth software on our computers in retaliation. This was an unbelievable and very costly assumption.

"There is nothing unusual about technology being used to protect intellectual property," said Cary Sherman, president of the Recording Industry Association of America (RIAA) a month before Christmas. You might feel half-inclined to agree with him, until you hear that music giant Sony had taken the law into its own hands by "enhancing" two million-plus of its CDs with a potent payload of stealth software called Extended Copy Protection or XCP.

Crippleware

If like me you sometimes play CDs on your PC while you're computing, any of them carrying XCP will infect your PC with a virtually untraceable program that provides an unlocked backdoor to hackers anxious to capture your credit card number and PIN.

At no time did the Sony Bertelsmann Music Group alert users to this crippleware or ask their permission. They just installed it anyway to prevent users making multiple copies of their CDs and prevent unprotected MP3 dubs being made. Worse, within hours electronic vandals had come up with ways of exploiting this malware for their own evil ends.

Outrageous or what? On what basis does Sony have the right to tamper with the content of computers that don't belong to them, without so much as by your leave? None whatsoever, even if the vast majority of users were cheats and criminals, which of course they are not.

Stop Digging

Once you're in a hole, most people stop digging, but not Cary Sherman, who argued, "You can't simply make an extra copy of a Microsoft operating system, or virtually any other commercially-released software program for that matter. Same with videogames. Movies, too, are protected. Why should CDs be any different?"

His only concession was this: "The problem with the SonyBMG situation is that the technology they used contained a security vulnerability of which they were unaware. They have apologised for their mistake, ceased manufacture of CDs with that technology and pulled CDs with that technology from store shelves. Seems very responsible to me. How many times have software applications created the same problem? Lots. I wonder whether they've taken as aggressive steps as SonyBMG has when those vulnerabilities were discovered, or did they just post a patch on the Internet?"

Frontier Action

Utter drivel: two wrongs never make a right, a fact that SonyBMG is now finding out the hard way. As well as facing massive negative publicity in the media, SonyBMG will now have to defend itself against major organisations supporting consumer rights in the USA.

A key player in this crusade is the Electronic Frontier Foundation (EFF), which has championed the public interest in every critical battle affecting digital rights. "After a series of embarrassing public revelations about security risks associated with the XCP software, including warnings issued by the United States Government, Microsoft and leading anti-virus companies, Sony BMG has taken some steps to respond to the security risks created by the XCP technology," say EFF. "Unfortunately it's not enough and the music company has created serious security, privacy and consumer protection problems that have damaged music lovers everywhere", they say.

All of which is why the EFF has launched a class action against Sony BMG, along with the state of Texas and five other bodies. EFF is demanding that the company repair the damage done by the software, which as well as restricting use of the music and blocking its transfer to iPods, is also alleged to report customer listening of the CDs. The spyware also installs undisclosed and, in some cases, hidden files on users' computers that can expose users to malicious attacks by third parties, all without appropriate notice and consent from purchasers.

It's this stealth aspect that has led Texas Attorney General Greg Abbot to sue SonyBMG under the state's anti-spyware laws. Some 50 titles released in North America contained XCP, which leaves computers vulnerable to third-party viruses and hack attacks. For every single violation of the law the state is demanding penalties of $100,000 (£56,000) as well as all legal fees and investigative costs.

Examining XCP

How does XCP work and how do you know if you have it on your PC? XCP employs a technology known as a rootkit, a disguise device that installs on your computer at the most fundamental level of the operating system (the root). It has the ability to hide evidence of malefactors doing nasty things to your computer, rather like some early Trojan Horse programs that treated you to a dazzling fireworks display while simultaneously wiping clean your hard drive. This cloaking capability creates a glaring security hole that would offer any malicious program easy and virtually undetectable access – and of course did.

One of the first people to spot this nasty piece of work was computer security expert Mark Russinovich while he was checking out the latest version of his RootkitRevealer program. You can download a copy for nothing (type RootkitRevealer into Google, but be warned, it's not for beginners). To his horror he found XCP on his computer and when he attempted to uninstall the rootkit, it retaliated by disabling his CD drive. However, he did manage to trace the problem to its source – a Van Zant audio CD on the Sony BMG label that was previously playing on his computer.

Spotter's Guide

Because the infected CDs were issued in the USA only, not many people outside North America are likely to have XCP on their computer. It is deliberately as untraceable as possible but the EFF has a helpful Spotter's Guide on its website at **www.eff.org/IP/DRM/Sony-BMG/guide.php**, where you can also check out a list of the US and Canadian albums infected with XCP. Sony has its own help page at **http://cp.sonybmg.com/xcp/english/faq.html**.

There's reassuring news that the next updates of Microsoft anti-spyware and the paid-for version of ZoneAlarm will contain tools for detecting and removing XCP, so is that it now?

Not on your nelly. Chances are that digital rights management and anti-copy software will become ever more ingenious. The crippling may not interfere with your computer either. There are already map and street atlas CD-ROMs on sale that contain crooked streets with bends in the wrong place or direction that might not inconvenience the user, but are a dead giveaway to investigators looking for illegal copies.

BT has taken action against people making disguised copies of its telephone number CDs by "seeding" the records with subscriber names and telephone numbers that don't exist. This won't trouble legitimate users, but pirates will be revealed with consummate ease. Spy vs Spy was never so much fun!

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MikroElektronika

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PICmicro

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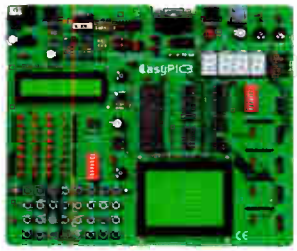

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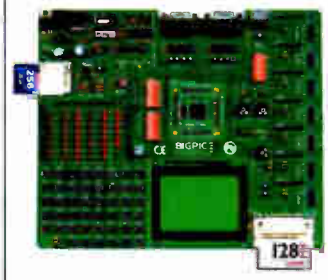

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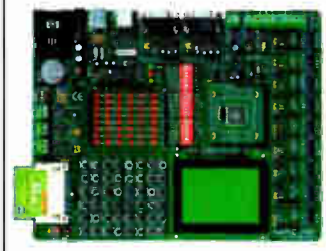

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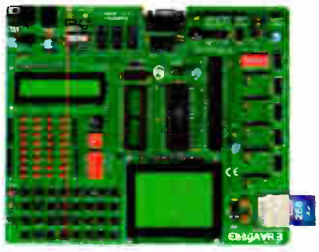

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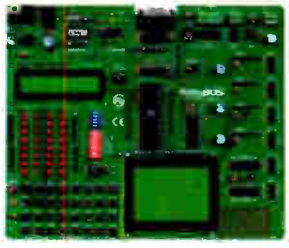

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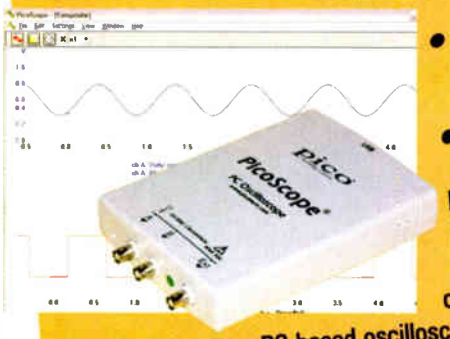

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Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. 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!**

Clipping Indicator for the STA7360 – *Above the Limit*

THE *20W Amplifier Module* (May 2005) has a "clip" output connection on pin 2 which can be used to show when the amplifier is over-driven. It is an excellent circuit but I also fancied adding an l.e.d. clipping indicator.

The STA7360 data sheet says "The device provides a circuit for the detection of clipping in the output stages. The output, an open collector, is able to drive systems with automatic volume control". In the table of electrical characteristics it says that, with a pull up to 5V with 10kΩ the Clip Detector Program Current is 70μA for d = 1% and 130μA for d = 5%. There is no other guidance on how to use it, in particular no information on the limits on what can be applied to the clip pin.

Clipping Circuit

So, to play safe, the author set up the circuit in Fig.1a as suggested in the data sheet, where TR1 is the internal transistor in the amplifier, and IC1 is a voltage regulator providing the 5V needed for the open collector pull-up over the whole range of amplifier supply voltages up to 18V. An oscilloscope soon showed what was going on, as illustrated in Fig.2.

When, as in the first cycle shown, the output is just below the clipping level, TR1 remains cut off and the voltage at pin 2 remains near 5V. In the next cycle the output is just clipped at the very peak of the wave; TR1 is turned fully on only during the clipped time, producing a short negative going pulse to near 0V on each half cycle. Presumably the currents quoted in the datasheet are the averages flowing in resistor R1 and the impression of a steady current flowing is misleading.

The pulse is ideal for driving an l.e.d. as in Fig.1b. To avoid loading the pull-up circuit, op.amp IC2, connected as a

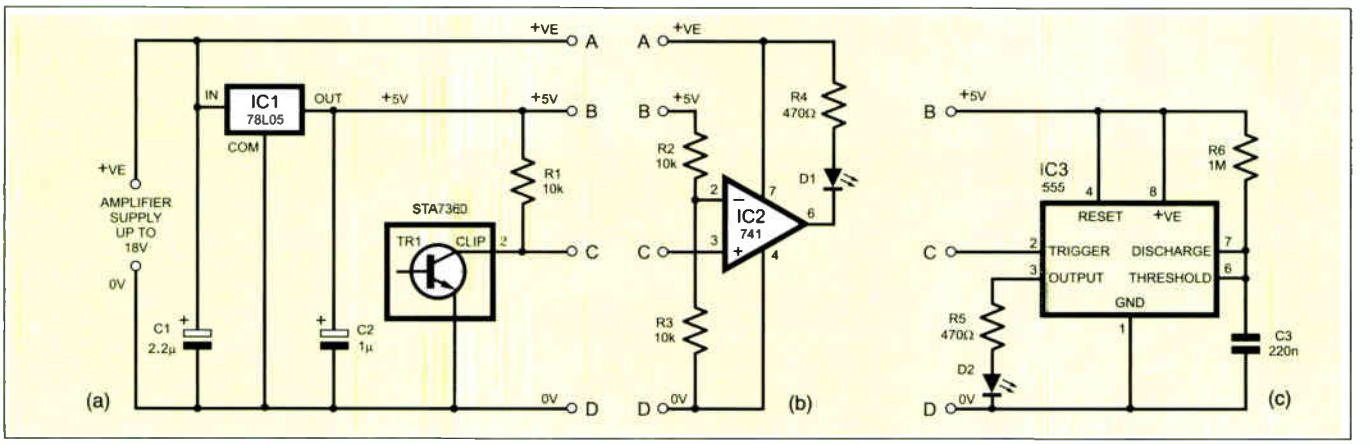

Fig.1. (a) Basic STA7360 Clipping Indicator circuit diagram, (b) driving an l.e.d. and (c) an alternative pulse stretcher add-on circuit

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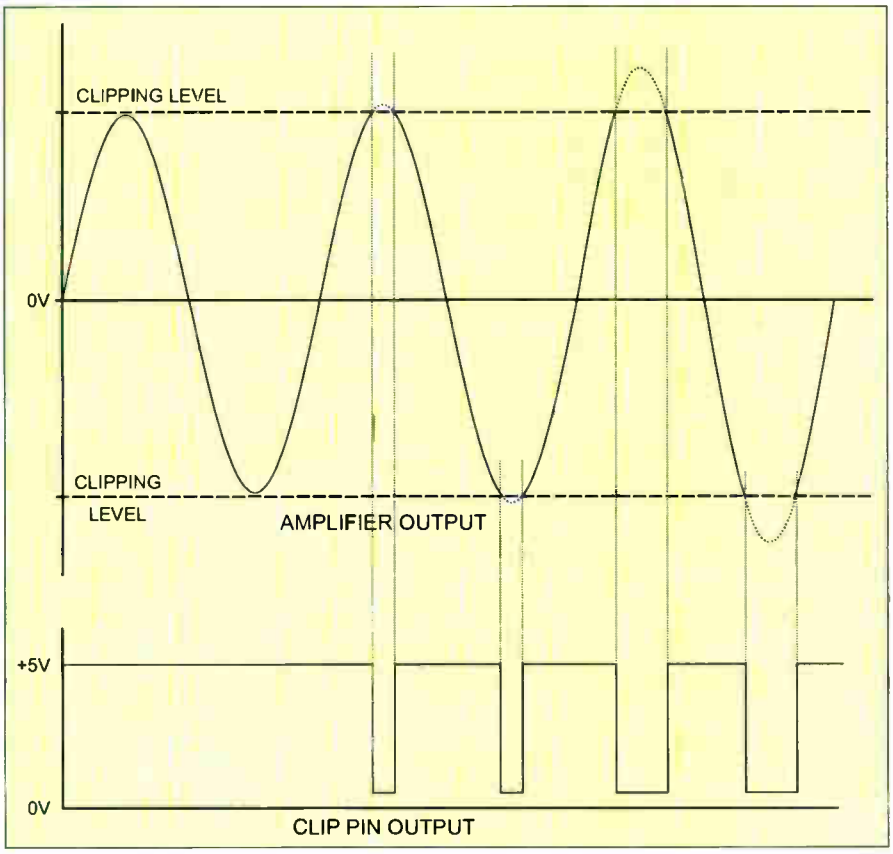

Fig.2. Waveform diagram showing the clipping action of the circuit

comparator, is used as a buffer. Resistors R2 and R3 hold the inverting input at about 2.5V, so the negative-going pulse on the non-inverting input drives the l.e.d. on the output, with resistor R4 providing buffering. In this instance, the l.e.d. is on for as long as negative-going clipping of the amplified signal occurs.

Alternatively, it is possible to use the circuit in Fig.1c as a pulse stretcher to extend the length of time for which the l.e.d. is turned on. The 555 timer, IC3, is configured as a monostable. With the given values, the negative going edge of the pulse at its trigger input (pin 2) causes a nice bright flash lasting about 0.25 second, showing clearly whenever clipping occurs at the input peaks, allowing the amplifier drive to be turned back to just below this point.

Harry Weston, Bognor Regis

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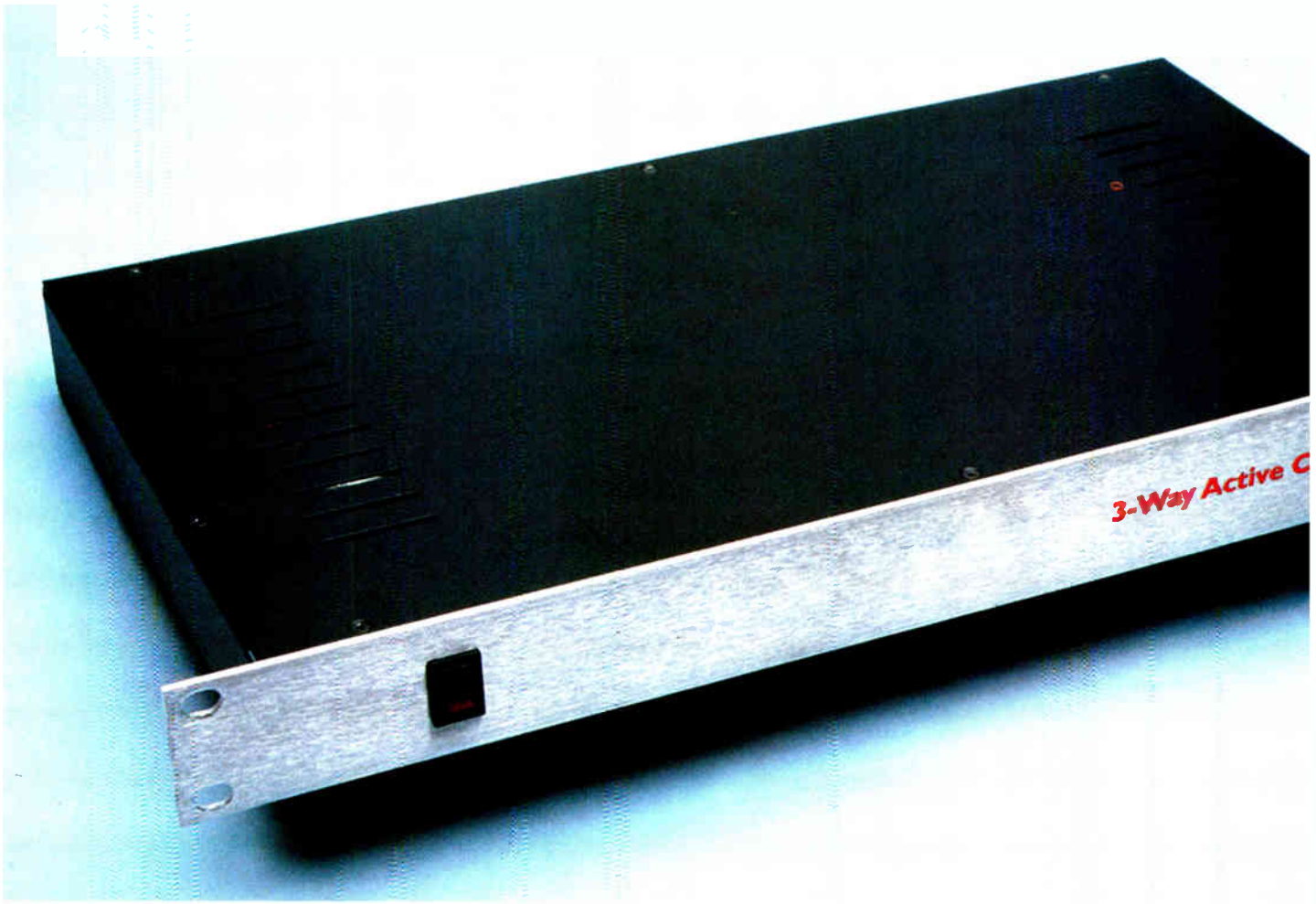

This stereo 3-way active crossover is for those enthusiasts who want the very best from their 3-way loudspeaker systems. It avoids the disadvantages of passive crossover networks and allows the power levels to the speakers to be optimised.

Main Features

- 1-unit rack case
- Single PC board
- 15V+15V 20VA toroidal transformer
- Stereo module
- Buffered input and output stages
- Individually variable outputs (trimpots)
- On-board power supply
- On-board RCA connectors
- Made from low-cost standard components

WHAT IS AN ACTIVE crossover and why would you want one? Most hifi enthusiasts are aware that 2-way and 3-way loudspeaker systems contain passive networks to split up the audio spectrum into two frequency bands in the case of 2-way systems and three bands in the case of 3-way systems.

Passive crossover networks use inductors, capacitors and resistors to split the audio into the various bands and set the signal levels to the various speaker drivers.

For example, the woofer is often less sensitive than the midrange driver and tweeter and so the signals to the latter drivers have to be reduced so that the overall output from the three drivers is equal.

In the higher performance speakers, the crossover networks are often very complex and they can be very difficult to design and optimise. And because they usually do attenuate the midrange and high signals, that means they do waste amplifier power.

They also interpose a complex network between the speakers and the amplifier which means a loss of damping factor, particularly for the lower frequencies where it is most needed, if you are to achieve tight, clean bass and midrange reproduction.

OK, so that's the passive approach. It involves just one stereo amplifier to drive the two speaker boxes in a stereo system.

In an "active" system, we eliminate the passive crossover networks and

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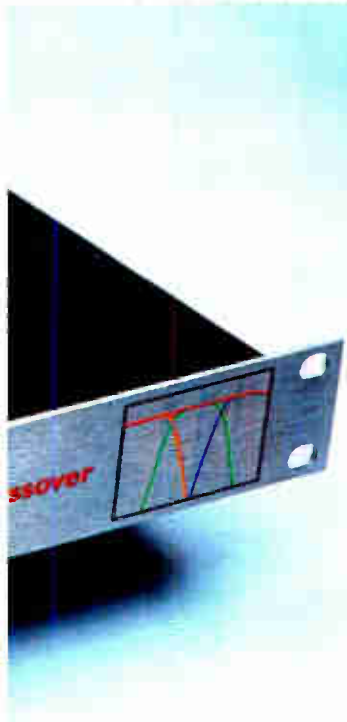

An active 3-way crossover for loudspeaker systems

Circuit Design by ROD ELLIOT
www.sound.westhost.com

electronically split each of left and right channel signals into three frequency bands: low, midrange and high. This is the job of the "active crossover".

Its output signals are fed to six (yep, six) separate amplifiers to drive the woofer, midrange and tweeter units in each loudspeaker enclosure. The overall system layout is shown in the block diagram of Fig.1.

So you end up with a lot more amplifiers than in a conventional system but it gives you a lot more flexibility. And ultimately, you can end up with a system with higher performance, including much higher power levels.

The active crossover approach also means you can mix 4Ω and 8Ω drivers

This shot inside the box reveals the simplicity of construction. Everything except the transformer is on one PC board!

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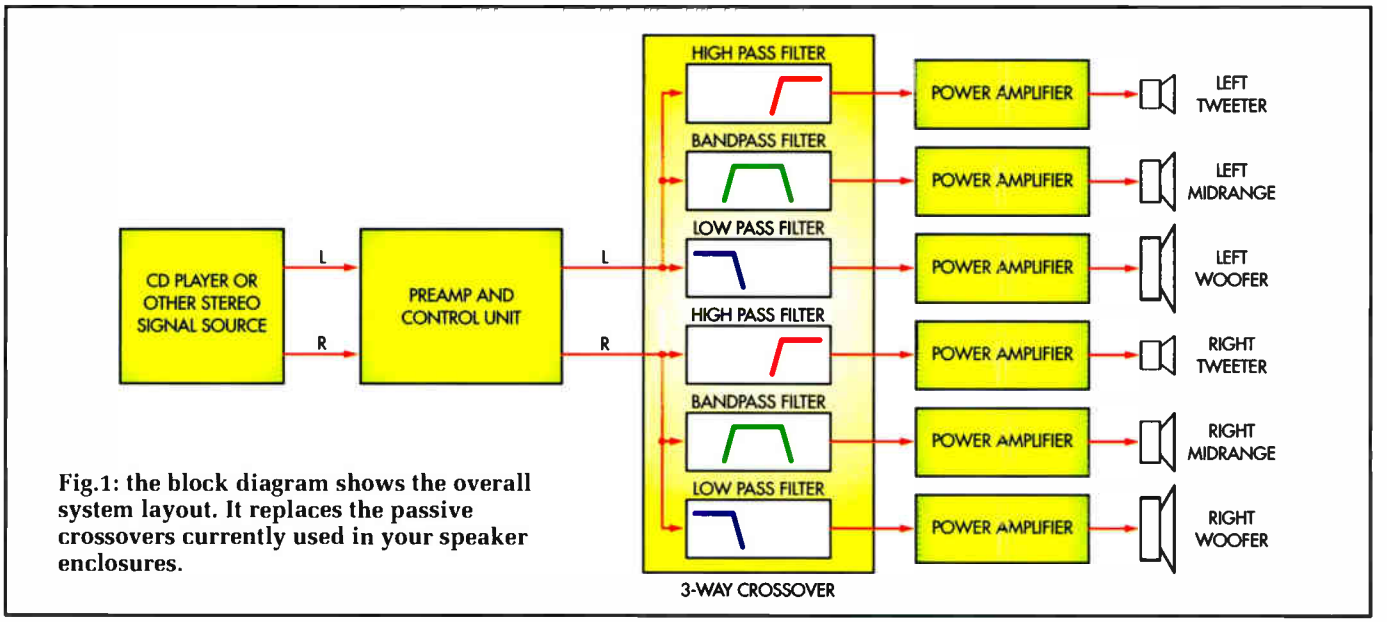

Fig.1: the block diagram shows the overall system layout. It replaces the passive crossovers currently used in your speaker enclosures.

in the same system and match the levels easily, without power wastage.

Active crossover

The Active Crossover presented here is housed in a 1-unit high rack case with just the power switch on the front panel.

There are no user controls for the crossover; no switches to alter the crossover frequencies nor external level controls for the output signals. To alter the drive to the loudspeakers, you will need to adjust the volume controls of the driver amplifiers.

On the rear panel, there are four pairs of RCA sockets, one pair for the stereo input signals while the other three are for the stereo low (woofer), midrange and high (tweeter) signals.

Also on the rear panel is the IEC mains power socket and a fuseholder for the primary circuit of the power transformer.

Inside the case, all the circuitry is on a PC board measuring 219 x 99mm and this includes the dual RCA input and output sockets. The only external wiring connections to the board are the secondary connections to the toroidal power transformer.

Circuit description

Now let's have a look at the circuit of Fig.2. Since both channels are identical, this shows only the left channel. While the power supply is also on the PC board, it is shown in Fig.3.

In total, the left channel uses 12 op amps, in three TL074 quad FET-input op amp packages. Four op amps, IC1a, IC1b, IC5a & IC5b, act as input or output buffers while the remaining eight op amps are Linkwitz-Riley active filter stages with 12dB/octave filter slopes.

In each case, two 12dB/octave filters are cascaded to give an overall filter slope of 24dB/octave. This is far steeper than is normally used in passive crossover networks. The voltage gain of all these filter stages in the passband is unity.

Low pass, high pass

Before we go any further we should explain some terms which often confuse beginners: low-pass, high-pass and bandpass.

A *low-pass* filter is one that allows low frequencies to pass through and it blocks the higher frequencies. Hence, a circuit to drive a subwoofer would be called a low-pass filter since it only delivers frequencies below 200Hz or thereabouts.

Similarly, a *high-pass* filter is one that allows high frequencies to pass through and it blocks low frequencies. Hence, the part of a crossover network which feeds a tweeter is said to be a high-pass filter, even though it may consist of only one capacitor.

If we cascade (ie, connect in series) a high pass filter with a low pass filter, the combination will pass a band of frequencies and we then refer to it as a *bandpass* filter. We use a bandpass filter for the midrange output in this active crossover circuit.

Specifications

Voltage gain	Unity
Frequency response	Within ±1dB from 10Hz to 20kHz (see Fig.5)
Filter attenuation slope	24dB/octave
Total harmonic distortion	Typically 0·003% at 1V RMS
Signal to noise ratio	-94dB unweighted (22Hz to 22kHz) with respect to 1V RMS
Separation between channels	Typically better than -100dB from 10Hz to 20kHz
Input impedance	47kΩ
Output impedance	less than 200Ω

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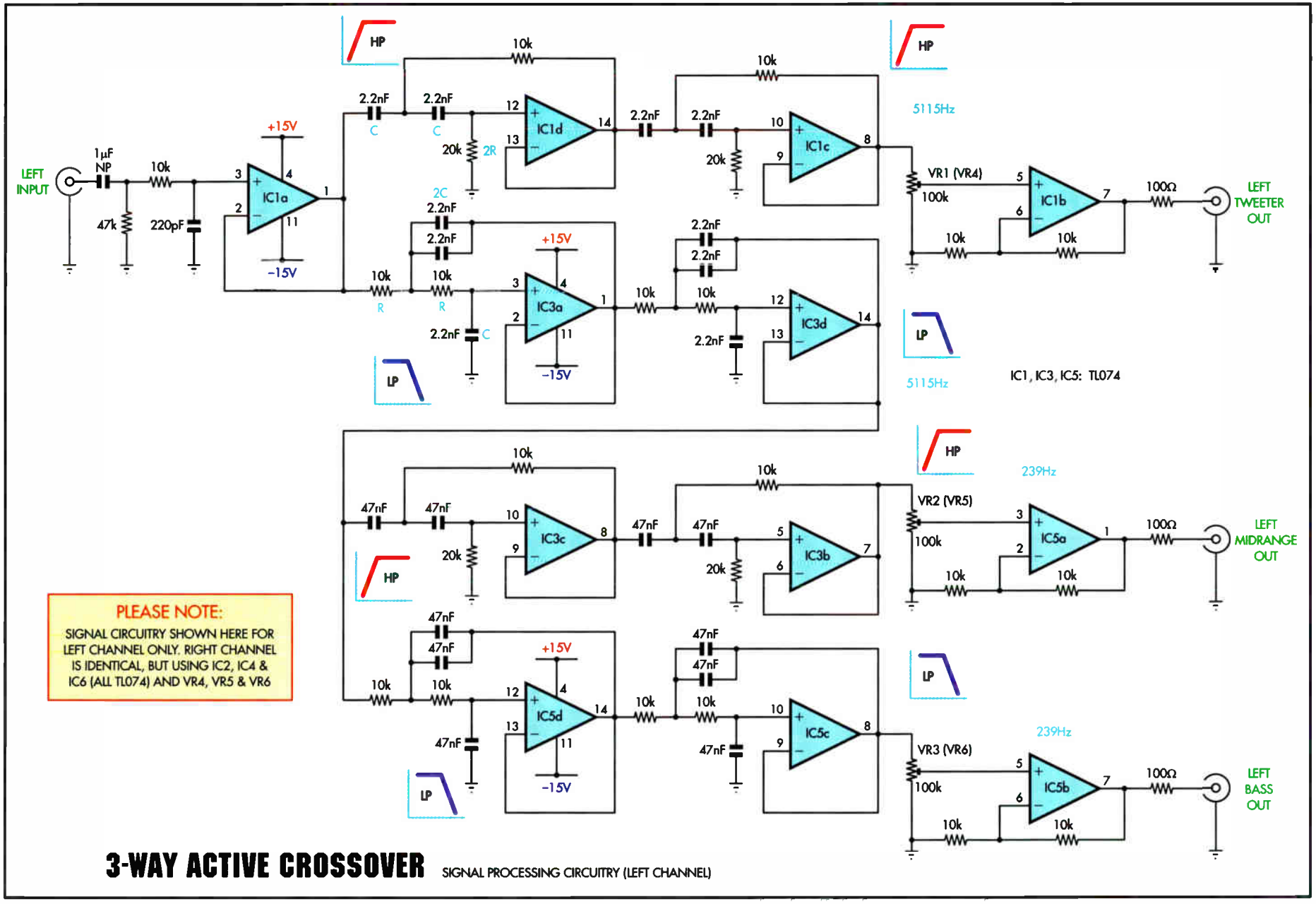

Fig.2: just 12 op amps and a few other components make up each channel of the active crossover. The six outputs (three only shown here; three more in the right channel) each drive separate power amplifiers for the tweeter, midrange and bass drivers in your loudspeakers.

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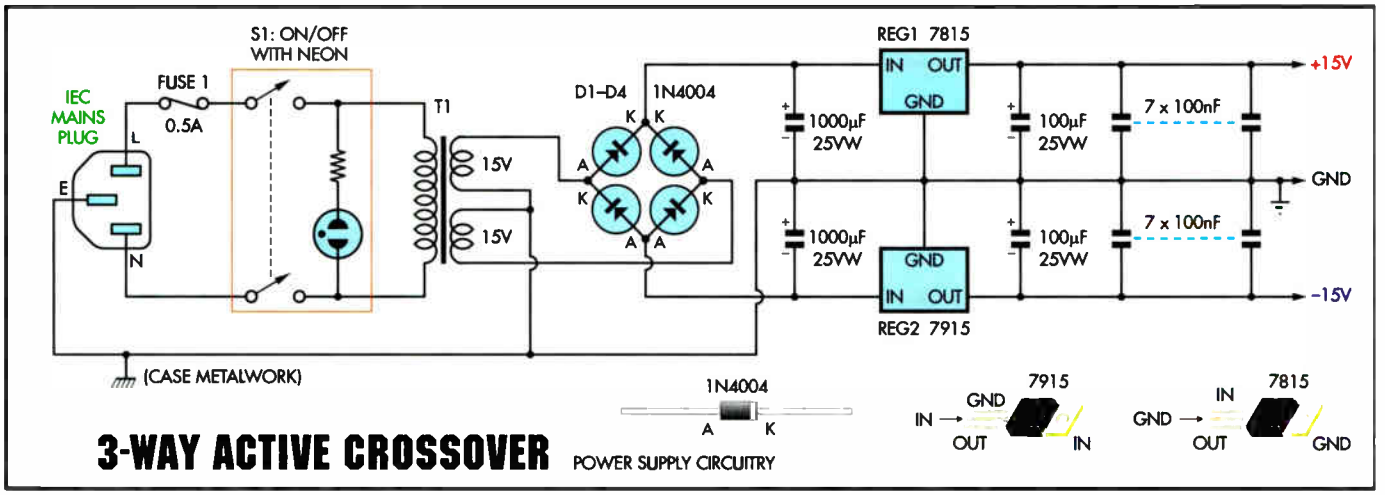

Fig.3: the power supply is conventional and uses a bridge rectifier (D1-D4) and two 3-terminal regulators (REG1 & REG2) to give ±15V rails. The seven 100nF capacitors are bypasses distributed around the PC board.

The other points you need to know about high and low-pass filters are the so-called *cut-off frequency* and the *filter slope*.

The filters used in this circuit have an attenuation of 12dB/octave; this is the filter slope and it applies for frequencies after the cut-off frequency. The cut-off frequency is where the signal output is -3dB down on the normal level.

For example, in a low-pass filter we might have a cut-off frequency of 1kHz (ie, -3dB point) and from there on the filter slope could be 12dB/octave. In theory, this means that the response at 2kHz (ie, one octave above 1kHz) will be -15dB, although in practice it might not be quite that good.

The filters used in our circuit are of the Linkwitz-Riley configuration and we use eight of these filters, four high-pass and four low-pass, in each channel. Each filter consists of an op amp connected as a voltage follower, preceded by two RC networks.

As already noted, for each high-pass and low-pass filter, we are using two 12dB/octave filters cascaded, to make the total roll-off 24dB/octave (4th order) per filter stage.

The basic filter configurations are shown in Fig.4, together with the formula for calculating the crossover frequency. In this particular case, the crossover frequency is at the -6dB point and the reason for this is that we are cascading two filters for each section (2 x 3dB = 6dB).

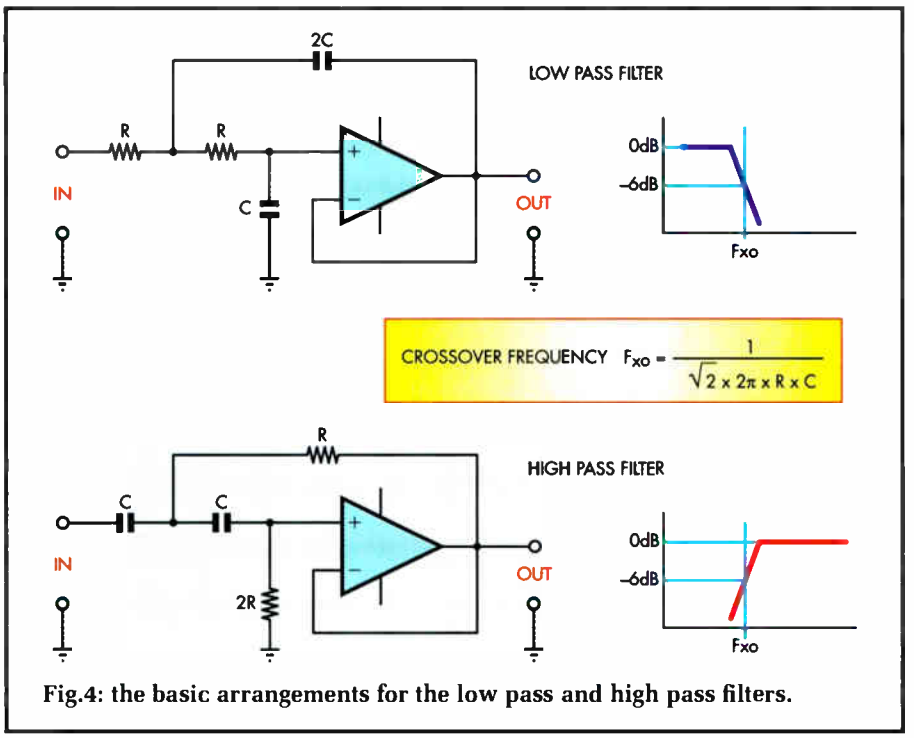

Fig.4: the basic arrangements for the low pass and high pass filters.

Note that the capacitors in the low-pass filter are shown with values of C and 2C, while in the high-pass filter, we use resistors with values of R and 2R.

In the main circuit of Fig.2 you will note that two capacitors of equal values have been used for the 2C component, as it is difficult to obtain capacitor values exactly double that of another. On the other hand, resistors are much easier and so we have values of 10kΩ for R and 20kΩ for 2R.

Now after that little diversion, let's refer back to the circuit of Fig.2.

The input to the left channel is fed via an RC filter, to roll off frequencies above 100kHz, and then to op amp IC1a which is connected as a unity gain buffer (or voltage follower). It drives two high-pass filter stages associated with IC1d & IC1c and two low-pass filters associated with IC3a & IC3d. Both these low-pass and high-pass filters have cutoff frequencies set to 5.1kHz.

The output of the second high-pass filter (IC1c) is fed to level setting trimpot VR1 and then to IC1b which is connected as a non-inverting amplifier with a gain of two. It drives the left treble output (tweeter). Hence the tweeter only gets frequencies above 5kHz.

Midrange band-pass

The output of low-pass filter IC3d feeds high-pass filters based on IC3c & IC3b, both with cut-off frequencies of

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239Hz. The output of high-pass filter IC3b is fed to trimpot VR2 and then to op amp IC5a which has a gain of two. This drives the left midrange output which gets the band of frequencies between 239Hz and 5.1kHz.

As well as driving high-pass filters IC3c & IC3b, op amp IC3d also drives the cascaded low-pass filters based on IC5d & IC5c, again with a cut-off frequency of 239Hz. IC5c drives trimpot VR3 and then op amp IC5b which has a gain of two. It drives the left bass output which only gets signals below 239Hz.

All the outputs from each stage are in phase at the crossover points. Voltage gain at the crossover frequency for each section is -6dB (ie, half the reference level). Thus, when the response curves for all three sections are added together, the result is an extremely flat frequency response with an overall gain of unity.

Just how well this works is shown in the response curves of Fig.5. We've plotted the three filter responses and then the resultant curve is plotted along the top. The adder circuit we used to do this is shown (for interest only) in Fig.8.

Fig.3 shows the power supply circuit. It uses a 20VA toroidal power transformer with two 15V secondary windings. These drive bridge rectifier (D1-D4) and two 1000µF capacitors to derive unregulated DC supply rails of around ±22V which are then fed to regulators REG1 and REG2 to produce ±15V rails. Each rail is bypassed by a 100µF capacitor and seven 100nF multi-layer ceramic capacitors which are distributed around the board.

Construction

As already noted, all the circuitry is on a single PC board measuring 219 x 99mm, so construction is very straightforward. The only complication will occur if you wish to set your own crossover frequencies. If so, you will need to select values from Table 1.

For example, if you decide you want a tweeter crossover frequency of around 3kHz, go to Table 1, run your finger down the righthand column until you get to 3100 and the R and C values are in columns 1 & 2.

In practice, the 2.2nF capacitors in the high pass and low pass filters associated with IC1 and IC3 now have to be changed to 3.3nF, while the 10kΩ resistors increase to 11kΩ and the 20kΩ values go to 22kΩ.

Parts List – 3-Way Active Crossover

1 1RU rack-mounting case
1 PC board, code 553, 219 x 99mm, available from the *EPE PCB Service*
1 panel-mount male IEC power socket
1 chassis-mount safety fuseholder (M205 or 3AG type)
1 0.5A fuse (3AG or M205 type to suit fuseholder)
1 DPST rocker switch with inbuilt neon (S1)
1 20VA toroidal mains transformer with 2 x 15V secondaries
1 3-way insulated terminal block
4 dual gold-plated RCA PC-mount sockets
6 multi-turn 100kΩ trimpots (VR1-VR6)

Semiconductors
6 TL074 quad FET-input op amps (IC1-IC6)
1 7815 positive 3-terminal regulator (REG1)
1 7915 negative 3-terminal regulator (REG2)
4 1N4004 silicon diodes (D1-D4)

Capacitors
2 1000µF 25V PC electrolytic
2 100µF 25V PC electrolytic
2 1µF 50V bipolar (non-polarised NP) electrolytic
14 100nF (0.1µF) multi-layer ceramic (code 100n or 104)
20 47nF (.047µF) metallised polyester (code 47n or 473)
20 2.2nF (.0022µF) metallised polyester (code 2n2 or 222)
2 220pF ceramic

Resistors (1% metal film)

2 47kΩ	(yellow violet orange brown or yellow violet black red brown)
8 20kΩ	(red black orange brown or red black black red brown)
38 10kΩ	(brown black orange brown or brown black black red brown)
6 100Ω	(brown black brown brown or brown black black black brown)

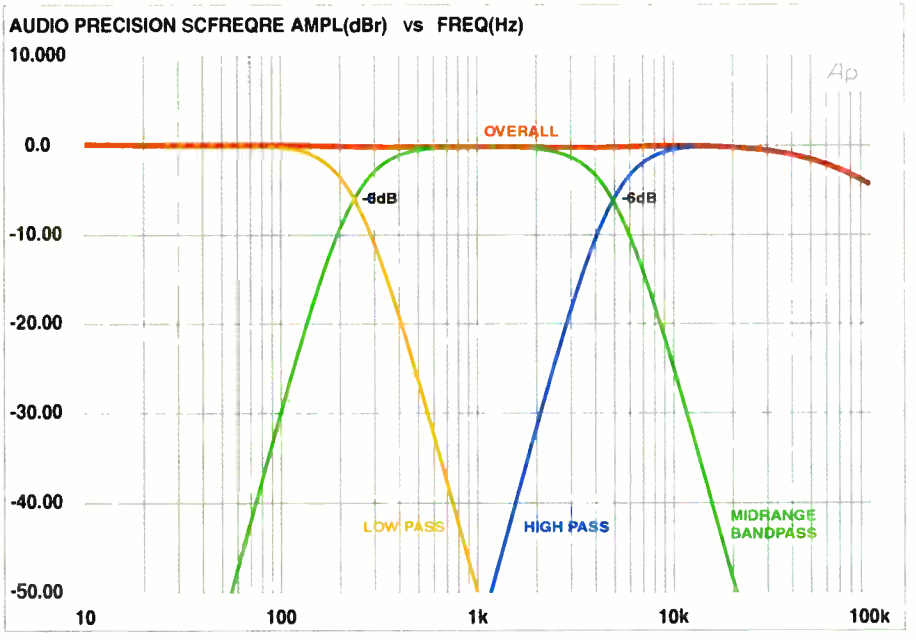

Fig.5: this graph shows the three filter response curves which were plotted separately. The overall response curve at top (red) was plotted using the mixer circuit shown in Fig.8. The overall response curve is extremely smooth.

Note that the high-pass filters (ICd & IC1c) for the tweeter and the low-pass filters (IC3a & IC3d) for the midrange must all have exactly the same cut-off

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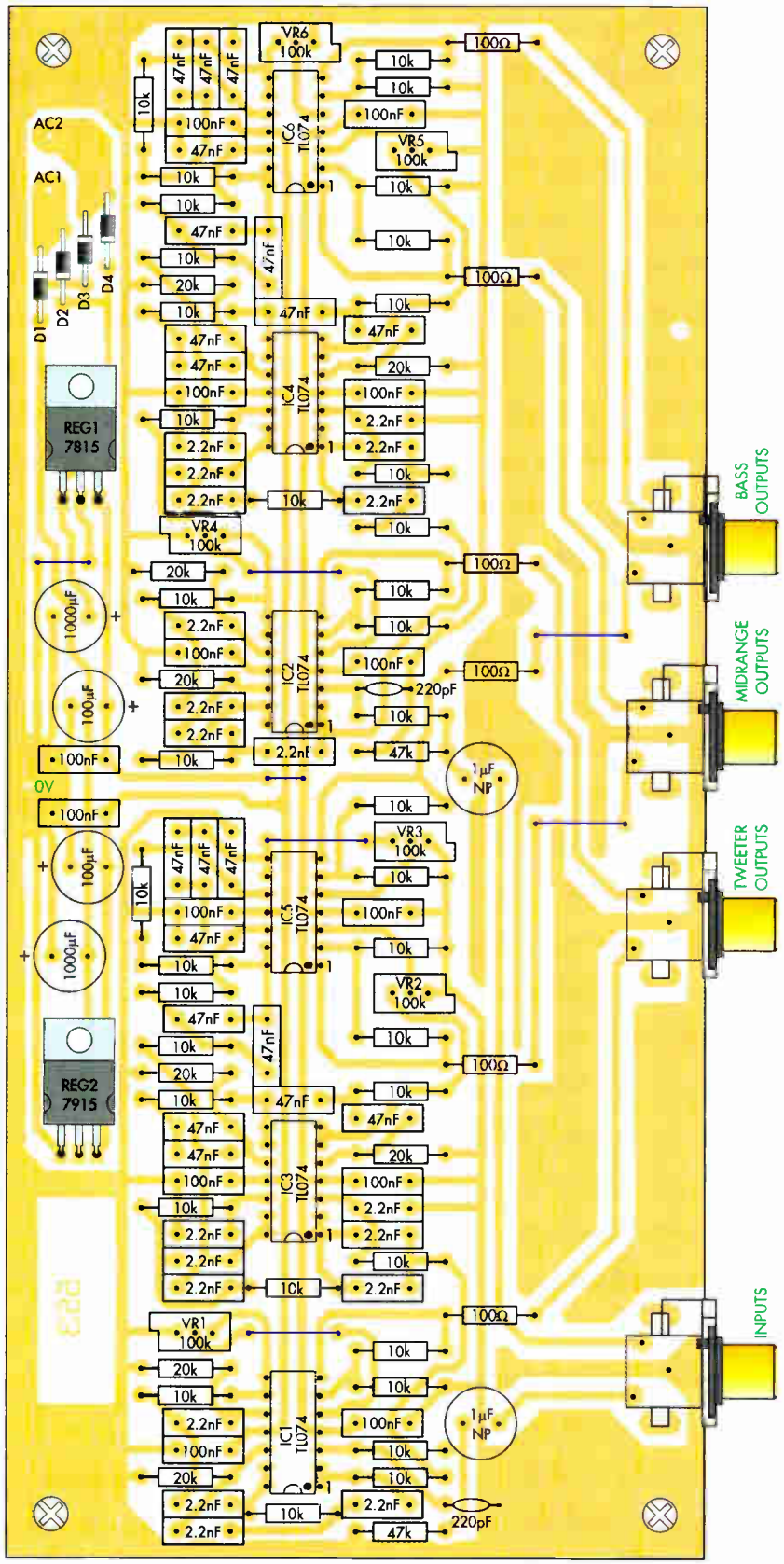

Fig.6: follow this parts layout diagram when building the PC board. Take care with the polarity of the electrolytic capacitors, diodes and the ICs when soldering them in!

frequencies, otherwise you will not get an overall flat frequency response.

Similarly, if you want to change the bass cut-off frequency to around 350Hz (say), run down the righthand column of Table 1 to 347Hz. The R values then become 12kΩ and 24kΩ, while the C values become 27nF.

Alternatively, if you want to do the calculations yourself, visit www.sherlab.com/filter/filter.htm for a filter calculator.

Lots more information regarding Linkwitz-Riley crossovers can be found at www.rane.com/note107. Here they discuss lobing errors, driver alignment & phase correction, phase shift vs frequency, etc.

Having decided on your crossover frequencies, you can start assembly of the PC board by closely checking it for shorts between tracks, open circuits etc, against the pattern opposite. Then install all the resistors, followed by the capacitors and multi-turn trimpots. Make sure that the electrolytic capacitors are installed the right way around. The bipolar electrolytics are not polarised and can go in either way.

Ideally, 1% capacitors should be used in all the filter circuits. As an alternative, purchase a bag of 100 capacitors of the value you require and pick the 20 that are the closest in value to each other, using a capacitance meter or DMM with capacitance ranges.

The two regulators are laid flat on the PC board. Be careful not to swap them over, otherwise you may have to replace quite a few damaged semiconductors. Finally, complete the board by installing the op amps and the RCA sockets.

That done, you can wire up the power transformer and install the chassis – see Fig.7. **Take special care with the mains wiring and be sure to sleeve all exposed connections with heatshrink tubing and bind the leads with cable ties, as shown. Note that the fuseholder must be a mains safety type.**

Voltage checks

Next, temporarily install the PC board into the chassis, apply power and check the regulated supply rails with your digital multimeter. They should be close to ±15V DC.

Check also that +15V is present on pin 4 of each TL074 and that -15V is present on pin 11 of each IC. Lightly

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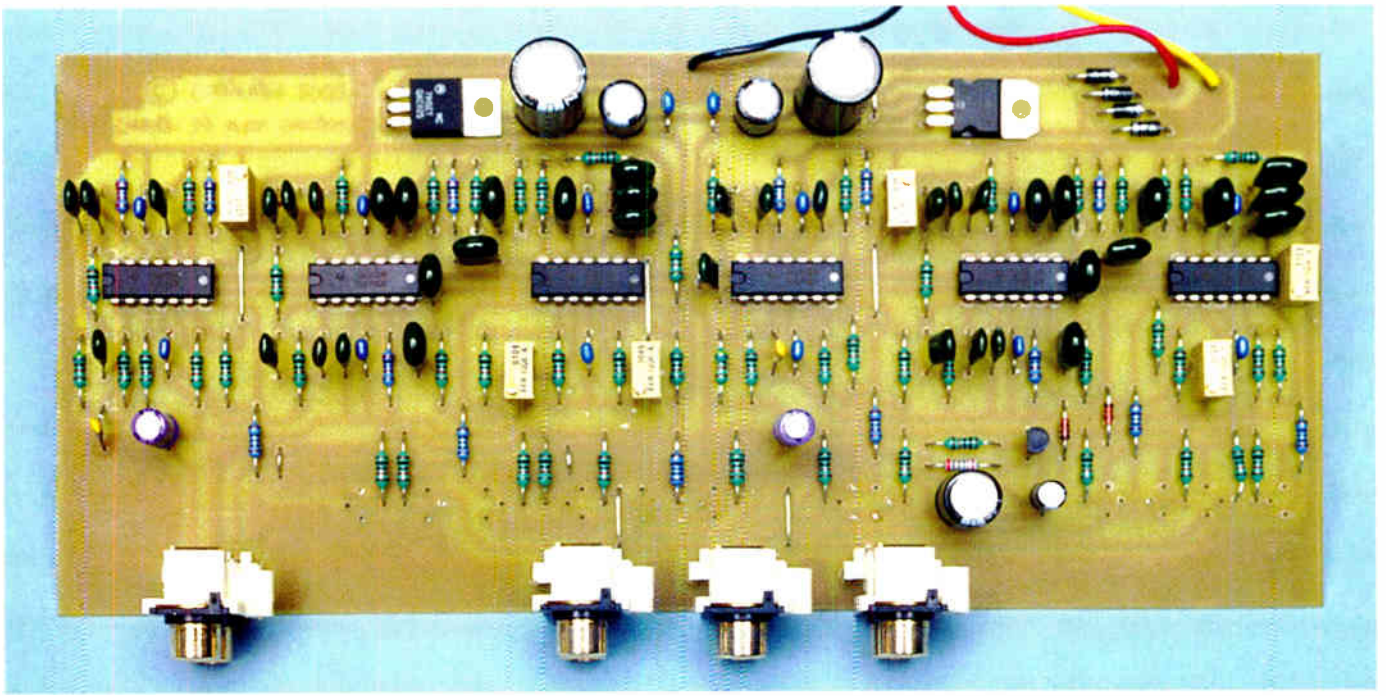


This photo of an early prototype PC board shows the general layout of components. Note, however, that there have been substantial changes since this photo was taken. The parts overlay (Fig.6) shows the final version.

touch each IC to ensure that none of them is getting hot – they should all be cool.

The next step is to align the whole circuit using the trimpots. This is a simple matter of setting up each output for unity gain in its passband. This can be done at three frequencies, say 100Hz for the bass, 1kHz for the midrange and 12kHz for the treble.

You will need an audio oscillator and a digital multimeter with an AC frequency response to 20kHz or better. Connect your audio oscillator to the input RCA connector in one channel. Set the frequency to 100Hz, 1kHz or 12kHz, depending on which section you wish to align. Set the level of the oscillator to 1V RMS.

Now measure the signal level at the output of the stage that you are adjusting. For the treble output, use 10kHz and adjust trimpot VR1 (left channel) or VR4 (right channel) to obtain 1V RMS at the output socket.

Similarly, for the midrange, use 1kHz and adjust VR2 (left channel) or VR5 (right channel) to obtain 1V RMS at the output sockets.

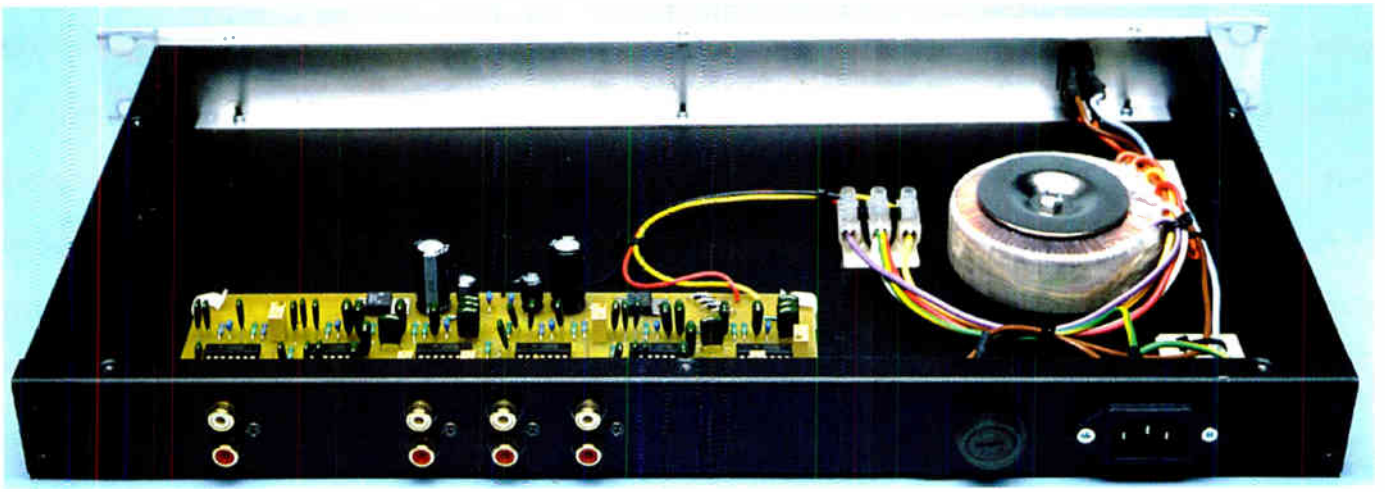
Finally, for the bass, use 100Hz and adjust VR3 (left channel) or VR6 (right channel) to obtain 1V RMS at the output. It is now just a matter of tidying up the wiring inside the case and checking it before connecting the unit to your amplifiers.

Power amplifiers

We mentioned before that six amplifiers are required – one for each of the bass, midrange and treble speakers, times two (for stereo). But what amplifiers should you use?

Typically, the woofer amplifier needs to be about double the power of the midrange and tweeter amplifiers, to take into account the lower sensitivity of the woofers.

So if you have been running a 100W per channel stereo amplifier into your 3-way speaker system, you will still



The completed project showing the rear panel arrangement, power supply wiring and PC board placement. Use this in conjunction with Fig.7 (opposite) during final assembly.

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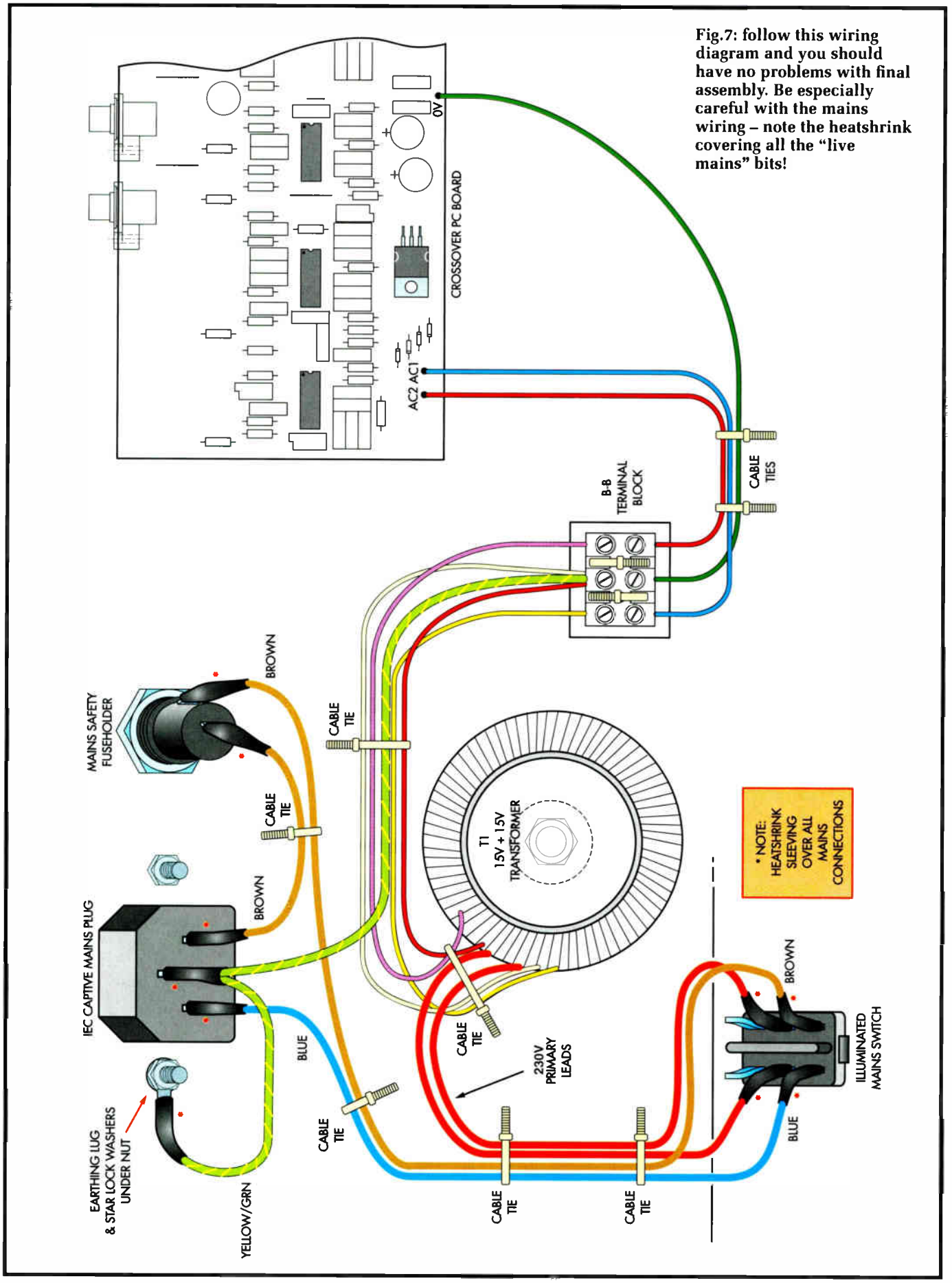

Fig.7: follow this wiring diagram and you should have no problems with final assembly. Be especially careful with the mains wiring – note the heatshrink covering all the "live mains" bits!

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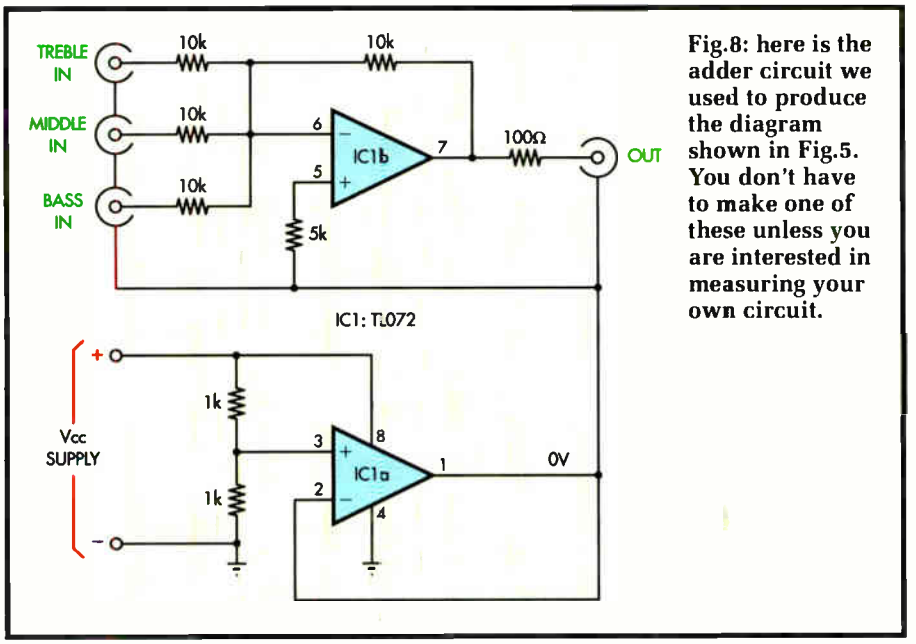

Fig.8: here is the adder circuit we used to produce the diagram shown in Fig.5. You don't have to make one of these unless you are interested in measuring your own circuit.

need two 100W amplifiers for the woofers (eg, your existing amplifier!) but you can get away with two 50W amplifiers for each of the midrange and tweeters (ie, four total).

You may be able to put back into service an amplifier that you pensioned off as "underpowered".

Connection

It is simply a matter of connecting the stereo outputs from the 3-Way Active Crossover to the appropriate bass, mid-range and treble stereo amplifier inputs, then connecting the amplifier outputs direct to the appropriate drivers in the speaker enclosures.

Of course, the existing crossover network in the speaker enclosures must be disconnected – and you have to add two extra sets of terminals on the back of your enclosures, with each of the three connected directly to an amplifier (and appropriately labelled).

The tone controls should ideally be flat on all amplifiers (although that can be a matter of individual taste – but the treble control won't do much on the bass amplifier nor the bass control on the treble amplifier!).

Finally, the volume controls can be individually adjusted to get the best balance between the bass, midrange and treble speakers. ***EPE***

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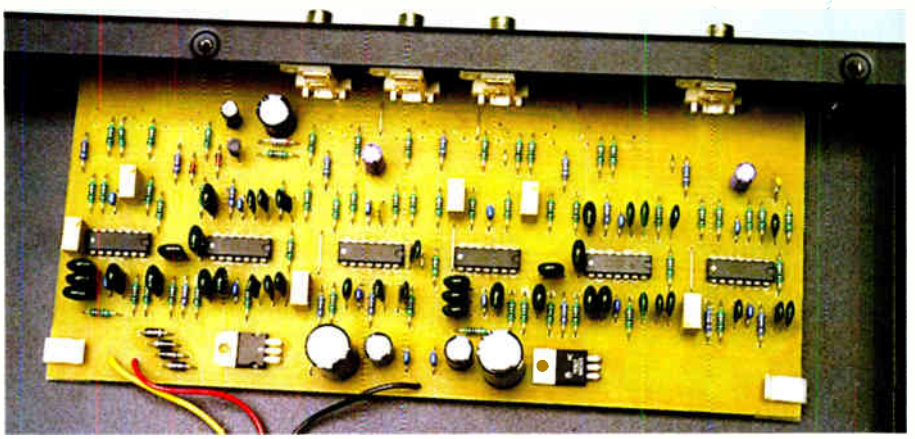

The PC board sits on self-adhesive holders (as used in computers) and is secured to the rear panel by the screws that go into the RCA sockets.

Table 1: R & C Values

R (kΩ)	C (nF)	2R (kΩ)	Crossover Frequency (Hz)
15	47	30	160
15	39	30	192
12	47	24	200
11	47	22	218
15	33	30	227
10	47	20	239
12	39	24	240
11	39	22	262
15	27	30	278
12	33	24	284
10	39	20	289
11	33	22	310
7.5	47	15	319
15	22	30	341
10	33	20	341
12	27	24	347
11	27	22	379
7.5	39	15	385
10	27	20	417
12	22	24	426
7.5	33	15	455
11	22	22	465
10	22	20	512
7.5	27	15	556
7.5	22	15	682
15	4.7	30	1596
15	3.9	30	1924
12	4.7	24	1995
11	4.7	22	2177
15	3.3	30	2274
10	4.7	20	2394
12	3.9	24	2405
11	3.9	22	2623
15	2.7	30	2779
12	3.3	24	2842
10	3.9	20	2886
11	3.3	22	3100
7.5	4.7	15	3193
15	2.2	30	3410
10	3.3	20	3410
12	2.7	24	3473
11	2.7	22	3789
7.5	3.9	15	3848
10	2.7	20	4168
12	2.2	24	4263
7.5	3.3	15	4547
11	2.2	22	4650
10	2.2	20	5115
7.5	2.7	15	5558
7.5	2.2	15	6821

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PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Using SPI Bus Devices – Part 2

Last month we explained why you may wish to use SPI devices (Serial Peripheral Interface). We now explain how to program them.

SPI Communication

So let's look at how to communicate with an SPI device, and how that translates into PIC code. We will start with the simpler device, the 25C256 EEPROM.

The 25C256 supports six commands over the SPI bus. Read data, write data, read status register, write status register, enable writes and disable writes. The last two are a protection mechanism to help avoid data corruption. When the device powers up, writes to memory are disabled until a Write Enable command is issued. This is one of the simplest commands requiring the 8-bit value "6" to be written to the device. The timing diagram for this operation is shown in Fig.2.

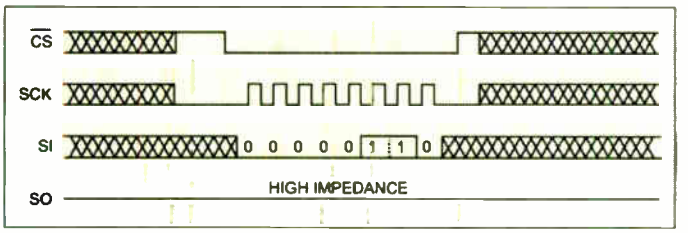

Fig.2. Serial Peripheral Interface (SPI) timing diagram

Starting from the top left of the diagram you can see that the CS signal is high (chip disabled), the clock is low and the data in/out signals are undefined. We first lower the CS line to enable the chip, then immediately write the first bit of data to the SI pin – a zero, for the most significant bit of the command byte.

After a delay to allow the chip time to setup (100ns according to the datasheet – not long!) we raise the clock signal SCK, which transfers the data on the SI pin into the chip. The clock signal is lowered, and then the data on SI changed to the next bit of the command byte. The process repeats another seven times to clock in all eight data bits. When the eighth data bit has been clocked in the clock line is left low, and the chip is disabled (but not turned off) by raising CS.

A read command is similar, except that after writing the command value, you write an additional 16 bits indicating the address of the byte you want to read. Following this you then toggle the clock line eight times to retrieve the eight bits of the data byte at that address, most significant bit (MSB) first. Raise the CS line once the byte has been retrieved.

Reading multiple bytes from the device is easy. Rather than raising CS, just keep toggling the clock signal. The device will automatically move onto the next address and return the data bits until you finish by raising the CS line.

Writing data bytes is just as simple. You send the Write Data command, followed by a 16-bit address, followed by the byte you want to write. The actual writing of data to the EEPROM memory is started when the CS line is raised, and can take up to 10ms.

During this time the only command you can send to the device is Read Status, which will tell you if the programming cycle is still in progress. It is a good idea to use this command rather than just wait 10ms since the device is typically much quicker than this, normally only a few milliseconds.

Page Write

If you are writing large amounts of data then there is a useful feature of the device, a Page Write, which allows up to 64 bytes to be programmed at once. To use this feature you start with a byte write and instead of raising the CS signal after the first data byte you just keep writing bytes. The device automatically updates the address for you.

There is a caveat with this: the block of bytes you write must all be contiguous and in the same 64 byte "page". So, for example, if you want to write 10 bytes at address 60, you must write three bytes starting at address 60, then raise CS, and then do a 7-byte write at address 64. The good thing about this is that there are only two 10ms delays involved, rather than ten.

The datasheet explains some more advanced features of the device such as partial protection of the device, but what has been covered here will suffice for many embedded projects. There are two sets of example code available as stated later demonstrating writing and reading to the device using both "bit-bashed" and SPI module methods, which we hope will be useful.

M25P32 Device

Now let's move on to a more complex device, the M25P32. This is also a non-volatile memory chip but it is implemented in Flash technology rather than EEPROM and has a huge 4M bytes of storage capacity. Although this is much smaller than you can get on (for example) a cheap compact flash card, those high density cards use NAND Flash technology which is much less reliable than the NOR type used in this chip.

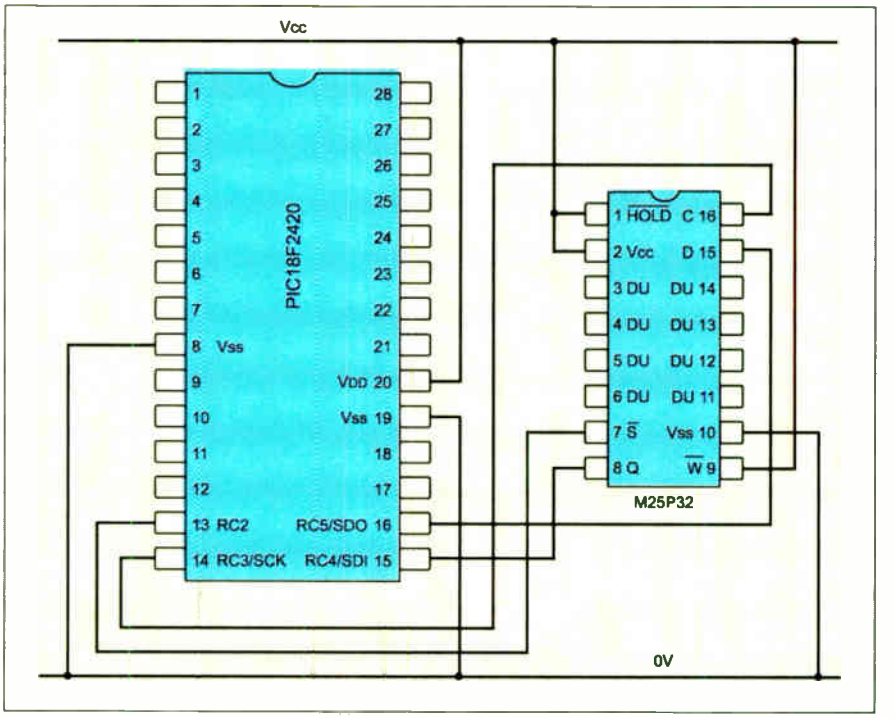

Fig.3. Interfacing a PIC18F2420 microcontroller to an M25P32 SPI chip

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NAND flash is expected to fail, and complicated error detection and management schemes have to be implemented in the code to compensate for this. Not so with the 25P32 and similar devices.

Although packaged in a 16-pin part, the 25P32 has exactly the same signals as the 25C256; only eight pins of the package are used (Fig.3). This is probably because the silicon die is so large that it wouldn't fit into an 8-pin package. Smaller members of the family do, for example the 512K byte device 25P40.

Electrically the signal operations are identical, we only need to be mindful of the different setup timing requirements. Unsurprisingly, this device is faster so any low level code written for the 25C256 will work fine here too. The higher level interface is similar too, the datasheet listing 12 commands, some of which are identical to the 25C256.

Differences

Where Flash memory does differ significantly from EEPROM is that the write command can only change data bits from the erased state of "1" to a "0". Therefore, it will be necessary to erase the device before reprogramming can be performed. Two erase commands are available: a sector erase, which erases a block of 64K bytes, and a global chip erase that does all.

A sector erase can take several seconds, and a bulk erase over one minute! Clearly, Flash and EEPROM memory address different design requirements. Flash is better suited to long term, rarely changing data, sound clips for example, or a log file. EEPROM is suited to frequently changing data.

Software

Example software is available from the *EPE* Downloads website in the PIC n' Mix section. This software builds on the low level code developed for the 25C256, so both bit-bashed and SPI module methods are implemented.

With such high capacity non-volatile devices becoming easier to include into your designs, having a file system interface starts to become a good idea. The speed of the erase cycle causes some headaches, but with careful thought a useful file system could be created. We will cover that in another article later in the year.

Datasheets for the two devices are freely available on the web, and copies can also be found here:

25C256:
www.solderit.co.uk/datasheets/cat25C256.pdf

25P32:
www.solderit.co.uk/datasheets/m25P32.pdf.

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Net Work

Alan Winstanley

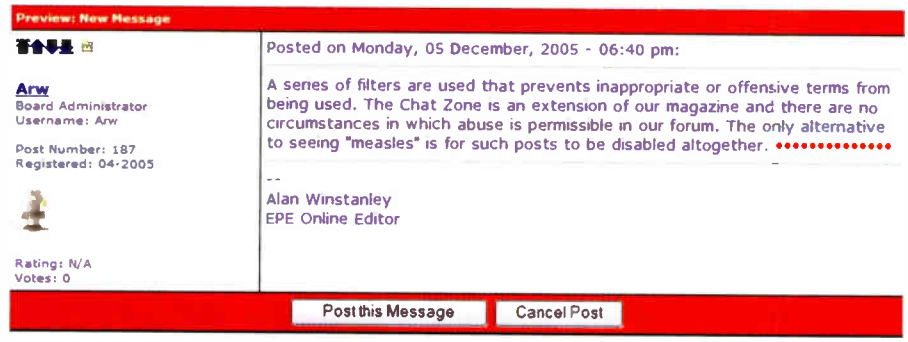
Last month I demonstrated some of Google's other tricks that the search engine keeps up its sleeve, such as converting from one unit to another and answering calculation queries posted in "plain English". Type "1 picofarad in nanofarads" into the Google box and it replies with "1 picofarad = 0·001 nanofarads". Almost every conceivable unit of measure can be handled by Google's conversion tools, whether Farads or fluid ounces. Some examples were shown last month to give you an idea.

An essential utility for your Internet Explorer or Firefox web browser is the free Google toolbar downloadable from **www.toolbar.google.com**. It provides a Google search box that is always to hand, and it can also search Google Groups and Google images. The Google toolbar also offers one-click-away access to *Google News* (also see **http://news.google.co.uk**), which is a digest of online news headlines and articles distilled from 4,500 news sources around the world.

Tried the EPE Chat Zone?

Since April 2005 we have been running an online forum where readers and Internet users can post messages and exchange hints or tips about hobby electronics. The original *EPE Chat Zone* of 1990s vintage was a primitive forum that became increasingly difficult for us to operate. Its simplicity of use was its only redeeming factor.

Last year it was replaced with a more powerful product that addressed all of its predecessor's shortcomings. It has a new domain name, too: **www.chatzones.co.uk**. It can be also accessed via the Chat Zone buttons displayed on the main *EPE* web site (**www.epemag.co.uk**).



The EPE Chat Zone has a built-in Profanity Filter that replaces most offensive terms with red dots or "measles"

The new forum is designed to be largely self-maintaining, which has become an increasingly important factor for us. It automatically archives postings, and allows files (75kB max) or inline graphics to be posted. Personal Messages can be sent to other users who choose to accept them. A technical/scientific notation markup language is available, and a Post Preview option allows for second thoughts.

Any user can read the messages but in order to post, a simple registration process is followed. Unfortunately some ISPs, notably AOL, may interfere with the delivery of our automated registration emails, but if users have any problems in that respect they can email **webmaster@epemag.demon.co.uk** advising us of their chosen username, and a new account and temporary password will be set up manually for them. At no time is a real email address or real name displayed to other users: these aspects are configured in the individual's Profile, which has good privacy default settings.

A Measly Exchange of Views

On the subject of *Chat Zone* netiquette, one factor to remember is that the *EPE* forum is unequivocally an extension of our printed magazine, and is therefore subjected to the same high standards of editorial control that we apply everywhere else. Our view is that the *EPE Chat Zone* is a near real-time version of our *Readout* readers' letters page, and so we strive to ensure that similar levels of etiquette and courtesy are observed as applied to the printed journal.

All messages are unmoderated in that they are not pre-approved by *EPE* before being published. *EPE* goes to some lengths to use a light touch and make *Chat Zone* members of all age groups, abilities and cultures feel at home: we want each user to enjoy the service and return again and again. In practice, *EPE Chat Zone* members have a lot of free rein, but there are of course limits and unfortunately it is sometimes necessary to wade in to encourage better netiquette or even remind some users whose forum it is that they are making use of – or misusing.

As every forum owner knows only too well, appeasement never works and without a firm hand on the tiller forums can become miserable and wretched places. We agree with one member who summed it up by saying that if members have nothing nice to say, then they should say nothing at all. This does not disallow friendly or robust debate from taking place, but when threads degenerate into mere mud-slinging or making personal attacks then we may act out of necessity – either by closing the thread or in the worst cases deleting posts and suspending members altogether.

No Profanities Please

Amongst other features, the new *Chat Zone* forum introduces a "Profanity Filter" that replaces potentially offensive terms with a series of measle-like red dots. It is seldom if ever needed, but we're glad it's there. The message Preview function highlights problems in such posts beforehand. Very rarely there may be a "false positive" when innocent words combine to trigger the filter. The only alternative is that such messages are disabled from appearing altogether, but we leave it to the user's discretion to either fix the problem or simply accept that the filters do what they do.

Posts remain unmoderated in every other sense, but some ridiculous accusations of "censorship" and "officiousness" or even being dubbed "Mary Whitehouse" (a British campaigner who strove to clean up the media – see Google) are, at best, thoughtless and unkind attacks on those who devote their valuable spare time to running the forum. At its worst, aggressive or obnoxious behaviour is unacceptable anywhere in *EPE's* online presence: there are no special privileges and any threads that have degenerated into misuse or abuse against other members or *EPE* staff will simply be closed and offending posts may be deleted.

The *EPE Chat Zone* is the writer's gift to the hobby electronics community. Every member has a part to play in helping it to run smoothly, showing good degrees of netiquette, tolerance and an eagerness to help others. For more background, the *Acceptable Use Policy* is published in the *Guidelines for Posting* area of the forum. You can email the writer at **alan@epemag.demon.co.uk**.

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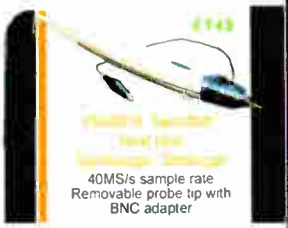

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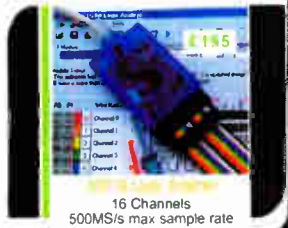

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Regular Clinic

Circuit Surgery

Ian Bell

Continuing with our transistor basics theme, this month our "consultant" looks at closely connected transistor pairs such as the Darlington

USER ***Cherrytree*** posted the following on the *EPE Chat Zone*.

Hi all, Can anyone explain basically what Darlington transistors do? I've got an old-ish electronics magazine and in it its got a complete layout diagram of a Sound Box. When built and done you listen to a morad of sound effects through headphones. And it uses the above transistors.

One of the responses to this mentioned a "fetlington" so we shall look at this too.

Darlington Pair

Both *npn* and *pnp Darlington circuits* are shown in Fig.1. In the Darlington configuration, one transistor is used to directly drive another, resulting in a sort of "super transistor" with very high gain (typically thousands) and high input impedance. Do not mix up the description "super transistor", with the term superbeta transistor, which is a high gain single transistor; although at the risk of causing great confusion the term superbeta pair is sometimes used for the Darlington configuration.

The Darlington pair behaves like a single transistor with twice the value of V_{BE} (i.e. it has a higher switch-on voltage) and a current gain equal to the product of the gains of the two transistors. The input resistance is increased by a factor comparable with the gain of one of the transistors. You can buy "ready made" Darlington transistors which often have a very high gain, say 20 to 50,000 or so.

In high power applications the first transistor (TR1) makes sure that the power transistor (TR2) receives sufficient base current to fully turn on. A high power transistor may require significant base current, which would not be readily available from the controlling circuit's output (e.g. logic gate) if it were connected directly. Darlington pairs are very useful for switching high power loads from logic outputs, but a word of caution is needed here as one disadvantage of the Darlington pair is that the configuration can be rather slow in switching.

Darlington configurations can be used in situations other than power outputs, for example a Darlington arrangement can be used to increase the gain of a phototransistor and Darlington pairs are used in the input and gain stages of some op.amps.

Sziklai Pair

The Darlington pair is not the only closely connected transistor pair arrangement. A similar configuration, which is known as a Sziklai pair or Complementary Feedback Pair (CFP), is shown in Fig.2.

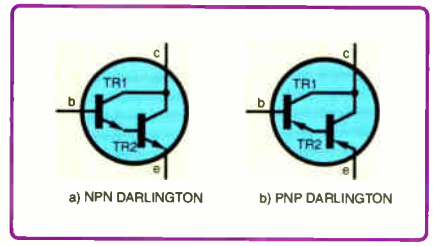

Fig.1. The Darlington configuration

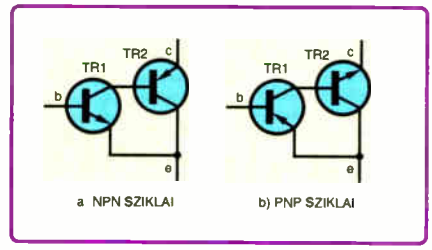

Fig.2. The Sziklai pair or Complimentary Feedback Pair (CFP) configuration

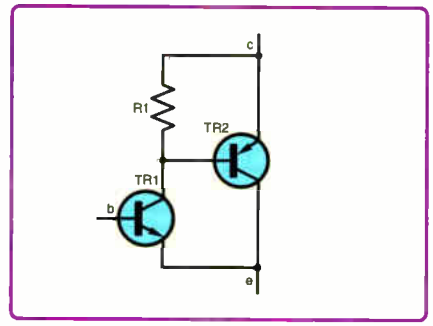

Fig.3. Sziklai pair with bias resistor.

One of the main features of this alternative compound transistor is that it only requires a single V_{BE} voltage to turn on, unlike the Darlington which has an effective V_{BE} equal to two V_{BE} drops. This gives the Sziklai pair the advantage of being able to be "plugged in" in place of a single transistor.

Furthermore, the lower effective V_{BE} makes it far easier to use in low voltage circuits. This is an important concern in modern chip design, where only a small number of V_{BE} diode drops can be stacked before all the headroom of the supply is used up. The Sziklai pair also has lower output resistance than the Darlington, about one tenth of the value when used in a common-emitter-style configuration under the same bias conditions.

Some Bias

The Sziklai pair is usually biased using a resistor as shown in Fig.3, where R1 is selected so that most of the current in TR1 flows through R1 rather than the base of TR2. This means that the quiescent current in TR1 is well defined and does not depend on the gain of TR2 and its collector current. The collector current of TR1, I_C1, is approximately $V_{BE}2/R1$ if we assume that TR2 has a high enough gain for I_B2 to be significantly smaller than I_C1.

Typically we want TR1 to have a quiescent current about one tenth of that of TR2 so, given this assumption, and given that we probably choose I_C2 as a key design parameter, we get $R1 = 10V_{BE}2/I_C2$, where as usual $V_{BE}2$ would typically be between 0·6 and 0·7V.

Complimentary Output

A typical use of the Sziklai pair is in audio power amplifier output stages where it is considered by many to deliver better performance in terms of thermal stability and large signal non-linearity due to the feedback effects within the transistors pairs (hence the Complementary Feedback Pair name), although these effects are reduced at high frequencies.

An outline schematic of a typical power amplifier output stage based on

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the Sziklai pair is shown in Fig.4. Here the transistor pairs are used in the same way as a standard push-pull emitter follower output stage. The pair TR1-TR2 handles the positive half of the signal, and the pair TR3-TR4 handles the negative half. The bias circuit ensures that the transistors switch on for the correct part of the signal waveform (for example to prevent crossover distortion).

The *pnp* Sziklai pair has played in role in integrated circuit design for a long time, particularly in essentially *npn* processes that allowed fabrication of good *npn* transistors, but which only provided low gain *pnps*. The compound transistor provides a means of obtaining a high-gain *pnp* in these technologies.

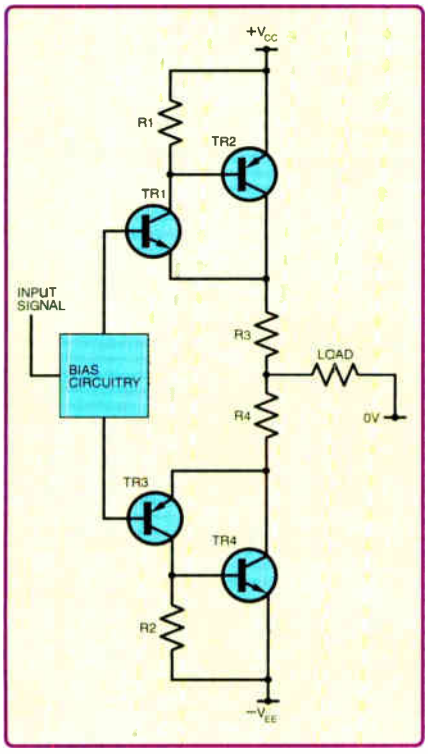

Fig.4. Sziklai pairs used in a power amplifier output stage

BICMOS

In the world of integrated circuits (i.c.s) there are of course CMOS chips (using MOSFETS) and bipolar chips (using Bipolar Junction Transistors), but there are also i.c. fabrication technologies which can create a mixture of MOSFET and bipolar devices on the same chip. This technology is often called BICMOS and exploits the combined advantages MOSFETS and bipolar transistors.

MOSFETS have very high input impedance, can be used to make very good signal switches (both analogue and digital), and allow the fabrication of very high density digital circuits with very low static power consumption (i.e. when not switching). Bipolar Transistors have higher gain than MOSFETS and generally provide higher speed and higher frequency performance than MOSFETS. Bipolar Transistors can typically produce lower noise analogue circuits than MOSFETS.

For digital circuits MOSFETS are almost ideal, but lack high current capability. This is not required for most of the gates and flip-flops on a typical digital chip. However, some of the gates, such as those driving large buses or off-chip loads, require high current capability. BICMOS technology can exploit the bipolar transistors to provide better, or simpler, high current buffer and driver circuits than MOSFETS alone.

Fetlington

This discussion of BICMOS technology leads us to the "fetlington" mentioned in the question. Here we take the term to mean a Darlington-like circuit using a MOSFET and a bipolar transistor; however, the word "fetlington" does not seem to be widely used, and in some cases seems to be used to describe devices which are not Darlingtons.

A search of the internet will show the 2N7000 being referred to as a "fetlington" in a number of places, but as the datasheet quickly confirms this device is just an *n*-channel MOSFET. If any readers can shed light on the origin and use of this term we would be interested to hear.

The MOSFET and bipolar Darlington configuration is also referred to as a BICMOS Darlington pair, a BiFET Darlington, a MOS-BJT Darlington pair, and a FET-BJT Darlington pair. You take your choice!

A couple of MOS-BJT closely coupled pairs are shown in Fig.5. Fig.5a is Darlington-like, whereas Fig.5b is more Sziklai-like. The MOS-BJT pairs provide the very high input impedance of the MOSFET together with much higher transconductance gain than a single MOSFET. The output resistance is also lower than a single MOSFET and thus the pair have a higher current capability than the single MOSFET.

Inverters

An important use of MOS-BJT pairs is in BICMOS logic, particularly inverters and gates with high current capability, as was discussed earlier. Fig.6 shows an ordinary CMOS inverter (NOT gate) and a BICMOS inverter built from the two transistor pairs from Fig.5. Note that both pairs use *npn* transistors, which generally have higher performance than *npn*, particularly on integrated circuits. The two bipolar transistors in the BICMOS inverter form a totem pole arrangement, which is same kind of output circuit as found in TTL logic.

The resistors in the BICMOS inverter are present to speed up switch-off of the bipolar transistors. Without these present when the MOSFET driving the bipolar transistor is switched off there would be no low impedance path for any charge left in the base to dissipate along. The charge would therefore stay around for a while keeping the bipolar transistor on longer than necessary.

The actual implementation of a real BICMOS inverter may differ a bit from Fig.6b. For example the resistors may be implemented using MOSFETS instead of simple resistors.

The MOS-BJT Darlington pair is similar to the Insulated Gate Bipolar Transistor (IGBT), which is used in high power electronics. The IGBT is not actually constructed from a separate MOSFET and bipolar transistor but is formed more directly as a single device.

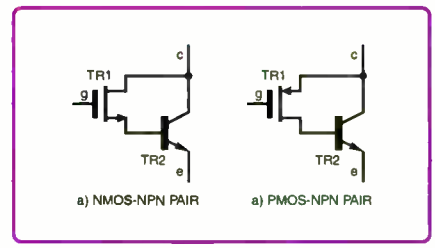

Fig.5. FET-BJT "Darlington" combinations

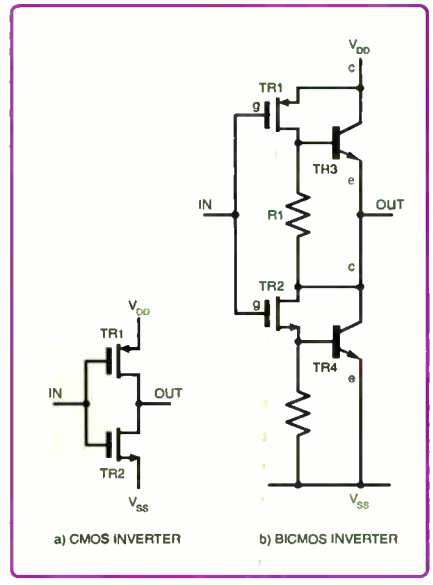

Fig.6. CMOS and BICMOS inverters

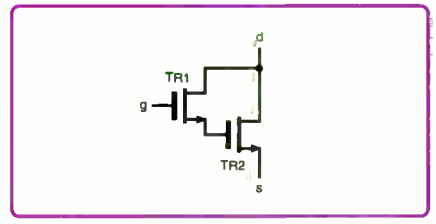

Fig.7. Unfortunately the FET/FET "Darlington" is not very useful

Like BICMOS integrated circuits the IGBT exploits the different advantages of the MOSFET and bipolar transistor. It has the high input impedance of the MOSFET with the bipolar device providing low on resistance and high current capability. The IGBT also has better "blocking" capabilities than the MOSFET – this concerns the ability to deal with high voltages in both forward and reverse direction when the device is switched off. This may be as high as 2500V for some IGBTs

An obvious question which follows from our discussion so far is "what about FET/FET Darlingtons?". A circuit schematic is shown in Fig.7, but in fact these are not really of much use. The increase in input impedance which is obtained relative to the single bipolar transistor with the bipolar Darlington, Sziklai pair and FET-BJT Darlington does not occur in a FET-FET arrangement compared with a single FET – the input is the FET gate in both cases.

Current gain is not of particular importance in FET circuitry as FET gain is in the form of transconductance, rather than current gain. (Transconductance is output current over input voltage and was discussed in detail last month).

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Status Monitor

Is your boiler or freezer still on? Remotely keep an eye on them!

By TERRY de VAUX-BALBIRNIE BSc

THE AUTHOR'S gas-fired central heating boiler is about five years old and the service engineer says there's nothing wrong with it. However, it has one annoying habit – every so often it "locks out" for no apparent reason. A red light-emitting diode (l.e.d.) on the front panel flashes and there is no more hot water until the Reset button has been pressed.

Fortunately, the boiler is conveniently placed. Keeping an eye on the warning light is therefore not difficult so any lock-out condition can be corrected promptly. However, many families have their boiler situated in the garage. It might then be some time before they are made aware that a problem exists – probably because the house becomes cold or there is a lack of hot water.

Repeater

This device is an indicator lamp repeater. Its purpose is to mimic operation of an l.e.d. or filament lamp at a distance. For example, if the l.e.d. on the boiler glows steadily, the l.e.d. on the remote unit will do similarly. If it flashes once every second, so will the l.e.d. on the new unit. Of course, the circuit could be used to monitor an l.e.d. or small filament lamp on any electrical appliance such as a washing machine or freezer – its use is not restricted to central heating boilers.

Link-up

The circuit comprises two parts – a transmitter and a receiver. The transmitter is placed close to the appliance and is wired to a small sensor attached to it. The receiver is placed where it may be easily seen. The two sections are radio-linked so interconnecting wires are avoided.

The operating range (maximum distance between transmitter and receiver) depends to a large extent on conditions. However, with the prototype transmitter located in a detached brick garage, it was possible to place the receiver inside the house some six to eight metres away (measured as a direct "line of sight"). This takes account of intervening building materials such as brick, wood and breeze block.

Note, however, that the presence of metal surfaces between the units reduces the range and may prevent operation altogether. Under ideal conditions, a considerably greater range may be achieved.

Sensor

The sensor is mounted in a small box which is attached over the lamp or l.e.d. to be monitored. By responding to its light, it avoids electrical connections having to be made to the existing appliance circuit. Making direct connections might not be easy, could be dangerous and would have warranty implications. A "status" l.e.d. on the transmitter unit is provided which mimics operation of the one on the appliance being monitored (because this is now covered up and therefore cannot be seen).

Both parts of the circuit are powered using nominal 12V commercial

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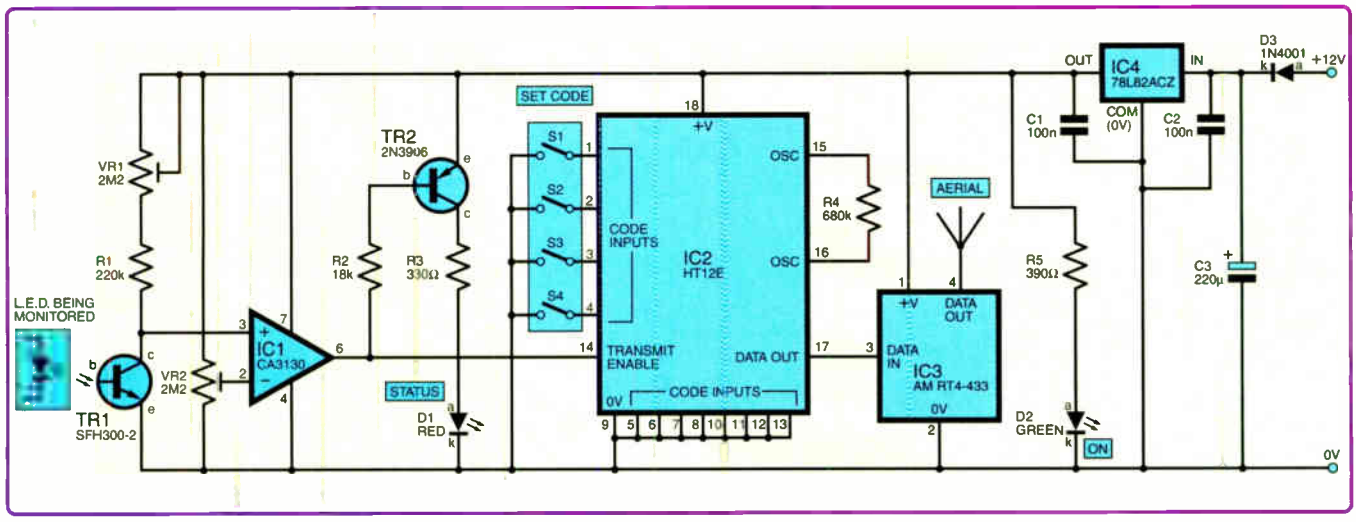

Fig.1. Circuit diagram for the Status Monitor Transmitter

plug-in adaptors. This is necessary because they will be operating continuously.

Although each section draws only 50mA approximately, batteries would soon be exhausted. A mains socket will therefore be needed close to each unit. Note that, since the supply is derived from the mains, both modules ***must*** be operated indoors and under dry conditions.

Transmitter circuit

The circuit diagram for the Status Monitor Transmitter is shown in Fig.1. Current flows from the supply (nominally 12V d.c.) via diode D3 to the input of voltage regulator IC4. The diode provides reverse-polarity protection, if the supply were to be connected in the wrong sense, it would not conduct and the rest of the circuit would be protected.

The regulator provides a constant 8·2V output to power the circuit. This is necessary because the voltage obtained from a plug-in adaptor is often much higher than its nominal value. Capacitor C3 provides additional smoothing if this is not already adequate (and in cheap power supplies it often is not).

Capacitors C1 and C2 promote stable operation of the regulator. Green l.e.d. D2 is the On indicator with series resistor R5 limiting its operating current to 16mA approximately.

Light detection

When phototransistor TR1 picks up light from the l.e.d. being monitored, the voltage between its collector (c) and emitter (e) falls. No connection is made to the base (b). Resistor R1 connected in series with preset potentiometer VR1 provide the collector load.

The voltage at TR1's collector is applied to the non-inverting input (pin 3) of op.amp IC1. The inverting input (pin 2) receives a voltage from the sliding contact (wiper) of preset potentiometer VR2, whose track is connected between the supply rails. In use, it is set so that the voltage at the inverting input is slightly less than that at the non-inverting one when TR1 is in darkness.

Under these conditions, the op.amp will therefore be on with its output, pin 6, high. When light of sufficient brightness is detected by phototransistor TR1, the voltage at the op.amp non-inverting input falls below that at the inverting one and the device switches off, with its output going low.

The signal from the op.amp output is applied to the base of transistor TR2 via resistor R2. Since this is a *pnp* transistor, a low state at the base will switch it on. Red l.e.d. D1 in TR2's collector path then operates with its current limited to approximately 16mA by resistor R3. Thus, when the l.e.d. being monitored is on, D1 will also be on. This is the Status l.e.d. which will be visible to the user on the front panel of the Transmitter unit.

Digital code

The signal from op.amp IC1 output is also applied to the "transmit enable" input (pin 14) of encoder device, IC2.

Transmitter Parts List

1 printed circuit board, available from the *PCB Service*, code 555 (Trans)
1 plastic case, size 112 × 62 × 31mm approx.
1 small plastic lightproof box
1 4-way d.i.l. switch (S1 to S4)
2 2-way p.c.b. mounting screw terminal blocks, 5mm pitch
1 8-pin d.i.l. socket
1 18-pin d.i.l. socket
2 plastic p.c.b. stand-offs
1 12V 100mA plug-in mains adaptor power supply, plus matching chassis-mounting socket (see text)
connecting wire, link wire, solder, glue etc.

Resistors (0·25W 5%)
1 330Ω
1 390Ω
1 18k
1 220k
1 680k

Pontentiometers
2 2M2 min. enclosed preset, vertical

Capacitors
2 100n metal, polyester
1 220µ radial elect, 25V

Semiconductors
1 red l.e.d., 3mm
1 green l.e.d., 3mm
1 1N4001 rectifier diode
1 SHF300-2 phototransistor (see text)
1 2N3906 *pnp* transistor
1 CA3130 op.amp i.c.
1 HT12E encoder i.c.
1 LM78L82ACZ 8·2V voltage regulator
1 AM-RT4-433 Transmitter module (see text)

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While this is low, a digital code (a string of on and off pulses) is provided repeatedly by the "data" output (pin 17). The value of the code is determined by the logic state of twelve pins – 1 to 8 and 10 to 13.

The code will be chosen to make the signal different to that from any similar devices (car central locking systems, burglar alarms, etc) which might be operating nearby. This avoids false operation.

Code switches

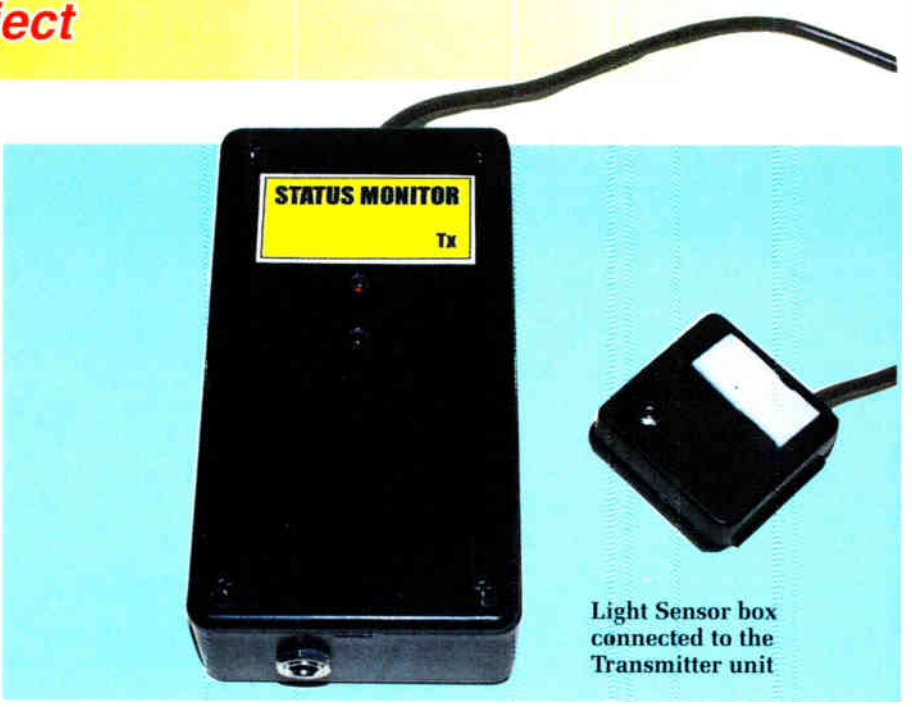
Switches S1 to S4 connected to IC2 pins 1 to 4 determine the code. Any switch that is *on* connects the associated input to the 0V line to provide a logic state of "0". A switch which is *off* leaves the input unconnected and it automatically assumes a logic state of "1".

There is little to be gained by allowing the logic state of all twelve code pins to be controlled in this way so pins 5 to 8 and 10 to 13 are permanently connected to the 0V line, giving a logic state of "0" to all of them.

The switches allow a choice of 16 possible codes, which should be found sufficient to avoid picking up any spurious transmissions from elsewhere.

An oscillator built into IC2 is necessary for its operation. Its frequency is determined by the value of resistor R4 connected between "OSC" inputs, pins 15 and 16. Using the specified resistor value, this will be 4·5kHz approximately.

The coded signal obtained from IC2 data output, pin 17, is applied to the "data input" (pin 3) of transmitter module IC3. A radio signal modulated with the code is then radiated by the aerial (which comprises a one quarter-wavelength section of p.c.b. track – see Fig.3) connected to "data output" pin 4.



Light Sensor box connected to the Transmitter unit

Receiver circuit

The circuit diagram for the Receiver is shown in Fig.2. The power supply arrangements are the same as those used in the Transmitter and comprise the nominal 12V plug-in adaptor, diode D3, smoothing capacitor C5, 8·2V regulator IC3 and associated capacitors C3 and C4. Green l.e.d. D2 operates through current-limiting resistor R4 to provide the On indicator.

The "coded" radio signal arriving from the Transmitter is picked up by the Receiver (IC1) aerial (a further section of p.c.b. track) which is connected to "data input" pin 3. The amplified data is then provided at "data out" pin 14.

The function of each pin is shown in Table 1. Capacitors C1 and C2 decouple the a.f. (audio frequency) and r.f. (radio frequency) sections of IC1.

The data provided by IC1 pin 14 is applied to the "data input" (pin 14) of

Table 1: Receiver Module AM-HRR3-433 pin details

Pins	Function
1	RF + Vcc
2	RF GND
3	Data in (aerial)
4, 5, 6	Non-existent
7	RF GND
8, 9	Non-existent
10	AF + Vcc
11	AF GND
12	AF + Vcc
13	Test point (not used)
14	Data Out
15	AF + Vcc

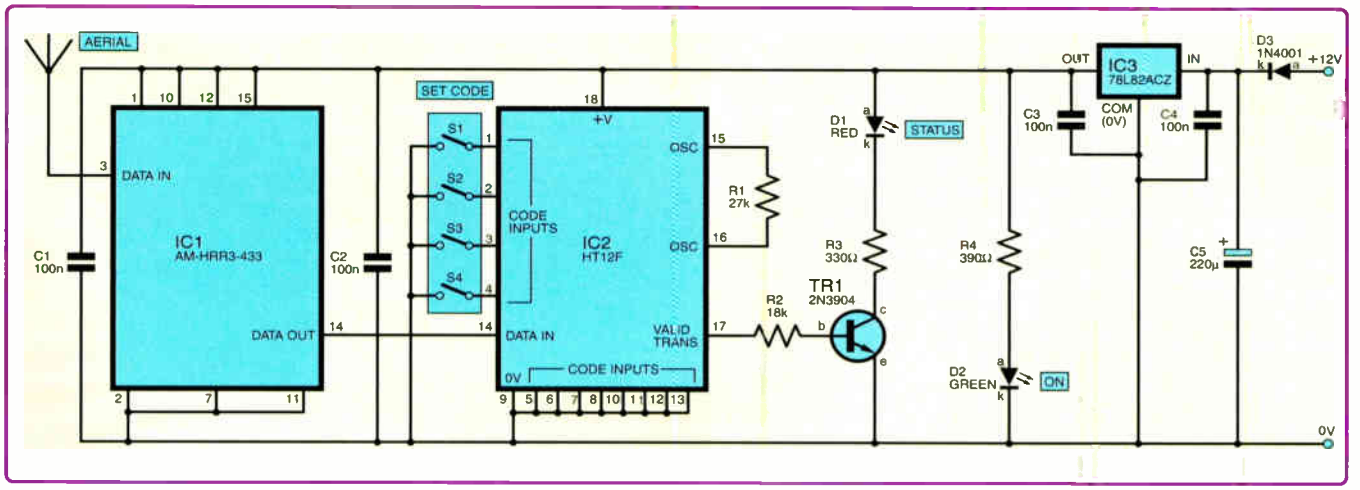
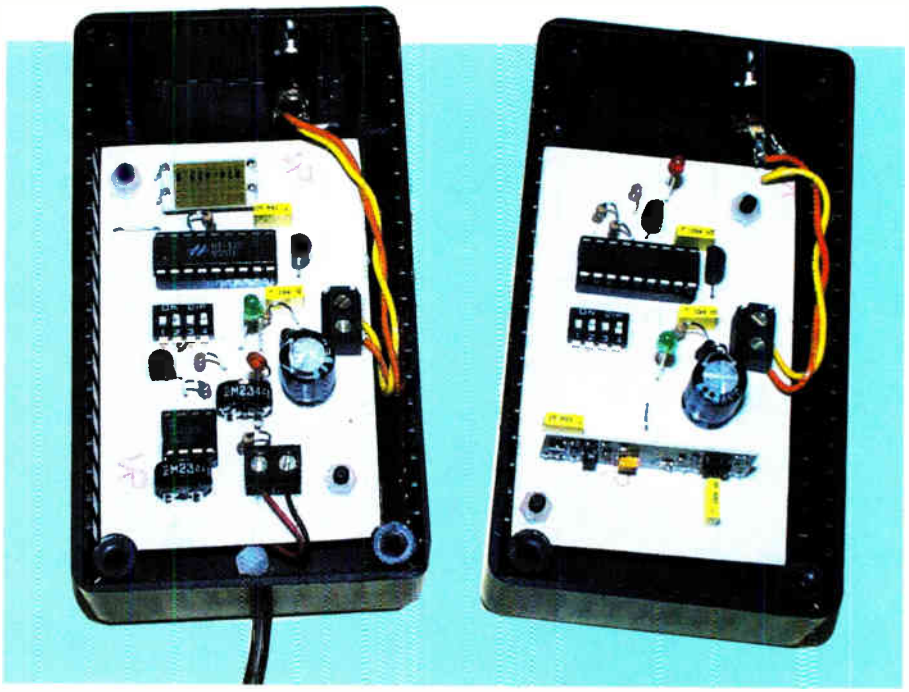


Fig.2. Circuit diagram for the Receiver section of the Status Monitor

World Radio History



decoder device, IC2. Switches S1 to S4 connected to pins 1 to 4 operate in the same way as those in the Transmitter and will be set at the end to provide the same code. All the other code inputs (pins 5 to 8 and 10 to 13) are permanently connected to 0V to give a logic state of "0" to each.

As with the transmitter, an internal oscillator is necessary for IC2's operation with the frequency determined by the value of resistor R1 connected between the "OSC" inputs, pins 15 and 16. Using the specified value, this will be 225kHz approximately. This fulfils the manufacturer's recommendation that the oscillator frequency of the decoder should be approximately 50 times that of the encoder.

When IC2 "sees" a signal arriving which carries the same code as its own, the "valid transmission" output (pin 17) goes high. Signals picked up from similar devices operating nearby do not do this because they are likely to carry an incorrect code.

When pin 17 goes high, it switches on transistor TR1 with base current entering via resistor R2. The red Status l.e.d. (D1) in its collector circuit then operates with series resistor, R3, limiting its current to 16mA approximately.

Wireless modules

The transmitter (IC3 in Fig.1) and receiver (IC1 in Fig. 2) are commercial modules of the type widely used in car remote locking systems, "wireless" burglar alarms and similar devices. The transmitter provides a very low radiated power at an authorised spot frequency – in this case, 433MHz and the receiver is pre-tuned to match it. The modules are of the amplitude modulated (a.m.) type and no traditional "radio skills" are needed to use them.

Subject to pin compatibility, various transmitter and receiver modules could be used. However, those specified in the parts list have been shown to work well. The transmitter used in the prototype has the advantage that the aerial does not need to be tuned to match the output. Some simple devices need considerable "fiddling" to achieve resonance (usually by adjusting a trimmer capacitor) so that maximum power is radiated.

The range could possibly be increased by using a superhet receiver rather than the specified TRF (tuned radio frequency) type. The range may also be extended by modification to the receiver aerial (of which more later).

Construction Transmitter

The Status Monitor is built on two single-sided printed circuit boards. These boards are available from the *EPE PCB Service*, code 555 (Trans.) and 556 (Rec.). The component and track layouts are shown in Fig.3 and Fig.4 respectively. Pinouts for the transmitter and receiver modules are included in the accompanying inset diagrams.

Starting with the Transmitter p.c.b., solder in position the two i.c. sockets, the two 2-way pieces of screw terminal block TB1 and TB2, d.i.l. switches S1 to S4 and the link wire near IC3 pin 4 position. Add all capacitors and resistors (including presets VR1 and VR2) taking care over the polarity of electrolytic capacitor C3.

Add diode D3, l.e.d.s D1 (red) and D2 (green) – to provide a neat appearance when mounted in the box the height of these should be the same. Solder transistor TR2 (flat face towards IC1) and voltage regulator, IC4 (flat face towards IC2) correctly observing the orientation of these devices.

Taking great care and using minimum heat, solder the transmitter module (IC3) in position. As an additional precaution against heat damage, push

Receiver Parts List

1 printed circuit board, available from the *EPE PCB Service*, code 556 (Rec)
1 plastic case, size 112 × 62 × 31mm approx.
1 4-way d.i.l. switch (S1 to S4)
1 18-pin d.i.l. socket
1 2-way p.c.b. mounting screw terminal block, 5mm pitch
2 plastic p.c.b. stand-offs
1 12V 100mA plug-in mains adaptor power supply, plus matching chassis-mounting socket (see text)
connecting wire, link wire, solder, etc.

Resistors (0·25W 5%)
1 330Ω
1 390Ω
1 18k
1 27k

Capacitors
4 100n metallised polyester
1 220μ radial elect. 25V

Semiconductors
1 red l.e.d., 3mm
1 green l.e.d., 3mm
1 1N4001 rectifier diode
1 2N3904 *npn* transistor
1 HT12F decoder i.c.
1 LM78L82ACZ 8·2V voltage regulator
1 AM-HRR3-433 receiver module (see text)

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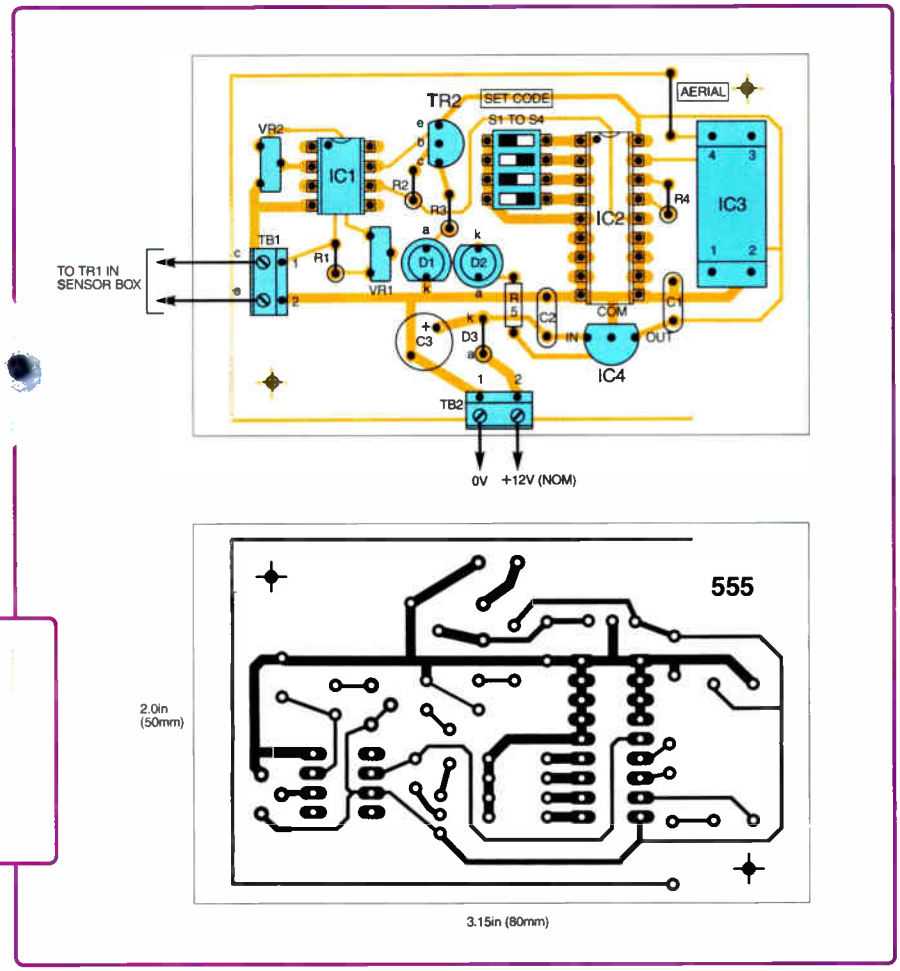
TRANSMITTER CIRCUIT BOARD



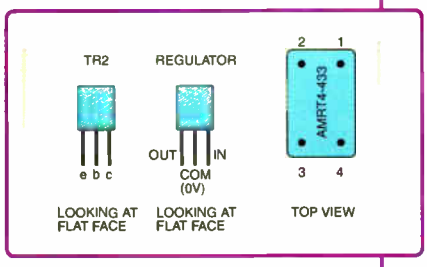


Fig.3. (right). Transmitter printed circuit board component layout and full-size copper foil master. Pinout details for TR2, IC4 and transmitter module are shown inset above

the pins through the p.c.b. by only the minimum amount needed to make good soldered joints. Note that pins 1 and 2 are placed nearer the bottom of the p.c.b. (see photograph).

Adjust VR1 to maximum resistance (fully anti-clockwise as viewed from the left hand edge of the p.c.b.). This will probably be correct if using the specified phototransistor but may need to be adjusted later if another type is used. Note that the phototransistor must be of a type that responds to visible light. It must not be of the infra-red variety.

Finish by inserting IC1 and IC2 into their sockets. These are CMOS devices and could be damaged by static charge on the body. Before handling the pins, therefore, touch something which is earthed (such as a metal water tap).

Connect a piece of light-duty twin stranded wire to terminal block TB1 for the phototransistor. The wire should be long enough to reach between the l.e.d./lamp being monitored and the proposed position of the unit. Do not make it any longer than necessary – say, one metre maximum.

Receiver Construction

Next, construct the Receiver section. Solder the 2-way section of screw terminal block TB1 and d.i.l. switches S1 to S4 in position. Solder the socket for IC2, the link wire near IC1 pin 7 position and all resistors and capacitors taking care over the polarity of C5. Add Transistor TR1 (flat face towards the bottom of the p.c.b.), diode D3, l.e.d.s D1 (red) and D2 (green). As with the Transmitter, the tops of the l.e.d.s should be at the same height.

Add voltage regulator IC3 (flat face towards IC2) observing the correct orientation of this device. Taking great care and using minimum heat, solder the receiver module (IC1) in place – this will only fit one way round with the component side towards to left-hand edge of the p.c.b. Again push the pins through the board by only the least amount needed to make good soldered joints.

Insert IC2 into its socket observing the precautions mentioned for the transmitter. Set switches S1 to S4 in both units to provide the same code. For example, On, Off, Off, On for S1 to S4 respectively in each unit.

Testing

Test the circuits using a battery – not the mains adaptors. Connect the phototransistor temporarily to the wires leading to TB1 in the Transmitter unit – terminal "c" on TB1 should connect to the collector and "e" to the emitter. The collector on the specified device has the shorter end lead and a flat on its body.

Make up a 12V battery (say eight AA-type cells in a suitable holder) and, observing the polarity, connect it to both units (TB2 in the Transmitter

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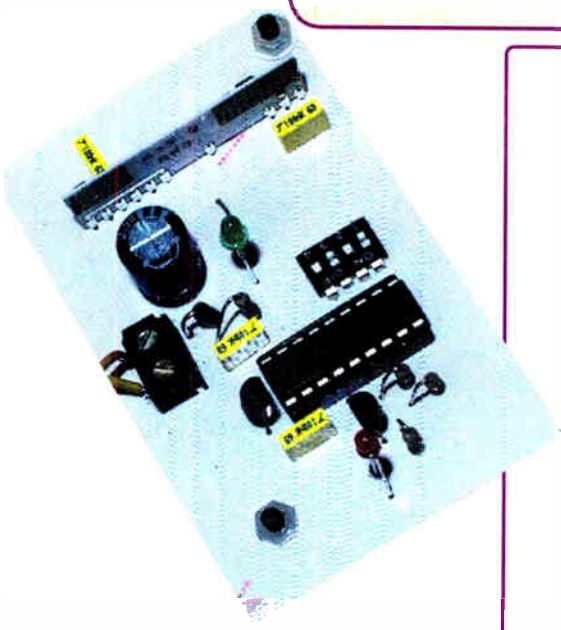
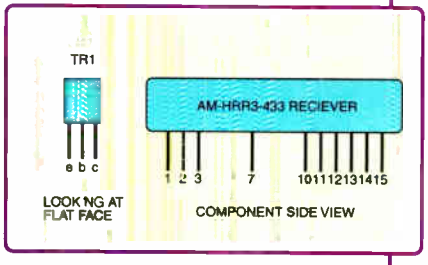
RECEIVER CIRCUIT BOARD





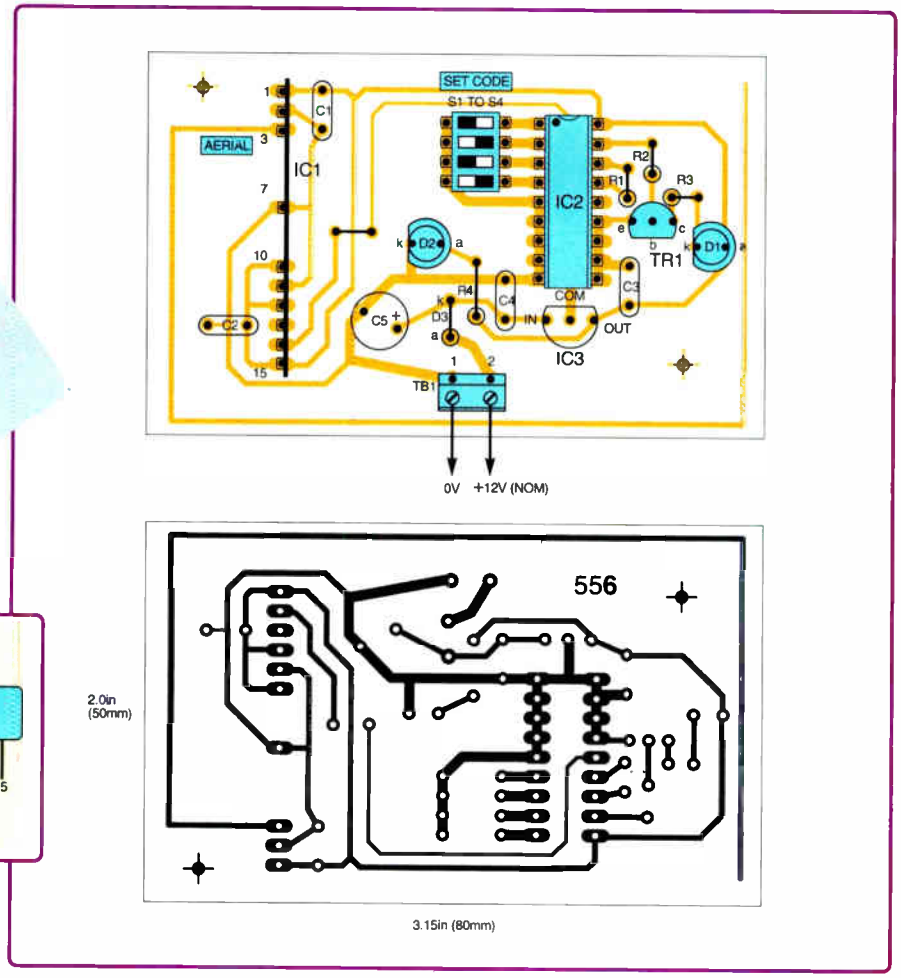


Fig.4. Component layout and full-size underside copper foil master pattern for the Receiver. Pinout details for the transistor and receiver module are shown inset

and TB1 in the Receiver) using pieces of twin stranded wire. Place the units a few metres apart and check that the green On l.e.d. operates in each.

Cover the phototransistor so that it is completely dark. Apply digital voltmeter probes to TB1 terminals on the transmitter unit (that is, between TR1's collector and emitter). If the voltage is rather more than one-half the regulated supply voltage (say, between 5V and 7V) leave preset VR1 adjusted as it is. If not, first check that the phototransistor is totally dark and, if necessary, re-adjust VR1. Unless maximum sensitivity is required, this setting is not particularly critical.

Now, adjust preset VR2 so that the local status l.e.d. (D1) is just off. You should see the matching l.e.d. (D1) in the distant unit is also off. If a little light is allowed to reach the phototransistor, both the local and distant status l.e.d.s should operate.

Boxing Up

Note that both units must be built in plastic (***not*** metal) cases. Metal boxes would prevent radio waves passing

The completed units showing the mains adaptor power-in sockets and the "mimic" Status l.e.d.s

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through and the circuit would not work.

Drill mounting holes in the bottom of each box to correspond with those in the p.c.b.s. Mount the p.c.b.s. on short plastic stand-off insulators so that the tops of the l.e.d.s will stand slightly higher than the lids of the boxes when these are in place.

Measure the position of each l.e.d. and make holes in the lids for them to show through. Drill small holes and mount the "power-in" sockets which are used to connect the plug-in adaptors. In the Transmitter unit, drill an additional small hole for the wire entering from the Sensor unit.

Connect the power-in sockets to TB2 (Transmitter) and TB1 (Receiver) using light-duty stranded wire. If the power supply output plugs have fixed polarity (for example, the "pin" being positive) observe this so that the polarity at each terminal block is correct. If it is incorrect, the circuits will not work and the wires at the terminal blocks will need to be reversed.

Sensor unit

The phototransistor should be mounted in a small lightproof box. The author used one in which a semiconductor device had been supplied. Drill a hole for the phototransistor itself and a further one for the sensor wire entering from the Transmitter unit. In the prototype, the phototransistor hole was drilled near one corner of the box since this was convenient for the l.e.d. being monitored.

Glue the phototransistor in place with its top a little higher than the top face of the box. Pass the sensor wires through the holes and solder them to the phototransistor's end wires taking care that the collector and emitter connect to the "c" and "e" points respectively at terminal block TB1. Make sure the connections cannot touch using insulation as necessary. Apply small cable ties to the wire inside of the sensor and main box to provide strain relief.

The sensor will be mounted on the front panel of the appliance being monitored so that its Status l.e.d. is directly opposite the phototransistor's "window". This could be done using adhesive fixing pads. It is essential to exclude all extraneous light because this would alter the operating point and reduce the sensitivity of the circuit. A piece of black foam with a circle cut in the centre for the phototransistor could be glued to the top of the sensor box for this purpose (a piece of electrically conductive foam supplied with an integrated circuit was used for the prototype).

The Sensor Unit

Plug in the Transmitter's power supply and conduct some tests. Adjust VR2 so that the Status l.e.d. copies operation of the l.e.d. on the appliance. If the l.e.d. being monitored is particularly dim, you will need to find the best position for the phototransistor and adjust VR2 carefully to achieve reliable operation. However, in most cases, setting-up will not be difficult.

Find a suitable place for the Receiver unit and check for correct operation. Unless it is only a few metres away, it may be necessary to adjust the position and orientation of both Transmitter and Receiver to give reliable operation. You could increase the range by fitting a small external whip aerial on the Receiver in place of the section of copper track. Do not modify the Transmitter aerial or the unit could be operating illegally.

Regulations

There are legal restrictions about using radio transmitter modules such as those used here. In the UK the regulations state that all transmitters shall use integral antennas only. Receivers may use an external antenna or an integral antenna. An integral antenna is defined as one which is designed to be connected permanently to the transmitter or receiver without the use of an external feeder.

To operate this transmitter legally in the UK, you must attach an inspection mark to the outside of the case with this wording:

MPT 1340 W.T.
LICENCE EXEMPT

The minimum size is 10mm x 15mm and the lettering must be at least 2mm high.

Response Code

The circuit should not respond to other similar devices that might be within range. If it does, change the code in both units. However, a strong signal can "swamp" the Receiver and it will not respond during that time. This might happen if the system is being used at maximum range. ***EPE***

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THE KIT

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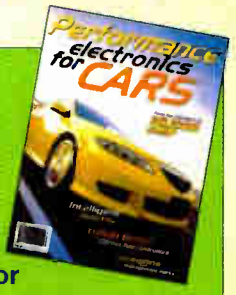
High Performance Electronic Projects for Cars



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, color 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.

Intelligent Turbo Timer

KC-5383 £14.75 + post & packing

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

60 mins

Hand Controller for Digital Adjusters

KC-5386 £25.95 + post & packing

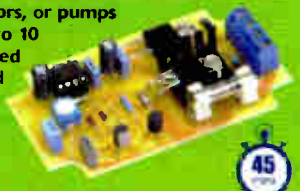
This hand controller is used for the mapping/ programming of both Digital Adjuster kits. It features a two line LCD, and easy to use pushbuttons. It can be used to program the adjusters then removed, or left permanently connected to display the adjuster's operation. It is designed as an interface and display, and is not required for general adjuster functions after they have been programmed. Kit supplied with silk screened and machined case, PCB, LCD, and all electronic components.

90 mins

Nitrous Fuel Mixture / Motor Speed Controller

KC-5382 £7.95 + post & packing

When activated, it will fire the injector at a preset duty cycle, adding a fixed amount of nitrous fuel. It also makes a great motor controller, to control an electronic water pump, additional fuel pump, cooling fans and more. Suitable for use with most fuel injectors, or pumps and motors up to 10 amps. Kit supplied with PCB and all electronic components.



45 mins

Independent Electronic Boost Controller

KC-5387 £25.95 + post & packing

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

- Suitable for EFI and engine management systems only.

2 hours

Smart Fuel Mixture Display

KC-5374 £8.95 + post & packing

This kit features auto dimming for night driving, emergency lean-out alarm, and 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.

90 mins

Recommended box
UB3 £1.40 each

Current Clamp Adaptor for Multimeters

KC-5368 £8.75 + post & packing

A great low cost alternative. It uses a simple hall effect sensor and iron ring core setup, 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. Much cheaper than pre-built units. It's supplied with PCB, clamp, case with silkscreened front panel and all electronic components.
As published in Every Day Practical Electronics.

2 hours

Video Enhancer/Stabiliser MkII

KC-6390 £31.95 + post & packing

Get the video quality you paid for.
Copy protection is put in place on videos and DVDs for a good reason, but this robs you of the true high quality reproduction that it is capable of. It supports composite and S- video signals and can be configured for NTSC or PAL format. Kit includes case, circuit board, all electronic components, and clear English instructions. Note: Some SMD soldering required.
Caution. During signal conditioning, this unit removes copyright protection. Piracy is a crime & Jaycar Electronics takes no responsibility for its potential for unlawful use.

2 hours

STOP PRESS

From this month EPE will be publishing a new series of popular projects by Silicon Chip Magazine, Australia. The projects are well designed, 'bullet proof' and already tested down under. Jaycar will support each project with a kit. Watch out in future Jaycar advertisements for details of the kits for these EPE projects.

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WIZARDS OF OZ

Smart Card Programmer Kit
KC-5361 £15.95 + post & packing

Program both the microcontroller and EEPROM in the popular Gold, Silver and Emerald wafer cards. Cards used need to conform to ISO-7816 standards, which includes ones sold by Jaycar. Powered by 9-12VDC plugpack or 9V battery. Instructions outline software requirements that are freely available on the Internet. Kit supplied with PCB, wafer card socket and all electronic components.
PCB measures: 141 x 101mm

Jaycar cannot accept responsibility for the operation of this device, its related software, or its potential to be used in relation to illegal copying of Smart Cards in Digital Cable T.V. set top boxes.

60 mins

Requires 9-12 VDC Wall Adapter (Maplin # JC91Y £14.99)

Gold Wafer Card
ZZ-8800 £3.85 + post & packing

This is a multi-chip 'smart card' based on the PIC 16F84A and is coupled with a 24LC16B EEPROM, and compatible with most reader/programmer units available.

Theremin Synthesiser Kit
KC-5295 £14.75 + post & packing

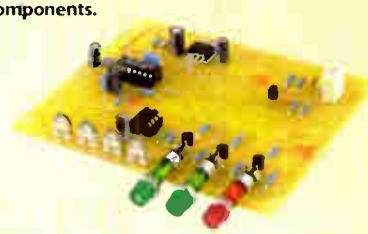
The Theremin is a weird musical instrument that was invented early last century but is still used today. The Beach Boys' classic hit "Good Vibrations" featured a Theremin. By moving you hand between the antenna and the metal plate, you create strange sound effects. Kit includes a machined, silk screened, and pre drilled case, circuit board, all electronic components, and clear English instructions.

4+ hours

9VDC power supply required (Maplin #G574R $9.99).

Gear Shift Indicator
KC-5265 £11.50 + post & packing

Reaching or exceeding the RPM 'red line' of your engine can cause severe damage. This rev limiter will restrict the RPM at an adjustable preset limit so that 'red line' will not be exceeded. Two lamps will illuminate consecutively before the 'red line'.
- Case not included.
- Kit supplied short-form including PCB, lamps and electronic components.



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- Kit supplied with diecast case, PCB and all electronic components.

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KJ-8750 £6.50 + post & packing

The circuit board may measure just 51(L) x 27(W)mm, but it can transmit signals over half a km 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.
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30 mins

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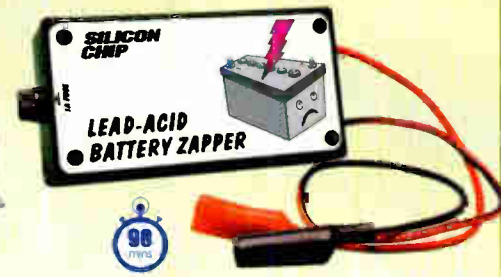
KC-5414 £11.75 + post & packing

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. 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



90 mins

30 mins

Icon Explanation
Indicates an approximate construction time for a competent constructor. It does not however, include any installation that may be required.

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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 silkcreened 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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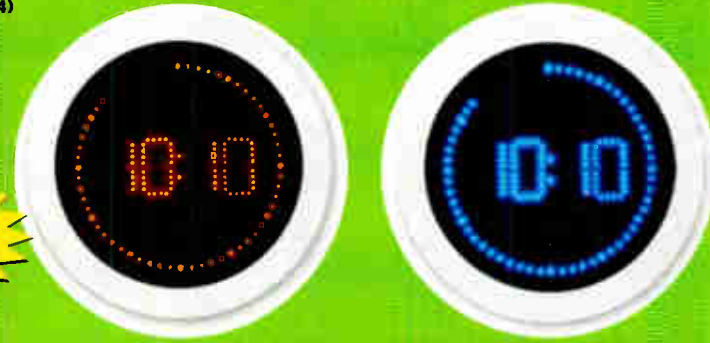

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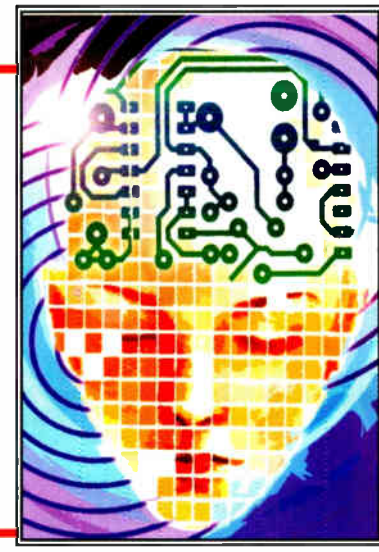
EPE Tutorial Series

TEACH-IN 2006

Part Four – Semiconductors, Introducing Diodes.



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 semiconductors in general and diodes in particular.

Semiconductors

Semiconductors form the basis of many important electronic components such as diodes, silicon controlled rectifiers, triacs, transistors and integrated circuits. Semiconductor devices are made from materials that are neither conductors nor insulators. We begin this part with a brief introduction to the principles of semiconductors and then go on to examine the characteristics of various diodes.

You should recall from Part One (Nov '05) that an atom contains both negative charge carriers (*electrons*) and positive charge carriers (*protons*). Electrons each carry a single unit of negative electric charge while protons each exhibit a single unit of positive charge.

Since atoms normally contain an equal number of electrons and protons, the net charge present will be zero. For example, if an atom has eleven electrons, it will also contain eleven protons. The end result is that the negative charge of the electrons will be exactly balanced by the positive charge of the protons.

Electrons are in constant motion as they orbit around the nucleus of the atom. Electron orbits are organized into *shells*, as shown in Fig.4.1.

The maximum number of electrons present in the first shell is two, in the second shell eight, and in the third, fourth and fifth shells it is 18, 32 and 50, respectively. In electronics, only the electron shell furthermost from the nucleus of an atom is important. It is also important to note that the movement of electrons between atoms only involves those present in the outer *valence shell*.

If the valence shell contains the maximum number of electrons possible the electrons are rigidly bonded together and the material has the properties of an insulator. If, however, the valence shell does not have its full complement of electrons, the electrons can be easily detached from their orbital bonds, and the material has the properties associated with an electrical conductor.

In its pure state, silicon is an insulator because the covalent bonding rigidly holds all of the electrons leaving no free (easily loosened) electrons to conduct current. If, however, an atom of a different element (i.e. an impurity) is introduced that has five electrons in its valence shell, a surplus electron will be present (see Fig.4.2). These free electrons become available for use as charge carriers and they can be made to move through the lattice by applying an external potential difference to the material.

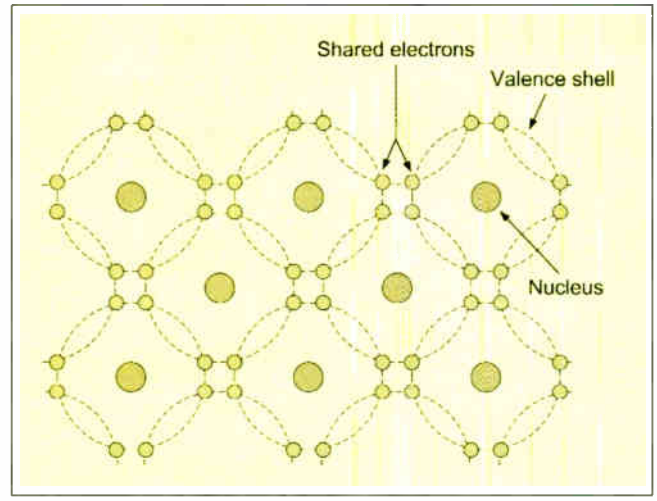


Fig.4.1. Shared electrons in the atomic matrix of a pure insulating material (for example pure germanuim which has a valency of 4)

Impurities

Similarly, if the impurity element introduced into the pure silicon lattice has three electrons in its valence shell, the absence of the fourth electron needed for proper covalent bonding will produce a number of spaces into which electrons can fit (see Fig.4.3). These spaces are referred to as *holes*. Once again, current will flow when an external potential difference is applied to the material.

Regardless of whether the impurity element produces surplus electrons or holes, the material will no longer behave as an

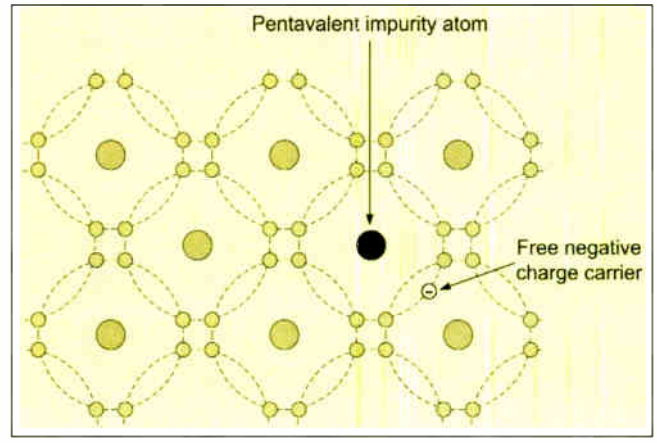


Fig.4.2. Effect of introducing a pentavalent impurity

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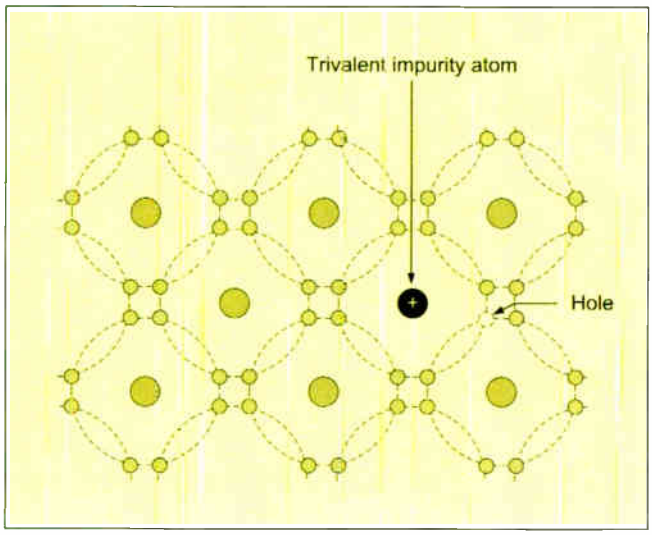

Fig.4.3. Effect of introducing a trivalent impurity

insulator neither will it have the properties that we normally associate with a metallic conductor. Instead, we call the material a semiconductor – the term simply indicates that the substance is no longer a good insulator or a good conductor but is somewhere in between! Examples of semiconductors include germanium (Ge) and silicon (Si). (The amount of impurity present determines how much the material conducts.)

The process of introducing an atom of another (impurity) element into the lattice of an otherwise pure material is called *doping*. When the pure material is doped with an impurity with five electrons in its valence shell (i.e. a *pentavalent impurity*) it will become an *n*-type (i.e. negative type) material. If, however, the pure material is doped with an impurity having three electrons in its valence shell (i.e. a *trivalent impurity*) it will become *p*-type material (i.e. positive type). An *n*-type semiconductor material contains an excess of negative charge carriers whilst *p*-type material contains an excess of positive charge carriers.

Check Point 4.1

In its pure state, silicon is an insulator because the covalent bonding rigidly holds all of the electrons leaving no free (easily loosened) electrons to conduct current. However, when atoms of a different element (i.e. an impurity) is introduced the material will conduct electric current and the resulting material is known as a semiconductor.

Semiconductor Classification

Semiconductor devices are classified using a unique part numbering system. Several schemes are in use including the American Joint Engineering Device Engineering Council (JEDEC) system, the European Pro-Electron system, and the Japanese based JIS system. In addition, some manufacturers have adopted their own coding schemes.

The JEDEC system

The JEDEC system of semiconductor classification is based on the following coding format:

Leading digit, letter, serial number, suffix (optional)

The leading digit designates the number of *p-n* junctions used in the device. Hence a device code starting with 1 relates to a single *p-n* junction (i.e. a diode) whilst a device code starting with 2 indicates a device that has two *p-n* junctions (usually a transistor). The letter is always N (signifying a JEDEC device) and the remaining digits are the serial number of the device. In addition, a suffix may be used in order to indicate the gain group. Table 4.1 shows the system.

The Pro-Electron system

The European Pro-Electron system for classifying semiconductors involves the following coding format:

First letter, second letter, third letter (optional), serial number, suffix (optional). See table 4.2.

The JIS system

The Japanese Industrial Standard (JIS) is based on the following coding format: *Leading digit, first letter, second letter, serial number, suffix (optional).* See table 4.3.

Introducing Diodes

When a junction is formed between *n*-type and *p*-type semiconductor materials, the resulting device is called a *diode*, as shown in Fig.4.4. This component offers an extremely low resistance to current flow in one direction and an extremely

Table 4.1. JEDEC coding system

Leading digit – number of *p-n* junctions	1 Diode 2 Transistor 3 Silicon controlled rectifier or dual gate MOSFET 4 Optocoupler
Letter – origin	N North American JEDEC coded device
Serial number – the serial number does not generally have any particular significance	
Suffix – some transistors have an additional suffix that denotes the gain group for the device (where no suffix appears the gain group is either inapplicable or the group is undefined for the device in question)	A Low gain B Medium gain C High gain

Table 4.2. The Pro-Electron system

First letter – semiconductor material	A Germanium B Silicon C Gallium arsenide, etc. D Photdiodes, etc.
Second letter – application	A Diode, low power or signal B Diode, variable capacitance C Transistor, audio frequency low power D Transistor, audio frequency power E Diode, tunnel F Transistor, high frequency low power P Photodiode Q Light emitting diode S Switch device T Controlled rectifier X Varactor diode V Power rectifier Z Zener diode
Third letter – if present this number indicates that the device is intended for industrial or professional rather that commercial applications	
Serial number – the serial number does not generally have any particular significance	
Suffix – some transistors have an additional suffix that denotes the gain group for the device (where no suffix appears the gain group is either inapplicable or the group is undefined for the device in question)	A Low gain B Medium gain C High gain

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Table 4.3. The JIS system

The JIS coding system is similar to the JEDEC system: **Leading digit** – number of *p-n* junctions	1 Diode 2 Transistor 3 Silicon controlled rectifier or dual gate MOSFET 4 Optocoupler
First and second letters – applications	SA *pnp* high frequency transistor SB *pnp* audio frequency transistor SC *npn* high frequency SD *npn* audio frequency SE Diode SF Silicon controlled rectifier SJ *p*-channel FET/MOSFET SK *n*-channel FET/MOSFET SM Triac SQ LED SR Rectifier SS Signal diode ST Diode SV Varactor SZ Zener diode
Serial number – the serial number does not generally have any particular significance	
Suffix – some devices have a suffix that denotes approval of the device for use by certain organisations	

Question 4.1

Q4.1. Classify each of the following semiconductor devices:
(a) 1N4002
(b) BFY52
(c) 3N200
(d) AA119
(e) 2N3053
(f) 2SA1077

Check Point 4.2

Depending upon their region of origin, semiconductors devices (such as diodes and transistors) are marked using one of several different coding systems. The most commonly used systems are the JEDEC (USA), Pro-Electron (Europe) and JIS (Japan) systems. In addition, some manufacturers also use their own "house codes".

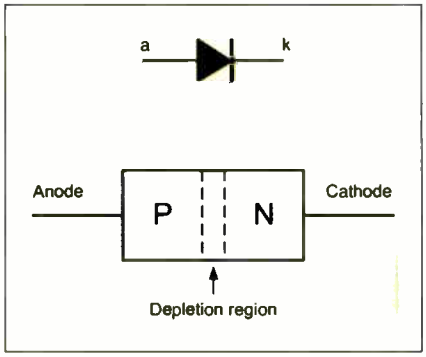

Fig.4.4. A p-n junction

high resistance to current flow in the other. This characteristic allows diodes to be used in applications that require a circuit to behave differently according to the direction of current flowing in it. An ideal diode would pass an infinite current in one direction and no current at all in the other direction.

Connections are made to each side of the diode. The connection to the *p*-type material is referred to as the *anode* while that to the *n*-type material is called the *cathode*. With no externally applied potential, electrons from the *n*-type material will cross into the *p*-type region and fill some of the vacant holes. This action will result in the production of a region either side of the junction in which there are no free charge carriers. This zone is known as the *depletion region*.

If a positive voltage is applied to the anode, see Fig.4.5a, the free positive charge carriers in the *p*-type material will be repelled and they will move away from the positive potential towards the junction. Likewise, the negative potential applied to the cathode will cause the free negative charge carriers in the *n*-type material to move away from the negative potential towards the junction.

When the positive and negative charge carriers arrive at the junction, they will attract one another and combine (recall that unlike charges attract). As each negative and positive charge carrier combine at the junction, a new negative and positive charge carrier will be introduced to the semiconductor material from the voltage source. As these new charge carriers enter the semiconductor material, they will move toward the junction and combine. Thus, current flow is established and it will continue for as long as the voltage is applied. In this *forward-biased* condition, the diode freely passes current.

If a negative voltage is applied to the anode, see Fig.4.5b, the free positive charge carriers in the *p*-type material will be attracted and they will move away from the junction. Likewise, the positive potential applied to the cathode will cause the free negative charge carriers in the *n*-type material to move away from the junction. The combined effect is that the depletion region becomes wider. In this *reverse-biased* condition, the diode passes a negligible amount of current.

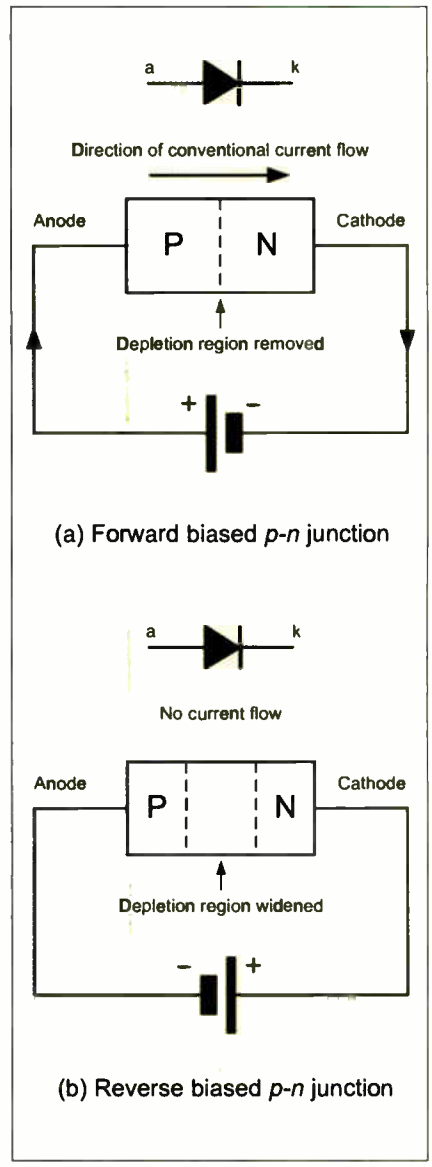

Fig.4.5. Forward and reverse biased p-n junction diode

Check Point 4.3

In the freely conducting forward-biased state, a diode acts like a closed switch. Conversely, when in the reverse-biased state, a diode will act like an open switch.

Diode Characteristics

Typical *I/V* characteristics for germanium and silicon diodes are shown in Fig.4.6. It should be noted from these characteristics that the approximate forward conduction voltage for a germanium diode is 0.2V whilst that for a silicon diode is 0·6V. This threshold voltage must be high enough to completely overcome the potential associated with the depletion region and force charge carriers to move across the junction.

Example 4.1

The characteristic of a diode is shown in Fig.4.7. Determine:

(a) the current flowing in the diode when a forward voltage of 0·3V is applied

(b) the voltage dropped across the diode

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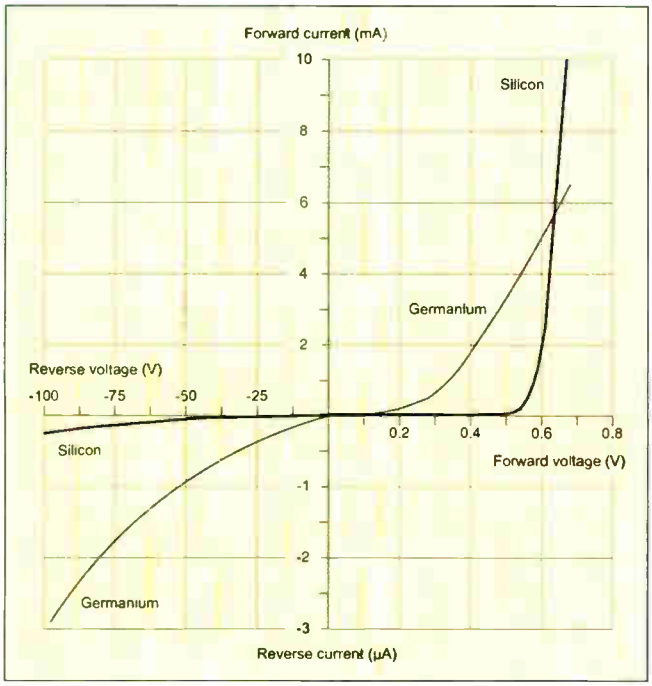

Fig.4.6. Typical I/V characteristics for germanium and silicon diodes

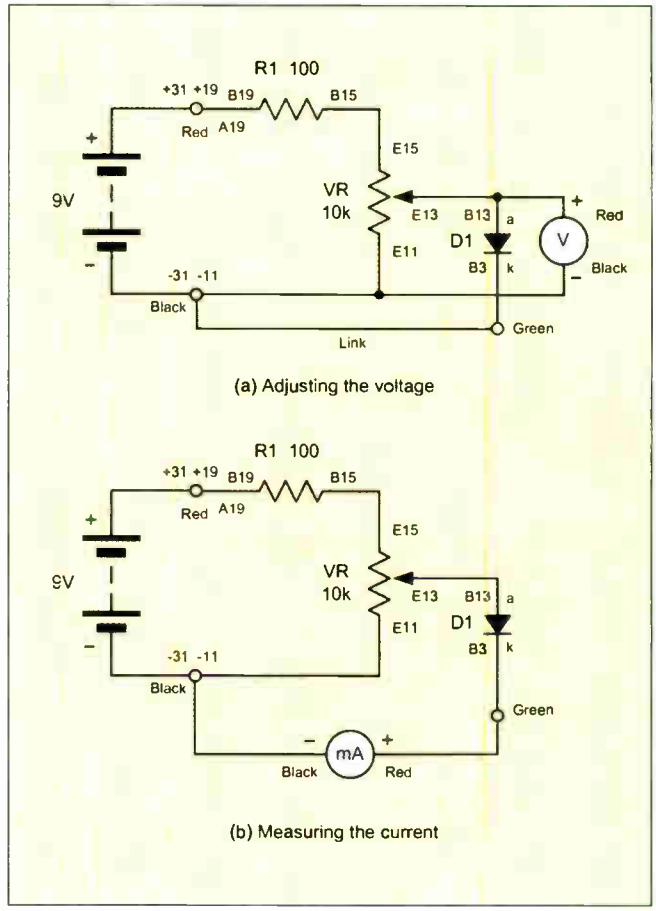

Fig.4.8. Circuit diagram for Practical Investigation 4.1

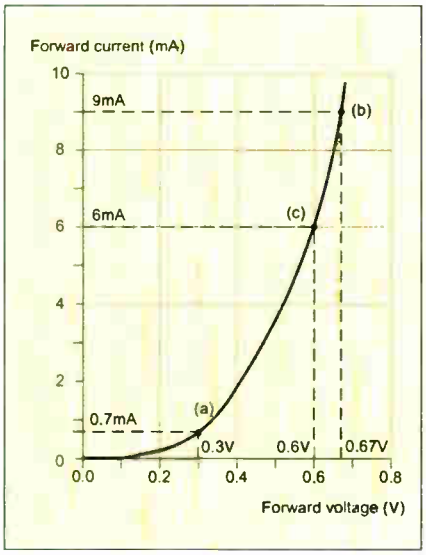

Fig.4.7. See Example 4.1

when a forward current of 9mA is flowing in it

(c) the resistance of the diode when the forward voltage is 0·6V

(d) whether the diode is a germanium or silicon type

Results
(a) When V = 0.3V, I = 0·7mA
(b) When I = 9mA, V = 0·67V
(c) From the graph, when V = 0·6V, I = 6mA. Thus V/I = 0·6/0·006 = 100Ω
(d) The onset of conduction occurs at approximately 0·2V. This suggests that the diode is a germanium type.

Check Point 4.4

The forward voltage for a germanium diode is approximately 0·2V whilst that for a silicon diode is approximately 0·6V.

Practical Investigation 4.1

Objective: To investigate the characteristics of a diode.

Components and materials: Breadboard; 9V DC power source (either a PP9 9V battery or an AC mains adapter with a 9V 400mA DC output); digital multimeter with test leads; 100Ω resistor; 10kΩ potentiometer, insulated wire links (various lengths); diodes (selection including one or more 1N4001, 1N4148 and OA91); assorted crocodile leads; short lengths of black, red, and green insulated solid wire. A watch or clock with a seconds display will also be required for timing.

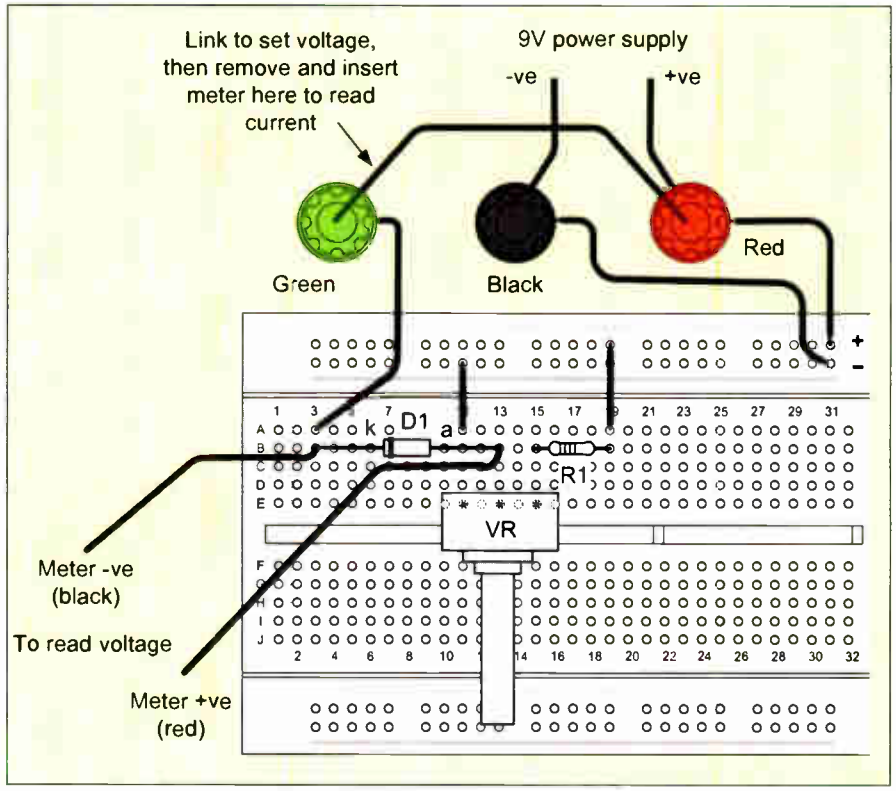

Fig.4.9. Wiring diagram for Practical Investigation 4.1

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Circuit diagram: See Fig.4.8

Wiring diagram: See Fig.4.9

Procedure: The required breadboard wiring is shown in Table 4.4.

Connect the circuit shown in Fig.4.8a and the links and meter as described in Table 4.5. Set the variable resistor (VR) to mid-position. Switch on the DC supply (or connect the battery), check that the meter is set to the 2V DC voltage range and read the diode forward voltage. Adjust VR to obtain a reading of exactly 0·25V.

Now remove the link and reconnect the meter as described in Table 4.6. Set the meter to the 20mA DC current range and read the diode forward current. Record the value of forward voltage (0·25V) and corresponding forward current in Table 4.7. Repeat steps 12 to 17 with the diode forward voltage set to the remaining values shown in the table and, for each value of forward voltage, measure and record the corresponding value of forward current. If time permits, repeat the investigation with other diodes (1N4148 and OA91).

Plot graphs of forward current (on the vertical axis) against forward voltage (on the horizontal axis) for each diode investigated using the graph sheet shown in Fig.4.10, which you could enlarge on a photocopier.

Conclusion: Comment on the shape of the graphs. Is this what you would expect? Can you say what type of semiconductor is used in the manufacture of each device? Based on the shape of the characteristic curves, estimate the forward voltage for each diode.

Table 4.4. Breadboard wiring for Practical Investigation 4.1

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	D1 1N4001	B13 (anode)	B3 (cathode)
6	R1 100Ω	B19	B15
7	Yellow link	A11	-11
8	VR	E11	
9	VR	E13	
10	VR	E15	
11	Green link	A19	+19

Table 4.5. To set the voltage for Fig.4.8a

Step	Connection, link or component	From	To
12	Green wire	Green terminal	A3
13	Meter positive	A (Red)	D1 anode (B13)
14	Meter negative	COM (Black)	D1 cathode (B3)

Table 4.6. To set the current for Fig.4.8b

Step	Connection, link or component	From	To
15	Remove green wire	Green terminal	A3
16	Meter positive	V (Red)	Green terminal
17	Meter negative	COM (Black)	Black terminal

Table 4.7. Measurements

Forward Voltage	Forward current (mA)		
(V)	1N4001	1N4148	OA91
0			
0·25			
0·5			
0·6			
0·7			
0·8			
0·9			
1·0			
1·1			
1·2			
1·25			

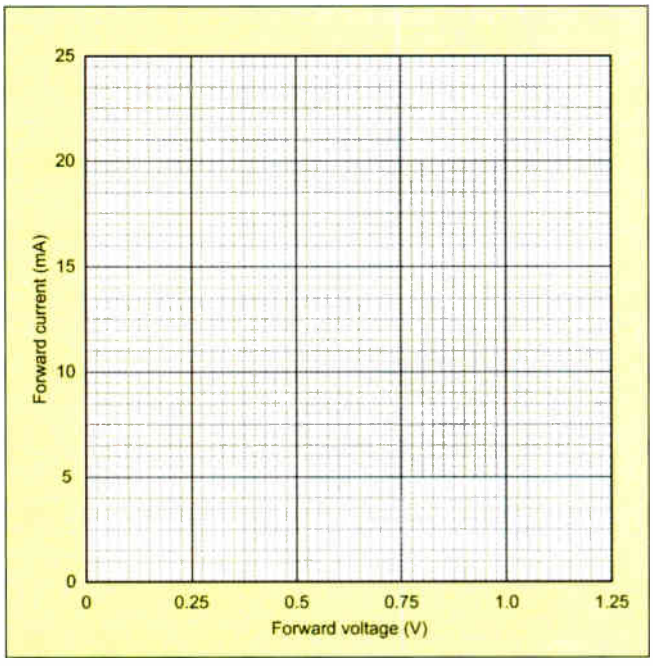

Fig.4.10. Graph sheet for plotting the results of Practical Investigation 4.1

Maximum Ratings

It is worth noting that diodes are limited by the amount of forward current and reverse voltage they can withstand. This limit is based on the physical size and construction of the diode. In the case of a reverse biased diode, the *p*-type material is negatively biased relative to the *n*-type material. In this case, the negative potential to the *p*-type material attracts the positive carriers, drawing them away from the junction. This leaves the area depleted; virtually no charge carriers exist and therefore current flow is inhibited.

The reverse bias potential may be increased to the breakdown voltage for which the diode is rated. As in the case of the maximum forward current rating, the reverse voltage is specified by the manufacturer. Typical values of maximum reverse voltage or peak inverse voltage (PIV) range from 50V to 500V.

The reverse breakdown voltage is usually very much higher than the forward threshold voltage. A typical general-purpose diode may be specified as having a forward threshold voltage of 0·6V and a reverse breakdown voltage of 200V. If the latter is exceeded, the diode may suffer irreversible damage.

Diode Types and Applications

Diodes are often divided into signal or rectifier types according to their principal

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Table 4.8. A Selection of Diode Types

Device code	Material	Max reverse voltage	Max forward current	Max reverse current	Application
1N4148	Silicon	100V	75mA	25nA	General purpose
1N914	Silicon	100V	75mA	25nA	General purpose
AA113	Germanium	60V	10mA	200μA	RF detector
OA47	Germanium	25V	110mA	100μA	Signal detector
OA91	Germanium	115V	50mA	275μA	General purpose
1N4001	Silicon	50V	1A	10μA	Low voltage rectifier
1N5404	Silicon	400V	3A	10μA	High voltage rectifier
BY127	Silicon	1250V	1A	10μA	High voltage rectifier

field of application. Signal diodes require consistent forward characteristics with low forward voltage drop. Rectifier diodes need to be able to cope with high values of reverse voltage and large values of forward current, consistency of characteristics is of secondary importance in such applications. Table 4.8 summarizes the characteristics of some common semiconductor diodes.

Semiconductor diodes are also available connected in a bridge configuration for use as a rectifier in an AC power supply. Photo 4.1 shows a selection of various diode types whilst Fig.4.11 shows the symbols used to represent them in circuit schematics.

Table 4.9. Typical Zener Diode Characteristics

Zener series	Description and rating
BZY88 series	Miniature glass encapsulated diodes rated at 500mW (at 25°C). Zener voltages range from 2·7V to 15V (voltages are quoted from 5mA reverse current at 25°C)
BZX61 series	Encapsulated alloy junction rated at 1·3W (25°C ambient). Zener voltages range from 7·5V to 72V
BZX85 series	Medium-powered glass-encapsulated diodes rated at 1·3W and offering Zener voltages in the range 5·1V to 62V
BZY93 series	High-power diodes in stud mounting encapsulation. Rated at 20W for ambient temperatures up to 75°C. Zener voltages range from 9·1V to 75V
1N5333 series	Plastic encapsulated diodes rated at 5W. Zener voltages range from 3·3V to 24V

Zener Diodes

Zener diodes are heavily doped silicon diodes that, unlike normal diodes, exhibit an abrupt reverse breakdown at relatively low voltages (typically less than 6V). A similar effect (avalanche) occurs in less heavily doped diodes. These *avalanche diodes* also exhibit a rapid breakdown with negligible current flowing below the avalanche voltage and a relatively large current flowing once the avalanche voltage has been reached.

For avalanche diodes, this breakdown voltage usually occurs at voltages above 6V. In practice, however, both types of diode are referred to as Zener diodes. The symbol for a Zener diode is shown in Fig.4.11 whilst typical Zener diode characteristics are shown in Fig.4.12.

Whereas reverse breakdown is a highly undesirable effect in circuits that use conventional diodes, it can be extremely useful in the case of Zener diodes where the breakdown voltage is precisely known. When a diode is undergoing reverse breakdown, and provided its maximum ratings are not exceeded, the voltage appearing across it will remain substantially constant (equal to the nominal Zener voltage) regardless of the current flowing. This property makes the Zener diode ideal for use as a voltage regulator.

Zener diodes are available in various families (according to their general characteristics, encapsulations and

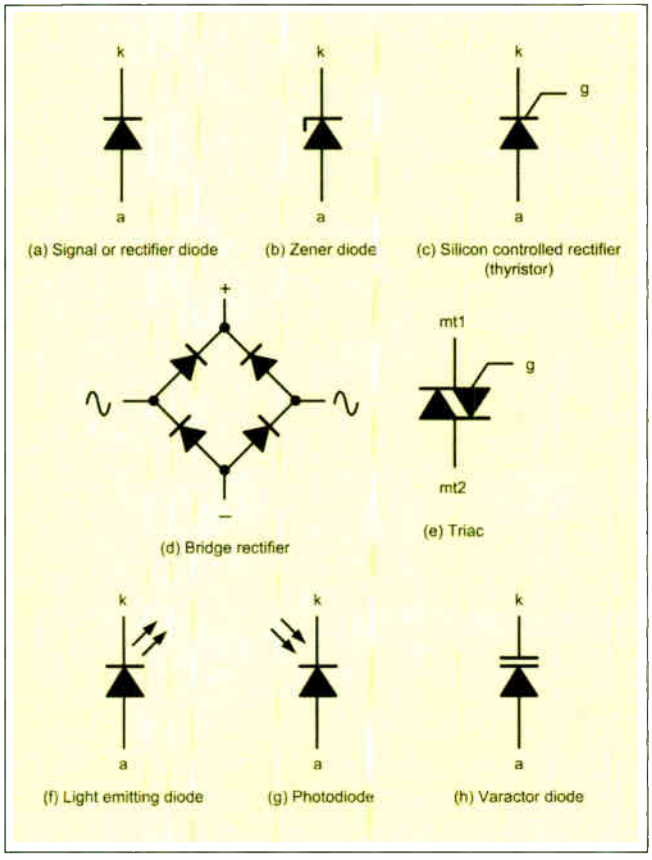

Fig.4.11. Diode symbols

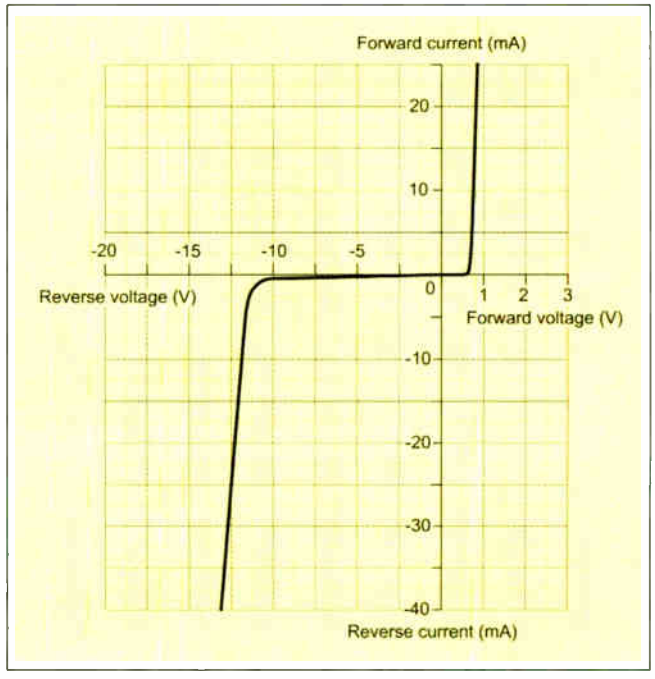

Fig.4.12. Typical Zener diode characteristic

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power ratings) with reverse breakdown (Zener) voltages in the range 2·4V to 91V. Table 4.9 summarizes the characteristics of common Zener diodes.

Example 4.2

The characteristic of a Zener diode is shown in Fig.4.13. Determine:

(a) the current flowing in the diode when a reverse voltage of 15V is applied

(b) the voltage dropped across the diode when a reverse current of 5mA is flowing in it

(c) the voltage rating for the Zener diode

(d) the power dissipated in the Zener diode when a reverse voltage of 15V appears across it.

Results:

(a) When V = -15V, I = -32·5mA
(b) When I = -5mA, V = -13·75mA
(c) The characteristic graph shows the onset of Zener action at 13V. This would suggest a Zener voltage rating of 13V.
(d) Now P = I × V from which P = (32·5 × 10^{-3}) × 15 = 0·488W = 488mW

Check Point 4.5

Zener diodes begin to conduct heavily when the applied voltage reaches a particular threshold value (known as the Zener voltage). Zener diodes can thus be used to maintain a constant voltage.

Silicon Controlled Rectifiers

Silicon controlled rectifiers (or *thyristors*) are three-terminal devices which can be used for switching and AC power control. Silicon controlled rectifiers can switch very rapidly from a conducting to a non-conducting state. In the off state, the silicon controlled rectifier exhibits negligible leakage current, while in the on state the device exhibits very low resistance.

This results in very little power loss within the silicon controlled rectifier even when appreciable power levels are being controlled.

Once switched into the conducting state, the silicon controlled rectifier will remain conducting (i.e. it is latched in the on state) until the forward current is removed from the device. In DC applications this necessitates the interruption (or disconnection) of the supply before the device can be reset into its non-conducting state.

Where the device is used with an alternating supply, the device will automatically become reset whenever the main supply reverses. The device can then be triggered on the next half-cycle having correct polarity to permit conduction.

Like their conventional silicon diode counterparts, silicon controlled rectifiers have anode and cathode connections; control is applied by means of a gate terminal. The symbol for a silicon controlled rectifier was shown earlier in Fig.4.11.

In normal use, a silicon controlled rectifier is triggered into the conducting (on) state by means of the application of a current pulse to the gate terminal (see Fig.4.14). The effective triggering of a silicon controlled rectifier requires a gate trigger pulse having a fast rise time derived from a low-resistance source. Triggering can become erratic when insufficient gate current is available or if the gate current changes slowly.

Table 4.10 summarizes the characteristics of several common silicon controlled rectifiers.

Table 4.10. Characteristics of several common silicon controlled rectifiers

Type	$I_F(AV)$ (A)	V_{RRM} (V)	V_{GT} (V)	I_{GT} (mA)
2N4444	5·1	600	1·5	30
BT106	1	700	3·5	50
BT152	13	600	1	32
BTY79-400R	6·4	400	3	30
TIC106D	3·2	400	1·2	0·2
TIC126D	7·5	400	2·5	20

Check Point 4.6

Silicon controlled rectifiers (SCR) are diodes that can be triggered into conduction by applying a small current to their gate input. SCRs are able to control large voltages and currents from a relatively small (low-current, low-voltage) signal.

Light Emitting Diodes

Light emitting diodes (l.e.d.s) can be used as general-purpose indicators. Compared with conventional filament lamps they operate from significantly smaller voltages and currents. They are also very much more reliable than filament lamps. Most l.e.d.s will provide a reasonable level of light output when a forward current of as little as 10mA to 15mA is supplied.

Light emitting diodes are available in various formats with the round types being most popular. Round l.e.d.s are commonly available in the 3mm and 5mm (0·2 inch) diameter plastic packages and also in a 5mm × 2mm rectangular format. The viewing angle for round l.e.d.s tends to be in the region of 20° to 40°, whereas for rectangular types this is increased to around 100°.

The symbol for an l.e.d. was shown earlier in Fig.4.11. Table 4.11 summarizes the characteristics of several common types of l.e.d.

In order to limit the forward current of an l.e.d. to an appropriate value, it is usually necessary to include a fixed resistor in series with an l.e.d. indicator, as shown in Fig.4.15. The value of the resistor may be calculated from the formula:

$$R = \frac{V - V_F}{I}$$

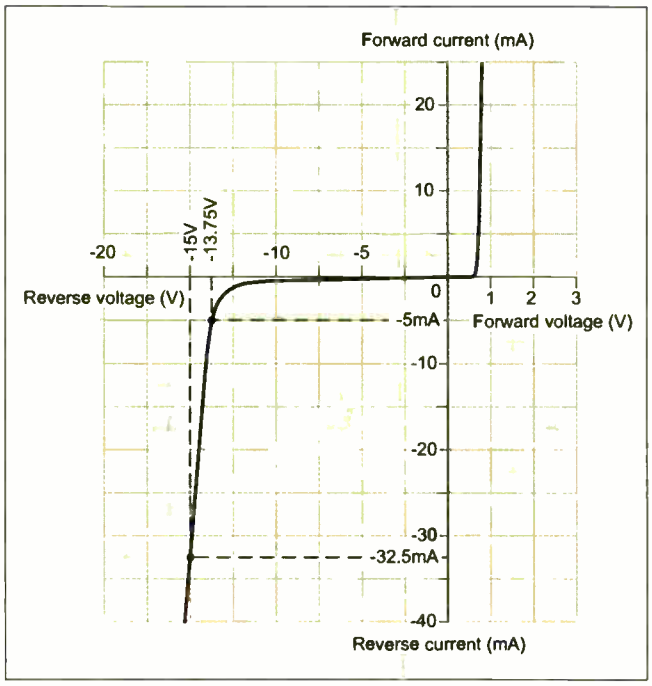

Fig.4.13. See Example 4.2

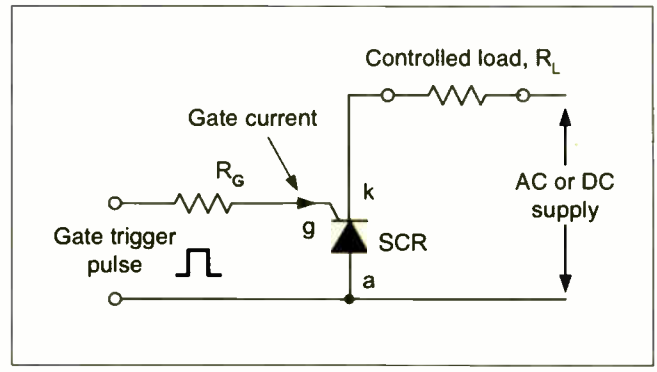

Fig.4.14. Triggering a silicon controlled rectifier

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Table 4.11. Characteristics of Several Common Types of LED

Parameter	Standard LED	Standard LED	High efficiency LED	High intensity
Diameter (mm)	3	5	5	5
Max. forward current (mA)	40	30	30	30
Typical forward current (mA)	12	10	7	10
Typical forward voltage drop (V)	2·1	2·0	1·8	2·2
Max. reverse voltage (V)	5	3	5	5
Max. power dissipation (mW)	150	100	27	135
Peak wavelength (nm)	690	635	635	635

Question 4.2

Q4.2. An l.e.d. is rated for operation with a forward voltage of 2.2V and a forward current of 15mA. If the l.e.d. is to operate from a 5V supply, what value of series resistor will be required and what is the nearest E12 resistor value?

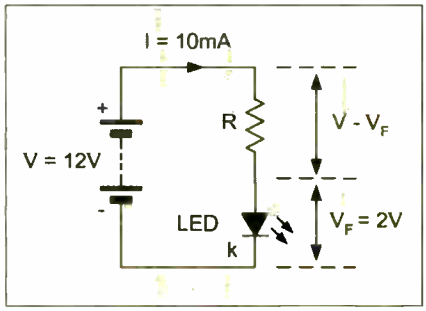

Fig.4.15. See Example 4.3

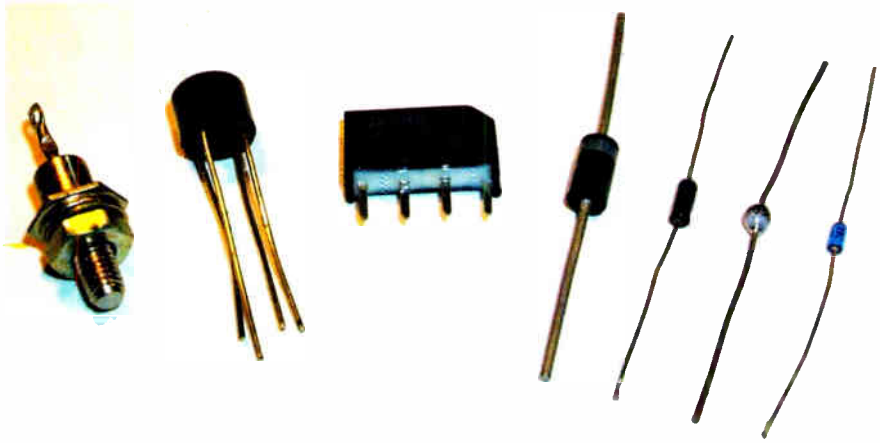

Photo 4.1. A Selection of diode types

where V_F is the forward voltage drop produced by the l.e.d. and V is the applied voltage. Note that, for most common l.e.d. V_F is approximately 2V.

Check Point 4.7

Light emitting diodes produce light when a small current is applied to them. They are generally smaller and more reliable than conventional filament lamps and can be used to form larger and more complex displays.

Answers To Questions

Q4.1 (a) Diode (JEDEC-coded)
(b) Silicon high-frequency low-power transistor (Pro-Electron coded)
(c) MOSFET (JEDEC-coded)
(d) Germanium low-power signal diode (Pro-Electron coded)
(e) Transistor (JEDEC-coded)
(f) *PNP* high-frequency transistor (JIS-coded)

Q4.2 187Ω, nearest preferred value is 180Ω

Example 4.3

A simple l.e.d. indicator circuit is shown in Fig.4.15. Determine the value for R if the diode is to operate with a current of 10mA and has a forward voltage drop of 2V.

Using the formula, $R = \frac{V - V_F}{I}$ gives:

$$R = \frac{12 - 2}{10 \times 10^{-3}} = 1 \times 10^3 = 1k\Omega$$

Next Month

In Part 5, next month, we shall be introducing magnetism, inductors and power supplies (for which we had no space this time). In the meantime you might like to see how you get on with our on-line quiz for Part 4. You will find this at: **www.miketooley.info/teach-in/quiz4.htm.**

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INTERFACE

Robert Penfold

IMPROVING THE INPUT VOLTAGE SPAN FOR AN A/D CONVERTER

IN RECENT *Interface* articles the subjects of analogue-to-digital and digital-to-analogue conversion have been considered. The conversion process itself is clearly an important part of getting analogue signals into and out of a computer, but it is unrealistic to expect the converter to exactly match your application.

The output from a digital-to-analogue converter will usually require a certain amount of amplification before it will have the desired effect of driving an electric motor, controlling lights, or whatever. Similarly, the signal from a sensor will usually require a certain amount of amplification or attenuation in order to provide a voltage span that matches the input range of an analogue-to-digital converter.

Step in the Right Direction

In some applications it is not just a matter of providing amplification or attenuation. It can sometimes be necessary to provide a voltage offset. For example, suppose a supply voltage must be monitored, and that it will be within the range 10V to 12·5V. One way of tackling the problem is to have (say) an 8-bit converter with a full scale value of 12·75V. This gives a bit of "headroom" just in case the monitored voltage goes somewhat higher than its normal range, together with a resolution of 50 millivolts (0·05V).

This might be adequate, and this obviously depends on the exact nature of the application. However, it is not really making very good use of the converter's resolution, and in practice it is likely that it would not give good enough results.

In the range that is of interest (10V to 12·5V) there are only 50 different levels covered by the converter, which compares to over 200 levels outside this range. The converter would effectively be reduced to about 5 or 6-bit operation.

One potential advantage of this method is that it requires only the most simple of signal processing. In fact it would probably require nothing more than a simple attenuator at the input of the converter. This makes it easy to ensure that the available accuracy is fully utilized.

High Resolution

Using a voltage offset in a situation of this type enables higher resolution to be obtained, with the converter being used at something close to its full 8-bit capability. Rather than attenuating the input voltage to match the range of the converter, a certain number of volts would be deducted from the input voltage.

Suppose the converter has an input voltage range of 0V to 2·55V. Using a circuit that reduces the input potential by ten volts would effectively give the converter a range of 10V to 12·55V with a resolution of 10 millivolts (0·01V). It would fully cover the appropriate range of voltages, but with five times the resolution obtained using an attenuator.

In this example the 0V to 2·55V volt range of the converter conveniently matched the 2·5 volt difference between 10V and 12·5V. Unfortunately, in practice it is unlikely that such a neat match will occur very often. However, it is just a matter of using an amplifier or attenuator ahead of the converter in order to produce a suitable input voltage range. The circuit that provides the required reduction in voltage is then added ahead of this.

Higher resolution could be obtained by first amplifying the output voltage of the converter by two. This would give a range of 0V to 5·1V, which is a reasonable match for the five volt span from 10V to 15V. Boosting the output by 10 volts would give a final output range of 10V to 15·1V with a resolution of 0·02V. This represents a five-fold boost in the resolution.

Fair Point

It is only fair to point out that there is a potential problem in using level shifting with either type of converter. Unless it is done well there will be a useful increase in resolution, but with a consequent reduction in absolute accuracy.

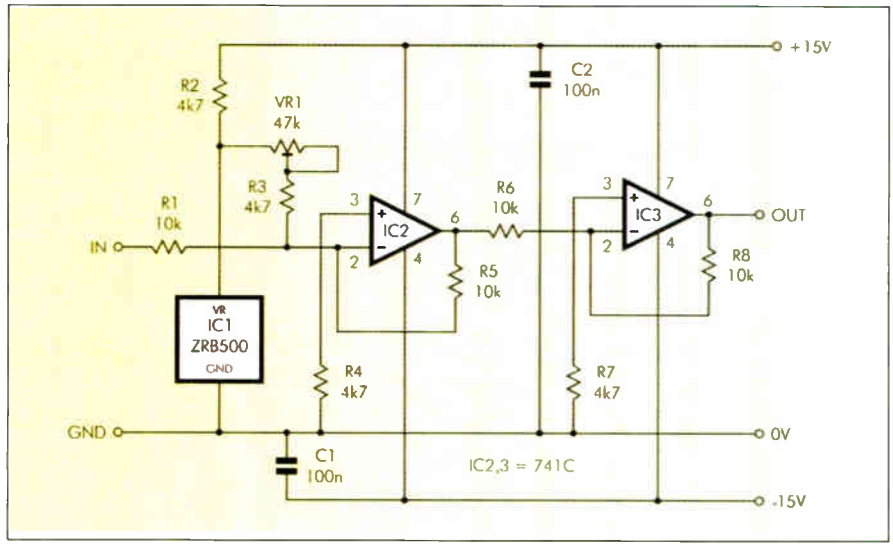

Fig.1. This circuit uses a summing mode mixer (IC2) to enable an offset voltage to be added to the output potential. Preset VR1 gives a range of just under 1V to a little over 10V. IC1 is a precision 5V voltage reference source

Stepping Up

Shifting the output voltage range of a digital-to-analogue converter can give more useful results, but in this context it is usually a boost in potential and not a reduction that is required. For example, a power supply having an output voltage in the range 10V to 15V might be required. With a converter having a 0V to 2·55V output range it would be possible to cover the required range using a small amount of voltage amplification. Boosting the output potential by a factor of 10 for instance, would give an output voltage range of 0V to 25·5V with a resolution of 100 millivolts (0·1V).

Once again, depending on the precise nature of the application, this may or may not be adequate. In either case it is not making very good use of the converter's resolution.

In other words, you could set the output of (say) a power supply unit in very fine steps, but the error in the output voltage could be relatively large. The circuit that provides the offset must be stable, and it must be set up precisely so that good absolute accuracy is obtained.

The simplest way of providing an offset voltage is to make use of the offset-null facility that is a feature of practically all single operational amplifier (op.amp) chips. There is a potential problem with this method in that this facility is really intended to enable small offset errors to be trimmed out. It might not be possible to introduce suitably large offset voltages using this method, and the stability of the circuit could be inadequate. It might work well with some operational amplifiers and where only a small offset is required, but good results are far from guaranteed.

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Mixing It

Operational amplifiers can be used in various permutations to provide a shift up or down in voltage. The circuit diagram shown in Fig.1 provides a simple but effective way of proving an upward offset in the output voltage. It is essentially just two inverting mode op.amps used in series.

The closed loop voltage gain of IC2 is set at unity by negative feedback loop (R1 and R5). The same is true of IC3, which has R6 and R8 as the negative feedback resistors. The inversion through IC2 is counteracted by the inversion through IC3, so that the overall action of the circuit is that of a simple non-inverting buffer stage that has unity voltage gain.

The offset in the output voltage is obtained by using IC2 as a summing mode mixer circuit, and it is effectively a DC version of the circuit that is often used as the basis of audio mixers. A slight problem with a summing mode mixer stage is that it provides an inversion, and it is for this reason that the second inverting amplifier is included.

The second input resistance of the mixer is provided by the series resistance of R3 and preset VR1. There is unity voltage gain with VR1 adjusted for a total resistance of 10 kilohms, and the output will be offset by an amount equal to the potential fed to this input of the mixer.

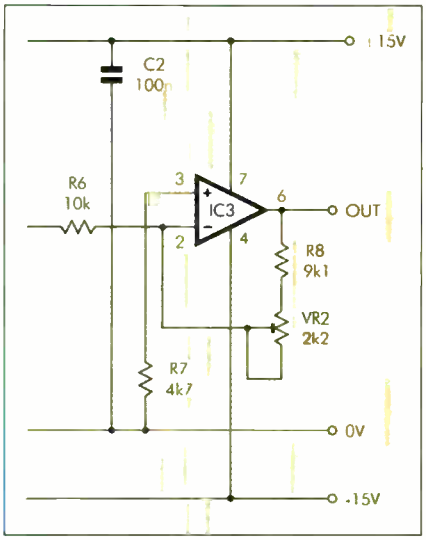

Fig.2. Trimming the closed loop gain of IC3 enables the circuit to be adjusted for optimum accuracy. Presets VR1 and VR2 must be high quality multiturn components

The voltage fed to this input of the mixer is provided by a precision 5V reference source based on IC1. This is used in a simple shunt regulator circuit that has resistor R2 as its load resistor.

Since the twin supplies of the circuit will usually be obtained via good quality regulators, the use of a further regulator might seem superfluous. In practice it is unlikely that an ordinary stabilised supply would provide sufficiently accurate results. There could be small but significant changes in the supply voltage due to changes in loading and temperature variations. A precision voltage regulator avoids these problems and ensures that accurate results are always obtained.

With preset VR1 set for unity voltage gain there will be an offset of +5V at the output of the circuit. Setting VR1 higher in value gives lower voltage gain and reduces the offset. The minimum available offset is a little under one volt, but using a higher value for VR1 would enable lower offsets to be obtained.

Taking VR1 lower in value produces a small amount of voltage gain and increases the output voltage. The maximum offset that can be achieved is just over 10V, which is the maximum practical amount with 15V supplies.

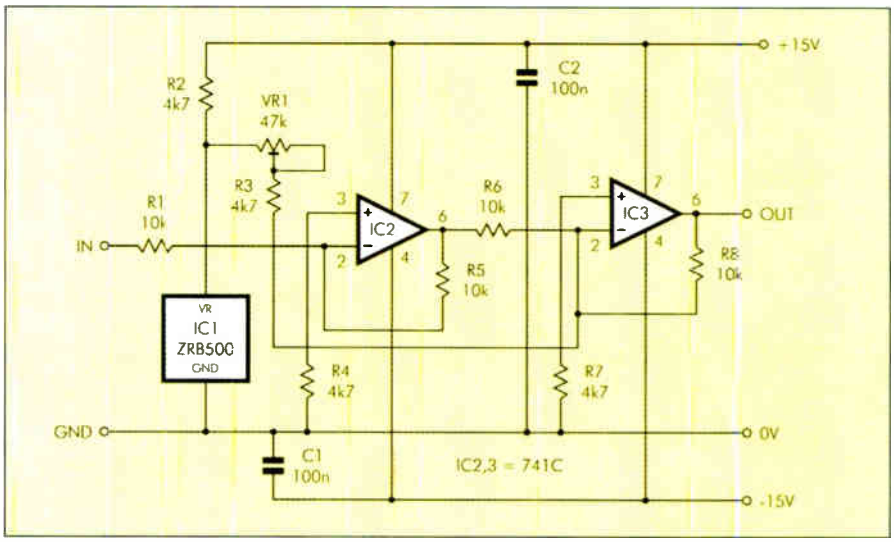

Fig.3. The circuit of Fig.1 is easily modified to produce a downwards shift in the output voltage. As before, a shift of around 1V to 10V can be achieved

Accuracy

As there are no significant voltage gains involved in this design, humble 741C operational amplifiers will work quite well. For optimum accuracy though, a precision op.amp should be used.

Some of these devices are very expensive and a bit "over the top" for the present application. A device such as the OP177GP is reasonably inexpensive and is more than adequate for use in this circuit. In some cases it could be necessary to opt for fast acting op.amps, but a typical op.amp is faster than most low-cost analogue-to-digital and digital-to-analogue converters.

The accuracy of the circuit is dependent on resistors R1, R5, R6, and R8 having very close tolerances. Even using components with a one-percent tolerance rating it is likely that the accuracy of the circuit would be compromised. With an 8-bit converter it would be preferable to have a tolerance rating of just 0·1 percent. Such components are made, but are expensive and difficult to obtain.

A more practical solution is to incorporate a preset gain control in one of the feedback circuits so that the voltage gain of the circuit can be trimmed to precisely the required level. One way of achieving this is shown in Fig.2. Here preset VR2, wired as a variable resistor, has been added in the negative feedback circuit of IC3.

Resistor R8 has been reduced slightly in value and VR2 has been added in series with this component. The closed loop voltage gain of the circuit is slightly more than unity with VR2 at maximum values and a little under unity when it is at minimum value.

Adding a preset gain control slightly complicates the setting up procedure for the circuit. Without this control it is just a matter of setting the output of the converter at zero and adjusting VR1 for the required offset voltage at the output of the circuit.

The setting up procedure starts in the same way if the gain control is included, with VR2 initially at a middle setting. The output of the converter is then set at maximum and VR2 is adjusted for the correct maximum output potential. This procedure is then repeated several times until no further adjustment of VR1 or VR2 is required.

For optimum stability the presets should be good quality types such as multiturn "trimpots". Using "bog standard" presets it could be difficult to make the adjustments with adequate accuracy, and there could be problems with drift over a period of time.

Downsizing

The circuit of Fig.1 is easily modified to provide a downwards shift in the output voltage. One way of achieving this is shown in the circuit diagram of Fig.3, where it is IC3 rather than IC2 that is used as the summing mode mixer.

The circuit operates much as before, but in this case the signal from the voltage reference is not re-inverted to produce a positive shift at the output. Instead, the output voltage of the circuit is shifted downwards by an amount that is controlled by preset VR1. As before, the shift can be varied from less than one volt to just over 10 volts.

Both the circuits featured here require dual balanced 15V supplies, and the current consumption will only be about 7mA. Bear in mind that the outputs of these circuits can go negative as well as positive. This could be an advantage in some applications and with some converters. However, in most cases when using one of these circuits with an analogue-to-digital converter it will be necessary to ensure that the input of the converter is protected against potentials of the wrong polarity.

Next time some more signal processing will be considered, together with a practical circuit.

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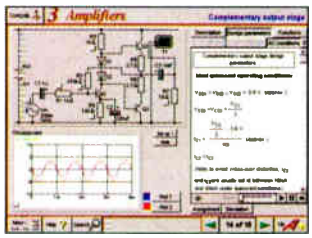
ANALOGUE ELECTRONICS



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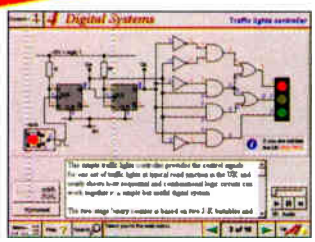

Virtual laboratory – Traffic Lights

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

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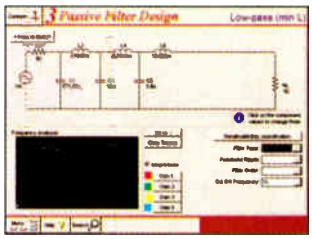
ANALOGUE FILTERS



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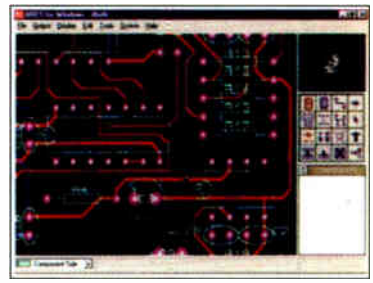
ELECTRONICS CAD PACK



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

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

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

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

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HARDWARE

VERSION 3 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

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

- Makes it easier to develop PICmicro projects
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- Fully featured integrated displays – 16 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)

£158 including VAT and postage

supplied with USB cable and programming software

SOFTWARE

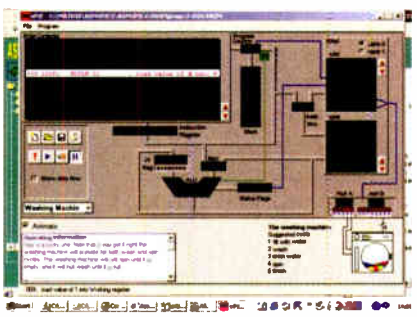
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

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

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

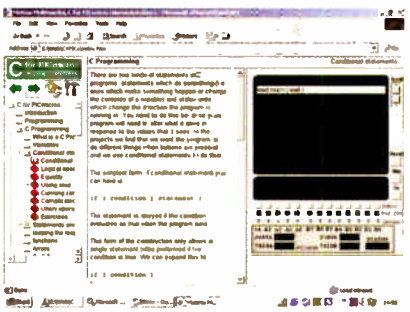


'C' FOR PICmicro VERSION 2

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

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

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



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

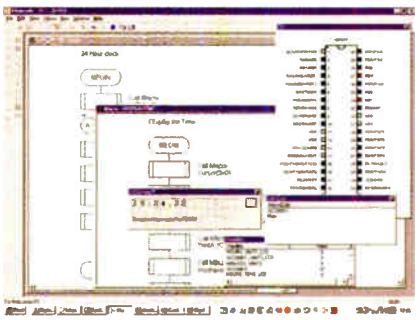
FLOWCODE FOR PICmicro V2

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

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

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

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



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Sine wave relationship values

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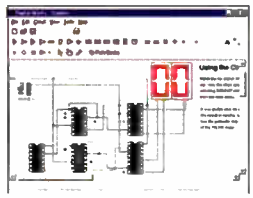

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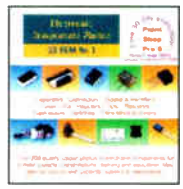

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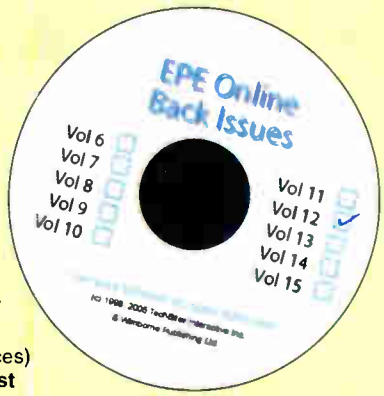

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World Radio History

Jazzy Heart Electronic Jewellery

By THOMAS SCARBOROUGH

Want a flashy piece of jewellery for the love of your life on Saint Valentine's Day? Then build the "JAZZY HEART", an eye-catching LED flasher in the shape of a heart. It could be worn as a brooch or as a pendant.

HERE'S A PIECE OF JEWELLERY that you can be sure is unique. Go to a party and you will know that nobody else will be wearing something like the Jazzy Heart.

It's a heart-shaped LED flasher using two ICs and eight different-coloured high brightness LEDs. It is powered by a 12V miniature battery and turned on and off by a tilt switch.

The Jazzy Heart randomly flashes eight LEDs using just two common CMOS ICs. The LEDs are arranged around the perimeter of a red plastic "heart" template (or for Christmas, a green plastic "Christmas tree" template) to pulse eight water-clear LEDs.

A special feature of the design is that all colour LEDs (red, green, blue, etc) may be used in all eight positions provided on the PC board while using just a single current-limiting resistor.

The Jazzy Heart really is jazzy. It needs to be seen to be appreciated – preferably associated with a fast disco beat to accompany it!

All eight LEDs essentially flash at random – but for fractions of a second, discernible patterns emerge. The LEDs may briefly whirl clockwise or anticlockwise, or bounce to and fro, sparkling in their water-clear encapsulations.

Circuit description

In concept, the circuit is very simple. At its heart lies a CMOS 4051 8-channel analogue multiplexer.

This can be thought of a single-pole, 8-position switch, with the important difference that the 4051 allows random access to each of the eight switch positions.

This means that it does not need to sequence through each of the eight positions as a normal

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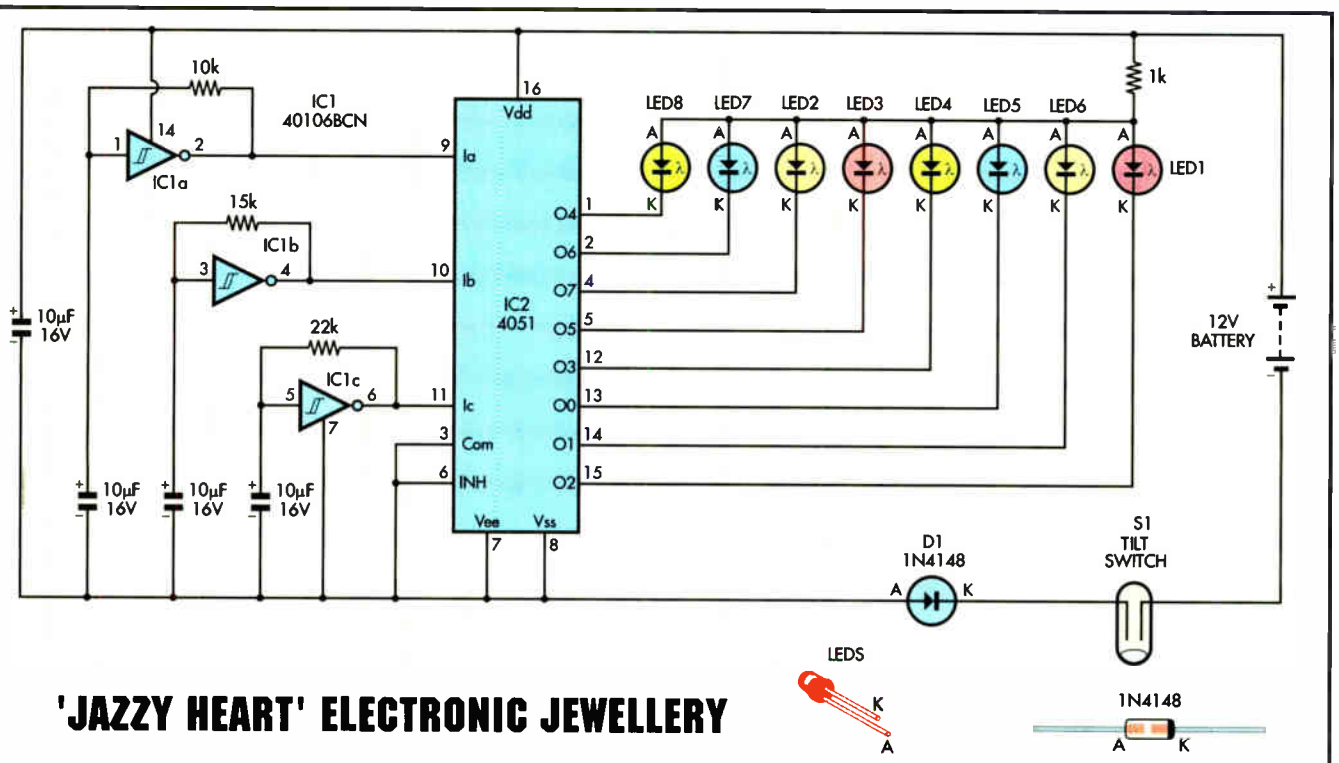


Fig.1: the beauty of the circuit is its simplicity, which means it can be made nice and small for an eye-catching display!

switch would do but has the ability to jump randomly from one position to the next.

Pin 3 is the centre or common pole of the switch, which is connected to any given switch position (numbered 0 to 7).

This is done by means of a three-bit binary number (or "word") which is presented to three "select" terminals (pins 9 to 11). The "select" terminals accept binary numbers from 000 to 111 and decode them to the eight separate switch positions.

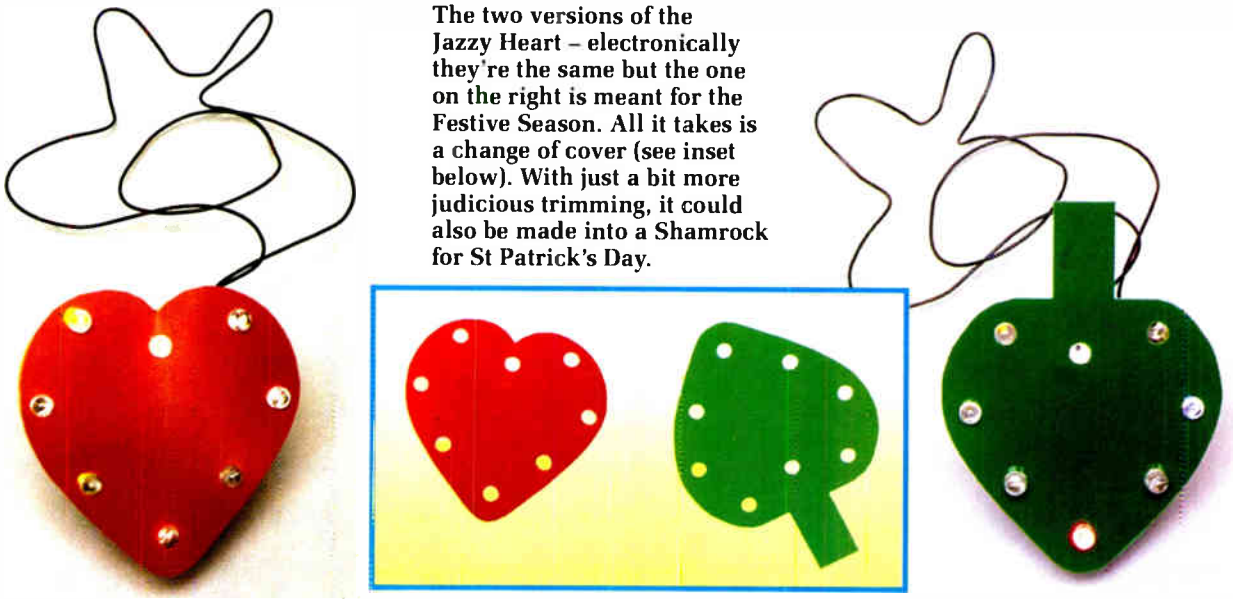
Since only one 3-digit word can be entered at a time, only one of the output terminals can go "high" at any time.

Each of the "select" terminals is fed separately by an oscillator running at about 5Hz. This means that each binary digit alternates between a binary 0 and 1 – independently of the other two binary digits.

Thus a practically random 3-digit binary word is generated, with the LEDs dancing more or less at random across switch positions 0 to 7, with fleeting patterns emerging.

Since pin 3, the centre or common pole in this circuit, is connected to 0V, each of the switch positions goes "low" when connected. Therefore the anodes of all the LEDs are connected to +12V, through a common 1kΩ current-limiting resistor.

Note that when a switch position is not connected to the common pole, the corresponding LED is disconnected from the power supply. This



The two versions of the Jazzy Heart – electronically they're the same but the one on the right is meant for the Festive Season. All it takes is a change of cover (see inset below). With just a bit more judicious trimming, it could also be made into a Shamrock for St Patrick's Day.

World Radio History

Parts List – Jazzy Heart

1 heart-shaped PC board, 63mm x 60mm, code 554, available from the *EPE PCB Service*
1 miniature tilt switch
4 10µF 16V electrolytic capacitors (or tantalums)
2 8mm crimp terminals for battery holder "end brackets"
1 round head (No.2) paper fastener for battery holder negative terminal
1 red plastic sheet for Jazzy Heart fascia, 65mm x 65mm
1 green plastic sheet for Jazzy Christmas Tree fascia, 65mm x 65mm
1 5mm drill bit to drill plastic fascias (if required)
1 MN21, 23A or equivalent 12V (alkaline) battery
1 suitable length of flexible wire or fishing line for "necklace"

Semiconductors
1 40106B hex Schmitt trigger (IC1)
1 4051B single 8-channel multiplexer (IC2)
1 1N4148 signal diode
2 5mm ultra-bright red water-clear LEDs
2 5mm ultra-bright yellow water-clear LEDs
2 5mm ultra-bright green water-clear LEDs
2 5mm ultra-bright blue water-clear LEDs

Resistors (0.25W 1%)	**4-Band Code (1%)**	**5-Band Code (1%)**
1 22kΩ	red red orange brown	red red black red brown
1 15kΩ	brown green orange brown	brown green black red brown
1 10kΩ	brown black orange brown	brown black black red brown
1 1kΩ	brown black red brown	brown black black brown brown

is in contrast with the 4028 CMOS IC, a BCD-to-decimal decoder, which serves a very similar function in digital circuits, but whose output terminals will only go "high" or "low".

Had a 4028 IC been used, the reverse voltage across the LEDs would then have been 12V, which exceeds the rating (of typical LEDs). While the supply voltage could have been reduced to overcome this, the design could not then have accommodated all colour LEDs.

Each of the three oscillators, based on a Schmitt NAND gate, is very simple, requiring only one resistor and one capacitor. For the purpose of preventing "frequency lock" (the tendency of oscillators to "lock on" to one another in close proximity), the values of the capacitors are relatively large (10µF).

A 10µF supply decoupling capacitor is included for "good practice", although this is not strictly necessary.

For a less jazzy (that is, more sedate) display, increase the values of the capacitors, and vice versa.

Due to the relatively high supply voltage (12V), and since only one LED is flashed at a time, a single current-limiting resistor can be used for all eight LEDs combined, thus simplifying and compressing the circuit.

While it would be possible to use four or eight resistors, thus perfectly matching them to each colour LED, this would considerably increase the component count, and is not necessary in practice.

The result is an exceedingly compact circuit, using just over one component for each randomly flashing LED. Do note, however, that when selecting LEDs, the luminous intensity should be roughly the same – or test first with 12V and a 1kΩ ballast resistor.

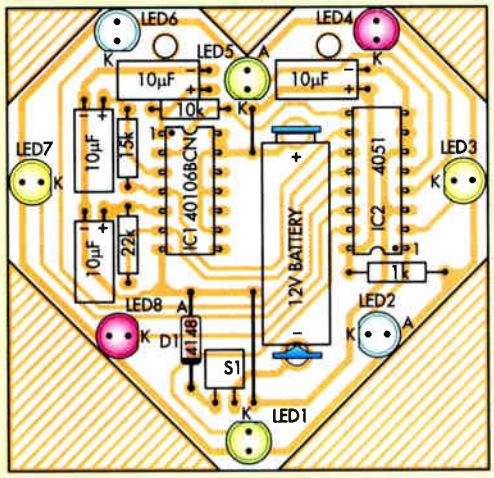
A miniature 12V battery is used (an MN21 or 23A or similar) and a 1N4148 diode is employed for reverse polarity protection. The reason why the diode is inserted in the 0V rail here is simply because this suits the circuit layout best.

Tilt switch

A tilt switch was chosen to switch off the circuit, partly because a standard switch (even a miniature one) would have taken up considerably more space on the PC board.

With the tilt switch as shown, the circuit is switched off as soon as the PC board is laid flat or turned upside-down. The inhibit pin (pin 6) of the 4051 CMOS IC is tied "low". When this pin is taken "high", all switch positions are disabled.

Finally, a question that is commonly asked about the 4051 is what purpose pin 7 (V_{EE}, or A/D) serves. When this terminal is tied "low", the IC will handle digital signals, as it does in the present circuit.



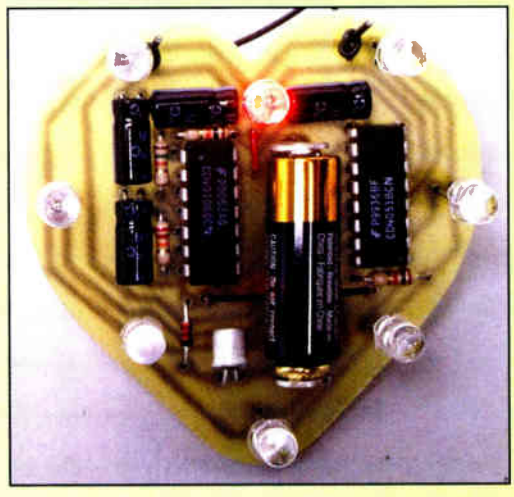


Fig.2: here's the PC board layout and a near-same-size photograph. Between the two of them, you should have no assembly problems!

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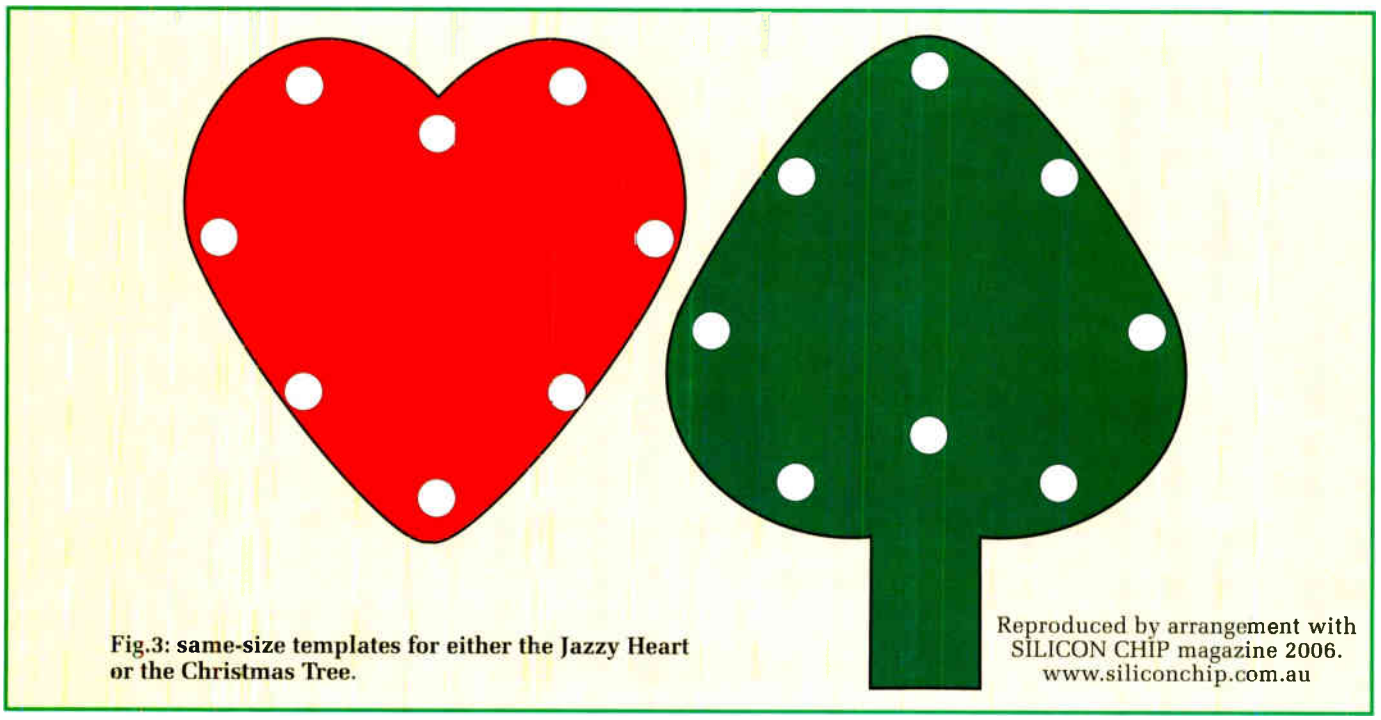

Fig.3: same-size templates for either the Jazzy Heart or the Christmas Tree.

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On the other hand, when analogue signals need to be routed through the IC, this pin would normally be connected to the lowest voltage level in the circuit. So, for instance, pins 16 and 7 could be connected to +6V and -6V respectively, while pin 8 could be connected to 0V. Thus analogue voltages of up to 12V could be handled with 6V digital control signals.

Assembly

The Jazzy Heart design is built on a single PC board measuring 63mm x 60mm, and this is further cut and filed to shape as shown.

To begin, the battery holder is constructed of two round 8mm crimp terminals which are inserted into the holes provided on the PC board. In the prototype, a brass round head (No.2) paper fastener was inserted into one of the crimp terminals and soldered into place, to accommodate the negative terminal of the battery.

Next, the resistors and capacitors are soldered to the PC board, as well as the 1N4148 diode and tilt switch S1. Be careful with the polarity of the capacitors and the diode.

Note that the tilt switch may need its legs to be raised a little, so that it is "off" when the circuit is laid on its back.

Then solder the two ICs, observing anti-static precautions (most importantly, touch your body to earth immediately before handling). Be quick with the soldering iron, so as not to damage the ICs. Alternatively, use dual-in-line (DIL) sockets.

The CD40106BCN IC is recommended for the oscillator section – other makes of the same IC may affect the "speed" of the Jazzy Heart. If other types are used, the capacitor values may need to be changed (probably reduced).

Solder the eight LEDs into place, noting their correct orientation (the "flat" on the encapsulation is the cathode). These LEDs are given fairly long legs, such that a "heart" or a "Christmas tree" template can be slipped over them after soldering. Thus they will just stand proud of the other components on the PC board.

Some ultra-bright LEDs are static sensitive, and anti-static precautions may need to be observed.

Finally, you may wish to attach a "necklace", which may be made from a flexible length of wire or fishing line inserted through the holes provided on the PC board and held with a knot at each hole.

Then fit the battery into its holder, taking care to insert it the correct way round. The Jazzy Heart should "fire up" as soon as it is vertical. When laid flat, it will "go to sleep".

Since the circuit draws a current of about 10mA, and the capacity of the specified battery is typically 33mAh, the Jazzy Heart should flash for three hours or more continuously before the battery is exhausted.

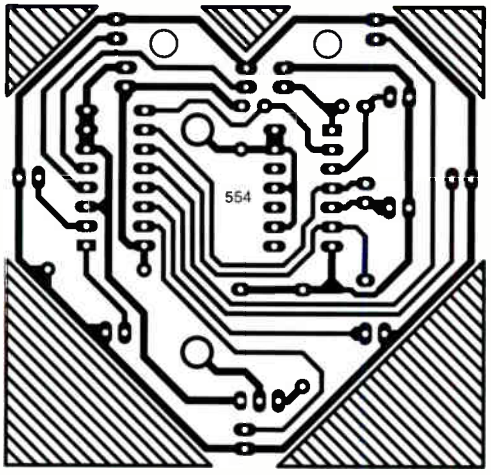

Fig.4: this is the full-size PC board artwork. All of the "stripey" bits are trimmed off.

These 12V batteries can be expensive but we have found a very cheap source to be at bargain stores and markets, where you can often pick up a pack of two or three "no name" Asian imports cheaply.

If a "Christmas tree" template is used, the circuit will of course be positioned "upside-down".

In this case, the position of the tilt switch will need to be adjusted accordingly, so that the Christmas tree is "on" when it is stood up vertically. ***EPE***

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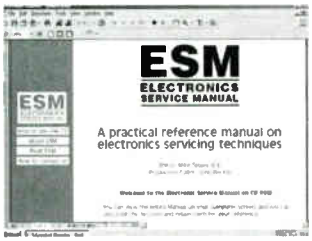

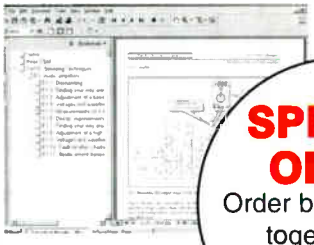

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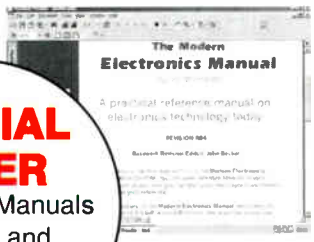

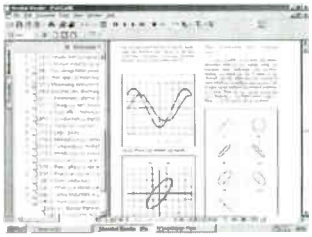

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★ LETTER OF THE MONTH ★

Soldering Iron Bits

Dear EPE.

I don't know whether I'm being stupid, but I've got a bit of a mystery with soldering. After many years of faithful service, the tip on my Antex XS25 soldering iron broke off. I filed it to a reasonable shape, but invested in a new tip, which I've been using.

Strangely it won't "tin". I wondered if there was some layer of something on it, or whether I'm so out of the ark that tips have been like this for years, or I've got a duff tip, or whether it is something to do with the new solder regulations. I'm still using lead-based solder, as I have enough to last me until I go to meet the great PIC expert in the sky. I have to say it is a bit weird trying to solder with an iron that doesn't tin – in fact I made a poor job of what I was doing.

Any ideas? If it is because of the solder regulations then it might be worth a brief mention in *EPE* . . . and then I must either find an "old" soldering iron, or transfer to the new solder.

Richard Hinckley, via email

I'd had the same problem with soldering for some time, blaming the new tips I'd got and emailed Richard to say so and that I'd drawn the same conclusion as he – down to the pending new regs. I hate the tips, and keep resorting to using the file on them! I suspect the new ones are steel-based, rather than copper. Richard came back:

On close inspection mine looks like steel rather than copper. Best solution for both of us is if we could find a supplier of copper tips for our respective irons.

So I asked readers on our Chat Zone *(via* ***www.epemag.co.uk****) if they had any comments. Several were forthcoming (mostly, their names are their "usernames" quoted on the site).* ***Barry*** *started off by offering to sell a number of Antex bits from 25 years ago. Then:*

Thomass: I have had a look on Antex's website and they say Antex replacement bits are manufactured from highgrade copper, plated first with iron and then chrome to give a long working life. Farnell say that the replacement tips are made from iron and chrome plated which last longer than iron and bright nickel tips. I have brought replacement tips from all over the place and never had a problem.

Istedman: I have had no issues with soldering iron tips, last one I bought was about a year ago. Two points to note:

I was always taught to tin the tip for the first time as the iron is heating up. Just dangle the solder on the tip until it melts. Always use distilled water on your soldering iron sponge, tap water damages the tips due to some chemical reaction. I have always followed these tips and had no problems.

Davy: On a related point, I switched to lead free about a year ago. Since then I've found my bits don't last very long at all (all Antex). Should I be using a different type of bit?

Alan Jones: I recall reading – more years ago than I care to remember – that new soldering iron tips (of whatever brand) have some sort of thin coating (wax?) to protect them in storage and that this must be removed prior to use. The recommended method was to leave the iron on for about ten minutes to burn off the coating, and then try to tin it. If it wouldn't tin properly the wax was still there, so wait a bit longer.

On a related subject, I have found that a soldering iron tip cleaner sold by Squire's (usual disclaimer) does exactly what it says. It keeps the tip clean and tins it at the same time. Like Richard Hinckley, I have been stocking up on ordinary solder before it becomes illegal to sell it: my ambition now is to live long enough to be forced to make the change to lead free!

Dean Huster: Makes the 63/36 solder in 5-pound rolls look really attractive, these days. I know that Weller tips were copper-based, iron-plated the business end and chrome-plated the rest to help control oxidation and keep solder from creeping all over the tip where you didn't need it. I won't be the least bit surprised when iron manufacturers start to make the tips from iron-clad aluminum, most likely aluminum with copper cladding and iron plating over that. It would make a lot more sense to do that rather than steel in lieu of copper because of the better heat conduction over steel.

I guess that I'm not in the trenches enough anymore. Is there legislation in the UK to eliminate lead completely that's imminent? What about the US – is there something going on here, too? It doesn't seem that critical here yet. . . either that, or my head's in the sand.

Porie: I've had no end of trouble changing to lead-free. One tip (sorry!) I would recommend – when the tip is new, and *before* you heat it up! clean it with a piece of green kitchen scourer. When it's hot it should then "tin" OK. Unfortunately, some tips I've had repeatedly retarnish and you can't use the green scourer on a hot iron.

Richard came back to me, saying;

The comments on the *CZ* were useful – it is so long since I changed my bit I'd forgotten the trick of applying some solder when the iron is heating up. I seem to be making better use of the new bit now. The new materials don't seem to let the solder adhere quite as well as the old copper bits, which is probably supposed to be an advantage, although I still think I prefer the old ones.

We also sent Richard's query on to Antex for their comments and received this reply:

I think the problem may be related to the fact that Antex soldering bits are not supplied tinned. Some manufacturers have already tinned their replacement soldering iron bits before shipping. At Antex we do not do this. The main reason is to try and keep the cost of manufacturing down in order that we can offer a good price in the market. (We still manufacture in the UK unlike *all* other soldering iron companies).

It is therefore important to tin the new soldering iron bit the first time it is used whilst the iron is heating up. If you do not do this as the iron heats up an oxide forms and it is thereafter very difficult to tin the bit. I should also point out that filing the tip will remove the iron plating on the bit which is put there to prolong the bit life.

Ian Lockhart, Sales Director, Antex (Electronics) Limited (www.antex.co.uk)

Thanks Ian and readers for all your comments. I've not actually used an iron for several weeks now, but I'll bear them in mind when next I do. Thanks Richard for sparking this off.

World Radio History

Rally Comps, FR4 and Hidden Dangers

Dear EPE,

Ken Barry's letter (*Readout*, Oct '05) reminds me of my early days in electronics. As a schoolboy in the early seventies, beginning to explore electronics on a shoe-string pocket-money budget, I got all my components by reclaiming them from old p.c.b.s in our local electronics junk shop.

It is little wonder that nothing I tried ever worked, until eventually the elation of my first functional two-transistor astable multivibrator making a note in a scrap loudspeaker.

I wouldn't use reclaimed components now, as Ken says, our time is too precious, but we all had to start somewhere.

In response to Paul's request for unclad FR4 laminate (same *Readout*), I have had a similar requirement in the past and resorted to using some single-sided board and removed the cladding.

Using a hot air gun (commonly used for paint stripping), warm the copper cladding to loosen the adhesive, then you will find it pulls off fairly easily. Mind your fingers though!

Also, Harry Weston's letter (*Readout*, Dec '05) is a very good point, well made. He might also like to be aware that metal-chassis equipment with a mains input filter relies on the earth wire in the mains lead to remain safe. Disconnect it (deliberately or through a fault), and the chassis floats to AC through the leakage in the mains filter, also making any non-earthed equipment connected to it live through the 0V connection (commonly connected to chassis). I know – I've been the alternative current path to earth!

Ken Wood, via email

Thanks for the comments Ken. You obviously learned from the experience of using reclaimed components, and persevered. As I said before, learning how to check for faulty parts has merit in its own right.

I too have been an "alternative current path to earth" and know that when it comes to mains electricity, we have to take all precautions we can, as we try to express in EPE *when publishing mains driven projects.*

Pain Monitor

Dear EPE,

Firstly, just want to say that I think your CD *Assembly for PICmicro V3.0* is really good. I have also the Development Board Mk2 and am really enjoying it. I do all the exercises and am half way through.

Regarding your *Pain Monitor* (Aug '05), we had a lecturer in post graduate electronic engineering, Heiko Rudolph (website **www.rmit.edu.au/browse/?QRY=heiko+rudolph&STYPE=PEOPLE**) who helped design and build a patient controlled analgesia (PCA) device whereby patients could self-medicate, controlling the amount of analgesia going into their bodies. It is possible if Heiko were to know about your device he may be able to offer some further suggestions to make it even more beneficial. It may for example tell the potential users of PCA how effective and how quickly their pain is dissipated after pressing the PCA by using the data from the *Pain Monitor*.

Peter Barrett, Australia

Thanks for the kind words and the info Peter. Readers interested in this subject might care to contact Heiko via his website.

Teach In 2006 Part 2

Dear EPE,

As a mathematician and computer nerd for nigh on 40 years, I am not too keen in putting units of measurement into algebraic equations, but if you must, then you must be consistent. So, in *Teach In Part 2* Example 2.2, after, "Re-arranging giving:" there should be an "A" for amps in the line -0.5 – I = 0.

Please keep up the good work.

Phil Warn, Orpington, Kent via email.

Mike Tooley replied to Phil:

With regard to including units in formulae, I realise that this is not considered to be "good practice" and I agonised about whether I should do this, or not. However, having taught electronics for nearly 40 years to large numbers of students, I've found that they often find it easier to understand formulae if the units are included in the formula – at least initially. My main reason for doing this is to emphasise the importance of recognising the fact that the unit (and the multiple of it) are important.

Including the units and multiples also helps students avoid the need to convert back to the basic units each time. For example, they can work in kΩ and mA and produce an answer directly in V.

So, instead of using: V = 0·003 ×10,000 = 30 V, I would use: V = 3mA × 10kΩ = 30 V.

You would be amazed to find how many students get the first version wrong these days!

Thanks again for getting back to me on this – your "input" is very much appreciated.

Mike Tooley, via email

Phil also spotted the error in Example 2.2 and we covered this at the end of Part Three.

Scart Leads and Cable Detectors

Dear EPE,

I have been following the discussions regarding analogue TV signals being switched off over the next few years. Anyone trying to connect their digital set-top box and perhaps a DVD player will probably use scart leads. Does anyone agree with me in thinking that scart leads are extremely poor, even the expensive ones?

1. Why are the plugs angled to one side? These foul nearby connectors or cables and if the cable has to be fed in from the opposite side to the angled plug, the stiffness of the cable can disconnect the plug. I note that new types are appearing on the market with square plugs and ribbon type cables which have to be an improvement.

2. Why are they not held firmly in place with screws, as you have for computer connections? The plugs are a very poor fit into the sockets and the slightest movement of the equipment will cause a disconnection. My wife does it regularly when she does the dusting.

3. Why are they typically supplied in lengths of one and a half metres? The units (digital box, DVD, VCR etc.) are usually stacked on top of each other needing only very short leads. The result is a tangled mess of cables stuffed behind the units which is not good practice. It is not too much of a problem for those of us who are capable of doing a bit of soldering to shorten them but what about members of the public who are not able to do this?

Before analogue TV signals are switched off I think that the industry has to get its act together and provide better quality connections for the equipment.

Also, I have just purchased a pipe and cable detector from my local DIY store and found that it gave a disappointing performance. I was trying to locate a 15mm copper pipe in a partition wall consisting of two skins of plasterboard with a cardboard egg crate centre. The pipe was immediately behind the plasterboard (about 12mm from the surface) but the detector failed to find it.

Does anyone know of a circuit for such a detector which is more sensitive and perhaps has the ability to be adjusted for its depth of penetration into a wall or floor?

Colin Rimington, Solihull, West Midlands.

Thanks for the pertinent observations Colin. Readers, can anyone help Colin with this question?

Prop Monitor

Dear EPE,

I was very interested in the *Propeller Monitor* (Dec '05). There has been some discussion recently in the Gauge 1 Model Railway Group about measuring the efficiency of the model steam locomotives and I believe the circuit could be adapted to do this.

By using a multi-segment wheel the speed of the locomotive can be measured in mm/sec instead of the RPS in the original circuit. The solenoid oscillator section with a suitable spring will measure the pull. The RPM calculation can be replaced with work done. The only reservation I have at the moment is the temperature stability of the solenoid oscillator because the temperature environment for garden railways is a very variable beast. Ideally it would need an additional couple of channels of data logging, but that's another story.

Alan Coombe, via email

We know a few other readers are interested in model railways and your possible idea could be of use to those who also know PIC programming and can modify the code to suit.

I don't know about temperature stability of the solenoid oscillator, but I guess you are possibly right.

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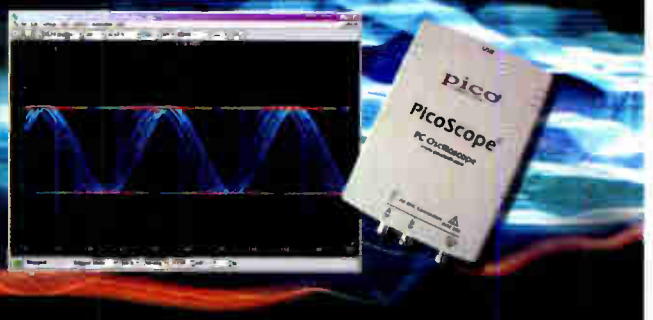

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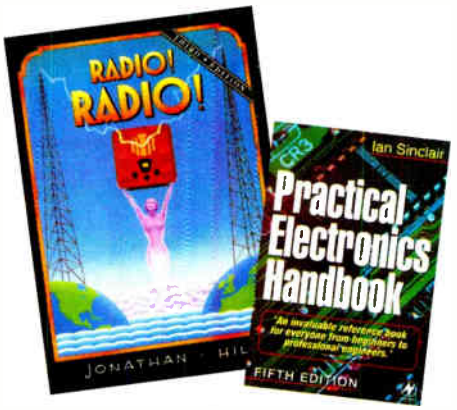

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Turns on all your equipment at the flick of a switch. Switch on your PC and your peripherals will come on as well. Switch on your amplifier and your hifi gear will come on too. Switch on your TV and the rest of your home theatre system will power up.

MEADE TELESCOPE INTERFACE

Allows existing GPS handsets to be used with Meade telescopes. The GPS interfaces to a PIC microcontroller, which extracts the following GPS data, local to where the telescope is positioned: • Current time in UTC (Universal Time Coordinate) • Calendar data • Latitude and longitude.

VIDEO-AUDIO BOOSTER FOR HOME THEATRE

If your home theatre setup involves sending video signals over fairly long cables, you'll really appreciate this project. It's a wide-band amplifier that can boost both composite and S-video signals, or even component video signals with the right cables. And it handles stereo audio signals as well.

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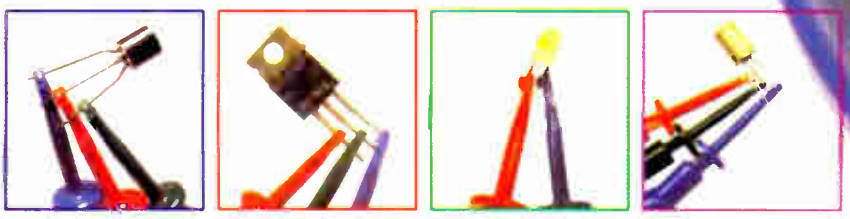

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