EVERYDAY
OCTOBER 1999

PRACTICAL ELECTRONICS

With ETI ELECTRONICS TODAY INTERNATIONAL

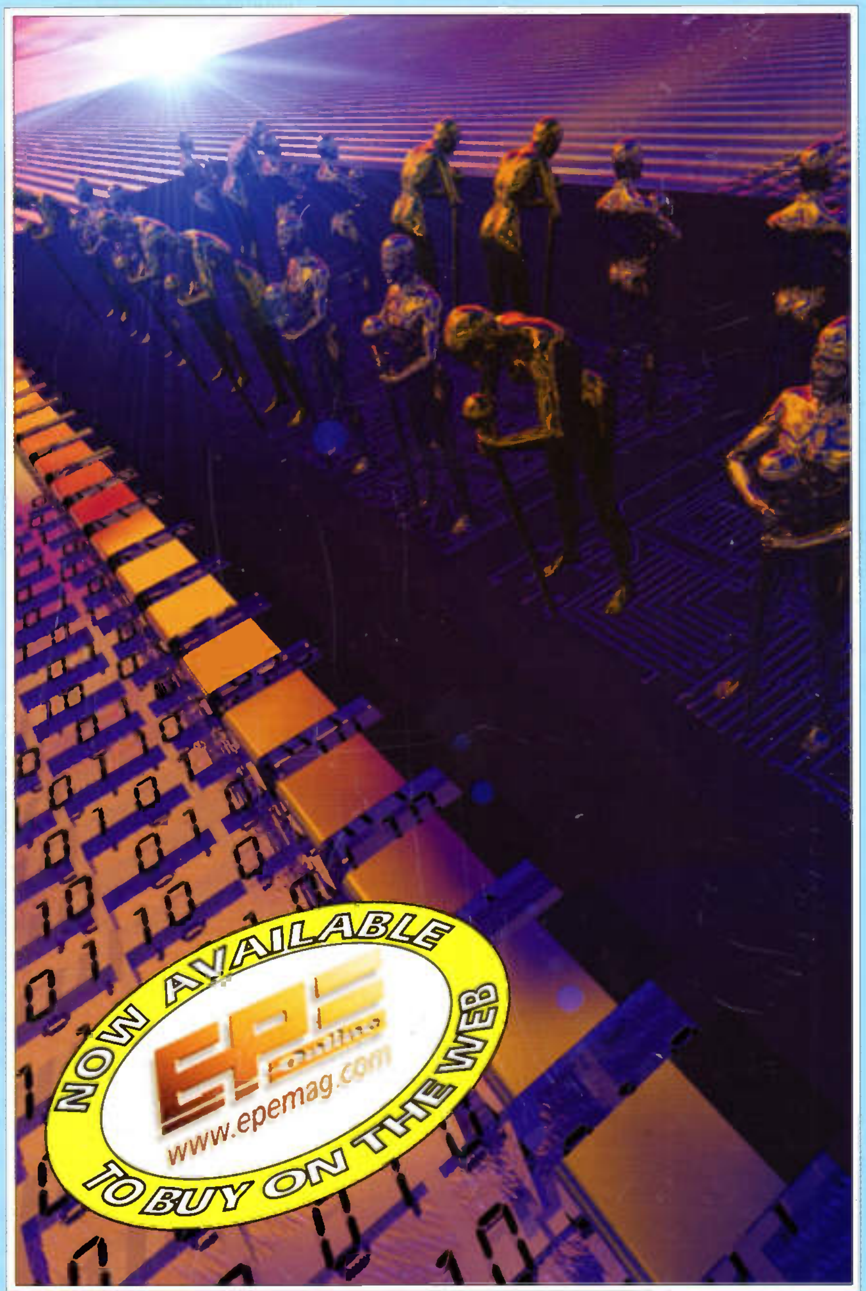
£2.65

PIC 16F87x MINI TUTORIAL

Understand and use these new chips

The QWL LOUD-SPEAKER

An updated design for the audiophile



INTERIOR LAMP DELAY

Luxury upgrade for your car

MAINS CABLE DETECTOR

Don't blow a fuse

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

10
9 770262 361089

PLUS Ingenuity Unlimited • Circuit Surgery
New Technology Update • Net Work

http://www.epemag.wimborne.co.uk

ECG MACHINES?/6v 10AH BATTS/24V 8A TX Ex government ECG machines! Measures 390X320X120mm, on the front are controls for scan speed, scan mode, loads of connections on the rear including video out etc. On the front panel are two DIN sockets for connecting the body sensors to. Sensors not included, Inside 2 x 6v 10AH sealed lead acid batts (generally not in good condition), pcb's and a 8A? 24v torroidial transformer (mains in). sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

HYDROPONICS DO YOU GROW YOUR OWN? We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, enviromental control, light fittings, plants, test equipment etc Ring for your free copy.

PC COMBINED UPS AND PSU The unit has a total power of 292 watts, standard mother board connectors and 12 peripheral power leads for drives etc. Inside is 3 12v 7.2aH sealed lead acid batteries. Backup time is 8 mins at full load or 30 mins at half load. Made in the UK by Magnum, 110 or 240vac input, +5v at 35A, -5v at 5A, +12v at 9A, -12v at 5A outputs 170x260x220mm, new and boxed £29 95 Ref PCUPS2

WINDOWS 95 CD As supplied with Hewlet Packard PC's these CD's have all the window files on them and were intended to be used to restore windows on a PC after a crash etc.£15 REF SX06

ALTERNATIVE ENERGY CD, PACKED WITH HUNDREDS OF ALTERNATIVE ENERGY RELATED ARTICLES,PLANS AND INFORMATION ETC £14.50 REF CD56

aerial photography kit This rocket comes with a built in camera! it flies up to 500 feet (150 m) turns over, and takes an aerial photograph of the ground below. The rocket then returns afely wih its film via its built in paracute. Takes standard 110 film. Supplied complete with everything including a launch pad and 3 motors (no film) £29 98 ref astro

SATELLITE MODULATOR MODULES prices from just 9p Surface mount modulators full of components. Fitted with an F type connector and a uhf type connector. Pack of 100 £9 95 ref SS20

PROJECT BOXES Another bargain for you are these smart ABS project boxes, smart two piece screw together case measuning approx 6"x5"x2" complete with panel mounted LED. Inside you will find loads of free bits, tape heads, motors, chips resistors, transistors etc. Pack of 20 £19.95 ref MD2

REMOTE HEATING CONTROLLERS WITH 30A MAINS RELAY from just 99p These units were designed to be plugged into a telephone socket. You then called the phone and some how it turned the heating on. Each box contains lots of bits including a mains 30A relay. pack of 20 £20 ref SS34

PIR CAMERA Built in CCTV camera (composite output) IR strobe light,PIR detector and battery backup. Designed to 'squirt' pictures down the 'phone line but works well as a standalone unit. Bargain price £39 95 ref SS81J. These units are brand new modules designed to take 'pictures' of intruders and then transmit the pictures down the telephone line. The PIR detects the intruder, fires the strobe light this ensures a perfect picture even in total darkness. The picture is stored in memory inside the module and then sent by modem (not included) down the telephone line. The units also have a nicad battery pack included presumably to maintain operation in the event of mains power failure. Output from the camera is standard b/w composite 320x240 pixels with a 90x65 degree field of view, the picture quality is excellent.Each PIR also contains a video capture and compression unit The infra red strobe has a range of 15m The pir has a range of 12m Power requirements are 12v dc 400mA. Power supplies available at £5 ref SS80The units are supplied with connection details etc but we do not have any information on using the compression and capture unit or interfacing to modems etc The units do have operational PIR's, strobes and camera's (camera is 12vdc and gives out standard composite 1v p-p video) how you adapt these to work together is entirely up to you!Retail price for the units was in excess of £200 each sale price £39 95 ref SS81JPower supplies £5 ref SS80

TELEPHONES Just in this week is a huge delivery of telephones, all brand new and boxed. Two piece construction with the following features- Illuminated keypad, tone or pulse (switchable) recall, redial and pause, high/low and off ringer switch and quality construction finished in a smart off white colour and is supplied with a standard international lead (same as US or modems) if you wish to have a BT lead supplied to convert the phones these are also available at £1 55 each ref BTLX. **Phones £4.99 each ref PH2 10 off £30 ref SS2**

3HP MAINS MOTORS Single phase 240v, brand new, 2 pole, 340x180mm, 2850 rpm, builtin automatice reset overload protector, keyed shaft (40x16mm)Made by Leeson. £99 each ref LEE1

BUILD YOU OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators and propellors. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS Could be adapted for laser listener, long range communications etc Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 Ref LOT4

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9 95 ref BAR31

Hi power 12v xenon strobe variable rate flasher modules and tubes £6Useful 12v PCB fitted with control electronics and a powerful Xenon tube! just apply 12v DC to the input and the tube will flash. On the board is a small potentiometer which can be used to vary the flash rat! PCB measures just 70x 55mm and could be incorporated into many interesting projects! £6 ref FLS1 Pack of 10 is £49 ref FLS2

Hydrogen fuel cells now in stock

Our new Hydrogen fuel cells are 1v at up tp 1A output, Hydrogen input, easily driven from a small electrolosis assembly or from a hydrogen source, our demo model uses a solar panel with the output leads in a glass of salt water to produce the hydrogen! Each cell is designed to be completely taken apart, put back together and expanded to what ever capacity you like, (up to 10watts and 12v per assembly. Cells cost £79 ref HFC11

We get over 8,000 hits a day..... check us out!

http://www.bullnet.co.uk

PHILIPS VP406 LASER DISC PLAYERS, SCART OUTPUT, RS232 CONTROLLED £24.95 REF VP406

SMOKE ALARMS Mains powered, made by the famous Gent company, easy fit next to light fittings, power point. Pack of 5 £15 ref SS23, pack of 12 £24 ref SS24

4AH D SIZE NICADS pack of 4 £10 ref 4AHPK

ELECTRIC FENCE KIT Everything you need to build a 12vdc electric fence, complete with 200m of fence wire. £49 ref AR2

SENDER KIT Contains all components to build a A/V transmitter complete with case £35 ref VSXX2

10 WATT SOLAR PANEL Amorphous silicon panel fitted in a anodized aluminium frame. Panel measures 3' by 1' with screw terminals for easy connection. **3' x 1' solar panel £55 ref MAG45 Unframed 4 pack (3'x1') £58.99 ref SOLX**

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses, ranging from solar fountains to hydroponics! Small and compact yet powerful works direct from our 10 watt solar panel in bright sun. Max hd 17 ft Max flow = 8 Lpm,1. 5A Ref AC8 £18 99

SOLAR ENERGY BANK KIT 50x 6"x12" 6v solar panels(amorphous)+50 diodes £99 ref EF112

PINHOLE CAMERA MODULE WITH AUDIO! Superb board camera with on board sound! extra small just 28mm square (including microphone) ideal for covert surveillance. Can be hidden inside anything , even a matchbox! Complete with 15 metre cable, psu and tv/vcr connnectors. £49.95 ref CC6J

SOLAR MOTORS Tiny motors which run quite happily on voltages from3-12vdc. Works on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick. £1 50 each

WALKIE TALKIES 1 MILE RANGE £37/PAIR REF MAG30

LIQUID CRYSTAL DISPLAYS Bargain prices,
20 character 2 line, 83x19mm £3.99 ref SMC2024A
16 character 4 line, 62x25mm £5.99 ref SMC1640A
40 character 1 line 154x16mm £6.00 ref SMC4011A

YOUR HOME COULD BE SELF SUFFICENT IN ELECTRICITY Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1

LOW COST CORDLESS MIC 500' range, 90 - 105mhz, 115g, 193 x 26 x 39mm, 9v PP3 battery required. £17 ref MAG15P1

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £12.99 REF AUG10P3

SOLAR POWER LAB SPECIAL 2x 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 relay or motor. £7.99 REF SA27

SOLAR NICAD CHARGERS 4 x AA size £9 99 ref 6P476, 2 x C size £9.99 ref 6P477

5.25" FLOPPY DISKS pack of 500 disks £25 ref FD1

REGISTER FOR OUR ELECTRONIC NEWSLETTERS BULL-ELECTRICAL.COM

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX . BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £4.00 P&P PLUS VAT.

24 HOUR SERVICE £6.50 PLUS VAT.

OVERSEAS ORDERS AT COST PLUS £3.50

(ACCESS,VISA, SWITCH, AMERICAN EXPRESS)

phone orders : 01273 203500

FAX 01273 323077

Sales@bull-electrical.com

30 WATTS OF SOLAR POWER for just £69, 4 panels each one 3'x1' and producing 8w, 13v. PACK OF FOUR £69 ref SOLX

200 WATT INVERTERS plugs straight into your car cigarette lighter socket and is fitted with a 13A socket so you can run your mains operated devices from your car battery. £49.95 ref SS66

THE TRUTH MACHINE Tells if someone is lying by micro tremors in their voice, battery operated, works in general conversation and on the 'phone and TV as well! £42.49 ref TD3

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra red output only using standard light bulbs Easily cut to shape. 6" square £15 ref IRF2

33 KILO LIFT MAGNET Neodynium,32mm diameter with a fixing bolt on the back for easy mounting. Each magnet will lift 33 kilos, 4 magnets bolted to a plate will lift an incredible 132 kilos! £15 ref MAG33

HYDROGEN FUEL CELL PLANS Loads of information on hydrogen storage and production. Practical plans to build a Hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

ENERGY SAVER PLUGS Saves up to 15% electricity when used with fridges, motors up to 2A, light bulbs, soldering irons etc. £9 ea ref LOT71, 10 pack £69 ref LOT72

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14 99 ref SB3. Type 2 is 20 smaller cannisters (suitable for simulated equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HI POWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49J

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102

IR LAMP KIT Suitable for cctv cameras, enables the camera to be used in total darkness! £6 ref EF138

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, gives out powerful pure infrared light! perfect for CCTV use, nightsights etc. £29 ref PB1

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser, X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front&r earwaveguides, 1.1"x2.7"x4.6" fits on visor or dash £149

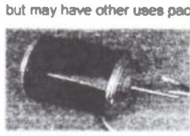
LOPTX Made by Samsung for colour TV £3 each ref SS52

LAPTOP LCD SCREENS 240x175mm. £12 ref SS51

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

HIGH POWER DC MOTORS, PERMANENT MAGNET 12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front. £22 ref MOT4

INFRA RED REMOTE CONTROLS made for TV's but may have other uses pack of 100 £39 ref IREM



Online web catalogue bull-electrical.com

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

SONY STEREO TV CHASSIS assemblies comprising complete TV PCB excluding tube and scan coils. Nicam stereo, mains input. Appear to be unused but sold 'as seen' Would probably be good for spares or as a nicam stereo TV sound receiver and amplifier. For KV29F1U and KV25F1U(BE3D) PCB no's 1-659-827-12 1-659-826-14 1-711-800-11 £20 ref STV1

RCB UNITS Inline IEC lead with fitted RC breaker. Installed in seconds. Pack of 3 £9.98 ref LOT5A

RADIO CONTROLLED CARS etc No remotes but good strippers for servo's motors and receivers. Sold as is, no returns, mixed types. £3 each ref RCC2

VOICE CHANGERS Hold one of these units over your phone mouth piece an you can adjust your voice using the controls on the unit! Battery operated £15 ref CC3

ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

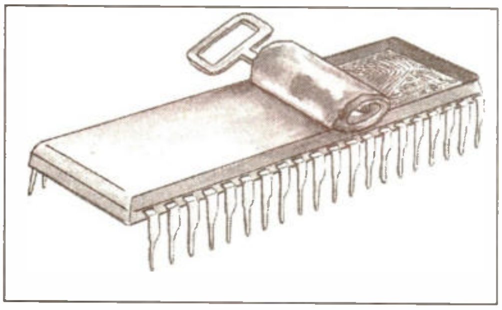
VOL. 28 No. 10 OCTOBER 1999
Cover illustration by Jonathan Robertson

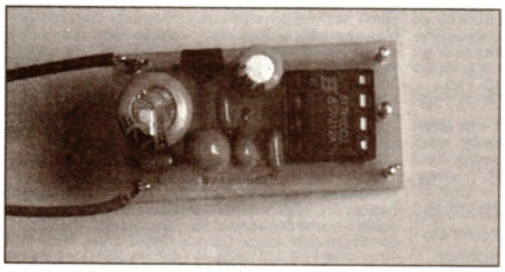
EVERYDAY PRACTICAL ELECTRONICS

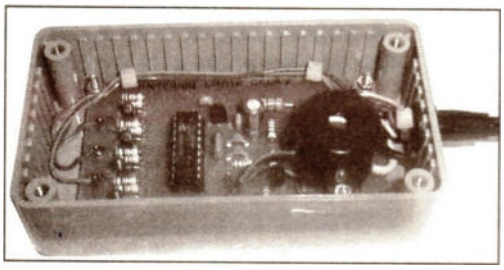
ETI ELECTRONICS TODAY INTERNATIONAL

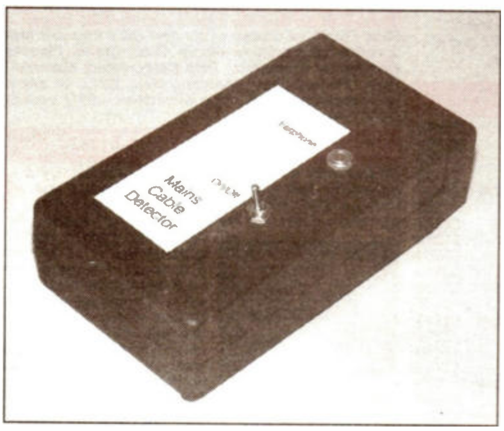
http://www.epemag.wimborne.co.uk

The No. 1 Magazine for Electronics Technology and Computer Projects









Projects and Circuits

INTERIOR LAMP DELAY by Steve Challis — 716
Don't you just hate being plunged into darkness when the car door shuts? Here's a solution! Plus lights on alarm and battery saver

MAINS CABLE DETECTOR by Robert Penfold — 726
This simple Starter Project detects mains cables by sensing their "hum"

QWL LOUDSPEAKER SYSTEM by John Dix — 736
Enjoy superb hi-fi sound at a fraction of the cost of an equivalent commercial speaker system

INGENUITY UNLIMITED hosted by Alan Winstanley — 758
Shoestring MW Radio; Auto Supply Crowbar

MICRO POWER SUPPLY by Andy Flind — 762
Supplies a well-regulated +5V even if your battery's nearly flat!

Series and Features

NEW TECHNOLOGY UPDATE by Ian Poole — 720
Sensing electron spin-directions increases hard disk densities

PRACTICAL OSCILLATOR DESIGNS – 4. Negative resistance oscillators by Raymond Haigh — 730
Worked examples and circuit info for hands-on constructors

PIC16F87x MINI TUTORIAL by John Becker — 742
Practical guidance on using the new PIC microcontroller family

INTERFACE by Robert Penfold — 756
More on serial interfacing to your PC

CIRCUIT SURGERY by Alan Winstanley and Ian Bell — 765
Low Voltage 555; Digital Panel Meters; Sound Levels and Decibels

NET WORK - THE INTERNET PAGE surfed by Alan Winstanley — 772
Explore New Options (MSIE 5·0); 1984 And All That; Looking Ahead

Regulars and Services

EDITORIAL — 715

NEWS – Barry Fox highlights technology's leading edge — 723
Plus everyday news from the world of electronics

SHOPTALK with David Barrington — 728
The *essential* guide to component buying for *EPE* projects

CD-ROMS FOR ELECTRONICS — 750
Parts Gallery + Electronic Circuits and Components; Digital Electronics; Analogue Electronics; *plus* PICtutor, *plus* Modular Circuit Design

READOUT John Becker addresses general points arising — 753

ELECTRONICS MANUALS — 760
Essential reference works for hobbyists, students and service engineers. Plus digital multimeter special offer

BACK ISSUES Did you miss these? — 764

DIRECT BOOK SERVICE — 768
A wide range of technical books available by mail order

ELECTRONICS VIDEOS Our range of educational videos — 771

PRINTED CIRCUIT BOARD AND SOFTWARE SERVICE — 773
PCBs for *EPE* projects – Plus *EPE* software

ADVERTISERS INDEX — 776

EPE TEACH-IN 2000
Starts next month
– see page 707

Our November '99 issue will be published on Friday, 1 October 1999. See page 707 for details.

Readers Services • Editorial and Advertisement Departments — 715

Visit our website www.distel.co.uk

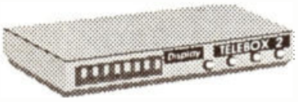
THE *ORIGINAL* SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER
*CABLE COMPATIBLE**

The TELEBOX is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors or AV equipment which are fitted with a composite video or SCART input. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers* (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Ideal for desktop computer video systems & PIP (picture in picture) setups. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard. Brand new - fully guaranteed.

TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

NEW State of the art PAL (UK spec) UHF TV tuner module with composite 1V pp video & NICAM hi fi stereo sound outputs. Micro electronics all on one small PCB only 73 x 160 x 52 mm enable full tuning control via a simple 3 wire link to an IBM pc type computer. Supplied complete with simple working program and documentation. Requires +12V & + 5V DC to operate.
BRAND NEW - Order as MY00. Only £49.95 code (B)
See www.distel.co.uk/data_my00.htm for picture + full details

FLOPPY DISK DRIVES 2½" - 8"

All units (unless stated) are ***BRAND NEW*** or removed from often brand new equipment and are fully tested, aligned and shipped to you with a full 90 day guarantee. Call or see our web site *www.distel.co.uk* for over 2000 unlisted drives for spares or repair.

3½" Mitsubishi MF355C-L. 1.4 Meg. Laptops only	£25.95(B)
3½" Mitsubishi MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" Teac FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" Teac FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" BRAND NEW Mitsubishi MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" Floppy / HD	£29.95(B)
8" Shugart 800/801 8" SS refurbished & tested	£210.00(E)
8" Shugart 810 8" SS HH *Brand New*	£195.00(E)
8" Shugart 851 8" double sided refurbished & tested	£260.00(E)
8" Mitsubishi M2894-63 double sided *NEW*	£295.00(E)
8" Mitsubishi M2896-63-02U DS slimline *NEW*	£295.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

HARD DISK DRIVES 2½" - 14"

2½" TOSHIBA MK1002MAV 1.1Gb laptop(12.5 mm H) *New*	£79.95
2½" TOSHIBA MK2101MAN 2.16 Gb laptop (19 mm H) *New*	£89.50
2½" TOSHIBA MK4309MAT 4.3Gb laptop (8.2 mm H) *New*	£105.00
2½" TOSHIBAMK6409MAV 6.1Gb laptop (12.7 mm H) *New*	£190.00
2½" to 3½" conversion kit for Pc's, complete with connectors	£14.95
3½" FUJI FK-309-26 20mb MFM I/F RFE	£59.95
3½" CONNER CP3024 20 mb IDE I/F (or equiv.) RFE	£59.95
3½" CONNER CP3044 40 mb IDE I/F (or equiv.) RFE	£69.00
3½" QUANTUM 40S Prodrive 42mb SCSI I/F, New RFE	£49.00
5¼" MINISCRIBE 3425 20mb MFM I/F (or equiv.) RFE	£49.95
5¼" SEAGATE ST-238R 30 mb RLL I/F Refurb	£69.95
5¼" CDC 94205-51 40mb HH MFM I/F RFE tested	£69.95
5¼" HP 97548 850 Mb SCSI RFE tested	£99.00
5¼" HP C3010 2 Gbyte SCSI *differential* RFE tested	£195.00
8" NEC D2246 85 Mb SMD interface. *New*	£199.00
8" FUJITSU M2322K 160Mb SMD I/F RFE tested	£195.00
8" FUJITSU M2392K 2 Gb SMD I/F RFE tested	£345.00

Many other drives in stock - Shipping on all drives is code (C1)

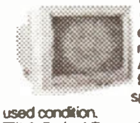
IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK
10,000,000 items EX STOCK
For ***MAJOR*** SAVINGS
CALL OR SEE OUR WEB SITE www.distel.co.uk

VIDEO MONITOR SPECIALS

One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

Mitsubishi FA3415ETKL 14" SVGA Multisync colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including IBM PC's in CGA, EGA, VGA & SVGA modes, BBC, COMMODORE (including Amiga 1200), ARCHIMEDES and APPLE. Many features: Etched faceplate, text switching and LOW RADIATION MPR specification. Fully guaranteed, in EXCELLENT little used condition.



Tilt & Swivel Base £4.75
VGA cable for IBM PC included.
Only £119 (E) Order as MITS-SVGA
External cables for other types of computers available - CALL

Ex demo 17" 0.28 SVGA Mitsubishi Diamond Pro monitors, Full multisync etc. Full 90 day guarantee. Only £199.00 (E)

Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors. Good SH condition - from £299 - CALL for info

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with both RGB and standard composite 15.625 Khz video inputs via SCART socket and separate phono jacks. Integral audio power amp and speaker for all audio visual uses. Will connect direct to Amiga and Atari BBC computers. Ideal for all video monitoring / security applications with direct connection to most colour cameras. High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99.00** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with standard composite 15.625 Khz video input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)

20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & *optional* sound input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc.In EXCELLENT little used condition with full 90 day guarantee.

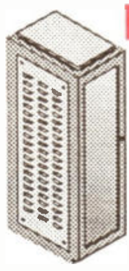
20"....£135 22"....£155 26"....£185 (F)

We probably have the largest range of video monitors in Europe, All sizes and types from 4" to 42" call for info.

DC POWER SUPPLIES

Virtually every type of power supply you can imagine.Over 10,000 Power Supplies Ex Stock Call or see our web site.

19" RACK CABINETS



Superb quality 6 foot 40U Virtually New, Ultra Smart
Less than Half Price!

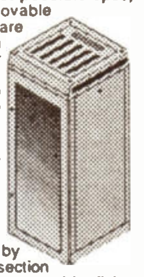
Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting ,plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the ***most versatile we have ever sold.*** Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays.
Overall dimensions are: 77½" H x 32½" D x 22" W. Order as:

OPT Rack 1 Complete with removable side panels.	£345.00 (G)
OPT Rack 2 Rack, Less side panels	£245.00 (G)

Over 1000 racks, shelves, accessories 19" 22" & 24" wide 3 to 46 U high. Available from stock !!

32U - High Quality - All steel RakCab

Made by Eurocraft Enclosures Ltd to the highest possible spec, rack features all steel construction with removable side, front and back doors. Front and back doors are hinged for easy access and all are lockable with five secure 5 lever barrel locks. The front door is constructed of double walled steel with a 'designer style' smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing members to take the heaviest of 19" rack equipment. The two moveable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A mains distribution panel internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin switched utility socket. Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of integral fans to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in excellent, slightly used condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)



Sold at LESS than a third of makers price !!

A superb buy at only £245.00 (G)

42U version of the above only £345 - CALL

12V BATTERY SCOOP - 60% off !!

A special bulk purchase from a cancelled export order brings you the most amazing savings on these ultra high spec 12v DC 14 Ah rechargeable batteries. Made by Hawker Energy Ltd, type SBS15 featuring pure lead plates which offer a far superior shelf & guaranteed 15 year service life. Fully BT & BS6290 approved. Supplied BRAND NEW and boxed. Dimensions 200 wide, 137 high, 77 deep. M6 bolt terminals. Fully guaranteed. Current makers price over £70 each ***Our Price £35 each*** (C) ***or 4 for £99*** (E)

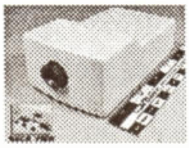
RELAYS - 200,000 FROM STOCK

Save ££££'s by choosing your next relay from our Massive Stocks covering types such as Military, Octal, Cradle, Hermetically Sealed, Continental, Contactors, Time Delay, Reed, Mercury Wetted, Solid State, Printed Circuit Mounting etc. , CALL or see our web site www.distel.co.uk for more information. Many obsolete types from stock. Save ££££'s

COLOUR CCD CAMERAS

BIG £ SAVER

Undoubtedly a miracle of modern technology & our special buying power ! A quality product featuring a fully cased COLOUR CCD camera at a give away price ! Unit features full autolight sensing for use in low light & high light applications. A 10 mm fixed focus wide angle lens gives excellent focus and resolution from close up to long range. The composite video output will connect to any composite monitor or TV (via SCART socket) and most video recorders. Unit runs from 12V DC so ideal for security & portable applications where mains power not available.



Overall dimensions 66 mm wide x 117 deep x 43 high. Supplied BRAND NEW & fully guaranteed with user data, 100's of applications including Security, Home Video, Web TV, Web Cams etc, etc.

Web ref = LK33 ***ONLY £99.00 or 2 for £180.00*** (B)

SOFTWARE SPECIALS

NT4 WorkStation, complete with service pack 3 and licence - OEM packaged. ***ONLY £89.00*** (B)

ENCARTA 95 - CDROM, Not the latest - but at this price !	£7.95
DOS 5.0 on 3½" disks with concise books c/w QBasic	£14.95
Windows for Workgroups 3.11+ Dos 6.22 on 3.5" disks	£55.00
Wordperfect 6 for DOS supplied on 3½" disks with manual	£24.95

shipping charges for software is code B

TEST EQUIPMENT & SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
FARNELL 0-60V DC @ 50 Amps, bench Power Supplies	£995
FARNELL AP3080 0-30V DC @ 80 Amps, bench Suppy	£1850
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£760
Wayne Kerr RA200 Audio frequency response analyser	£2500
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
ALLGON 8360.11805-1880 MHz hybrid power combiners	£250
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
Marconi 2022C 10KHz-1GHz RF signal generator	£1550
Marconi 2030 opt 03 10KHz-1.3 GHz signal generator,New	£4995
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & HP3782A Error Detector	£POA
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP8130A opt 020 300 MHz pulse generator, GPIB etc	£7900
HP A1, A0 8 pen HPGL high speed drum plotters - from	£550
HP DRAFTMASTER 1 8 pen high speed plotter	£750
EG+G Brookdeal 95035C Precision lock in amp	£1800
View Eng. Mod 1200 computerised inspection system	£POA
Sony DXC-3000A High quality CCD colour TV camera	£995
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS - New batteries	£9500
Emerson AP130 2.5KVA industrial spec.UPS	£2100
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£945
Siemens K4400 64Kb to 140Mb demux analyser	£2950
HP6030A 0-200V DC @ 17 Amps bench power supply	£1950
Intel SBC 486/125C08 Enhanced Multibus (MSA) New	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
PHILIPS PM5518 pro. TV signal generator	£1250
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM high speed band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 299B Infrared spectrophotometer	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3250
LightBand 60 output high spec 2u rack mount Video VDA's	£495
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
B&K 2633 Microphone pre amp	£300
Taylor Hobson Tallysurf amplifier / recorder	£750
ADC SS200 Carbon dioxide gas detector / monitor	£1450
BBC AM20/3 PPM Meter (Ernest Turner) + drive electronics	£75
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	£5650
ANRITSU MS9001B1 0.6-1.7 uM optical spectrum analyser	£POA
ANRITSU ML93A optical power meter	£990
ANRITSU Fibre optic characteristic test set	£POA
R&S FTDZ Dual sound unit	£650
R&S SBUF-E1 Vision modulator	£775
WILTRON 6630B 12.4 / 20GHz RF sweep generator	£5750
TEK 2445 150 MHz 4 trace oscilloscope	£1250
TEK 2465 300 Mhz 300 MHz oscilloscope rack mount	£1955
TEK TDS380 400Mhz digital realtime + disk drive, FFT etc	£2900
TEK TDS524A 500Mhz digital realtime + colour display etc	£5100
HP3585A Opt 907 20Hz to 40 Mhz spectrum analyser	£3950
PHILIPS PW1730/10 60KV XRAY generator & accessories	£POA
CLAUDE LYONS 12A 240V single phase auto. volt. regs	£325
CLAUDE LYONS 100A 240/415V 3 phase auto. volt. regs	£2900

DISTEL on the web !! - Over 16,000,000 items from stock - www.distel.co.uk

DISPLAY -ELECTRONICS-

ALL MAIL TO
Dept PE, 29/35 Osborne Rd
Thornton Heath
Surrey CR7 8PD
Open Mon - Fri 9.00 - 5:30

LONDON SHOP
Open Mon - Sat 9:00 - 5:30
215 Whitehorse Lane
South Norwood
On 68A Bus Route
Nr.Thornton Heath &
Selhurst Park SR Rail Stations

NEW **DISTEL©**
Visit our web site
www.distel.co.uk
email = admin@distel.co.uk

ALL ☎ ENQUIRIES
0208 653 3333
FAX 0208 653 8888

NEXT MONTH

EPE TEACH-IN 2000

★ *During this 10-part series we shall lead you through the fascinating maze of what electronics is all about!*
★ *We shall assume that you know nothing about the subject!*
★ *We shall take individual components and concepts in simple steps and show you, with lots of examples, that using electronic components need not be a complex task and that you too can actually design and build something that works!*

Much of electronics is about building blocks, and once you have understood what they can do and why they can do it, these blocks can be combined in many different ways to achieve increasingly more sophisticated goals. To assist you in getting to know about the various building blocks, a set of illustrative computer programs has been prepared. We believe these to be capable of running on any comparatively recent PC-compatible computer (from Windows 3.1 upwards). We stress, though, that it is not necessary to own a computer in order to gain benefit from following this Teach-In *series.*

The programs not only illustrate particular electronics concepts discussed in each Tutorial, but also offer you interactive involvement, with the ability to specify your own component values and voltages. Self-test and experimental exercises are included. The programs also allow you to use your computer as an item of test equipment, letting you input data from both analogue and digital circuits, displaying it as meaningful screen data and/or waveforms.

PLUS: FREE 48-PAGE BOOKLET: IDENTIFYING ELECTRONIC COMPONENTS

STOPWATCH

A PIC-based l.c.d. stopwatch design giving Start, Stop and Lap functions and a maximum time of 10 hours in increments of hundredths of a second. Not only can the functions be triggered by pushbuttons or by remote infra-red beams via a radio frequency link, but the unit will also output serial data to feed a large, high brightness l.e.d. display.

Part 1 describes the design and construction of the Stopwatch and radio links, etc. Part 2, in the December issue, gives details of the large l.e.d. display – each digit measures approximately 200mm by 125mm.

This versatile unit could be used for timing – and displaying times to competitors and crowd – athletic, equestrian, sailing, cycling or motoring events, etc.

Starter Project

ACOUSTIC PROBE

This project could be regarded as the audio equivalent of a telescope. Its basic function is to pick up sounds via a microphone, greatly amplify the resultant signal, and then feed it to a pair of headphones. This gives users a sort of "larger than life" version of what they would normally hear, permitting them to detect sounds that would otherwise be inaudible.

Apart from making sounds louder, it is often possible to place the microphone very close to the sound source, or even actually touching it, so that otherwise inaudible sounds can be monitored. When used in this way the unit acts as a sort of electronic stethoscope, and the barely audible sound from a watch can be made to sound more like a shipyard in full production. It is even possible to place the microphone underwater, perhaps to monitor the wildlife in a pond, provided the microphone is given adequate waterproofing.

PLUS: ALL THE REGULAR FEATURES

NO ONE DOES IT BETTER

EVERYDAY PRACTICAL ELECTRONICS

ETI ELECTRONICS TODAY INTERNATIONAL

DON'T MISS AN ISSUE – PLACE YOUR ORDER NOW!
Demand is bound to be high

NOVEMBER ISSUE ON SALE FRIDAY, OCTOBER 1

TELNET

8 CAVANS WAY,
BINLEY INDUSTRIAL ESTATE.
COVENTRY CV3 2SF
Tel: 01203 650702
Fax: 01203 650773
Mobile: 0860 400683

(Premises situated close to Eastern-by-pass in Coventry with easy access to M1, M6, M40, M42, M45 and M69)

OSCILLOSCOPES

Beckman 9020 – 20MHz – Dual Channel	£150
Gould OS 245A/250/255/300/3000/3351/4000	from £125
Hewlett Packard 180A/180C/181A/182C	from £150
Hewlett Packard 1740A, 1741A, 1744A, 100MHz Dual Channel	from £300
Hewlett Packard 54100D – 1GHz Digitizing	£1250
Hewlett Packard 54200A – 50MHz Digitizing	£500
Hewlett Packard 54201A – 300MHz Digitizing	£1250
Hewlett Packard 54512B – 300MHz – 1 GS/s 4-Channel	£2250
Hewlett Packard 54501A – 100MHz – 100 Ms/s 4-Channel	£1250
Hitachi V152F/V302B/V302F/V353F/V550B/V650F	from £105
Hitachi V650F – 60MHz Dual Channel	£200
Hitachi V1100A – 100MHz 4-Channel	£900
Intron 2020 – 20MHz Digital Storage (NEW)	£450
Iwatsu SS5710/SS5702 – 20MHz	from £125
Meguro – MSO 1270A – 20 MHz Digital Storage (NEW)	£450
Lecroy 9304 AM – 200MHz – 100 Ms/s 4-Channel	£3000
Lecroy 9450A – 300MHz/400 Ms/s D.S.O. 2-Channel	£2250
Philips PM 3055 – 50MHz Dual Timebase	£450
Philips PM 3211/PM 3212/PM 3214/PM 3217/PM 3234/PM 3240/PM 3243/ PM 3244/PM 3261/PM 3262/PM 3263/PM 3540	from £125
Philips PM 3295A – 400MHz Dual Channel	£1600
Philips PM 3335 – 50MHz/20 Ms/s D.S.O. 2-Channel	£950
Tektronix 455 – 50MHz Dual Channel	£200
Tektronix 464/466 – 100MHz Analogue Storage	from £300
Tektronix 465/465B – 100MHz Dual Channel	from £300
Tektronix 468 – 100MHz D.S.O.	£500
Tektronix TAS 475 – 100MHz – 4-Channel	£995
Tektronix 475/475A – 200MHz/250MHz Dual Channel	from £400
Tektronix 485 – 350MHz – 2-Channel	£750
Tektronix 2211 – Digital Storage – 50MHz	£800
Tektronix 2213 – 60MHz Dual Channel	£350
Tektronix 2215 – 60MHz Dual Trace	£375
Tektronix 2220 – 60MHz Dual Channel D.S.O.	£950
Tektronix 2221 – 60MHz Digital Storage 2-Channel	£950
Tektronix 2225 – 50MHz Dual Channel	£350
Tektronix 2235 – 100MHz Dual trace	£600
Tektronix 2335 – Dual Trace 100MHz (portable)	£800
Tektronix 2440 – 300MHz/500 Ms/s D.S.O. 2-Channel	£2500
Tektronix 2445 – 150MHz – 4-Channel + DMM	£900
Tektronix 2445A – 100MHz – 4-Channel	£900
Tektronix 2476B – 400MHz – 4-Channel	£6500
Tektronix 5403 – 60MHz – 2 or 4-Channel	from £150
Tektronix 7313, 7603, 7623, 7633 – 100MHz 4-Channel	from £225
Tektronix 7704 – 250MHz 4-Channel	from £350
Tektronix 7904 – 500MHz	from £400
Trio CS-1022 – 20MHz – Dual Channel	£125

Other scopes available too

SPECIAL OFFER

HITACHI V212 – 20MHz DUAL TRACE	£160
HITACHI V222 – 20MHz DUAL TRACE + ALTERNATE MAGNIFY	£180

SPECTRUM ANALYSERS

Ando AC8211 – Spectrum Analyser 1·7GHz	£1995
Anritsu MS62B – 10kHz-1700MHz	£1995
Anritsu MS3401A + MS3401B – (10Hz-30MHz)	£3500 + £3995
Anritsu MS610B – 10kHz-2GHz – (Mint)	£4500
Anritsu MS710F – 100kHz-23GHz Spectrum Analyser	£5500
Avcom PSA65S – 1000MHz – portable	£850
Hameg 8028/8038 – Spectrum Analyser/Tracking Gen + 100MHz Oscilloscope	£1000
Hewlett Packard 182R with 8559A (10MHz-21GHz)	£2750
Hewlett Packard 182T + 8558B – 0·1 to 1500MHz	£1250
Hewlett Packard 853A + 8558B – 0·1 to 1500MHz	£2250
Hewlett Packard 3562A Dual Channel Dynamic Sig. Analyser	£5750
Hewlett Packard 3580A – 5Hz-50kHz	£800
Hewlett Packard 3582A – 0·02Hz-25·6kHz (Dual Channel)	£2000
Hewlett Packard 3585A – 20HZ-40MHz	£4000
Hewlett Packard 8569B – (0·01 to 22GHz)	£4250
Hewlett Packard 85046A – 'S' Parameter Test Set	£2500
Hewlett Packard 8753A – Network Analyser	from £3000
Hewlett Packard 8753B – Network Analyser	from £4500
IFR 7750 – 10kHz-1GHz	£2000
Meguro MSA 4901 – 1-300GHz (AS NEW)	£750
Meguro MSA 4912 – 1-1GHz (AS NEW)	£1000
Rohde & Schwarz – SWOB 5 Polyskop 0·1-1300MHz	£1500
Takeda Riken 4132 – 1·0GHz Spectrum Analyser	£2100
Tektronix 7L18 with mainframe (1·5-60Ghz with external mixers)	£2000
Tektronix 495P – 100Hz-1·8GHz programmable	£4500
Tektronix 496P – 1kHz-1·8GHz Spectrum Analyser	£4250

MISCELLANEOUS

Adret 740A – 100kHz-1120MHz Synthesised Signal Generator	£800
Anritsu MG 3601A Signal Generator 0·1-1040MHz	£1250
Anritsu ME 462B DF/3 Transmission Analyser	£2500
Anritsu MG 645B Signal Generator 0·05-1050MHz	£750
Boonton 92C R/F Millivoltmeter	£195
Boonton 93A True RMS Voltmeter	£195
Dranetz 626 – AC/DC – Multifunction Analyser	£500
EIP 331 – Frequency Counter 18GHz	£450
EIP 545 – Frequency Counter 18GHz	£1250
EIP 575 – Frequency Counter 18GHz	£1450
Eltek SMPS – Power Supply 60V-30V	£350
Farnell TSV-70 MKII Power Supply (70V – 5A or 35V – 10A)	£200
Farnell DSG-1 Synthesised Signal Generator	£125
Farnell AP 30250A Power Supply 3V – 250A	£1750
Feedback PFG 605 Power Function Generator	£150
Fluke 5100A – Calibrator	£1950
GN ELMI EPR31 PCM Signalling Recorder	£2000
Guildline 9152 – T12 Battery Standard Cell	£550
Hewlett Packard 1630D – Logic Analyser (43 Channels)	£500
Hewlett Packard 16500A/B and C – Fitted with 16510A/1651A/161530A/16531A – Logic Analyser	from £2000
Hewlett Packard 331A – Distortion Analyser	£300
Hewlett Packard 333A – Distortion Analyser	£300
Hewlett Packard 334A – Distortion Analyser	£300
Hewlett Packard 3325A – 21MHz Synthesiser/Function Generator	£900
Hewlett Packard 3335A – Synthesised Signal Generator (200Hz-81MHz)	£2750
Hewlett Packard 3336C – Synthesised Signal Generator (10Hz-21MHz)	£800
Hewlett Packard 3455A – 6½ Digit Multimeter (Autocal)	£500
Hewlett Packard 3456A – Digital Voltmeter	£800
Hewlett Packard 3488A – HP – 1B Switch Control Unit (various Plug-ins available)	£550
Hewlett Packard 35600A – Dual Channel Dynamic Signal Analyser	£3750
Hewlett Packard 3586A – Selective Level Meter	£800
Hewlett Packard 3711A/3712A/3791B/3793B – Microwave Link Analyser	£1500
Hewlett Packard 3746A – Selective Measuring Set	£500
Hewlett Packard 3776A – PCM Terminal Test Set	£1000
Hewlett Packard 3779A/3779C – Primary Mux Analyser	from £400
Hewlett Packard 3784A – Digital Transmission Analyser	£5000
Hewlett Packard 3785A – Jitter Generator + Receiver	£1250
Hewlett Packard 37900D – Signalling Test Set (No. 7 and ISDN)	£4250
Hewlett Packard P382A – Variable Attenuator	£250
Hewlett Packard 4192A – LF Impedance Analyser	£6500
Hewlett Packard 4262A – Digital LCR Meter	£950
Hewlett Packard 4342A – 'Q' Meter	£600
Hewlett Packard 435A or B Power Meter (with 8481A/8484A)	from £400
Hewlett Packard 436A and 437B – Power Meter and Sensor	from £900
Hewlett Packard 4948A – (TIMS) Transmission Impairment M/Set	£1000
Hewlett Packard 4972A – Lan Protocol Analyser	£1250
Hewlett Packard 5183 – Waveform Recorder	£1250
Hewlett Packard 5238A – Frequency Counter 100MHz	£250
Hewlett Packard 5314A – (NEW) 100MHz Universal Counter	£250
Hewlett Packard 5316A – Universal Counter (IEEE)	£400
Hewlett Packard 5335A – 200MHz High Performance Systems Counter	£600
Hewlett Packard 5324A – Microwave Frequency Counter (500MHz-18GHz) Opts 1 + 3	£800
Hewlett Packard 5359A – High Resolution Time Synthesiser	£2950
Hewlett Packard 5370B – Universal Timer/Counter	£2000
Hewlett Packard 5384A – 225MHz Frequency Counter	£500
Hewlett Packard 5385A – Frequency Counter – 1GHz – (HP1B) with OPTS 001/003/004/005	£750
Hewlett Packard 6033A – Power Supply Autoranging (20V – 30A)	£750
Hewlett Packard 6253A – Power Supply 20V – 3A Twin	£200
Hewlett Packard 6255A – Power Supply 40V – 1·5A Twin	£200

HEWLETT PACKARD 6261B
Power Supply 20V – 50A £350 *Discount for Quantities*

Hewlett Packard 6264B – Power Supply (0-20V, 0-25A)	£300
Hewlett Packard 6266B – Power Supply 40V – 5A	£220
Hewlett Packard 6271B – Power Supply 60V – 3A	£225
Hewlett Packard 6624A – Quad Power Supply	£2000
Hewlett Packard 6632A – Power Supply (20V – 5A)	£800
Hewlett Packard 6652A – 20V – 25A System P.S.U.	£750
Hewlett Packard 7475A – 6 Pen Plotter	£250
Hewlett Packard 7550A – 6 Pen Plotter	£350
Hewlett Packard 778D – Coax Dual Directional Coupler	£600
Hewlett Packard 8015A – 50MHz Pulse Generator	£500
Hewlett Packard 8165A – 50MHz Programmable Signal Source	£1250
Hewlett Packard 8180A – Data Generator	£1500
Hewlett Packard 8182A – Data Analyser	£1500
Hewlett Packard 8350B – Sweep Oscillator Mainframe (various plug-in options available)	£2500
Hewlett Packard 83554A – Wave Source Module 26·5 to 40GHz	£3500
Hewlett Packard 83555A – Millimeter – Wave Source Module 33-50GHz	£4250
Hewlett Packard 8405A – Vector Voltmeter	£350
Hewlett Packard 8620C – Sweep Oscillator Mainframe	from £250
Hewlett Packard 8640B – Signal Generator (512MHz + 1024MHz)	from £850
Hewlett Packard 8642A – Signal Generator (0·01 to 1050MHz) High Performance Synthesiser	£6500
Hewlett Packard 8656A – Synthesised Signal Generator (990MHz)	£850
Hewlett Packard 8656B – Synthesised Signal Generator	£1450
Hewlett Packard 8657A – Signal Generator (100kHz-1040MHz)	£1900
Hewlett Packard 8660D – Synthesised Signal Generator (10kHz-2600MHz)	£3250
Hewlett Packard 8750A – Storage Normaliser	£295
Hewlett Packard 8756A – Scalar Network Analyser	£1500
Hewlett Packard 8757A – Scalar Network Analyser	£2250
Hewlett Packard 8901A – Modulation Analyser	£1000
Hewlett Packard 8901B – Modulation Analyser	£2000
Hewlett Packard 8903E – Distortion Analyser	£1600
Hewlett Packard 8903B – Distortion Analyser (Mint)	£1500
Hewlett Packard 8920A – R/F Comms Test Set	£2500
Hewlett Packard 8922B/G/H – Raadio Comms Test Sets (G.S.M.)	from £8000
Hewlett Packard 8958A – Cellular Radio Interface	£1000
Keytek MZ-15/EC – Minizap 15kV Hand-Held ESD Simulator	£1750
Krohn-Hite 2200 – Lin/Log Sweep Generator	£995
Kroh-Hite 4024A – Oscillator	£250
Krohn-Hite 5200 – Sweep, Function Generator	£350
Krohn-Hite 6500 – Phase Meter	£250
Leader LDM-170 – Distortion Meter	£350
Leader 3216 – Signal Generator (100kHz-140kHz) AM/FM/CW with built-in FM stereo modulator (mint)	£995
Marconi 1066B – Demultiplexer and Frame Alignment Monitor (new)	£POA
Marconi 2019 – 80kHz-1040MHz Synthesised Signal Generator	£750
Marconi 2019A – 80kHz-1040MHz Synthesised Signal Generator	£1000
Marconi 2111 – UHF Synthesiser (new)	£POA
Marconi 2185 – 1·5GHz Programmable Attenuator (new)	£POA
Marconi 2305 – Modulation Meter	£1750
Marconi 2337A – Automatic Distortion Meter	£150
Marconi 2610 – True RMS Voltmeter	£700
Marconi 2871 – Data Comms Analyser	£500
Marconi 2955 – Radio Comms Test Set	£2000
Marconi 6310 – Sweep Generator – Programmable – new (2-20GHz)	£3500
Marconi 6950/6960 – Power Meter & Sensor	from £500
Marconi 6960 – Power Meter & Sensor	from £950
Marconi 893 – A/F Power Meter	£250
Philips PM5167 MHz Function Generator	£400
Philips 5190 – L.F. Synthesiser (G.P.I.B.)	£800
Philips 5518 – Synthesised Function Generator	£1500
Philips PM5519 – TV Pattern Generator	£350
Philips PM5716 – 50MHz Pulse Generator	£525
Prema 4000 – 6½ Digit Multimeter (NEW)	£350
Quartzlock 2A – Off-Air Frequency Standard	£200
Racal 1992 – 1·3GHz Frequency Counter	£700
Racal 6111/6151 – GSM Radio Comms Test Set	£POA
Racal Dana 9081/9082 – Synthesised Signal Generator 520MHz	from £400
Racal Dana 9084 – Synthesised Signal Generator 104MHz	£450
Racal 9301A – True RMS R/F Multivoltmeter	£300
Racal Dana 9302A – R/F Multivoltmeter (new version)	£375
Racal Dana 9303 – R/F Level Meter & Head	£650
Racal Dana 9917 – UHF Frequency Meter 560MHz	£175
Rohde & Schwarz LFM2 – 60MHz Group Delay Sweep Generator	£950
Rohde & Schwarz CMTA 94 – GSM Radio Comms Analyser	£6995
Schaffner NSG 203A – Line Voltage Variation Simulator	£750
Schaffner NSG 222A – Interference Simulator	£700
Schaffner NSG 223 – Interference Generator	£700
Schlumberger 2720 – 1250MHz Frequency Counter	£400
Schlumberger 4031 – 1GHz Radio Comms Test Set	£4995
Schlumberger Stabilock 4040 – Radio Comms Test Set	£1995
Schlumberger 7060/7065/7075 – Multimeters	from £350
Stanford Research DS 340 – 15MHz Synthesised Function (NEW) and Arbitrary Waveform Generator	£1200
Systron Donner 6030 – Microwave Frequency Counter (26·5GHz)	£1995
Tektronix AM503 + TM501 + P6302 – Current Probe Amplifier	£995
Tektronix PG506 + TG501 + SG503 + TM503 – Oscilloscope Calibrator	£1995
Tektronix 577 – Curve Tracer	£1150
Tektronix 1240 – Logic Analyser	£500
Tektronix 141A – PAL Test Signal Generator	£250
Tektronix AA5001 & TM5006 M/F – Programmable Distortion Analyser	£1995
Tektronix TM5003 + AFG 5101 – Arbitrary Function Generator	£1500
Tektronix – Plug-ins – many available such as SC504, SW503, SG502, PG508, FG504, FG503, TG501, TR503 + many more	£POA
Time 9811 – Programmable Resistance	£400
Time 9814 – Voltage Calibrator	£550
Valhalla Scientific – 2724 Programmable Resistance Standard	£POA
Wandel & Goltermann PFJ-8 – Error/Jitter Test Set	£11500
Wandel & Goltermann PCM4 (+ options)	£9950
Wandel & Goltermann MU30 – Test Point Scanner	£1500
Wayne Kerr 4225 – LCR Bridge	£600
Wavetek 171 – Synthesised Function Generator	£250
Wavetek 172B – Programmable Signal Source (0·0001Hz-13MHz)	£POA
Wavetek 184 – Sweep Generator – 5MHz	£250
Wavetek 3010 – 1·1GHz Signal Generator	£1250
Wiltron 6409 – RF Analysers (1MHz-2GHz)	£POA
Wiltron 6620S – Programmable Sweep Generator (3·6GHz-6·5GHz)	£650
Wiltron 6747-20 – Swept Frequency Synthesiser (10MHz-20GHz)	£3950
Yokogowa 3655 – Analysing Recorder	£POA

MANY MORE ITEMS AVAILABLE –
SEND LARGE SAE FOR LIST OF EQUIPMENT
ALL EQUIPMENT IS USED –
WITH 30 DAYS GUARANTEE.
PLEASE CHECK FOR AVAILABILITY BEFORE ORDERING –
CARRIAGE & VAT TO BE ADDED TO ALL GOODS

£1 BARGAIN PACKS – List 1

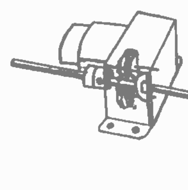
1,000 items appear in our Bargain Packs List – request one of these when you next order.

2 LITHIUM COIN CELLS, 3V p.c.b. mounting, Order Ref: 1078.
2 × 5A BRIDGE RECTIFIERS with heatsink couplers for 12V charger, Order Ref: 1070.
2 × AMP PULL CORD CEILING SWITCHES, brown. Order Ref: 921.
5 × REELS INSULATION TAPE. Order Ref: 911.
2 × CORD GRIP SWITCH LAMP HOLDERS. Order Ref: 913.
1 × DC VOLTAGE REDUCER, 12V-6V. Order Ref: 916.
LIGHTWEIGHT STEREO HEADPHONES, moving coil so superior sound. Order Ref: 896.
2 × 25W CROSSOVERS for 4ohm loudspeakers. Order Ref: 22.
2 × Nicad CONSTANT CURRENT CHARGERS, easily adaptable to charge almost any NiCad Battery. Order Ref: 30.
18V-0-18V 10VA mains transformer. Order Ref: 813.
2 × WHITE PLASTIC BOXES with lids, approx. 3in. cube. Lid has square hole through the centre so these are ideal for light-operated switch. Order Ref: 132.
2 × REED RELAY KITS, you get 8 reed switches and 2 coil sets. Order Ref: 148.
12V-0-12V 6VA mains transformer, p.c.b. mounting. Order Ref: 938.
1 × BIG-PULL SOLENOID, mains operated, has ½in. pull. Order Ref: 871.
1 × BIG-PUSH SOLENOID, mains operated, has ½in. push. Order Ref: 872.
1 × MINI MONO AMP. 3W into 4 ohm speaker or 1W into 8 ohm. Order Ref: 495.
1 × MINI STEREO 1W AMP. Order Ref: 870.
15V DC 150mA P.S.U., nicely cased. Order Ref: 942.
1 × IN-FLIGHT STEREO UNIT is a stereo amp. Has two most useful mini moving coil speakers. Made for BOAC pasengers. Order Ref: 29.
1 × 0-1mA PANEL METER. Full vision face 70mm square. Scaled 0-100. Order Ref: 756.
2 × LITHIUM BATTERIES. 2·5V penlight size. Order Ref: 874.
2x3m TELEPHONE LEADS. With BT flat plug. Ideal for 'phone extensions, fax, etc. Order Ref: 552.
1 × 12V SOLENOID. Has good ½in. pull or could push if modified. Order Ref: 232.
3 × IN-FLEX SWITCHES. With neon on/off lights, saves leaving things switched on. Order Ref: 7.
2 × 6V 1A MAINS TRANSFORMERS. Upright mounting with fixing clamps. Order Ref: 9.
1 × HUMIDITY SWITCHES. As the air becomes damper, the membrane stretches and operates a microswitch. Order Ref: 32.
4 × 13A ROCKER SWITCH. Three tags so on/off, or changeover with centre off. Order Ref: 42.
1 × SUCK OR BLOW-OPERATED PRESSURE SWITCH. Or it can be operated by any low pressure variation, such as water level in tanks. Order Ref: 67.
1 × 6V 750mA POWER SUPPLY. Nicely cased with mains input and 6V output lead. Order Ref: 103A.
12 VERY FINE DRILLS. For p.c.b. boards etc. Normal cost about 80p each. Order Ref: 128.
5 × MOTORS FOR MODEL AEROPLANES. Spin to start so needs no switch. Order Ref: 134.
6 × MICROPHONE INSERTS. Magnetic 400 ohm, also act as speakers. Order Ref: 139.
6 × NEON INDICATORS. In panel mounting holders with lens. Order Ref: 180.
1 × IN-FLEX SIMMERSTAT. Keeps your soldering iron etc. always at the ready. Order Ref: 196.
1 × ELECTRIC CLOCK. Mains operated. Put this in a box and you need never be late. Order Ref: 211.
4 × 12V ALARMS. Makes a noise about as loud as a car horn. All brand new. Order Ref: 221.
2 × (6in. × 4in.) SPEAKERS. 16 ohm 5 watts, so can be joined in parallel to make a high wattage column. Order Ref: 243.
1 × PANOSTAT. Controls output of boiling ring from simmer up to boil. Order Ref: 252.
2 × OBLONG PUSHSWITCHES. For bell or chimes, these can switch mains up to 5A so could be footswitch if fitted in pattress. Order Ref: 263.
50 × MIXED SILICON DIODES. Order Ref: 293.
1 × 6 DIGIT MAINS OPERATED COUNTER. Standard size but counts in even numbers. Order Ref: 28.
2 × 6V OPERATED REED RELAYS. One normally on, other normally closed. Order Ref: 48.
1 × CABINET LOCK. With two keys. Order Ref: 55.
6½ 8Ω 5 WATT SPEAKER. Order Ref: 824.
1 × SHADED POLE MAINS MOTOR. ¾in. stack, so quite powerful. Order Ref: 85.
1 × CASE, 3½ × 2¼ × 1¾ with 13A socket pins. Order Ref: 845.
2 × CASES. 2½ × 2¼ × 1¾ with 13A pins. Order Ref: 565.
4 × LUMINOUS ROCKER SWITCHES. 10A mains. Order Ref: 793.

12V 8A POWER SUPPLY. Totally enclosed with its own cooling fan. Normal mains operation, 12V comes out on a 2m heavy duty lead. Price £11. Order Ref: 11P6.
EXCEPTIONALLY NICE PROJECT CASE. This is totally enclosed, well ventilated and the front is cut out to accept a 12V brushless fan size 80mm square. This is held in by 4 spring clips. The size of the case is 6x6x3¼in. deep. Price £4. Order Ref: 4P111.
12V BRUSHLESS FANS. Both square and black, multi-bladed. The smaller is 80mm square, the larger one 90mm square. Both brand new. Price £3.50 each. Order Ref: 3.5P24 for the 80mm and 3.5P25 for the 90mm.
VERY USEFUL POWER SUPPLY. German make by the Vastec company, model ref. no. EN660950. This is a very well made and neatly cased unit with its own 12 brushless cooling fan built in. The case size is approximately 6in. square by 4in. high. The maximum load of the unit is 200VA and split up as follows: +5V 20A, –5V 3A, +12V 8A, –12V 3A. Price £9. Order Ref: 9P22.

> **SPECIAL PRICE FOR TWO MONTHS**
> **A SUPER 12V YUASA BATTERY.** It is 18AH Yuasa made jelly type so maintenance free and usable in any position. Brand new and guaranteed 12 months. The regular price of these is £40 but for the months of September and October you can buy at £15 including VAT, two or more also carriage free. Order Ref: 15P78.

VERY POWERFUL BATTERY MOTOR. Intended to operate portable screwdriver. It is 2½in. long and 1½in. diameter. Has a good length spindle. Will operate with considerable power off any voltage between 6V and 12V d.c. Price £2. Order Ref: 2P456.
D.C. MOTOR WITH GEARBOX. Size 60mm long, 30mm diameter. Very powerful, operates off any d.c. voltage between 6V and 24V. Speed at 6V is 200 rpm but higher with higher voltages of course. Price £3. Order Ref: 3P108.
MOTOR SPEED CONTROLLER. For d.c. motors up to 24V and any power up to 1/6 h.p. They reduce by intermittent full voltage pulses so there should be no loss of power. In kit form £12. Order Ref: 12P34. Or made up and tested, £20. Order Ref: 20P39.
VERY THIN DRILLS. 12 assorted sizes vary between 0·6mm and 1·6mm, price £1. Order Ref: 128.
EVEN THINNER DRILLS. 12 that vary between 0·1 and 0·5mm, price £1. Order Ref: 129.
BT TELEPHONE EXTENSION WIRE. This is proper heavy-duty cable for running around the skirting board when you want to make a permanent extension. 4 cores properly colour coded, 25m length, only £1. Order Ref: 1067.
A MUCH LARGER PROJECT BOX. Size 216mm × 130mm × 85mm with lid and 4 screws. This is an ABS box which normally retails at around £6. All brand new, price £2.50. Order Ref: 2.5P28.
LARGE TYPE MICROSWITCH with 2in. lever, changeover contacts rated at 15A at 250V, 2 for £1. Order Ref: 1/21R7.
BALANCE ASSEMBLY KITS. Japanese made, when assembled ideal for chemical experiments, complete with tweezers and 6 weights 0·5 to 5 grams. Price £2. Order Ref: 2P444.
CYCLE LAMP BARGAIN. You can have 100 6V 0·5A MES bulbs for just £2.50 or 1,000 for £20. They are beautifully made, slightly larger than the standard 6·3V pilot bulb so they would be ideal for making displays for night lights and similar applications.
DOORBELL PSU. This has a.c. voltage output so is ideal for operating most doorbells. The unit is totally enclosed so perfectly safe and it plugs into a 13A socket. Price only £1. Order Ref: 1/30R1.
FLASHING BEACON. Ideal for putting on a van, a tractor or any vehicle that should always be seen. Uses a Xenon tube and has an amber colour dome. Separate fixing base is included so unit can be put away if desired. Price £5. Order Ref: 5P267.
MOST USEFUL POWER SUPPLY. Rated at 9V 1A, this plugs into a 13A socket. Is really nicely boxed, £2. Order Ref: 2P733.
1·5-6V MOTOR WITH GEARBOX. Motor is mounted on the gearbox which has interchangeable gears giving a range of speeds and motor torques. Comes with full instructions for changing gears and calculating speeds, £7. Order Ref: 7P26.



SPECIAL 12V RECHARGEABLE BATTERY. This is the Jap made Yuasa. It is sealed so can be used in any position. £3.50 each or 5 for £15. Order Ref: 3.5P11. The batteries have a capacity of 2·3AH which may be a bit low for some jobs but remember you can join them in parallel to give a high amperage.

FOR QUICK HOOK-UPS. You can't beat leads with a croc clip each end. You can have a set of 10 leads, 2 each of 5 assorted colours with insulated crocodile clips on each end. Lead length 36cm, £2 per set. Order Ref: 2P459.
BIG 12V TRANSFORMER. It is 55VA so over 4A. Beautifully made and well insulated. Live parts are in a plastic frame so cannot be accidentally touched, £3.50. Order Ref: 3.5P20.
TWIN 13A SWITCHED SOCKET. Good British make, white, quite standard size so suitable for flush mounting or in a surface box. £1.50. Order Ref: 1.5P61.
1mA PANEL METER. Approximately 80mm × 50mm, front engraved 0-100, price £1.50. Order Ref: 1/16R2.
LIGHT ALARM. Or it could be used to warn when any cupboard door is opened. The light shining on the unit makes the bell ring. Completely built and neatly cased, requires only a battery, £3. Order Ref: 3P155.
WATER LEVEL ALARM. Be it bath, sink, cellar, sump or any other thing that could flood. This device will tell you when the water has risen to the present level. Adjustable over quite a useful range. Neatly cased for wall mounting, ready to work when battery fitted. £3. Order Ref: 3P156.
BIKE RADIO. In fact, it's more than a radio, it's an alarm and a spotlight. The radio is battery operated, of course, and needs 3 AA cells. Only one band but this is the FM band so will receive Radio 1 and 2. Comes complete with handlebar fixing clips. Price £4. Order Ref: 4P72.
PHILIPS 9in. MONITOR. Not cased, but it is in a frame for rack mounting. It is high resolution and was made to work with the IBM. 'One per disk' computer. Price £15. Order Ref: 15P1.
METAL CASE FOR 9in. MONITOR. Supplied as a flat pack. Price £12. Order Ref: 12P3.
TELEPHONE EXTENSION LEAD. Nicely made and BT approved. Has the plug into BT socket one end and the telephone socket the other end, total length 12m. £2. Order Ref: 2P338.
INSULATION TESTER WITH MULTIMETER. Internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. Ex-British Telecom but in very good condition, tested and guaranteed, probably cost at least £50 each, yours for only £7.50 with leads, carrying case £2 extra. Order Ref: 7.5P4.
REPAIRABLE METERS. We have some of the above testers but faulty, not working on all ranges, should be repairable, we supply diagrams. £3. Order Ref: 3P176.
CHARGER FOR YUASA BATTERY. This battery charger plugs into a 13A socket, charges at approximately 1/2A so it would charge this battery overnight. Complete with croc clips, ready to go. £5. Order Ref: 5P269.

TOROIDAL MAINS TRANSFORMERS

All with 220/240V primary winding

24V + 24V at 25VA would give 25V at 1A or 50V at ½A, price, £3. Order Ref: 3P245.
0-7V 40VA, has main winding 7V at 5A and a secondary winding 12V 1A, price £3. Order Ref: 3P238.
0-110V + 0-110V at 120VA would give you 110V at just over 1A or 220V at ½A, price £8. Order Ref: 8PG3.
35V + 35V at 150VA would give 35V at 4A or 70V at 2A, price £8. Order Ref: 8PG9.
35V + 35V at 220VA would give 35V at 6½A or 70V at 3¼A, price £10. Order Ref: 10PG4.
110V + 110V at 220VA would give 110V at 2A or 220V at 1A, price £12. Order Ref: 12PG5.
110V + 110V at 500VA would give 110V at 5A or 220V at nearly 3A, price £25. Order Ref: 25PG8.

SUPER WOOFERS.

A 10in. 4ohm with power rating of 250W music and normal 150W. Normal selling price for this is £55 + VAT, you can buy at £29 including VAT and carriage. Order Ref: 29P7. The second one is an 8in. 4ohm, 200W music, 200W normal, again by Challenger, price £18. Order Ref: 18P9.
Deduct 10% from these prices if you order in pairs or can collect. These are all brand new in maker's packing.

TERMS

Send cash, PO, cheque or quote credit card number – orders under £25 add £3.50 service charge.

J & N FACTORS
Pilgrim Works (Dept. E.E.)
Stairbridge Lane, Bolney,
Sussex RH17 5PA
Telephone: 01444 881965

1099

ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats, Tyne & Wear, NE30 4PQ

All Major Credit cards Accepted SOLO

Prices Exclude Vat @17½%. Add £1.25 carriage & Vat to all orders. Cheques / Postal orders payable to ESR Electronic Components.

See Next/Last Months Ad. for COMPONENT ACCESSORIES

4000 Series

4000B	£0.17
4001B	£0.20
4002B	£0.17
4006B	£0.40
4007UB	£0.18
4008B	£0.23
4009UB	£0.23
4010B	£0.23
4011B	£0.18
4012B	£0.16
4013B	£0.20
4014B	£0.30
4015B	£0.24
4016B	£0.28
4017B	£0.24
4018B	£0.27
4019B	£0.25
4020B	£0.36
4021B	£0.31
4022B	£0.32
4023B	£0.19
4024B	£0.31
4025B	£0.20
4026B	£0.78
4027B	£0.25
4028B	£0.34
4029B	£0.40
4030B	£0.17
4031B	£0.61
4035B	£0.31
4040B	£0.32
4041B	£0.31
4042B	£0.22
4043B	£0.28
4044B	£0.35
4046B	£0.38
4047B	£0.32
4048B	£0.34
4049B	£0.28
4049UB	£0.24
4050B	£0.26
4051B	£0.33
4052B	£0.32
4053B	£0.29
4054B	£0.56
4055B	£0.34
4060B	£0.31
4063B	£0.29
4066B	£0.29
4067B	£2.20
4068B	£0.16
4069UB	£0.19
4070B	£0.25
4071B	£0.23
4072B	£0.17
4073B	£0.17
4075B	£0.17
4076B	£0.30
4077B	£0.28
4078B	£0.20
4081B	£0.21
4082B	£0.21
4085B	£0.28
4086B	£0.25
4093B	£0.25
4094B	£0.29
4095B	£0.56
4097B	£1.20
4098B	£0.48
4099B	£0.39
4502B	£0.32
4503B	£0.40
4508B	£1.40
4510B	£0.45
4511B	£0.38
4512B	£0.32
4514B	£0.77
4515B	£0.99
4516B	£0.44
4518B	£0.44
4520B	£0.34
4521B	£0.62
4526B	£0.40
4527B	£0.40
4528B	£0.40
4529B	£0.44
4532B	£0.32
4536B	£1.00
4538B	£0.37
4541B	£0.33
4543B	£0.47
4555B	£0.32
4556B	£0.40
4566B	£1.96
4584B	£0.24
4585B	£0.47
4724B	£0.94
40106B	£0.24
40109B	£0.58
40174B	£0.46
40175B	£0.41

74 Series

7407	£0.40

SAMEDAY DESPATCH

No Minimum Order Value

74HC Series

74HC00	£0.19
74HC02	£0.21
74HC03	£0.21
74HC04	£0.20
74HC08	£0.21
74HC10	£0.16
74HC11	£0.20
74HC14	£0.23
74HC20	£0.28
74HC27	£0.16
74HC30	£0.22
74HC32	£0.20
74HC42	£0.36
74HC73	£0.40
74HC74	£0.22
74HC75	£0.40
74HC76	£0.20
74HC85	£0.24
74HC86	£0.22
74HC107	£0.40
74HC123	£0.33
74HC125	£0.26
74HC126	£0.46
74HC132	£0.35
74HC133	£0.34
74HC137	£0.30
74HC138	£0.25
74HC139	£0.31
74HC151	£0.33
74HC153	£0.30
74HC154	£0.85
74HC157	£0.40
74HC158	£0.23
74HC160	£0.64
74HC161	£0.28
74HC162	£0.45
74HC163	£0.26
74HC164	£0.35
74HC165	£0.35
74HC173	£0.38
74HC174	£0.27
74HC175	£0.35
74HC192	£0.72
74HC195	£0.32
74HC240	£0.37
74HC241	£0.37
74HC244	£0.42
74HC245	£0.42
74HC251	£0.30
74HC253	£0.25
74HC257	£0.25
74HC259	£0.57
74HC273	£0.32
74HC299	£0.64
74HC365	£0.34
74HC367	£0.25
74HC368	£0.25
74HC373	£0.35
74HC374	£0.40
74HC390	£0.52
74HC393	£0.38
74HC541	£0.32
74HC563	£0.56
74HC564	£0.48
74HC573	£0.38
74HC574	£0.45
74HC595	£0.39
74HC688	£0.64
74HC4002	£0.31
74HC4017	£0.64
74HC4020	£0.36
74HC4040	£0.36
74HC4049	£0.31
74HC4051	£0.40
74HC4052	£0.43
74HC4053	£0.38
74HC4060	£0.44
74HC4075	£0.27
74HC4078	£0.32
74HC4511	£0.64
74HC4514	£0.84
74HC4538	£0.41
74HC4543	£0.90

74LS Series

74LS00	£0.23
74LS01	£0.14
74LS02	£0.26
74LS03	£0.29
74LS04	£0.21
74LS05	£0.14
74LS08	£0.23
74LS09	£0.15
74LS10	£0.14
74LS11	£0.17
74LS12	£0.14
74LS13	£0.29
74LS14	£0.25
74LS15	£0.24
74LS20	£0.25
74LS21	£0.14
74LS26	£0.14
74LS27	£0.14
74LS30	£0.20
74LS32	£0.21
74LS37	£0.14
74LS38	£0.18
74LS40	£0.14
74LS42	£0.42
74LS47	£0.58
74LS51	£0.26
74LS73	£0.40
74LS74	£0.32
74LS75	£0.30
74LS76	£0.40
74LS83	£0.38
74LS85	£0.48
74LS86	£0.25
74LS90	£0.40
74LS92	£0.45
74LS93	£0.42
74LS107	£0.30
74LS109	£0.21
74LS112	£0.24
74LS113	£0.23
74LS114	£0.36
74LS122	£0.31
74LS123	£0.31
74LS125	£0.28
74LS126	£0.25
74LS132	£0.26
74LS133	£0.36
74LS136	£0.23
74LS138	£0.40
74LS139	£0.24
74LS145	£0.56
74LS148	£0.64
74LS151	£0.25
74LS153	£0.40
74LS154	£0.70
74LS156	£0.36
74LS157	£0.22
74LS158	£0.21
74LS160	£0.48
74LS161	£0.32
74LS162	£0.44
74LS163	£0.32
74LS164	£0.24
74LS165	£0.48
74LS173	£0.24
74LS174	£0.24
74LS175	£0.24
74LS190	£0.60
74LS191	£0.24
74LS192	£0.60
74LS193	£0.24
74LS195	£0.24
74LS196	£0.24
74LS221	£0.41
74LS240	£0.32
74LS241	£0.32
74LS243	£0.30
74LS244	£0.32
74LS245	£0.36
74LS247	£0.32
74LS251	£0.24
74LS257	£0.24
74LS258	£0.24
74LS259	£0.45
74LS266	£0.14
74LS273	£0.32
74LS279	£0.24
74LS365	£0.21
74LS367	£0.21
74LS368	£0.21
74LS373	£0.33
74LS374	£0.34
74LS378	£0.20
74LS390	£0.24
74LS393	£0.33
74LS395	£0.26

Linear ICs

AD524AD	£23.04
AD548JN	£2.48
AD590JH	£5.28
AD592AN	£4.48
AD595AQ	£12.65
AD620AN	£9.88
AD625JN	£16.20
AD633JN	£7.54
AD648JN	£2.57
AD654JN	£7.18
AD708JN	£5.69
AD711JN	£1.46
AD712JN	£2.38
AD736JN	£8.75
AD797AN	£8.69
AD811N	£6.24
AD812AN	£6.32
AD817AN	£3.85
AD820AN	£3.41
AD822AN	£5.20
AD829JN	£6.41
AD830AN	£5.44
AD847JN	£5.95
AD9696KN	£7.73
ADEL2020A	£5.06
ADM222AH	£3.55
ADM232AA	£3.55
ADM485JN	£2.97
ADM690AN	£5.13
ADM691AN	£6.48
ADM695AN	£6.48
ADM699AN	£3.58
CA741CE	£0.24
CA747CE	£0.39
CA3046	£0.42
CA3059	£1.33
CA3080E	£0.73
CA3130E	£0.87
CA3140E	£0.52
CA3189E	£1.26
CA3240E	£1.00
DG211CJ	£1.55
DG212CJ	£1.55
DG411DJ	£2.00
ICL7106CPL	£2.80
ICL7107CPL	£2.00
ICL7109CLP	£8.99
ICL7611DCP	£0.75
ICL7621	£0.96
ICL7660SCP	£0.86
ICL8038	£3.84
ICM7555	£0.38
ICM7556	£0.84
L165V	£2.72
L272M	£1.84
L293E	£3.84
L297	£6.72
L298N	£6.67
L6219	£4.48
LF347N	£0.46
LF351N	£0.45
LF353N	£0.40
LF356	£0.84
LM301AN	£0.40
LM308N	£0.58
LM311N8	£0.25
LM318	£0.98
LM319N14	£0.90
LM324	£0.26
LM335Z	£0.97
LM339N	£0.26
LM348N	£0.31
LM358N	£0.29
LM380N	£0.88
LM381N	£2.64
LM386	£0.45
LM392N	£0.79
LM393N	£0.21
LM748CN8	£0.37
LM1881	£3.92
LM2917N8	£3.10
LM3900N	£0.72
LM3909N	£1.18
LM3914	£2.16
LM3915	£2.70
LM13600	£1.12
LMC660CN	£1.44
LMC6032IN	£1.55
LP311N	£0.74
LP324N	£0.75
LP339N	£0.75
LT1013CN8	£4.64
MAX202CPE	£2.97
MAX208CN	£6.99
MAX220CPE	£5.06
MAX222CPE	£5.06
MAX232CPE	£1.80
MAX483CP	£3.13
MAX485CP	£2.08
MAX631ACP	£4.99
MAX635ACP	£4.99
MAX1232CP	£2.80
MC1458N	£0.27
MC1488	£0.40
MC1489	£0.40
MC3302	£0.56
MC3340P	£1.60
MC4558P	£0.33
MV601DP	£2.97
NE521N	£6.39
NE555N	£0.21
NE556N	£0.36
NE565N	£1.94
NE566N	£0.90
NE567N	£0.39
NE571N	£2.72
NE592	£0.62
NE5532N	£0.55
NE5534N	£0.64
NE5539N	£4.35
OP07CN	£0.90
OP27CN	£2.90
OP77GP	£1.99
OP90GP	£3.11
OP97FP	£2.43
OP113GP	£3.44
OP176GP	£2.09
OP177GP	£1.89
OP200GP	£5.60
OP213FP	£5.20
OP275GP	£2.57
OP282GP	£2.27
OP283GP	£5.20
OP290GP	£5.40
OP297GP	£5.74
OP400GP	£11.81
OP495GP	£8.69
RC4136	£1.00
SAA1027	£4.40
SG3524N	£0.96
SG3543	£6.88
SSM2017P	£3.12
SSM2131P	£4.19
SSM2141P	£3.63
SSM2142P	£6.16
SSM2143P	£3.78
TBA120S	£0.90
TBA800	£0.75
TBA810S	£0.64
TBA820M	£0.40
TDA1170S	£4.80
TDA2004	£2.88
TDA2030	£1.18
TDA2050V	£2.84
TDA2611A	£1.88
TDA2822A	£0.86
TDA2653A	£2.99
TED3718DP	£5.03
TEA5115	£3.11
TL061CP	£0.35
TL062CP	£0.60
TL064CN	£0.72
TL071CP	£0.38
TL072CN	£0.32
TL074CN	£0.35
TL081	£0.29
TL082CN	£0.35
TL084CN	£0.50
TL494CN	£0.70
TL7705ACP	£0.82
TLC271	£0.68
TLC272	£0.90
TS555CN	£0.34
TMP01FP	£5.60
ULN2003	£0.52
ULN2004A	£0.44
ULN2803	£0.60
ULN2804A	£1.64
XR2206	£3.84

EPROM's

2716	£5.22
2732	£5.51
2764-200	£3.99
27C64-250	£2.88
27128-200	£3.99
27C128-15	£3.02
27256-200	£3.99
27C256-20	£3.68
27C512-150	£2.64
27C1001-15	£3.12
27C2001-15	£4.50
27C4001-120	£5.73

RAM

GM76C88	£3.60
HM62128.-7	£9.14
HT6116-10	£0.88
U6264ADC7	£1.42
KM62256.-7	£3.20
41256-10	£3.52

A/D Converters Data Acquisition

AD420AN	£25.38
AD557JN	£8.75
AD7528JN	£11.42
AD7545AKN	£14.04
AD7828KN	£20.33
DAC0800	£2.72
ICL7109CPL	£7.75
TLC549IP	£1.76
ZN448E	£7.34

µControllers

AT89C2051	£6.43
12C508-04P	£0.99
16C54A04P	£3.07
16C54JW	£12.48
16C56-04P	£2.05
16C71-04P	£4.88
16C71JW	£17.34
16F84-04P	£3.40

PHONE FOR OTHER DEVICES

Voltage Regulators

7805	£0.31
7806	£0.32
7808	£0.35
7812	£0.38
7815	£0.38
78L05	£0.20
78L06	£0.32
78L08	£0.23
78L12	£0.25
78L15	£0.24
78L24	£0.39
78S05	£0.70
78S12	£0.70
78S15	£0.98
7905	£0.40
7912	£0.38
7915	£0.38
7924	£0.38
79L05	£0.23
79L12	£0.23
79L15	£0.28
79L24	£0.30
ADM666AN	£3.44
L200CV	£1.50
L296	£6.30
L387A	£2.72
LM2940CT5	£0.96
LM317LZ	£0.30
LM317T	£0.43
LM317K	£2.48
LM323K	£2.40
LM334Z	£1.35
LM337T	£0.64
LM338K	£5.52
LM338T	£1.48
LM723	£0.29
LP2950CZ	£2.70
REF01CP	£3.44
REF02CP	£4.66
REF12Z	£1.28
REF195GP	£4.72
REF25Z	£1.24
REF50Z	£1.20
TL431CP	£0.20
ZN423	£0.82
ZN4588	£1.41

Diodes

1N914	£0.06
1N916	£0.05
1N4001	£0.04
1N4002	£0.04
1N4003	£0.04
1N4004	£0.04
1N4005	£0.04
1N4006	£0.04
1N4007	£0.05
1N4148	£0.04
1N4149	£0.07
1N5400	£0.09
1N5401	£0.08
1N5402	£0.08
1N5404	£0.09
1N5406	£0.10
1N5407	£0.10
1N5408	£0.11
6A05	£0.27
6A1	£0.27
6A2	£0.27
6A4	£0.28
6A6	£0.29
6A8	£0.30
6A10	£0.35
BA157	£0.10
BA158	£0.10
BA159	£0.14
BAT41	£0.12
BAT42	£0.10
BAT46	£0.20
BAT49	£0.36
BAT85	£0.15
BAV21	£0.07
BAW62	£0.07
BAX13	£0.05
BAX16	£0.05
BB405B	£0.26
BB909A	£0.28
BB909B	£0.36
BY126	£0.13
BY127	£0.18
BY133	£0.10
OA47	£0.44
OA90	£0.11
OA91	£0.26
OA200	£0.56
OA202	£0.30
Zeners 2.7 to 33V 500mW	£0.06
1.3W	£0.10

Bridge Rectifiers

1.5A 50V	£0.19
1.5A 200V	£0.20
1.5A 400V	£0.22
1.5A 600V	£0.22
1.5A 800V	£0.27
1.5A 1kV	£0.24
3A 200V	£0.36
3A 400V	£0.40
3A 600V	£0.33
6A 200V	£0.70
6A 800V	£0.59
10A 400V	£1.39
25A 200V	£1.54
25A 600V	£1.81

Thyristors

C106D	£0.30
PO102AA	£0.30
TIC116D	£0.66
TIC126D	£0.77

Triacs

ZO105DA	£0.42
TIC206D	£0.55
TIC226D	£0.94
BTA08-6008	£0.88
TIC236D	£1.12

Diac, Si. Switch

DB3 32V	£0.16
BRY39	£1.30

Transistors

2N1613	£0.31
2N1711	£0.26
2N1893	£0.29
2N2218A	£0.28
2N2219A	£0.24
2N2222A	£0.19
2N2646	£1.06
2N2904A	£0.25
2N2905A	£0.25
2N2907A	£0.19
2N3053	£0.27
2N3054	£0.85
2N3055	£0.58
2N3439	£0.62
2N3440	£0.50
2N3702	£0.09
2N3703	£0.10
2N3704	£0.11
2N3705	£0.10
2N3706	£0.10
2N3771	£1.44
2N3772	£1.51
2N3773	£1.70
2N3819	£0.34
2N3820	£0.66
2N3904	£0.09
2N3905	£0.11
2N3906	£0.10
2N4036	£0.34
2N5245	£0.80
2N5296	£0.57
2N5401	£0.12
2N5460	£0.54
2N5551	£0.11
2N6107	£0.60
2N6491	£1.58
2SB548	£0.30
2SD1730	£1.44
AC126	£0.44
AC127	£0.50
AC128	£0.72
AC187	£0.68
AC188	£0.96
ACY17	£3.84
AD149	£1.67
AD161	£0.92
AD162	£0.92
BC107	£0.16
BC107B	£0.17
BC108	£0.14
BC108B	£0.16
BC108C	£0.15
BC109	£0.17
BC109C	£0.17
BC114	£0.19
BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.34
BC143	£0.38
BC154	£0.36
BC157	£0.12
BC159	£0.17
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.16
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.18
BC182	£0.10
BC182A	£0.11
BC182B	£0.12
BC182L	£0.09
BC183	£0.10
BC183L	£0.08
BC183LB	£0.08
BC184	£0.10
BC184L	£0.10
BC204C	£0.72
BC206B	£0.72
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213B	£0.10
BC213LC	£0.08
BC214	£0.08
BC214L	£0.10
BC225	£0.15
BC237B	£0.09
BC238B	£0.11
BC239C	£0.10
BC250A	£0.15
BC252	£0.13
BC261B	£0.30
BC262B	£0.24
BC267B	£0.30
BC307	£0.10
BC308	£0.10
BC319C	£0.10
BC327	£0.13
BC328	£0.10
BC328-16	£0.10
BC337	£0.10
BC337-25	£0.10
BC338	£0.10
BC338-25	£0.10
BC348B	£0.14
BC357	£0.25
BC393	£0.73
BC441	£0.40
BC461	£0.46
BC463	£0.29
BC478	£0.32
BC479	£0.32
BC516	£0.21
BC517	£0.17
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546B	£0.08
BC546C	£0.08
BC547A	£0.09
BC547B	£0.09
BC547C	£0.09
BC548C	£0.08
BC549C	£0.10
BC550C	£0.09
BC556A	£0.08
BC557B	£0.09
BC557C	£0.08
BC558B	£0.09
BC559B	£0.11
BC560A	£0.09
BC560B	£0.09
BC637	£0.19
BC638	£0.21
BC639	£0.21
BC640	£0.13
BCY70	£0.22
BCY71	£0.20
BCY72	£0.20
BD124P	£6.86
BD131	£0.52
BD135	£0.21
BD136	£0.21
BD137	£0.23
BD138	£0.24
BD139	£0.25
BD140	£0.25
BD150C	£0.82
BD165	£0.42
BD166	£0.35
BD187	£0.39
BD201	£0.40
BD202	£0.70
BD204	£0.40
BD225	£0.42
BD232	£0.50
BD237	£0.32
BD238	£0.44
BD240C	£0.37
BD244A	£0.53
BD245C	£1.18
BD246	£1.18
BD246C	£1.18
BD283	£0.61
BD284	£0.61
BD400	£0.79
BD442	£0.37
BD534	£0.47
BD535	£0.50
BD536	£0.65
BD581	£0.62
BD597	£0.92
BD646	£0.52
BD648	£0.52
BD650	£0.53
BD807	£0.80
BDX32	£1.78
BDX33C	£0.56
BDX34C	£0.50
BDX53C	£0.47
BDX54C	£0.50
BF180	£0.31
BF182	£0.31
BF185	£0.58
BF194	£0.31
BF194B	£0.19
BF195	£0.14
BF244	£0.35
BF244B	£0.35
BF244C	£0.35
BF257	£0.33
BF259	£0.33
BF337	£0.40
BF355	£0.38
BF423	£0.13
BF451	£0.19
BF459	£0.33
BF469	£0.36
BFX29	£0.29
BFX84	£0.31
BFX85	£0.32
BFY50	£0.30
BFY51	£0.24
BFY52	£0.28
BS107	£0.21
BS170	£0.23
BSW66	£1.35
BU126	£1.32
BU205	£1.41
BU208A	£1.24
BU326A	£1.40
BU500	£1.54
BU508A	£1.30
BU508D	£0.98
BU526	£1.74
BU806	£1.06
BUT11A	£0.57
BUT11AF	£1.14
BUX84	£0.78
IRF530	£0.48
IRF540	£1.26
IRF740	£1.88
MJ2501	£1.60
MJ3001	£1.80
MJ11015	£2.45
MJ11016	£2.56
MJE340	£0.40
MJE350	£0.48
MPSA05	£0.14
MPSA06	£0.11
MPSA13	£0.13
MPSA42	£0.15
MRF475	£7.28
TIP29A	£0.32
TIP29C	£0.30
TIP30A	£0.47
TIP30C	£0.37
TIP31A	£0.27
TIP31C	£0.41
TIP32A	£0.26
TIP32C	£0.26
TIP33C	£0.74
TIP41A	£0.38
TIP41C	£0.32
TIP42A	£0.32
TIP42C	£0.39
TIP50	£0.31
TIP110	£0.28
TIP120	£0.28
TIP121	£0.34
TIP122	£0.41
TIP125	£0.33
TIP126	£0.28
TIP127	£0.40
TIP132	£0.68
TIP137	£0.64
TIP141	£0.93
TIP142	£1.10
TIP147	£1.12
TIP2955	£0.74
TIP3055	£0.72
VN10KM	£0.44
ZTX300	£0.15
ZTX500	£0.16
ZTX653	£0.33

FREE Catalogue, send A4 SAE (66p stamps) or with any order when requested

Electrolytic Radial / Electrolytic Axial

µF	Radial 16v	Radial 25v	Radial 40v	Radial 63v	Radial 100v	Axial 16v	Axial 25v	Axial 40v	Axial 63v	Axial 100v	Axial 250v	Axial 450v
0.47	---	---	---	£0.05	---	---	---	---	---	---	---	---
1.0	---	---	---	£0.05	£0.05	---	---	---	£0.13	---	---	£0.22
2.2	---	---	---	£0.05	---	---	---	---	£0.13	---	---	£0.30
4.7	---	---	£0.05	£0.05	£0.05	---	---	---	£0.13	---	---	£0.41
10	£0.05	£0.05	£0.05	£0.05	£0.09	£0.12	---	£0.12	£0.13	£0.17	£0.40	£0.67
22	£0.05	£0.05	£0.05	£0.07	£0.11	£0.12	£0.13	£0.14	£0.15	£0.21	£0.52	£1.06
33	£0.05	---	£0.05	---	---	---	---	---	---	---	---	---
47	£0.05	£0.05	£0.08	£0.10	£0.19	£0.13	£0.13	£0.15	£0.19	£0.32	£0.57	---
100	£0.07	£0.06	£0.10	£0.13	£0.26	£0.14	£0.16	£0.19	£0.26	£0.44	---	---
220	£0.09	£0.09	£0.13	£0.28	---	£0.19	£0.20	£0.27	£0.39	£0.48	---	---
330	£0.09	---	£0.19	---	---	---	---	---	---	---	---	---
470	£0.13	£0.17	£0.24	£0.33	---	£0.24	£0.28	£0.43	£0.53	---	---	---
1000	£0.21	£0.33	£0.34	£0.75	---	£0.33	£0.43	£0.59	£1.08	---	---	---
2200	£0.27	£0.55	£0.70	---	---	£0.53	£0.66	£1.18	£1.55	---	---	---
3300	---	£0.94	---	---	---	---	---	---	---	---	---	---
4700	£0.67	£1.05	---	---	---	£0.86	£1.11	---	---	---	---	---

We carry a large range of capacitors in stock, including: Ceramic Mini Disc, Dipped Ceramic Multilayer, Dipped & Boxed Polyester, Mylar Film, Polystyrene, MKT Polyester, Tantalum Bead, Sub-miniature Radial, 105°C Radial, Low Leakage Radial, Non Polarised Radial, PCB Can Electrolytics, Polypropylene & Ceramic Trimmers and Tuning, Dilecan & O Type Variable capacitors. Full technical details available.

Resistors - Please State Value Required (per 100 of one value only)

1/8W Carbon Film 5%	E12 Series	10Ω-1M0	£0.02 Each, £0.80 per 100
¼W Carbon Film 5%	E12 Series	1Ω-10M	£0.02 Each, £0.60 per 100
¼W Metal Film 1%	E24 Series	10Ω-1M	£0.04 Each, £1.72 per 100
½W Carbon Film 5%	E12 Series	1Ω-10M	£0.02 Each, £0.95 per 100
2.5W Wirewound 5%	E12 Series	0Ω1-220Ω	£0.23 Each

1W & 2W Carbon Film in stock - selected values only, contact sales dept. for details.

Preset Resistors - Please State Value Required

Enclosed, 10mm Square Horz / Vert.	100Ω - 1M0 0.15W	£0.15 Each
Skeleton, 10mm Dia. Horizontal.	100Ω - 1M0 0.1W	£0.11 Each
Sub-min, 6mm Dia, Horizontal	E3 200Ω-1M0 0.1W	£0.13 Each
Multiturn, 10mm Square, Top Adjust.	E3 100Ω-1M0 0.5W	£0.89 Each
Multiturn, 19mm Long, End Adjust.	E3 50Ω-1M0 0.5W	£0.60 Each

Potentiometers - Please State Value Required

Single Gang ¼" Shaft, 25mm Dia.	470Ω-2M2 Linear	£0.49 Each
Single Gang ¼" Shaft, 25mm Dia.	4k7,10k,47k,100k,1M,2M2 Log	£0.49 Each
Dual Gang ¼" Shaft, 20mm Dia.	1k0-2M2 Linear	£1.65 Each
Dual Gang ¼" Shaft, 20mm Dia.	10k-1M0 Logarithmic	£1.68 Each
Switched ¼" Shaft, 20mm Dia.	1k0-2M2 Linear	£1.86 Each
Switched ¼" Shaft, 20mm Dia.	4k7-2M2 Logarithmic	£1.86 Each
PCB Mount, Splined Shaft, 16mm Dia.	470Ω-1M0 Linear	£0.42 Each
PCB Mount, Splined Shaft, 16mm Dia.	470Ω,4k7,100k,1M0 Log	£0.42 Each
Dual PCB, Splined Shaft, 16mm Dia.	10k,50k100k,500k Lin	£0.85 Each
Dual PCB, Splined Shaft, 16mm Dia.	10k,50k,100k,500k Log	£0.85 Each

Tel: 0191 2514363 Fax: 0191 2522296 Email: sales@esr.co.uk http: //www.esr.co.uk

EVERYDAY PRACTICAL ELECTRONICS

ETI ELECTRONICS TODAY INTERNATIONAL

VOL. 28 No. 10 OCTOBER 1999

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS/ETI EDITORIAL
ALLEN HOUSE, EAST BOROUGH, WIMBORNE
DORSET BH21 1PF
Phone: Wimborne (01202) 881749
Fax: (01202) 841692. **Due to the cost we cannot reply to overseas orders or queries by Fax.**
E-mail: editorial@epemag.wimborne.co.uk
Web Site: http://www.epemag.wimborne.co.uk
See notes on Readers' Enquiries below – we regret lengthy technical enquiries cannot be answered over the telephone.
Advertisement Offices:
EVERYDAY PRACTICAL ELECTRONICS/ETI ADVERTISEMENTS
MILL LODGE, MILL LANE
THORPE-LE-SOKEN, ESSEX CO16 0ED
Phone/Fax: (01255) 861161

WORRY

It's amazing what you have to consider in this job. For instance, we spent quite some time thinking, altering and worrying about this month's cover. Most people will wonder why but a few will see it straight away and, no doubt, take us to task; hopefully we have done enough to pacify t hem.

What is he babbling on about? Sexism, that's the problem.

You see, the concept of this month's cover was to illustrate the workings of a microprocessor. We thought that if we showed some "robots" pulling levers as the workings inside the chip it would be quite interesting. I think you will agree that Jonathan has come up with an unusual and artistic design. however, when we first saw it we were worried that all the "operators" were obviously of the female gender and some would see that as sexist, so we decided to make sure both male and female androids were shown. Personally, I know which I prefer – oh dear, now I'm treading on dodgy ground.

Someone also suggested they should be clothed but it's not the nudity of the androids that worried us, after all androids don't need clothes do they? Come to that they don't need gender either; perhaps they should have sexlessness?

INTELLIGENT SLAVES

We could, of course, have argued that female androids had been chosen for their higher level of intelligence, but some would say they depicted female androids as slaves – whatever argument we use it's still sexist. Best to steer well clear of such arguments, particularly in an electronics magazine. We always find it hard to win arguments with androids anyway, they're so logical.

Anyway, inside your microcontroller are thousands of intelligent "beings" (we only have room to show a handful) pulling levers to make decisions that are interpreted into binary data that's sent to the connection pins that connect to the outside world – or that's what we would have you believe. If you do want to understand more about using microcontrollers, please read John's *Mini Tutorial* on the new PIC16F87x this month.

All (non sexist) comments on our covers will be of interest.

Mike Kenward

Editor: MIKE KENWARD
Secretary: PAM BROWN
Deputy Editor: DAVID BARRINGTON
Technical Editor: JOHN BECKER
On-Line Editor: ALAN WINSTANLEY
Business Manager: DAVID J. LEAVER
Subscriptions: MARILYN GOLDBERG
Editorial: Wimborne (01202) 881749
Advertisement Manager:
PETER J. MEW, Frinton (01255) 861161
Advertisement Copy Controller:
PETER SHERIDAN, Wimborne (01202) 882299

READERS' ENQUIRIES

E-mail: techdept@epemag.wimborne.co.uk

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

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.

COMPONENT SUPPLIES

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

ADVERTISEMENTS

E-mail: adverts@epemag.wimborne.co.uk

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

The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture. Legal remedies are available in respect of some of these circumstances, and readers who have complaints should first address them to the advertiser.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

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

AVAILABILITY

Copies of *EPE/ETI* are available on subscription anywhere in the world (see right), from all UK newsagents (distributed by Comag and from the following electronic component retailers: Omni Electronics and Maplin in S. Africa. *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased from **www.epemag.com**

SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £26.50. Overseas: £32.50 standard air service, £50 express airmail. Cheques or bank drafts (in **£ sterling only**) payable to Everyday Practical Electronics and sent to EPE Sub. Dept., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Fax: 01202 841692. **E-mail:** subs@epemag.wimborne.co.uk. Also via the Web at: http://www.epemag.wimborne.co.uk. Subscriptions start with the next available issue. We accept MasterCard or Visa. (For past issues see the *Back Issues* page.)

BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £5.95 plus £3.50 p&p (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas.*

Payment in £ sterling only please. Visa and MasterCard accepted, minimum credit card order £5. Send, fax or phone your card number and card expiry date with your name, address etc. Or order on our secure server via our web site. Overseas customers – your credit card will be charged by the card provider in your local currency at the existing exchange rate.

Constructional Project

INTERIOR LAMP DELAY

STEVE CHALLIS

Add a touch of luxury and practicality to your vehicle. Also provides lights on warning and battery saving.

IT'S a sad fact that you often don't appreciate something until you no longer have it! This was driven home recently to the author when he acquired a "new" car. The first dark evening he jumped in and shut the door, and was plunged into total darkness. The mere 12-second delay fitted to the previous vehicle was ample to settle in and drive away. It was then decided that some form of interior lamp delay was a must.

There have been plenty of past articles showing potentially usable circuits based around chips such as the ubiquitous 555. Whilst perfectly functional, these circuits are limited in additional features. In this design, full advantage is made of a PIC16x84 to provide features that would have required a large amount of logic not so long ago.

The basic operational features are as shown in Table 1.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Interior Lamp Delay is shown in Fig.1. The vehicle 12V battery supply is fed through diode D1 to the voltage regulator IC1, which supplies +5V for PIC microcontroller IC2. The diode is included to provide protection against reverse supply connection. Capacitors C1, C2 and C3 provide supply decoupling for the regulator.

Because IC2 runs at 5V, each of its inputs needs to be conditioned prior to application. In the case of the door switch input this is effected by resistors R8 and R9, capacitor C6 and diode D3. Resistors R8 and R9 form a potential divider, which reduces the input voltage by half. For a supply voltage of 13·8V this would give 6·9V.

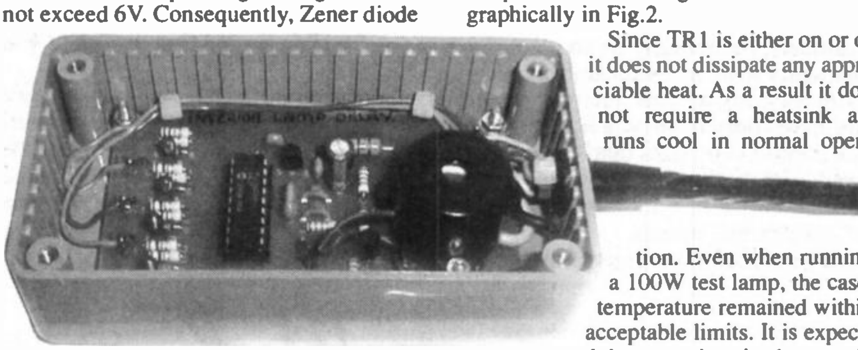
This is still too high for IC2, whose recommended operating voltage should not exceed 6V. Consequently, Zener diode D3 is included to limit the voltage to 5·1V. Some of you might wonder why the potential divider should not be arranged to give the correct voltage without the use of a Zener diode. Well, the supply voltage in a motor vehicle can vary over a large range, from typically 9V whilst cranking, to just over 14·5V when charging with a minimal load.

Table 1. Operational Features.

Unlock the vehicle	Interior lights on for 30 seconds then fade off.
Lock the vehicle	Interior lamps directly off.
Open the door	Interior lamps directly on.
Close the door (ignition off)	Interior lamps fade off after 30 seconds.
Close the door (ignition on)	Interior lamp delay function cancelled but lamps fade off.
Side lamps on	If the ignition is turned from on to off with the lights on (or having been on within the last 10 seconds) then the interior lamp will fade on and remain illuminated for up to 30 seconds before fading off again. If the ignition is turned on during the 30-second period then the interi or lamps will fade off.
Battery saver	If the doors are left open for more than five minutes the interior lamps are switched off to reduce battery drain.
Lights on warning	If a door is opened with the side lamps on and the ignition off then an audible warning is activated for 10 seconds.

Thus the potential divider configuration used here is arranged to give the correct logic level inputs under most conditions. Capacitor C6 is included to filter out any unwanted noise. The same circuit arrangement is used on the other three inputs.

The vehicle's interior lamp is controlled by the PIC through the network around transistors TR1 to TR3. To provide a dimming feature, pulse width modulation is employed. Power-f.e.t. TR1 is switched on/off at a high frequency. The on/off ratio affects the average power delivered to the lamp and hence its brightness, as illustrated graphically in Fig.2.



Since TR1 is either on or off it does not dissipate any appreciable heat. As a result it does not require a heatsink and runs cool in normal operation. Even when running a 100W test lamp, the case temperature remained within acceptable limits. It is expected that most interior lamps will be around 10W to 20W!

In order to turn TR1 hard on, a voltage of around 12V is needed at its gate terminal. Transistors TR2 and TR3 convert a logic 1 output at IC2 pin RB7 from 5V to 12V. With RB7 at 0V, TR2 and TR3 are turned off. When RB7 goes high (5V) current flows via R7 into the base of TR3.

Transistor TR3 then conducts, drawing current via R2 and R3, the resulting voltage drop at their junction causes TR2 to turn on. The collector potential of TR2 then rises to 12V and this is applied via R6 to the gate of TR1 causing it to conduct. The drain to source resistance of TR1 falls to a low value and the interior lamp illuminates.

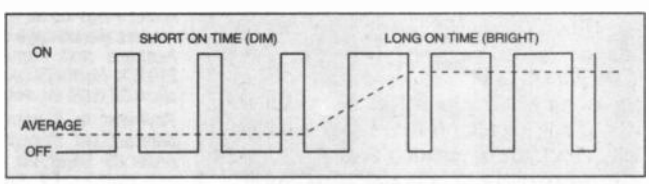


Fig.2. Pulse width modulation varies the average power/brightness of the lamp, as represented by the dotted line.

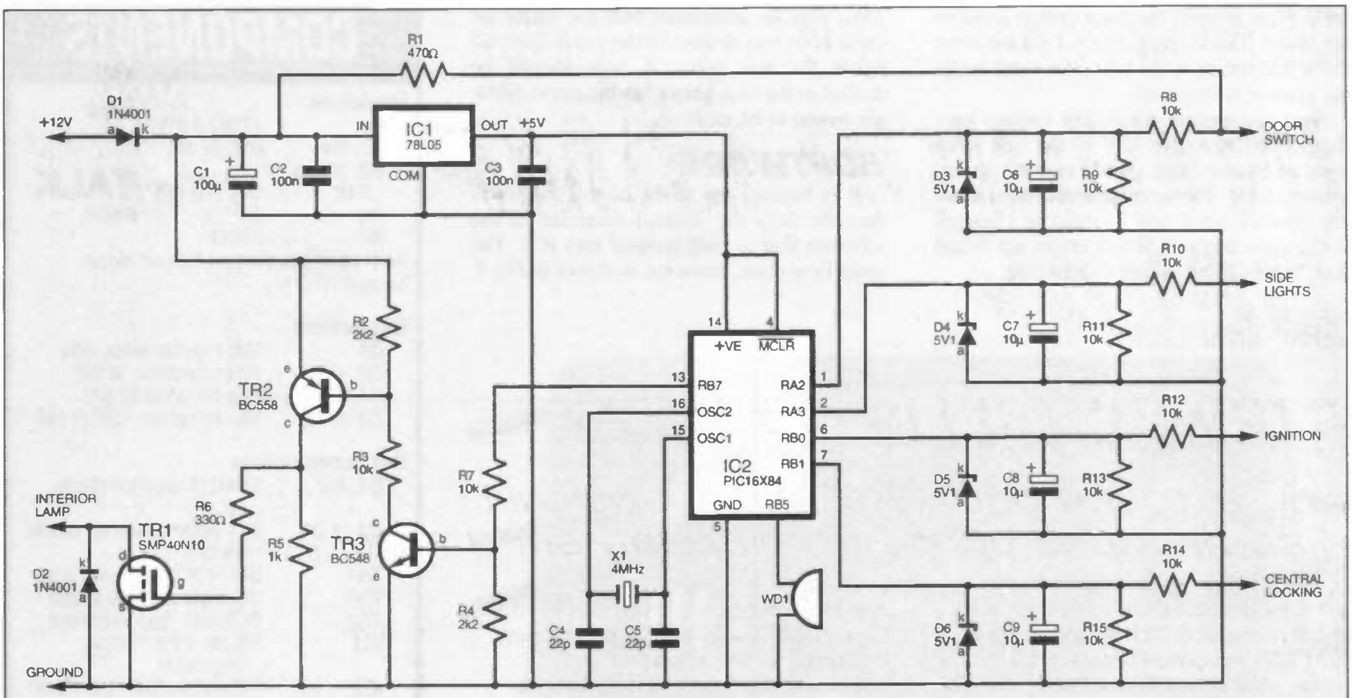


Fig.1. Complete circuit diagram for the Interior Lamp Delay.

When the RB7 output of IC2 goes to 0V, TR3 switches off, as do TR2 and TR1, and so current no longer flows in the interior lamp.

Resistor R1 is fitted to provide a "pull-up" voltage from the 12V power supply for the door switch input.

During periods of full brightness, the RB7 output of IC2 has to remain at 5V. When dimming is required a pulse-width modulated signal is generated and the On time is gradually reduced until the interior lamp is off. Diode D2 is included to prevent any reverse voltage spikes entering TR1.

Resonator X1, in conjunction with capacitors C4 and C5, forms the 4MHz oscillator needed by IC2.

An audible alarm facility has been included in the form of WD1. This is connected directly to IC2 pin RB5, which pulses the buzzer when the vehicle lights are inadvertently left on.

CONSTRUCTION AND TESTING

The components for the Interior Lamp Delay are mounted on a single-sided printed circuit board (p.c.b.), whose details are shown in Fig.3. This board is available from the *EPE PCB Service*, code 244.

Begin construction by using the board as a template to drill the equivalent mounting holes in the suggested case.

Solder the components into the board observing their correct orientation, where appropriate, and using a socket for IC2. Do not insert IC2 yet. Once all the components have been fitted, carefully check the board for solder splashes and other signs of bad soldering. A current-limited power supply (if available) set to 12V should now be connected to the board.

With a multimeter check that the 5V supply is correct at pin 14 of the socket for IC2. If not, switch off the supply and carefully check the orientation of IC1.

It is necessary to next check each of the used inputs to IC2, namely socket pins 1, 2, 6 and 7 (RA2, RA3, RB0 and RB1). The voltage reading at pin 1 should be about

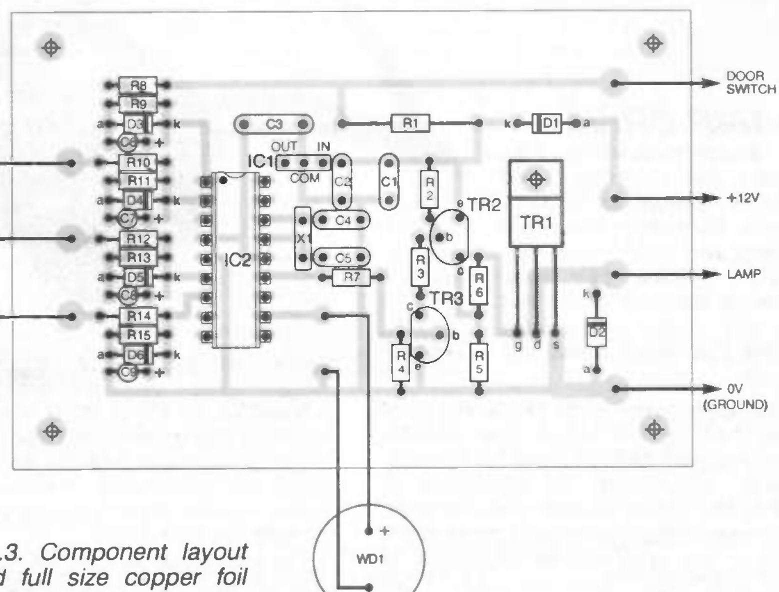
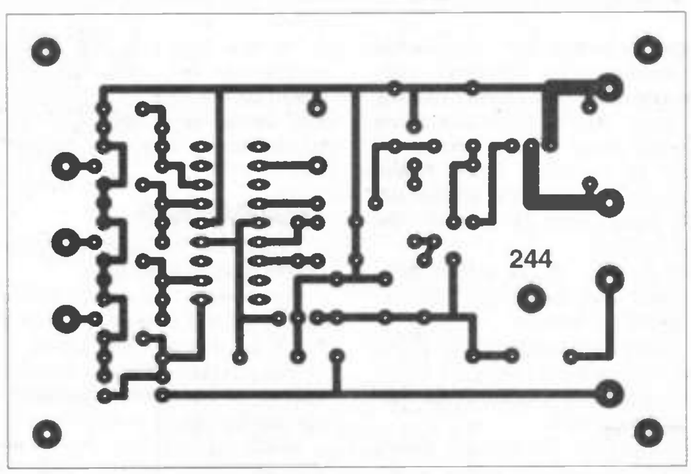


Fig.3. Component layout and full size copper foil track pattern for the Interior Lamp Delay.



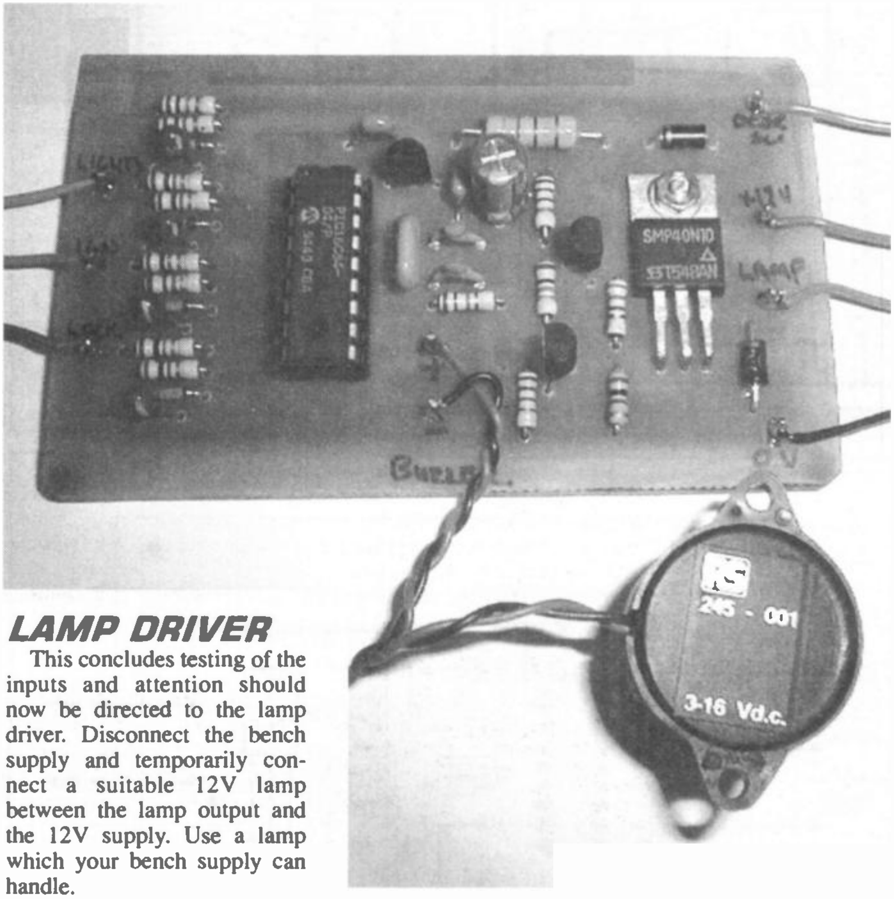
5·1V. Now ground the door switch input to the board. The reading at pin 1 should drop to 0V and return to the previous value when the ground is removed.

Next move on to pin 2. The voltage here should be 0V. Apply 12V to the side lamp input and the voltage should rise to approximately 5·1V. The ignition and central locking inputs (pins 6 and 7) must be checked in the same manner. If any errors are found then rectify them before continuing.

TR1, plus an additional bolt for which an extra hole was drilled in the p.c.b. (no pad exists for this hole). A hole should be drilled in the case above the buzzer to allow the sound to be emitted.

SOFTWARE

It is beyond the scope of this article to describe fully the internal operation of the software that is programmed into IC2. The main flow chart, however, is shown in Fig.4.



LAMP DRIVER

This concludes testing of the inputs and attention should now be directed to the lamp driver. Disconnect the bench supply and temporarily connect a suitable 12V lamp between the lamp output and the 12V supply. Use a lamp which your bench supply can handle.

Re-apply power to the board. The lamp should not light. If it does, then carefully check around TR1, TR2 and TR3 for any errors. Also check the orientation of diode D2. Using a small piece of wire, carefully bridge pins 13 and 14 of IC2's socket. The lamp should illuminate. If not, once again, check for errors. If all appears OK disconnect the supply, remove the link, and insert IC2 (which needs to have been pre-programmed, of course).

Again re-apply power. The lamp should remain off. Using another link wire, carefully apply power to the central locking input. The lamp should illuminate when power is applied and go off when removed. There should be no delay. Leave power applied to the lock input. Now ground the door switch input. After 30 seconds, the lamp should fade off.

The main features of the circuit have now been tested. Full functional tests can be carried out on the vehicle.

Remove power from the board and finish construction by attaching the board to the case and fitting suitable lengths of the correct gauge insulated wire.

The accompanying photograph shows how the author attached the buzzer to the p.c.b., making use of the mounting bolt for

Basically, the PWM signal is generated by an interrupt routine. The value passed to it (BULB) controls whether the lamp is turned on, faded on/off, or turned off. A second variable (BUZZ) is used to control the lights-on buzzer WD1.

The source code was written in C and is fully commented. It was compiled using the excellent Custom Computer Services PCM compiler. Their web site is at **http://www.ccsinfo.com** and is well worth a visit.

All the files for the software, both source and hex code, are obtainable as stated on the *EPE PCB Service* page. The PIC should be initialised for HS oscillator, power-up timer on, watchdog timer on.

WARNING

Please read the following notes carefully before installing the unit.

A car battery can deliver a very high current. This will almost certainly result in a fire if not treated with caution. In addition to this, modern vehicles are fitted with a variety of electronic modules. A wrong connection can be costly!

When tapping into supply wires (permanent supply, ignition, side lamps, central locking) it is advisable to connect a

COMPONENTS

Resistors — See SHOP TALK page

R1	470Ω 0·5W
R2, R4	2k2 (2 off)
R3, R7 to R15	10k (10 off)
R5	1k
R6	330Ω

All 0·25W 5% carbon film or better, except R1.

Capacitors

C1	100μ radial elect. 35v
C2, C3	100n ceramic (2 off)
C4, C5	22p ceramic (2 off)
C6 to C9	10μ tantalum 10V (4 off)

Semiconductors

D1, D2	1N4001 rectifier diode (2 off)
D3 to D6	5V1 400mW Zener diode (4 off)
TR1	SMP40N10 power f.e.t.
TR2	BC558B *pnp* transistor
TR3	BC548B *npn* transistor
IC1	78L05 +5V 100mA regulator
IC2	PIC16C84/04P (or 'F84) microcontroller (preprogrammed)

Miscellaneous

WD1	buzzer, low current, 3V to 16V
X1	4MHz ceramic resonator

Printed circuit board, available from the *EPE PCB Service*, code 244; 18-pin d.i.l. socket; terminal pins (9 off); plastic case to suit; cable ties; cable connectors (see text); connecting wire; solder, etc.

Approx. Cost Guidance Only £24

low value fuse as close as practical to the tapping point. This will protect your additional wiring should a fault occur. The author used 20mm 1A fuses in suitable holders. These are available from accessory shops.

Another item that requires respect is the Airbag. If your vehicle is fitted with one of these devices then it is advisable to disconnect the vehicle battery and wait for at least 10 minutes before attempting to fit any electrical accessory. Finally, if you have a coded radio please make sure you know the security code before disconnecting the supply!

INSTALLATION

Do not be tempted to use the "scotch lock" type of connectors. These are great for temporary use but could cause trouble at a later date. If possible solder all connections. If you are unsure at all then enlist the help of a competent friend. It's better to be safe than have to walk!

Choose a location for the unit where you will be able to hear the buzzer, but away from heat and moisture. Nylon cable ties are excellent for mounting the completed unit.

You will need to locate the wire that connects between the interior lamp and the door switch. Cut into this wire and connect the wires from the unit as indicated schematically in Fig.5. Connect the remaining wires and secure neatly. Ensure that the wires are not resting against any

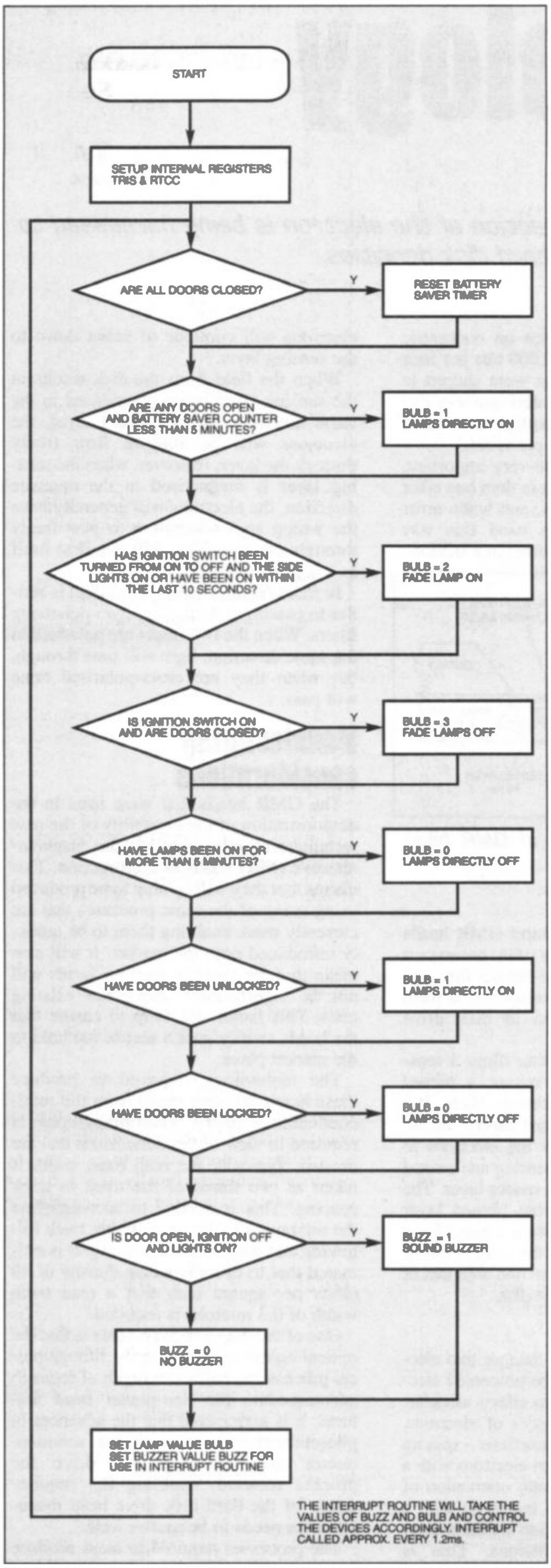


Fig.4. Software flow-chart.

Photo: Interior view of the assembled printed circuit board mounted inside its plastic case. Note that the buzzer is bolted to the board.

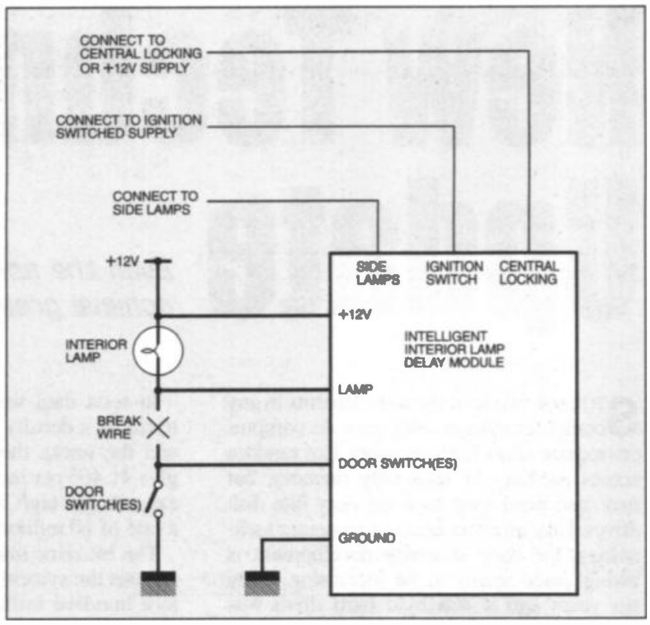


Fig.5. Schematic representation of the connections between the p.c.b. and the car's utilities.

sharp edges or in danger of becoming trapped in any moving object.

The central locking input must be connected to a wire that is at 12V when the doors are unlocked. If your vehicle is not fitted with central locking or a suitable wire cannot be found then connect this wire to the permanent supply. If it is grounded or left open circuit the unit will not function.

When completed, reconnect the vehicle battery and continue testing the unit.

FINAL TESTING

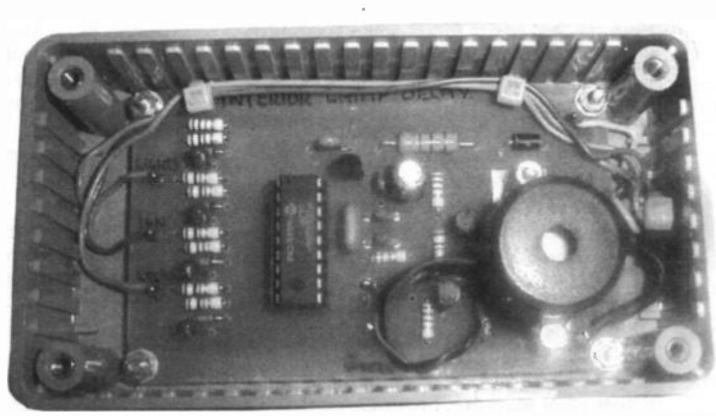
Sit in the vehicle and close the door. After 30 seconds the interior lamp should fade off. Open the door and the interior lamp should illuminate. The interior lamp will remain illuminated for as long as the door is open (up to five minutes). Now switch on the ignition. When the door is closed the interior lamp should fade off after a delay of about two seconds.

Switch off the ignition. The interior lamp should remain off. Turn on the side lights. Now switch the ignition on then off. The interior lamp should fade on. Turn on the ignition. The interior lamp (if still on) should fade off. Finally switch off the ignition and open the door. The lights-on buzzer should now activate for 10 seconds or until the door is closed or the lights turned off.

If you feel patient, the battery saving function can now be tested. Leave the door open. After about five minutes the interior lamps should extinguish. To re-enable the lamps close the door and re-open it.

Finally, if the central locking input has been connected, switch off the lights, ignition, and close the door. Lock the vehicle. The interior lamp should extinguish immediately. When the vehicle is unlocked the interior lamp should illuminate immediately and remain illuminated for up to 30 seconds.

Now wait for it to get dark and reap the benefits. □



New Technology Update

Even the spin direction of the electron is being harnessed to achieve greater hard disk densities.

STORAGE is one of the key elements in any computer system. Not only do computers require short term memory like random access memory or read only memory, but they also need long term memory like disk drives. Like all other areas of computer technology, the pace at which development is taking place seems to be increasing. Only ten years ago a 40Mbyte hard drive was large. Now most computers sold in the High Street today come with drives that have storage capacities of a few Gigabytes. The access time of the drives is also much shorter despite their greatly increased capacities.

To give an indication of the staggering improvements that have been made in the technology, industry reports indicate that in 1991 the average disk size was only 140Mbytes, whereas the average size in 1999 is just over 7Gbytes. The cost has also fallen dramatically from well over £1000 per Gbyte in 1991 to around £20 per Gbyte in 1999.

New record

In May of this year IBM announced they had set a new world record in hard disk data storage density with a figure of 20 billion bits per square inch. This is more than three times the density of any disk drive that is being manufactured today. It would enable every square inch of disc space to hold two TV quality films, four CD ROMs worth of data, or the text from about 2500 average sized novels.

To achieve this density milestone, significant advances have been made in the development of the heads that read and write the data. In 1999, IBM launched the first magneto-resistive (MR) heads, and since then data density has increased at greater than 60% per year. However, to maintain this trend IBM have further developed this technology in the form of a Giant Magneto-Resistive head (GMR).

One of the problems with increasing the data density is that the space occupied by a single bit becomes smaller and the output from the head is reduced when reading it. Using older technologies the output would fall to the point where noise would cause the data being read to be filled with errors.

The new GMR head is now the most sensitive type of head available for reading magnetic data from disk. In addition to the GMR head required for reading the data, a narrow track thin film inductive write head was used in combination with the associated disk electronics using a system known as Partial Response Maximum Likelihood (PRML) that is used in many drives today. The disk media itself was an integral part of the system and used an ultra-low noise cobalt alloy magnetic material.

In tests data was written on concentric tracks at a density of 490,000 bits per inch and the tracks themselves were spaced to give 41,400 per inch. The data rate was also exceedingly high, being written and read at a rate of 10 million bytes per second.

The bit error rate is also very important. In tests the system gave less than one error in a hundred million bits, and when error correction circuitry was used this was reduced to less than one error in a trillion.

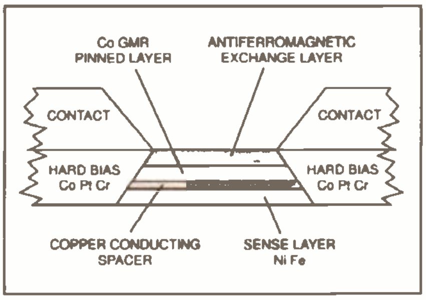


Fig.1. Representation of GMR head construction.

GMR Heads

The basic principle behind GMR heads was discovered at IBM in 1988, however it took another three years before the idea had been sufficiently developed to a form where it could be used in disk drive technology.

The sensors consist of four films: a sensing layer; a conducting spacer; a pinned layer; and finally an exchange layer. The sensing, spacer and pinned layers are all very thin and they allow the electrons to move freely between the sensing and pinned layers via the conductive spacer layer. The magnetic orientation of the pinned layer remains constant, held by the exchange layer that adjoins it. However, the orientation of the sensing layer changes in line with that of the magnetic field from the disk.

Spin Doctor

To turn these magnetic changes into electrical variations that can be processed electronically, the head exploits effects associated with the quantum physics of electrons. Electrons have two spin directions – spin up and spin down. Conduction electrons with a spin parallel to the magnetic orientation of the material move freely, but those with a spin in the opposite direction are hampered, experiencing more collisions. This is exhibited as a high resistance.

In a GMR head, electrons with one spin direction will pass through the pinned layer. Those with the opposite spin direction will not move freely and as a result fewer will pass through the layer. These electrons will continue to move down to the sensing layer.

When the field from the disk results in the sensing layer being magnetised in the same direction as the pinned layer, the electrons will be able to flow freely through the layer. However, when the sensing layer is magnetised in the opposite direction, the electrons will generally have the wrong spin orientation to pass freely through the layer. This will manifest itself as a high resistance.

In more familiar terms, this effect is similar to passing light through two polarising filters. When the two filters are polarised in the same direction, light will pass through, but when they are cross-polarised none will pass.

Manufacturing considerations

The GMR heads that were used in the demonstration of the capability of the new technique closely resemble the magneto-resistive (MR) heads in construction. This means that they will be able to be produced using many of the same processes that are currently used, enabling them to be quickly introduced onto the market. It will also mean that the costs of the new heads will not be significantly above the existing ones. This factor will help to ensure that the heads swiftly gain a secure foothold in the market place.

The technology required to produce these heads borrows much from the semiconductor industry. Photolithography is required in view of the dimensions that are needed. Typically the read track width is taken as two thirds of the track to track spacing. This is needed to accommodate the tolerances in the track width, track following and track to track spacing. It is estimated that to provide a data density of 40 Gbits per square inch that a read track width of 0.3 microns is required.

One of the major requirements is that the optical equipment used in the lithographical process has sufficient depth of focus to accommodate the non-planar head features. It is anticipated that the advances in photolithography required for semiconductor manufacturing will drive the process forward, enabling the requirements of the hard disk drive head manufacturers needs to be met as well.

The processes required to mass-produce heads capable of attaining the record densities is now well advanced, and it is expected that it will be possible to produce these heads by the year 2000. With densities of these values, this type of head is certainly to be the head of the future.

SAVE OVER 60%

QR4 FULL ACCESS JUST £99

(Normal price £249)
Offer ends 31st October 1999
(Price excludes post & packing and VAT)

QR4™

QUICKROUTE

CAD CAM RECOMMENDED

Quickroute Makes it Easy

SPECIFICATION

- Modern user interface with dockable tool bars & active buttons
- Multi-sheet schematic capture at the press of a button.
- Power rail & data bus support
- 32 Bit mixed mode analogue & digital simulation
- Support for a range of SPICE .MODEL statements.
- Copper flood fill
- Netlist import & export
- CAD/CAM file import/export. Gerber Viewer.
- PCB Design with 1-8 layer autorouter
- WMF, DXF, & SPICE file export
- 1000+ Library Symbols
- Engineering Change & Design Checking

FREE DEMO

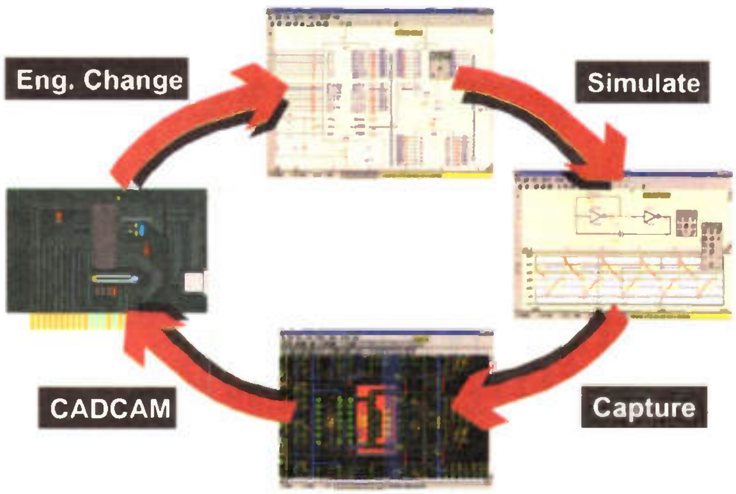
Download a free demonstration version from our web site at http://www.quickroute.co.uk

30 DAY MONEY BACK GUARANTEE

It's not hard to see why Quickroute is so easy to use! We've integrated mixed mode simulation, schematic capture, PCB design with autorouting and CAD-CAM support into one integrated environment. Best of all, prices start at just £99.88 inclusive* for the complete system with support for 300 pins - less than the price of some simulators alone!

Quickroute 4.0 features a modern user interface with active buttons and dockable tool bars. Frequently used tools can appear on floating tool pallettes for quick access, and with tool-tips and on-line help you can be sure of getting information on Quickroute's features fast.

To create a schematic in Quickroute 4.0, simply click on the symbol browser and select and place symbols onto the design area. Use the 'intelligent' wires, power rails and data bus elements to quickly wire up your schematic and simulate the design as required. When completed, simply press a button to capture the schematic, a PCB rats nest will then appear (no messy netlists required!).



Use the multi layer autorouter, and/or manual routing to complete your PCB together with copper fill, etc as required. Finally print your design, or create CADCAM files suitable for manufacture (we even include a Gerber viewer for checking).

But it doesn't end there! Quickroute 4.0 includes engineering change for automatic updating of your PCB from the schematic, netlist import & export so that you can link to other EDA packages (including many simulators), DXF, SPICE, and WMF file export together with over 1000 library symbols.

Call us now and find out why Quickroute 4.0 Makes it Easy!

	Price	UK Inclusive Price*
QR4 300 Pin	£79.00	£99.88
QR4 800 Pin	£149.00	£182.13
QR4 Full	£249.00	£299.63

*Includes UK P&P and VAT. Phone for EC/World prices.
**Design cycle figure shows screen shots from different projects.
Prices & specification subject to change without notice.

FREEphone Ref 411
0800 731 28 24

FAX 0161 476 0505 TEL 0161 476 0202
Quickroute Systems Ltd Regent House
Heaton Lane Stockport SK4 1BS UK

News . . .

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

SOUNDLY DIGITAL

Have analogue amps had their day? Barry Fox finds that Sharp think so.

JAPANESE electronics company Sharp thinks analogue audio amplifiers have had their day, because its new digital amplifier reproduces sound more faithfully, costs less, is smaller and consumes less power.

Conventional amplifiers are analogue, taking in a weak waveform and putting out a more powerful replica to drive loudspeakers. All add spurious noise, so designers have tried amplifiers which boost digital words of shape that describe the waveform. The circuitry is expensive and runs hot. Sharp's researchers in Hiroshima have worked with Professor Yoshio Yamazaki of Waseda University on 1-Bit Delta-Sigma Modulation. This uses a very rapid stream of single bits instead of words.

Sharp chops or "samples" the analogue waveform at 64 times the speed at which a CD system samples sound (64 × 44·1kHz). The level of the wave at each sample point is measured, compared with previous samples (in a network of seven feedback loops) and a single digital bit switched between 1 and 0 to represent whether the wave is moving up or down. The stream of 2·8 million bits a second is so rapid that the steering description is very accurate.

The bit stream switches the level of a power signal to re-create a waveform that replicates the original, but much stronger.

Sharp has developed a chip set which reduces power consumption and heat generation to one half that of an analogue amplifier of similar audio performance. Bat-eared hi-fi buffs should be happy, because the high sampling rate provides an audio frequency range of 0-100kHz (which far exceeds human hearing).

Super Hi-Fi

The first product, a super hi-fi amplifier, is expected before the end of the year. The technology will then spin down into budget home audio systems, portables, car stereos and PCs.

Sharp's team leader Yasutomi Katano acknowledges two practical problems. His amplifier performs best when connected direct to one of the new super hi-fi DVD players promised for Christmas (by several manufacturers including Sharp), because there is no need to convert an analogue waveform into digital code. But the record companies worry that consumers will connect their disc players to a recorder instead of an amplifier, and make digital clones. Sharp proposes a deliberately non-standard 13-pin connector which works intelligently, hand-shaking with a similar connector on a disc player so that it only sends high quality code to an amplifier.

Because the amplifier is switching a powerful signal at 2·8MHz, it is effectively a radio transmitter with the speaker cables working as an aerial in a band used for radio-location, maritime services etc.

Katano acknowledges that it is "a fundamental requirement" to trap all electromagnetic radiation with shielding and filter coils. "We are confident we have solved the problem", he says.

Twenty years ago Sony launched a digital amplifier which streamed digital words at 500kHz, the radio frequency allocated for international radio distress calls. The circuit leaked signals and Sony quickly withdrew the product.

YEDA 1999 WINNERS

WE ARE always pleased to encourage people to take up electronics, especially the young, and it is good to report on others who do so as well. For as long as we can remember, we have annually highlighted the *Young Electronic Designer Awards* (YEDA), both as a forthcoming event and as a concluded ceremony.

This year's YEDA had 20 national finalists and the winners received their awards from His Royal Highness The Duke of York. Ashley Jordan (17) of Ludlow College, Shropshire, with his Excavator Bucket-Alignment System won the Duke's own award for the most imaginative concept. The prize was £2000, shared by Ashley and his school.

Ian Thomas (16) of Trent College, Nottingham, won the prize for the most commercially viable project with his Guitar Anti-tamper Device. The IEE Award for the best new entrant to YEDA was won by Simon Green (16) of Helena Romanes School, Dunmow, Essex – his design was an Electronic Metronome for musicians, for which he and his school also received £2000.

It's good to see that girls also featured as finalists – electronics is a subject that can be explored and enjoyed by either gender. For example, Laura Haughian (16) of St Mary's High School, Lurgan, Northern Ireland, was highly commended for her "Easy Find" sound-activated device for locating lost remote controls.

We were pleased to see that our friends at Radley College, Oxon, participated as well. Max Horsey's student Chris Shelmerdine (15) invented "Catomatic", a device for feeding a cat automatically for a five day period, for which he was "highly commended".

The annual YEDA competition was sponsored this year by CPC (Combined Precision Components), DTI (Department of Trade and Industry), EMTA (Engineering and Marine Training Authority) and the IEE (Institution of Electrical Engineers). The competition is open to students between the ages of 12-25 in secondary schools, colleges and universities. It challenges young designers to invent and produce a novel electronic device that meets an everyday need.

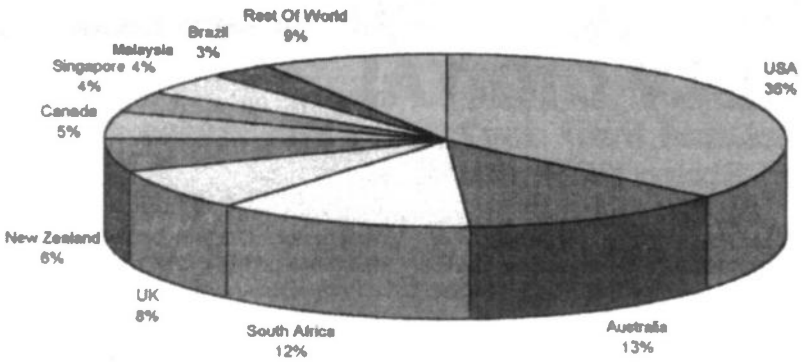
The overall objective is for contestants to have fun putting their ideas into practice and in doing so to discover the exciting opportunities which a career in the electronics, communications and IT industries can offer.

If your school or other educational establishment does not already participate in YEDA, persuade your teacher/tutor to contact the organisers:

The YEDA Trust, 60 Lower Street, Pulborough, W. Sussex RH20 2BW. Tel: 01798 875559. Fax: 01798 873550. Web: www.yeda.org.uk.

EPE ONLINE UPDATE!

Readers Worldwide



Shipping the printed copy of *EPE* to customers outside of the UK is slow and/or expensive. For example, express airmail delivery of a printed magazine can cost as much as $83 US Dollars for a 12-month subscription! This is one of the reasons why we teamed with Maxfield & Montrose Interactive Inc (a polymedia design company based in the United States) to launch the online version of the magazine – *EPE Online* – in November 1998.

Since its inception, *EPE Online* has fulfilled its promise of providing the worldwide community with instant access to our state-of-the-art technical information and high-quality constructional articles without delays or paying exorbitant shipping charges.

Online subscribers can purchase issues 24 hours a day, seven days a week, 365 days a year from our highly secure server in the USA, then download and read their online copies of the magazine anytime they wish. Furthermore, by cutting out printers, distributors, retail stores, and others who do not contribute to the knowledge and information contained in our magazines, we are able to pass on these savings to our international customers. In fact a 12-month subscription to *EPE Online* costs just $9.99 US Dollars (about £6.25), which makes it highly accessible to those readers in less affluent countries who simply cannot afford the rates associated with print copy international magazines.

The pie-chart reveals that *EPE Online* has met its mandate to supply a worldwide audience. Subscribers cover the globe from North and South America, "Down Under" (Australia and New Zealand), South Africa, Western and Eastern Europe, Scandinavia, Asia, and the Pacific Rim.

Of course *EPE Online* contains many useful features in its own right, such as active links that can take readers directly to any web sites of the companies and suppliers featured in our articles, thereby augmenting the knowledge and information contained in our magazine. Readers can also quickly and easily create their own "sticky notes" and attach them anywhere in the machine-readable copy of the magazine to remind themselves of useful information, thoughts and ideas at a later time.

EPE Online originally used sophisticated locking technology, which was only available for use on the Windows 95, 98 and NT platforms. More recently we've moved to a new scheme, which is much easier to use, and which has the added advantage of making *EPE Online* available on Macs, UNIX, and indeed any computer for which an un-ZIP utility is available. Furthermore, readers can now download and read the magazine on multiple computers (for example a desktop at home and a notebook whilst travelling).

EPE continues to lead the magazine industry by using state-of-the-art technologies to deliver the world's first (and easiest to use) web-delivered electronics and computing hobbyist magazine!

RIGHT CONNECTIONS

ESR Electronic Components will be well-known to many of you for their wide range of essential hardware components such as plugs, sockets, switches, cases etc. They have also built up a good reputation for the quality and low cost of their kits for many *EPE* constructional products, which they supply and advertise via their website.

We are pleased to learn from ESR that they have introduced a new range of popular cable hardware. This, they say, is the beginning of many new additions to the hardware side of their business.

The new range of cable hardware includes all the popular items required to complete hobbyist or service engineer work to a professional standard. The range includes such basic products as cable ties and bases, up to cable clips and glands. A large (and colourful) selection of heat-shrink is added as well, with sizes from 1·6mm to 25·4mm.

The new range is included in ESR's latest shortform datasheet. To obtain a copy, or for more information, contact:

ESR Electronic Components, Dept. EPE, Station Road, Cullercoats, Tyne & Wear NE30 4PQ. Tel: 0191 2514363. Fax: 0191 2522296. E-mail: sales@esr.co.uk. Web: http://www.esr.co.uk.

In Record Time

By Barry Fox

SONY is going back to basics with a new VCR, soon to be launched in Europe. Smart Dial is for people who are baffled by the timers on modern VCRs, or have lost the remote control needed to set them.

The new VCR has a "rotary button" on the front. Press once and turn to set the start time on an l.c.d. Press again to set the stop time. Press a third time to set the channel. Push to confirm and go out for the evening, sure in the knowledge that the programme will be recorded to watch later.

B.A.E.C.

WE are pleased to see that the latest newsletter from the British Amateur Electronics Club shows that membership of the Club continues to grow, and that all new members quote "their magazine" as *EPE*! We do try to encourage readers to take an interest in this worthwhile Club and it's obviously paying-off!

It's difficult to summarise the aims of B.A.E.C., but in a nut-shell, it's a forum where electronics enthusiasts can share their enthusiasm and ideas with each other. Its quarterly newsletter is just one aspect of this, get-togethers at various venues around the UK are another (Mr Chairman-Editor, why not include a brief para on the Club's aims in each newsletter so that newcomers and newswriters have it spelt out for them?).

For more info on joining B.A.E.C. contact the Secretary, Martyn Moses, 5 Park View, Cwmaman, Aberdare, Mid Glam CF44 6PP. Tel: 01685 877808. E-mail: mpmoses@compuserve.com.

Radio Show

THIS year's Leicester Amateur Radio Show (the 28th) will once again be held at Donnington Park, Castle Donnington, between 24 and 25 September, from 9.30am to 5pm daily.

The show will feature 150 stands of amateur radio, computer, electronics and related equipment. There will be a Clubland area featuring both local and national Clubs and Societies, including the RSGB. There will also be (amongst many other things) many component stalls and computer stands which will be of interest to electronics enthusiasts.

Enquiries to Geoff Dover G4AFJ. Tel: 01455 823344. Fax: 01455 828273.

E-mail: g4afj@argonet.co.uk.

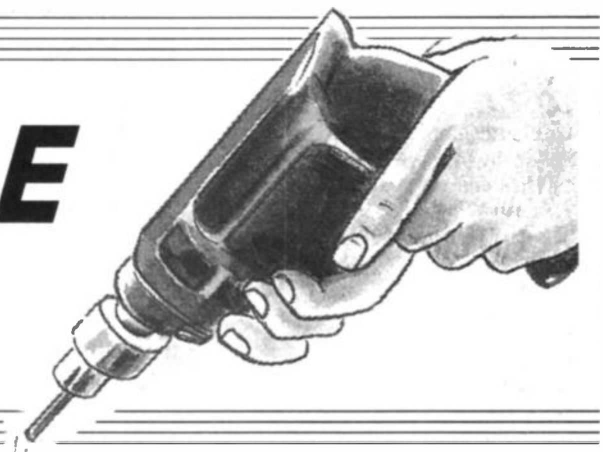
Web: http://www.lars.org.uk.

DUE CREDIT

WCN Supplies of Southampton have sent us a copy of their 12-page catalogue together with a letter saying that, as a goodwill gesture to readers, they will redeem any credit notes issued by Greenweld before they went into liquidation, provided the credit notes are only used to pay for up to 50% of any order; i.e. if you have a £5 Greenweld credit note then you can use it as part payment for any order over £10.

Note that the company that took over the Greenweld name and customer list (see *News* last month) have not taken on responsibility for the original company's debts.

WCN Supplies are at 61 Millbrook Road East, Southampton SO15 1HN. Tel. 01703 226522.



MAINS CABLE DETECTOR

ROBERT PENFOLD

A back-up mains cable locator for your DIY toolbox.

PROBABLY most keen do-it-yourself enthusiasts are aware of the dangers of drilling into the walls of practically any building, and use some form of pipe/cable detector to check that it is safe prior to doing any work of this type. Such precautions should ensure that there are no nasty surprises, but some types of cable can be difficult to detect.

Most pipe and cable locators are actually metal locators that are optimised for this application. They are quite good at finding things like nails in doors and plasterwork, locating metal pipes, and finding cables in metal conduits. However, they tend to be less effective at finding electric cables that are in plastic conduits.

The problem seems to be that there is simply not that much metal in an electric cable, especially a lighting type that is only designed to carry modest currents. This makes such cables difficult to detect unless they are close to the surface of a wall.

MAKING A HUM

The project featured here uses an alternative approach to finding cables, which is to pick up the 50-Hertz mains "hum" signal produced by the cable. This signal seems to be relatively easy to locate, even with a small cable that is buried deep in a wall.

One obvious drawback of this method is that it will not detect any form of pipe or small metal objects such as screws and nails. It is, therefore, best used as a backup to a conventional pipe and cable locator rather than as the sole method of detecting drilling hazards.

SYSTEM OPERATION

Units of this type sometimes use an inductive coupling from the cable to the detector. This requires a current to be flowing in the cable, which effectively becomes the primary winding of a transformer. An inductor at the input of the detector circuit acts as the secondary winding, and a small 50Hz "hum" signal is produced in this inductor if it is close enough to the cable.

Practical tests with this type of cable detector were not very encouraging, and the signal from the inductor was often so weak that it was virtually impossible to detect. The design finally evolved uses the slightly different arrangement shown in the block diagram of Fig.1.

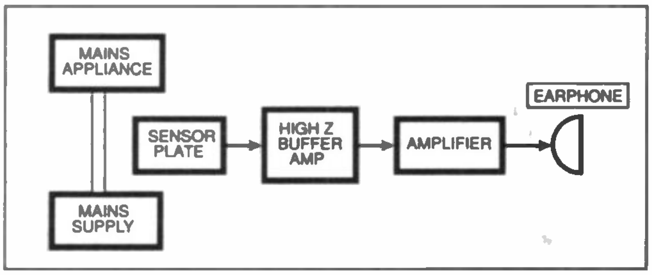


Fig.1. Block diagram for the Mains Cable Detector.

Rather than an inductor, the sensor is a small metal plate. The mains cable and the plate form a very low value capacitor, with the air, etc. between them acting as the dielectric.

This gives an extremely loose coupling from the cable to the input of the detector circuit, but the large signal level in the cable of around 650V peak-to-peak helps to give a reasonable signal level from the plate. A high impedance buffer amplifier at the input of the detector circuit also helps to minimise losses through the capacitive coupling.

This stage is followed by a voltage amplifier that further boosts sensitivity, but only a modest amount of amplification is needed here. The output signal is monitored via a crystal earphone, and it is due to the good sensitivity of this type of earphone that high gain is not needed in the detector circuit.

CIRCUIT OPERATION

The full circuit diagram for the Mains Cable Detector appears in Fig.2. In Fig.1 the unit is shown as having separate buffer and voltage amplifier stages, but in the final circuit these have been merged into a single amplifier based on operational amplifier, IC1.

Having a very high input impedance plus some voltage gain in a single stage can cause problems with stray feedback and consequent instability. However, in this case the voltage gain of the circuit is quite low and no stability problems were encountered.

The circuit is basically just a non-inverting mode amplifier. The non-inverting input (pin 3) of IC1 is biased to half the supply voltage by resistors R1 to R4. IC1 is a bifet device that has a j.f.e.t. input stage and an extremely high input impedance. In fact, its input impedance at low frequencies is so high that it can be ignored. The input impedance of the circuit as a whole is

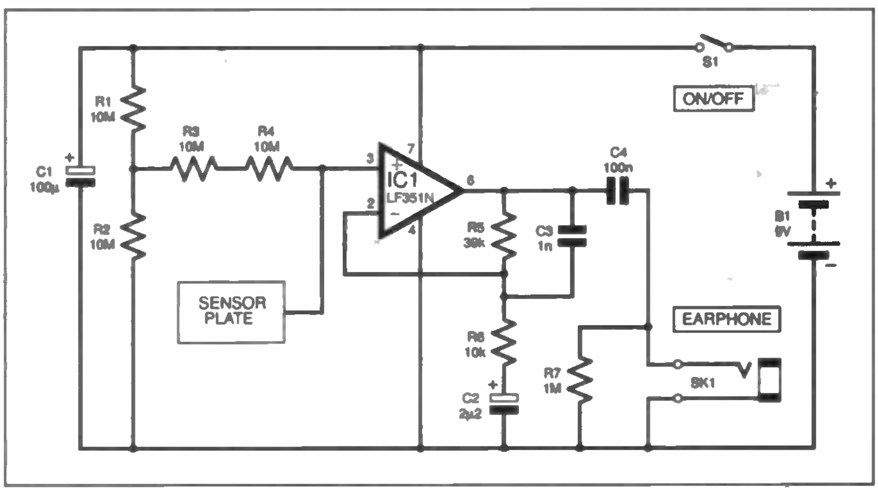


Fig.2. Complete circuit diagram for the Mains Cable Detector.

therefore equal to the parallel resistance of R1 and R2 in series with R3 and R4, or some 25 megohms.

LOOP GAIN

The closed loop voltage gain of IC1 is controlled by negative feedback resistors R5 and R6, and is equal to (R5 + R6)/R6, or approximately five times in other words. Capacitor C3 provides increased negative feedback at middle audio frequencies and above, and therefore provides a progressive roll-off in the gain of the circuit over this frequency range.

The "hum" signal is predominantly at low frequencies, and the high frequency roll-off does not reduce the sensitivity of the unit to this signal. It does help to reduce general noise and breakthrough of r.f. (radio frequency) signals. It also reduces the risk of instability due to stray feedback at high frequencies.

Capacitor C4 and resistor R7 couple the output signal to the crystal earphone and remove the d.c. component in the signal at the output of IC1. The unit is unlikely to work properly using any other type of earphone or headphones. A small 9V battery is adequate to power the circuit, which has a current consumption of less than two milliamps.

CONSTRUCTION

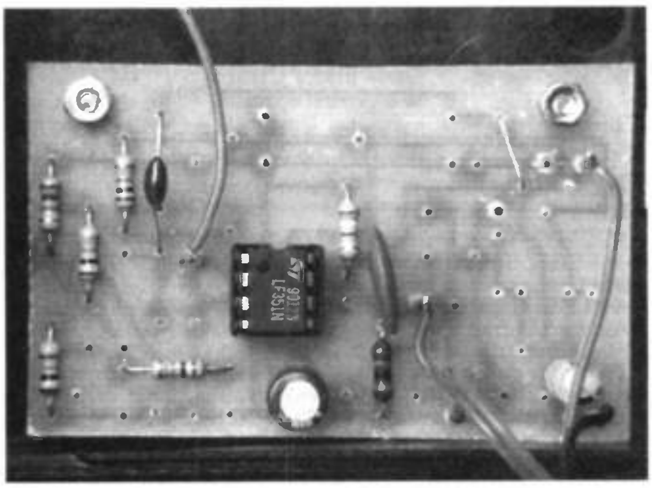
The Mains Cable Detector *starter project* is based on the *EPE* multi-project printed circuit board. This board is available from the *EPE PCB Service*, code 932. The component layout, together with the actual size foil master pattern and interwiring are shown in Fig.3.

The usual warning regarding this pc.b. therefore has to be given. Unlike a normal custom printed circuit board, the multi-project board has numerous holes and pads that are left unused. In order to avoid placement errors it is therefore essential to take slightly more care than normal when fitting the components, and to thoroughly check the finished board for errors.

Construction of the board follows along the normal lines with resistors and capacitors being added first, taking care to fit the electrolytic capacitors with the correct polarity. There is a single link-wire towards the top right hand corner of the board, which should also be fitted at this stage. This link can be made from a piece of wire trimmed from a resistor leadout.

Single-sided solder pins are fitted to the board at the points where connections to switch S1, socket SK1, the battery, and the sensor plate will be made. "Tin" the tops of the pins with a generous coating of solder.

Finally, add IC1, being careful to fit it the right way round. This device is not static-sensitive, but it is still a good idea to fit it in a holder.

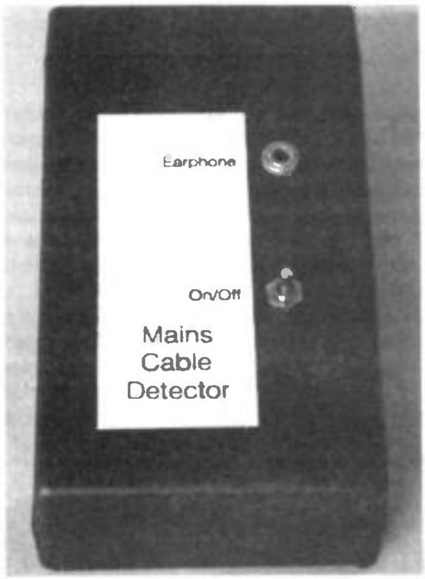


Components mounted on the Multi-project printed circuit board. Note the single link wire, top right.

MAKING SENSE

Practically any small to medium size plastic case should accommodate this project. It is best ***not to use*** a metal case, as this would make it difficult to get the sensor plate working effectively.

The general layout of the unit is not too



COMPONENTS

Resistors

R1 to R4	10M (4 off)	
R5	39k	
R6	10k	
R7	1M	

All 0·25W 5% carbon film

See SHOP TALK page

Capacitors

C1	100μ radial elect. 10V
C2	2μ2 radial elect. 50V
C3	1n Mylar
C4	100n ceramic

Semiconductors

IC1	LF351N bifet op.amp

Miscellaneous

S1	s.p.s.t. min toggle switch
SK1	3·5mm jack socket
B1	9V battery (PP3)

Small plastic case, size to choice; multi-project printed circuit board available from the *EPE PCB Service*, code 932; copper clad board or aluminium plate for sensor, size 50mm x 50mm approx; crystal earphone; 8-pin d.i.l. holder; battery connector; wire; solder pins; solder, etc.

Approx. Cost Guidance Only **£9** ***excl. batt. & case***

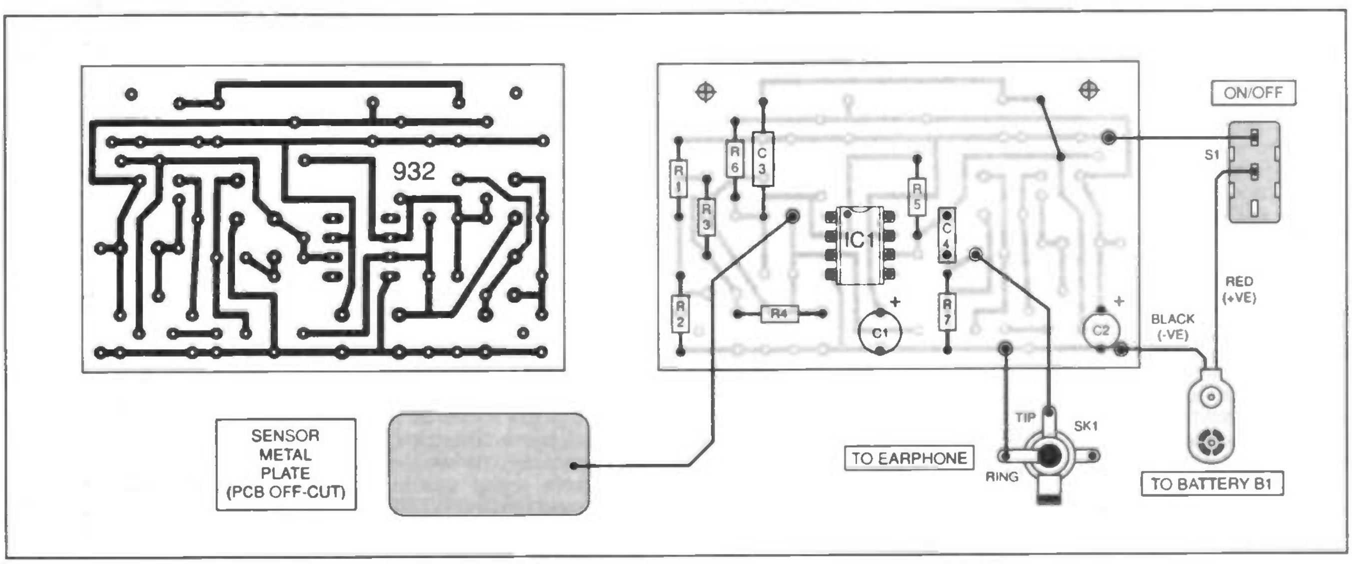
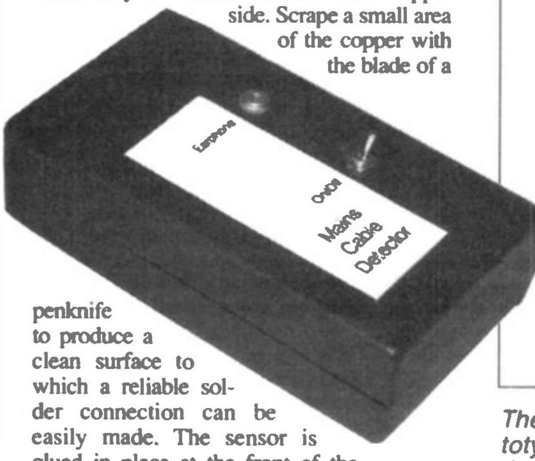
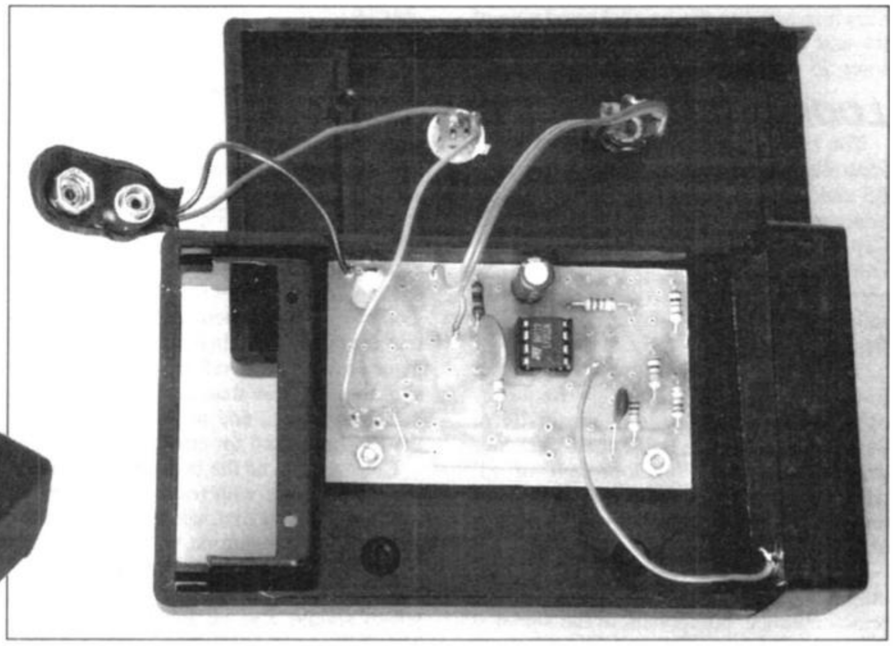


Fig.3. Multi-project printed circuit board component layout, underside full size copper foil master and wiring to off-board components. Not all holes/copper pads are used, so you must double-check component positioning before soldering in place.

important, but try to keep output socket SK1 and its wiring reasonably well separated from the sensor plate and the wire that connects it to the circuit board. The sensor plate can be a piece of copper laminate board (as used for do-it-yourself printed circuit boards) having an area of around five square centimetres or so.

As supplied, this type of board often has a rather dirty and corroded finish on the copper side. Scrape a small area of the copper with the blade of a penknife to produce a clean surface to which a reliable solder connection can be easily made. The sensor is glued in place at the front of the unit, inside the case.





The completed detector, above left, and layout of components inside the prototype case. The sensor plate is glued in place at the front of the unit, inside the case.

A small piece of aluminium can be used instead of copper laminate board, but soldering to aluminium can be difficult even if the special solder is used. It is easier to bolt a solder tag to the piece of aluminium and then make the connection to the tag.

IN USE

When first switched on there will almost certainly be some "hum" and general noise on the output of the unit even if it is not placed close to a mains lead. The output level should be quite low though. Placing the unit near to the mains lead of any appliance that is plugged into the mains supply should produce a loud 50Hz "hum" signal from the earphone.

In practice, there is a fair amount of noise on the "hum" signal, which will consequently produce more of a "buzzing" sound from the earphone. It seems to be possible to detect cables whether or not they are actually passing a current, but detection is certainly easier if there is a current flow.

Walls, floorboards, etc. do not significantly hinder signal pickup, but there can be a general spreading of the apparent signal source. Even so, it is not usually too difficult to follow the path of power or lighting cables. □

SHOP TALK
with David Barrington

Interior Lamp Delay

A number of components called-up for the *Interior Lamp Delay* project could cause constructors local sourcing problems. Fortunately, most seem to be *RS* components and can be ordered through a local *bona fide* dealer or through **Electromail** (☎ *01536 204555* or RS ***http://rswww.com***), their mail order outlet.

The SMP40N10 power f.e.t. (code 264-816); the 4MHz ceramic resonator (656-186); small plastic case (508-914) and the low current, 3V to 16V d.c., buzzer (2245-001) all came from the above source. Apart from the power f.e.t., most of our advertisers should be able to supply similar/identical devices.

For those readers who want a ready-programmed PIC16F84 (the C84 is no longer produced), one is available from **Magenta Electronics** (☎ ***01283 565435*** or ***http://magenta2000.co.uk***) for the inclusive price of £5.90 (overseas readers add £1 for postage). For those who wish to program their own PICs, the software is available from the Editorial Offices on a 3·5in. PC-compatible disk, see *EPE PCB Service* page. If you are an Internet user, it can be downloaded *Free* from our FTP site:
ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/interiorlamp.

The printed circuit board is available from the *EPE PCB Service*, code 244 (see page 773). Finally, you must read the ***Warning*** notes and installation advice ***before*** commencing this project.

QWL Loudspeaker System

As far as the woodworking requirements for the *QWL Loudspeaker System* are concerned, these will have to be obtained from your local timber merchant or large DIY superstore. Also, as indicated in the article, the square metre of Terylene damping material may be purchased from the dressmaking department of your local store.

Turning now to the loudspeakers and crossover units. These were chosen by the designer after a visit to **South Coast Speakers Ltd** of Southampton and are of Norwegian origin. Contacting them, they offered the following (VAT inclusive) pricing for the SEAS speakers and their own crossovers, in kit form or ready assembled:

Driver unit set (two P17REX polypropylene bass units and two H457(25TFF) dome tweeters) £147.88 plus £5.49 post and packing, total £153.37. Crossover kit (pair) £39.08 plus £2.49 p&p = £41.57. Asssembled crossover £45.08 plus £2.49 p&p = £47.57. Full, all inclusive kit £192.45; assembled £198.45. They can also supply the ancilliary items, such as the black speaker fixing screws, damping material etc. To spread the cost, single drive units and crossovers can be purchased.

For further details and orders contact: **South Coast Speakers Ltd, Dept EPE/ETI, 58 Wilton Road, Southampton, Hants, SO15 5SZ**. Phone: 01703 703221 or Fax: 01703 778221. Payments should be made payable to South Coast Speakers Ltd.

Micro Power Supply

Not too many problems should be experienced when gathering together the parts for the *Micro Power Supply* project.

The LP2950 +5V voltage regulator was chosen, in preference to the standard 78L05, because it has improved regulation, draws much less supply current and will operate with a very low differential between input and output voltages; ideal for battery powered circuits. If your usual supplier is unable to supply the specified regulator, it is currently listed by **Electromail** (☎ ***01536 204555*** or RS ***http://rswww.com***), code 648-567 or 411-826, and by **Maplin** (***http://www.maplin.co.uk***), code AV35Q.

Regarding the "switched capacitor" voltage converter, the one used in the prototype is marked as an IS7660 but after numerous catalogue searches only Maplin, code YY75S, had it listed. It would appear that the most popular version is the one with prefix letters **ICL** (7660) and should be available from most good component suppliers. It is certainly stocked by **Electromail**, code 651-490.

The small single-sided printed circuit board is available from the *EPE PCB Service*, code 243 (see page 773).

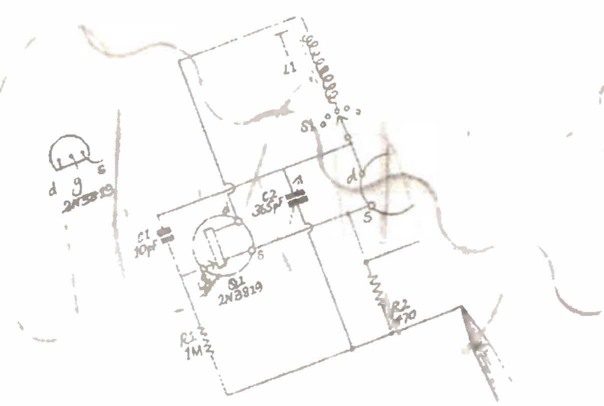
Mains Cable Detector

Apart from the case, all components required to build the *Mains Cable Detector* should be readily available, off-the-shelf items. Most of our components advertisers stock the high impedance crystal earpiece.

Unfortunately, the two-piece case, with battery compartment, used in the model would appear to be one originally purchased from **Greenweld** (code CS4330) and may no longer be available. You could try contacting the new owners by Fax on 01992 613020 or by E-mail: **greenweld@aol.com**. In the meantime, the original case measured roughly 120mm × 60mm × 32mm and, no doubt, advertisers should be able to offer a suitable alternative.

Special Series

PRACTICAL OSCILLATOR DESIGNS



RAYMOND HAIGH

Most text books deal with oscillators in a theoretical way. This series, prepared with the electronics enthusiast and experimenter very much in mind, is intensely practical. Tried and tested circuits are fleshed out with component values, and their vices and virtues are exposed.

PART FOUR – NEGATIVE RESISTANCE OSCILLATORS

THE PHENOMENON of negative resistance has been known and understood since the earliest days of radio. Indeed, its application to oscillatory circuits pre-dates the thermionic valve. Put simply, it occurs when the current flowing through a device or circuit is rising whilst the voltage across it is falling and Ohm's law appears to have been reversed.

Cavity magnetron oscillators, which depend on negative resistance, are used in many homes for generating the microwaves which heat food. They also power the RADAR (RAdio Direction And Ranging) systems which help to ensure the safety of travellers by air and sea.

Some rather unusual transistor circuits which exploit negative resistance, form the subjects of this article.

MAINTAINING OSCILLATIONS

The sudden application of a direct voltage to a tuned circuit formed by an inductor (coil) and capacitor shock-excites oscillations. Because of resistive losses (mainly in the coil), the oscillations gradually fade away, their duration and magnitude being directly related to the Q factor of the tuned circuit (the higher the Q the lower the resistive losses).

Oscillations can be maintained by connecting an amplifier to the tuned circuit and feeding back energy in order to continually repeat the excitation. Earlier articles in the series have described a number of oscillators of this kind.

The feedback eliminates or cancels out the resistive losses. Viewed in this way, it can be said to create negative resistance.

It follows that devices and circuits which display negative resistance, even those which do not function as amplifiers, can also be used to maintain oscillations. An electric arc, Hull's Magnetron, the Esaki or tunnel diode, all have a characteristic which exhibits falling voltage with rising current; i.e. *negative resistance*.

They function by cancelling out the resistance in the tuned circuit so that the oscillations can continue. When circuits of this kind are analysed from the feedback standpoint, the positive feedback is said to exist within the device itself.

NEGATIVE RESISTANCE

Negative resistance is created when the current flowing through a circuit is *rising* whilst the voltage across it is falling, and Ohms law appears to have been reversed. Devices which display this characteristic can maintain oscillations in a tuned circuit by cancelling out its resistive losses.

The technique was used by early radio pioneers before the invention of the thermionic valve. Today, powerful microwave generators and devices on the frontiers of semiconductor technology exploit the phenomenon of negative resistance.

TUNNEL DIODE

A Japanese scientist, Leo Esaki (*b* Osaka, Japan 12 Mar 1925 – now an American citizen), first described his tunnel diode in 1958. A two-terminal device, it represents a particularly vivid example of the phenomena of negative resistance, which enables it to function as an oscillator.

Tunnel diodes comprise a junction of p and n-type semiconductor material and, in this respect, resemble conventional junction rectifiers. Pure silicon and germanium have to be doped with impurities before they can function as semiconductors. Pentavalent impurities, such as antimony, phosphorous and arsenic, convert the silicon or germanium into n-type material. If a trivalent impurity, such as boron, gallium or indium, is added, a p-type semiconductor is produced.

Normal junction diodes have impurity levels of about one part in 10^8. Esaki discovered that if the doping levels are increased to around 1 part in 10^3, the characteristics of the diode are completely changed.

The current/voltage characteristic of a typical tunnel diode is displayed in Fig.1b. Conduction is high in the reverse direction (p side of the junction negative with respect to the n side) and current rises with forward voltages until a peak is reached.

Beyond this point, increasing the forward voltage reduces the flow of current and the diode displays negative resistance. A further increase in

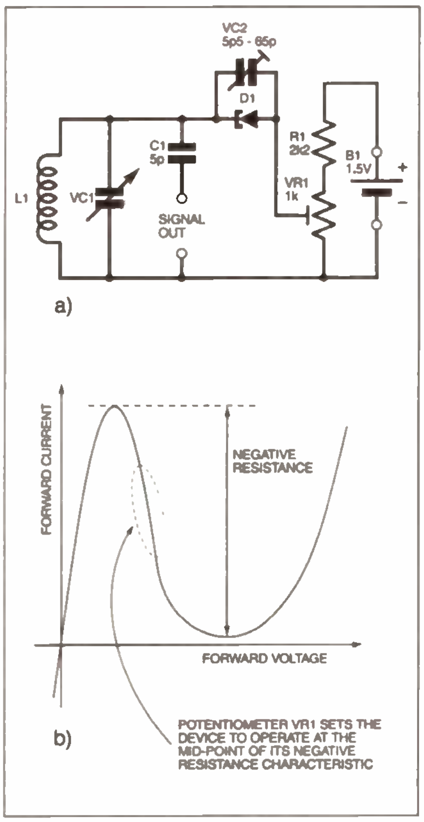


Fig.1a. Typical circuit diagram for Esaki's tunnel diode negative resistance oscillator and (b) tunnel diode current/voltage characteristic.

forward voltage restores the normal current/voltage relationship, and the biasing of the device is critical.

A typical circuit diagram of a negative resistance oscillator using a tunnel diode is given in Fig.1a. The tuned circuit formed by coil L1 and variable capacitor VC1 determines the frequency of oscillation, and the resistor network, R1 and VR1, reduces the voltage of a single cell (B1) to the few hundred millivolts needed to bias tunnel diode D1 to the correct operating point. Preset potentiometer VR1 enables the bias voltage to be adjusted to suit different devices.

When working at medium and high frequencies, shunting the diode with a trimmer capacitor, VC2, makes the circuit more willing to oscillate. As the frequency of operation increases into the v.h.f. and u.h.f. region, this component can be dispensed with.

Tunnel diodes are low-cost, low noise devices, capable of operating at very high speeds. When they were introduced in the late 50s it was widely anticipated that, because of these attributes, they would find wide application in the then new computer industry.

However, they have the disadvantage of low output voltage swing and, being a two-terminal device, there is no isolation between input and output and this causes circuit design problems. These drawbacks, combined with the dramatic developments in transistors, seem to have eased the tunnel diode into an early obsolescence.

MORE NEGATIVE

Following Esaki's discovery of the tunnel diode, more work was done during the 60s on the development of negative resistance devices of this kind. Significant discoveries were made, and much effort seems to have been expended on the invention of acronyms.

In 1964, American scientists, R. L. Johnston and B. C. de Loach, working at the Bell laboratories, discovered the IMPATT (IMPact, Avalanche, Transit Time) diode. The application of a d.c. voltage to these devices results in the direct generation of microwaves.

Three years later, Americans, Prager, Chang and Weisbrod, developed the TRAPPATT (TRAPped, Plasma, Avalanche, Transit Time) diode. Comparatively high efficiencies were claimed for these devices, but the maximum operating frequencies are somewhat lower than those achieved by the IMPATT diode.

In 1968, a British scientist, G. T. Wright, described a new negative resistance microwave device which he called the BARITT (BARier controlled Injection and Transit Time delay) diode. Capable of operating in the microwave region, the BARITT diode shares the low-noise, low-cost advantages offered by other semiconductor structures of this kind.

Although the physics of these devices is extremely complex, they all depend for their operation on the creation of negative resistance, a phenomena first exploited more than half a century earlier. They are not readily available to the home constructor, but any reference to negative resistance oscillators would have been incomplete without a brief mention being made of them.

Ordinary transistors can, however, be persuaded to operate in this way, and a number of circuits will now be considered.

50kHz OSCILLATOR

It is not too widely known that the emitter/collector structure of some small signal transistors can be made to display a pronounced negative resistance characteristic. A circuit which exploits this is given in Fig.2a, where the emitter/base/collector junctions of an *npn* bipolar transistor are connected across a power supply via load resistor R2 and a voltage divider chain comprising preset VR1 and resistor R1.

The characteristic curve of the semiconductor structure is shown in Fig.2b, and the device can be set around the mid-point by means of VR1. No connection is made to the base (b) of the transistor, and the polarity of the supply voltage has to be reversed (supply positive to the emitter (e) of an *npn* transistor).

The impedance of the semiconductor is low, and it is best suited to maintaining oscillations in a series tuned circuit which has a matching low impedance at resonance. Accordingly, the tuned circuit is formed by capacitor C1 in series with coil L1, and the components specified in Fig.2a can be made to resonate at 50kHz.

The output signal is taken from across the coil via coupling capacitor C2. Oscillation continues to be maintained when the output is fed into an impedance as low as 4·7 kilohms, but signal voltage is reduced and preset VR1 has to be set very precisely.

If possible, the input impedance of the accepting circuit should be at least 100 kilohms and, preferably, 470 kilohms. The value of capacitor C2 should be as low as possible consistent with the delivery of sufficient output.

Output and waveform quality depend, to a considerable extent, on the *L/C* ratio of the tuned circuit. Formulae relating inductance, capacitance and frequency were given in Part One (see also Part Three), and the tuning capacitor values suggested there would ensure good results with this circuit. Electrolytic components can be used to provide the comparatively high values of capacitance required for tuning below 100Hz without there being any perceptible deterioration in performance.

The circuit will oscillate vigorously from the lowest audio frequencies to around 150kHz, but 100kHz should be taken as the upper frequency limit for reliable operation. With a reasonable *L/C* ratio in the tuned circuit, careful adjustment of preset VR1 will produce a perfect sinewave output in the region of 5V r.m.s. Current flow through the device is a little more than 4mA when the circuit is oscillating.

All of the transistors listed in Fig.2a will oscillate reliably up to 100kHz, but the various specimens of BC237 and 2N3707 tried produced the greatest output. Readers who wish to experiment with this circuit will be assured of good results if they start by using one or other of these devices.

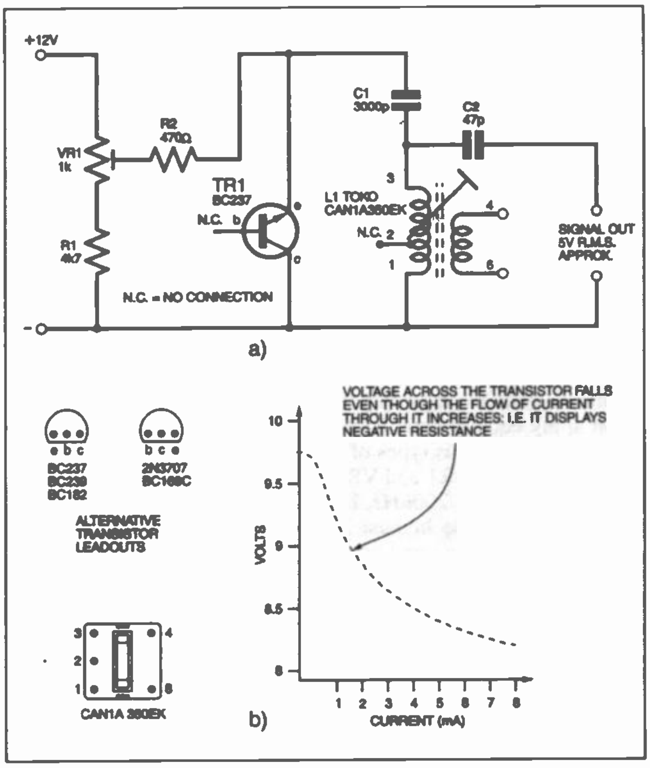


Fig.2a. Circuit diagram for a 50kHz Negative Resistance Oscillator. This circuit exploits the negative resistance characteristic within a transistor. Note that the emitters of npn*-transistors must be connected to supply* positive *for this circuit to function. The current/voltage characteristics of an* npn *transistor connected as shown is given in (b).*

A 50kHz OSCILLATOR

The 50kHz negative resistance oscillator is the simplest and, at the same time, the most unusual oscillator in the series. Illustrated in Fig.2, and relying on the semiconductor junctions within a transistor to create negative resistance, it has something in common with Esaki's tunnel diode.

The circuit will oscillate vigorously from low audio frequencies to more than 100kHz and, when carefully adjusted, will produce a good output waveform. Its characteristic curve (Fig.2b) clearly displays falling voltage with rising current.

100kHz TO 10MHz OSCILLATOR

The two-transistor circuit shown in Fig.3 uses changing bias voltages on a directly-coupled pair of transistors to create the rising current/falling voltage characteristic associated with negative resistance. It will oscillate from low audio frequencies to around 10MHz, and is tolerant of high values of capacitance in the tuned circuit.

Waveform quality is reasonably good provided the controls are set to ensure that the output does not exceed 3V r.m.s. The internal capacitance of the circuit is relatively high, and this will slightly curtail the frequency coverages of the coil and capacitor combinations scheduled in Table 1.

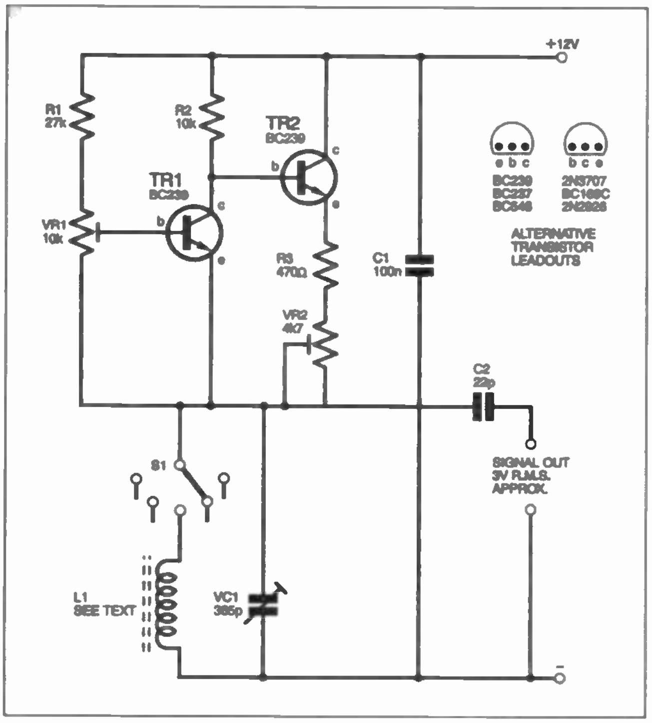


Fig.3. Circuit for a 100kHz to 10MHz negative resistance oscillator.

A number of *pnp* transistors were tried, with the supply polarity reversed, but they could not be persuaded to oscillate.

TWO TRANSISTOR OSCILLATOR

The two transistor combination depicted in Fig.3 is sometimes offered as a tunnel diode substitute. The profile of its characteristic curve is certainly very similar, but the actual operation of the circuit has nothing in common with Esaki's tunnel diode.

When the voltage across the circuit is low, most of the current flows through transistor TR2, and, as voltage increases, so does the flow of current. However, if the supply voltage continues to be increased, a point is reached when transistor TR1 begins to conduct. This transition point is, of course, determined by the setting of TR1's base bias potentiometer VR1.

As the current through TR1 increases, the voltage dropped across its collector load resistor R2 increases. The collector (c) of TR1 is directly coupled to the base (b) of TR2, and the falling voltage reduces the current drawn by the second transistor. The net result is a fall in the current flowing through the circuit, even though the voltage across it is rising; i.e. negative resistance is being created.

When placed in series with a parallel tuned circuit, this two transistor combination will maintain oscillation from audio frequencies up to 10MHz or so. The tuned circuit of Fig.3 is connected on the negative side so that the moving vanes and frame of tuning capacitor VC1 can be grounded. Switch S1 selects inductors, L1, and the output is taken from the "hot" end of the tuned circuit, via capacitor C2.

Earlier comments regarding the input impedance of the accepting circuit apply equally here. Bypass capacitor C1 ensures consistent operation with various types of power supply.

Potentiometers, VR1 and VR2, should be adjusted to get the circuit working at, say, 200kHz, before refining the settings to ensure oscillation across the highest frequency range. They can also be adjusted to produce a good waveform at the expense of output.

This arrangement thrives on relatively high ratios of capacitance to inductance in the tuned circuit (with parallel tuning, this lowers impedance at resonance and increases the Q factor). Capacitors of 2000pF can be wired in parallel with inductors as low as 50μH and the circuit will still oscillate vigorously, with no reduction in output, and the quality of the waveform is improved. This should be kept in mind if the circuit is used as a spot frequency generator.

F.E.T. OSCILLATOR (100kHz to 30MHz)

Although it is claimed that valves possess distinct advantages as the maintaining devices in oscillatory circuits, there are some transistor configurations which valves cannot emulate. One of these is the combining of pairs of transistors of opposite polarity.

An arrangement of this kind is shown in Fig.4, where a complimentary pair of field-effect transistors (f.e.t.s) has been used to create negative resistance. Close scrutiny reveals a variant of the Butler source (originally cathode) coupled oscillator discussed last month.

In Fig.4, f.e.t. TR1 is a source follower and TR2 a grounded gate stage, and the different polarity of the two devices (*npn* and *pnp*) enables the inputs and outputs to be directly connected. This combination results in a "two terminal" device which will maintain oscillation when placed in series with a parallel tuned circuit.

Preset potentiometer VR1 enables the circuit to be set at the midpoint of its negative resistance characteristic. It should be adjusted to ensure that oscillation is maintained at the maximum capacity setting of VC1 on the highest frequency range. The circuit will then perform satisfactorily on all switched ranges.

The internal resistance of the power supply has to be reasonably low or operation becomes erratic on the higher frequency ranges. The value suggested for VR1 should, therefore, be adhered to.

Current changes triggered by the circuit going in and out of oscillation induce voltage changes across VR1, making it difficult to adjust the operating point. Zener diode D1 holds the voltage across the potentiometer constant and makes the setting up process much easier.

If the power supply delivers less than 12V, the value of resistor R1 should be reduced accordingly. With low resistance supplies of 6V or less, R1 and D1 can be dispensed with.

The negative resistance generator (TR1/TR2) is placed in series with the tuned circuit formed by L1 and VC1. The output is taken from the "hot" end of the tuned circuit via capacitor C1, and, again, it should be fed into an impedance of at least 100 kilohms to avoid excessive damping. The power supply is bypassed by capacitor C2.

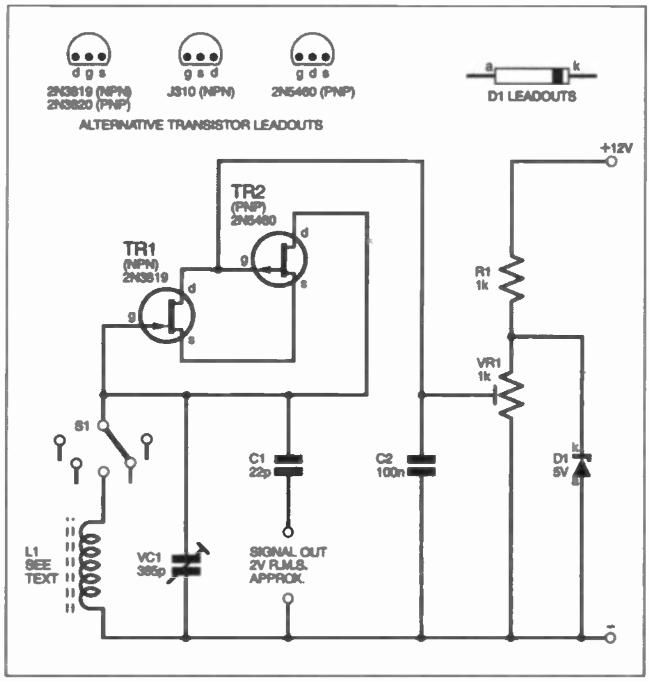


Fig.4. Circuit diagram for a 100kHz to 30MHz negative resistance oscillator using a complimentary pair of f.e.t.s.

TABLE 1:
NEGATIVE RESISTANCE OSCILLATORS
Frequency coverage with Toko coils and a 10pF to 365pF tuning capacitor. (See Fig.4 and Fig 5 for circuit diagrams).

Band	Toko coil L1	Base wiring	Min. Freq. (MHz)	Max.Freq. (MHz)
1	CAN1A350ER	B	0·1	0·25
2	CAN1A350ER	D	0·22	0·64
3	RWR331208N2	A	0·52	1·73
4	154FN8A6438EK	A	1·4	5·4
5	154FN8A6439EK	A	3·8	15·5
6	KXNK3767EK	A	7	30

Notes:
(1) See Fig.6 for details of coil base wiring.
(2) Coverage can be varied, between fairly wide limits, by adjusting the coil ferrite cores.

100kHz TO 30MHz OSCILLATORS

Directly-coupled, complimentary pairs of transistors are used to generate negative resistance in the 100kHz to 30MHz circuits given in Fig.4 and Fig.5.

Bipolar and f.e.t. versions oscillate vigorously, from the lowest audio frequencies to above 50MHz. Biasing arrangements are more complicated with the bipolar transistor circuit, but there are no setting up adjustments.

As with all of the negative resistance oscillators, a single winding, untapped coil will suffice, and this simplifies range switching. The frequency coverages obtained with Toko coils and the specified tuning capacitor are given in Table 1.

Waveform is reasonable, but both circuits display slightly more drift than the oscillators described earlier in the series. They are, however, perfectly suitable for use as simple signal generators.

IN OPERATION

Most combinations of *npn* and *pnp* field-effect transistors should work in this circuit, but only those listed in Fig.4 have been tried. The use of a J310 type ensures reliable oscillation, on the highest frequency range, with the tuning capacitor set at maximum.

Frequency coverage with a 10pF to 365pF tuning capacitor and a range of Toko coils is scheduled in Table 1. Details of the coil base connections are given in Fig.6. Readers who would prefer to wind their own coils should refer to Part One for details.

Signal output is reasonably constant over the various ranges and across the swing of the variable capacitor, but it falls to around 1V r.m.s. at the maximum setting of the capacitor on the highest frequency range. Oscillation is maintained from the lowest audio frequencies to above 60MHz.

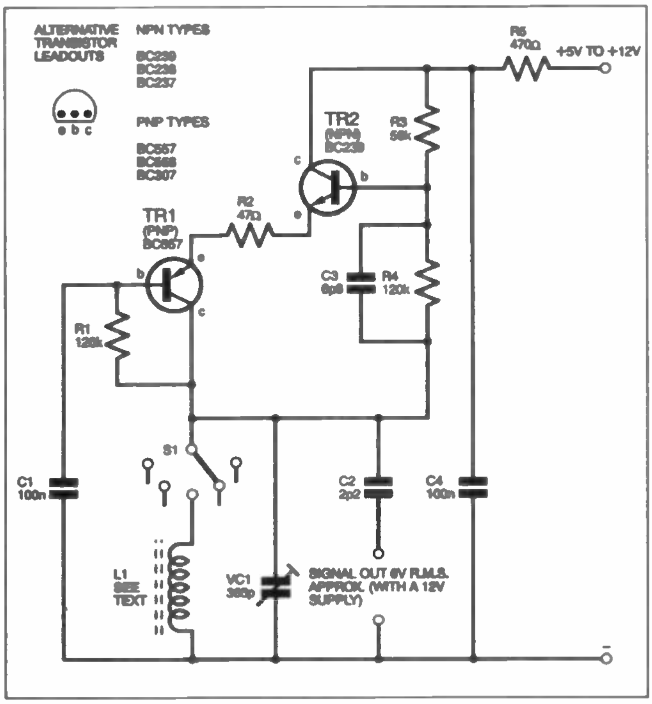


Fig.5. Circuit diagram for a 100kHz to 30MHz negative resistance oscillator using a complimentary pair of bipolar transistors.

If the circuit is to be used exclusively for the generation of low frequencies (100kHz and below), delete the Zener diode and increase VR1 to 4·7 kilohms. At low frequencies, a higher supply voltage and a higher ratio of capacitance to inductance in the tuned circuit ensure a better waveform, and the signal voltage is correspondingly increased.

Above 30MHz, the circuit becomes reluctant to oscillate with high tuning capacitor values, and VC1 should be reduced to 50pF or even 25pF. Leads must be kept as short as possible, and stray capacitance minimised, or the upper frequency limit will be curtailed.

BIPOLAR OSCILLATOR (100kHz to 30MHz)

A bipolar transistor version of the previous circuit is given in Fig.5. Biasing arrangements are more complicated, but the circuit oscillates vigorously and does not require setting up.

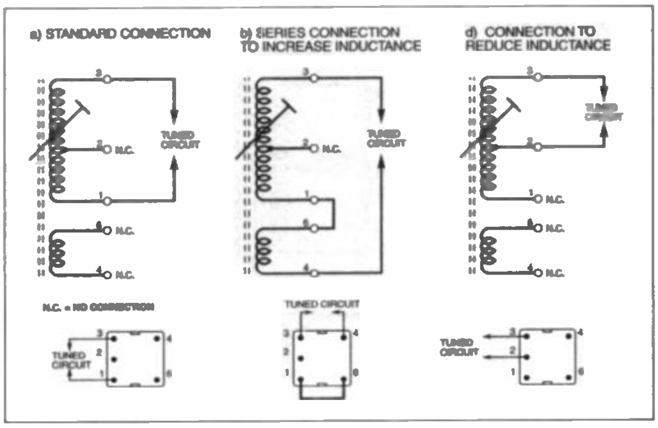


Fig.6. Base connection details for Toko coils.

Base bias is applied to *pnp* transistor TR1 via resistor R1, and voltage divider resistors R3 and R4 fix the bias on the base (b) of *npn* transistor TR2. Capacitor C3 is necessary to ensure adequate feedback at radio frequencies. Low value resistor R2 prevents the circuit behaving erratically. The base of TR1 is grounded by capacitor C1, whilst C4, together with resistor R5, decouples the oscillator from the power supply.

Again, the output is taken from across the tuned circuit, and its r.m.s. value is approximately equal to half the d.c. supply voltage. Output coupling capacitor C2 has been given a very low value in order to attenuate the rather high signal level, which is extremely constant over the swing of the tuning capacitor and the switched ranges.

The circuit has a slightly higher internal capacitance than the f.e.t. version, and this modifies coverage. However, the particulars given in Table 1 still approximate closely to the frequency ranges achievable with the specified variable capacitor. At low frequencies, below 100kHz, operation may become erratic if the ratio of capacitance to inductance in the tuned circuit is low.

Most small signal transistors will work well in this circuit. Those that are known to be suitable are listed in Fig.5.

PERFORMANCE

The field-effect and bipolar transistor versions of the wide range, negative resistance oscillator exhibit slightly greater drift than the conventional feedback oscillators described in earlier instalments of the series. The bipolar version also applies a rough audio modulation to the r.f. output when the circuit is oscillating at high frequencies. Modifying the time constants of the various circuit elements did not cure this.

Both versions of this circuit are vigorous oscillators, capable of delivering a constant output with a reasonably good waveform. They are certainly suitable for use as simple, wide-range signal generators, as audio modulators, or for generating spot frequencies.

MAINS POWER

Readers who lack experience of constructing and commissioning MAINS-POWERED equipment are reminded that the voltages involved can cause DEATH OR SERIOUS INJURY. Anyone who is uncertain about his or her ability to construct or work on equipment of this kind should seek the guidance of an experienced person, use batteries or purchase a commercially produced mains isolated power supply.

PROBLEMS WITH BATTERIES

The current consumed by the transistor circuits included in this series is extremely modest, and well within the capability of small dry batteries. However, the voltage of dry cells varies over quite wide limits, from when they are fresh to the point when they can only just power a circuit.

Voltage reduces imperceptibly, and the unwary can be left wondering why an oscillator won't spring into life when the problem is one of fading batteries. Ageing also effects the internal resistance of dry cells, and this can influence the performance of oscillators, even when bypass capacitors have been provided. There is, therefore, much to recommend a mains power supply unit to the serious experimenter.

LOW-VOLTAGE REGULATED SUPPLY

A circuit diagram for a mains driven Low-Voltage Power Supply, with alternative regulated outputs, is given in Fig.7.

The mains transformer, TR1, primary winding must, of course,

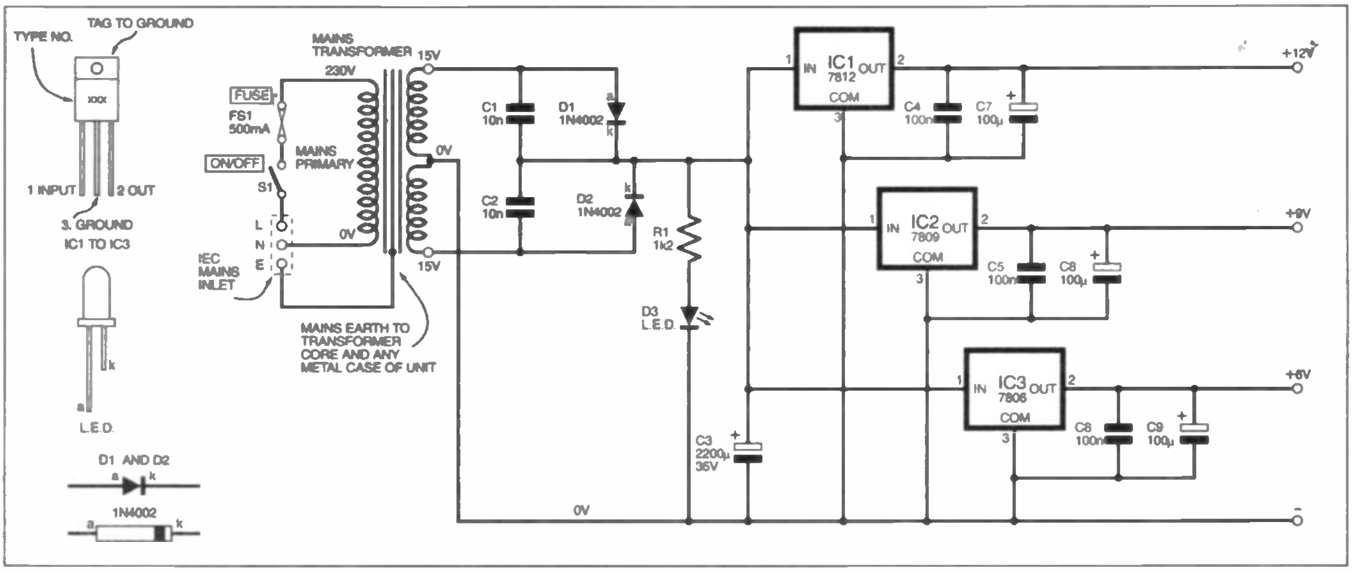


Fig.7. Suggested circuit for a low voltage regulated mains power supply giving outputs of 12V d.c., 9V d.c. and 6V d.c. (Please read warning note, under "Mains Power", given earlier.)

suit the local supply voltage, and the current rating of the secondary winding need be no more than 500mA if the unit is to be used solely for powering the oscillator circuits included in this series. A bench power supply of this kind will, however, be useful for other projects, and a transformer with a 2A or 3A secondary rating would be a sound investment.

The secondary winding output voltages should be 15V-0V-15V for the bi-phase, full-wave rectifier arrangement. This will produce a no-load d.c. voltage across reservoir capacitor C3 of around 21V. Under maximum load, this will fall to approximately 16V, leaving a safety margin above the 15V minimum input required for the 12V regulator, IC1.

An 18V-0V-18V secondary transformer can be used if one is to hand. This will produce an off-load voltage of around 25V, which can exceed the input rating of some 6V regulator i.c.s (this is usually 24V). If an 18V-0V-18V transformer is used, the input to the 6V regulator, IC3, should, therefore, be connected to the output of the 12V regulator, IC1 (i.e., the devices should be connected in tandem) in order to avoid exceeding its input rating.

SAFETY FIRST

The inclusion of a low-current mains fuse, an on-off switch and an IEC mains input chassis plug are good features on equipment of this kind. Mains Earth should be connected to the transformer core and the case of the unit, which should be made of metal. It is best not to connect the mains earth to the output negative rail: electrical interference can be carried into sensitive equipment via the earth wiring.

The specified rectifier diodes D1 and D2 are rated at 1A. If a more powerful unit is contemplated, 3A (1N5402) components must be fitted. Capacitors C1 and C2 are connected across the rectifiers in order to prevent any modulation hum.

The switching action of the diodes will modulate any r.f. current flowing in the circuit at a multiple of the mains frequency, usually 100Hz, and this interference can be picked up by a radio receiver powered by the unit. Modulation hum is tuneable; i.e. it only becomes audible when a signal is tuned in on the receiver. These capacitors should be ceramic components with a minimum working voltage of 50V.

An "on" indicator, comprising an l.e.d., D3, and its dropping resistor R1 is a useful, but not essential, feature.

SMOOTH TALK

The d.c. output from the rectifiers is smoothed by reservoir capacitor C3. An approximate formula for determining the value of power supply reservoir capacitors is:

Value of capacitor in μF = current drain in Amps × 2000.

This formula gives the lower limit of value, and a decent quality power supply should have twice as much reservoir capacitance as this. However, when the supply is regulated, the regulator i.c.s remove much of the ripple which develops under load, and the specified 2200μF will be adequate provided the total current drain does not exceed 1A.

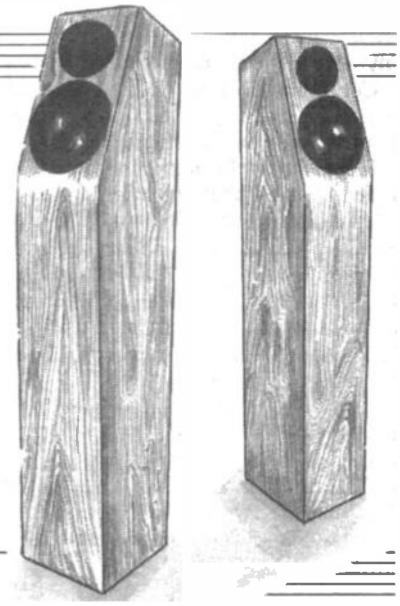
The voltage regulators, IC1 to IC3, are all 1A rated types chosen to deliver dry-battery related voltages. If difficulty is encountered obtaining the 6V and 9V types, 5V and 8V regulators can be substituted without detracting from the versatility of the unit.

If the power supply is to be used to deliver output currents close to the regulator's 1A maximum rating, the i.c.s should be fitted with small heatsinks, especially if an 18V-0V-18V transformer is installed.

Regulator i.c.s produce about 40μV of broadband noise which extends into the r.f. spectrum. The combination of ceramic and electrolytic capacitors connected across each output bypasses this interference to ground.

Outputs regulated in this way have a very low resistance (around 70 milliohms) and a high degree of isolation from one another. This last feature is particularly desirable when powering the different sections of an item of equipment; e.g., an oscillator stage and a buffer stage.

Next month: Crystal controlled oscillators will be considered.



QWL LOUDSPEAKER SYSTEM

JOHN DIX

An updated design that should appeal to all audiophiles

THIS design originally appeared in 1988 (*ETI*, Aug '88), and a modified version is presented here describing the incorporation of improved drivers and a matching crossover.

After many hours of measurement and listening, it is hoped that the design will appeal to existing owners of the QWL in terms of an upgrade, as well as to new constructors looking for a wide frequency range loudspeaker system occupying a reasonable floor space.

INTRODUCTION

The factors governing the size of a loudspeaker invariably involve considerations of overall performance, cost and domestic acceptability. Referring specifically to moving coil drive units and their enclosures, the larger the size of the enclosure the more extended is the bass response, which in turn adds to the scale of the sound by providing a certain low frequency ambience.

The full benefit of this improved ambience can only be achieved in a large room where, of course, the larger size of enclosure stands a better chance of being domestically acceptable. Unfortunately, the larger size loudspeaker system also tends to be more complex, because the use of a larger diameter bass unit requires the addition of a smaller unit, to cover the critical mid-frequency range adequately smoothly, before handing over finally to a high frequency unit.

Overall then, the design becomes more expensive arising from difficulties in integrating the responses of the individual drive units over the complete frequency range and constructing the cabinet to keep wall vibration to a minimum.

SYSTEM OPTIONS

From what has been outlined above, it is not surprising to find that the loudspeaker system manufacturer has concentrated on the smaller enclosure designs to achieve a cost reduction without an appreciable sacrifice in performance.

Although it is more difficult to maintain the low frequency response of the small enclosure speaker, there are also a number of important advantages associated with a reduction in the dimensions of the enclosure. Thus, it is not unusual to discover a so called budget design that represents really excellent value for money with a performance that can only be surpassed by designs costing a great deal more; sometimes by a factor of three or more.

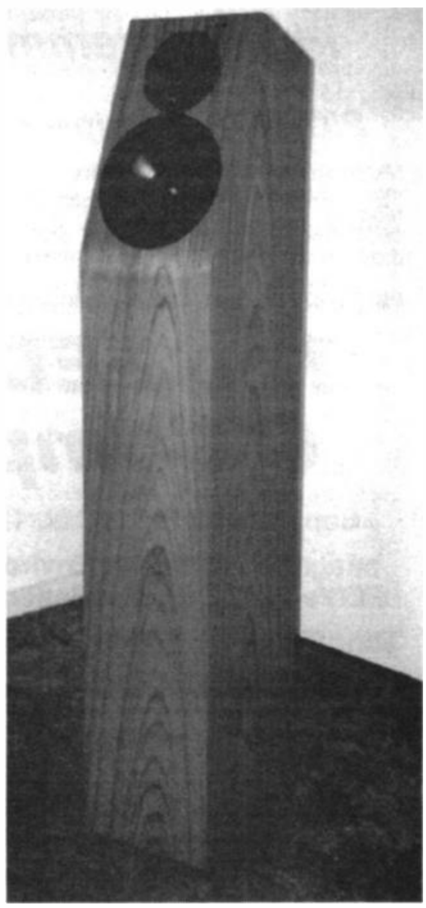
The advantages arising from the smaller enclosure stem from the dimensions of both the cabinet and the loudspeaker drive units. The smaller cabinet dimensions provide not only a reduction in material costs but also a significant increase in structural stiffness, reducing unwanted radiation from the cabinet walls. The narrower frontal area also improves the sound distribution.

By using a smaller bass unit the complete frequency range can be covered simply by adding a high frequency unit or tweeter. The "seamless" coverage provided by the small bass/mid-range unit can then be made to extend smoothly just beyond the critical mid-frequency range easing the crossover design and producing a radiation pattern conducive to a natural spread of sound and a usefully wide stereo sound stage[1].

IN RESPONSE

As far as a reduced power handling at low frequencies is concerned, it does not represent a too serious disadvantage because in most types of music, including the organ, the power is distributed in such a way that, below about 200Hz, spectral levels fall off naturally at a rate of about 3dB/octave[2]. However, if the small enclosure results in too abrupt a roll-off in bass level below 100Hz then the bass lightness becomes readily apparent, reducing the enjoyment of certain types of music. It follows that there is a limit to the economy feasible with the small diameter bass unit if it is to provide reasonably linear long-throw cone excursions necessary for adequately low frequency radiation.

When it comes to domestic acceptability, the small enclosure has an obvious advantage particularly if it could be tucked away inconspicuously on, say, a shelf. However, close proximity to a wall can give rise to interfering standing wave patterns causing some deterioration in the stereo image and, in the author's experience, an obvious audible improvement, in terms of depth and precision of stereo image, is obtained by spacing the



loudspeaker units out from the wall by anything up to about one metre.

Continuing to follow the small enclosure approach, the additional requirement is for a pair of loudspeaker stands to locate the enclosures stably in space at a height such that the high frequency information reaches the ears of a seated listener without undue absorption by soft furnishings. Possibly the next logical step is to consider whether the space within and under the stands could be usefully utilised perhaps to enhance the low frequency performance.

Bearing all these points in mind, the author embarked on a design aimed at satisfying the requirements for low cost, a free-standing configuration, and the minimum of dimensions consistent with an adequate low frequency performance.

DESIGN CONSIDERATIONS

A free-standing loudspeaker cabinet with similar dimensions to that of a small enclosure on a stand, if of conventional design and construction, can present a difficult acoustic problem to the designer because of the long narrow parallel cabinet walls. The walls will tend to vibrate and resonate at similar frequencies giving rise to a resonant pipe-like colouration to the low frequency sound, which is difficult to control and eliminate.

An alternative approach, that is satisfying from an acoustic engineering point of view, is to deliberately use and exploit the characteristics of a resonant pipe in such a way that the loudspeaker unit is correctly loaded and terminated at the low frequencies, whilst adequately suppressing unwanted pipe resonant modes. The low frequency efficiency of such an arrangement is somewhere between that of a horn and a bass reflex enclosure and therefore reduces the demands made on the low frequency excursions of the small diaphragm bass speaker unit[3].

The principle involved utilises the properties of a closed-at-one-end quarter wavelength pipe as originally proposed by Voigt[4] in his patent and subsequently adapted and described by R. West and R. Baldock in their designs. The design produced by R. West[3] was intended for a corner position with the speaker unit firing into the corner to spread the high frequency sound by reflection from the walls, and R. Baldock's designs were intended for either a semi-omnidirectional sound distribution[5] or a wall reflected distribution[6].

References

1. "Loudspeaker System Design" by S. Linkwitz *Wireless World* May 1978 pp52-56; Jun 1978 pp67-72; Dec 1978 pp79-83
2. "Some Factors in Loudspeaker Quality" by H. D. Harwood *Wireless World* May 1976 pp45-54
3. "The Decca Corner Speaker" by R. West *HI-FI News* Mar 1959 pp 724-726
4. Voigt Patent No 447749
5. "The Tricolumn" by R. N. Baldock *HI-FI News* Apr 1961 pp 786-790 Vol 5 No 12 May 1961 pp 853-855
6. "The Paraline" by R. N. Baldock *HI-FI News* Apr 1963 pp 782-789

Present day practice favours loudspeaker operation away from corners and walls, firing directly at the listeners. It is the author's aim to revise the previous design to cater for this latest approach, which is more closely matched to the improved stereo depth and imaging available from some of the current stereo sources.

QUARTER-WAVE LOADING

Having finally decided to keep to the original Quarter-Wave Loading (QWL) enclosure design, an overall view and cabinet dimensions (two required) can be gained by looking at Fig.10 and Fig.11. The finished appearance of the completed two-speaker "column" can be seen from the accompanying photographs.

The bass enclosure consists of a quarter wavelength rectangular section pipe with a linear taper, resonant at about 50Hz. The bass loudspeaker unit is situated at approximately half way along the acoustic axis in the best position to suppress higher order resonant modes.

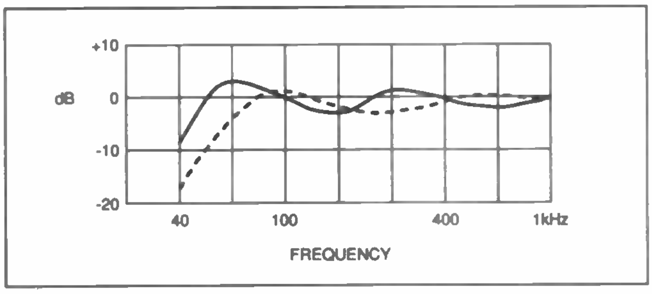


Fig.1. Bass response comparison between quarter-wave design (solid) and 10 litre sealed enclosure (dashed).

At resonance the acoustic pressure is high at the tapered end and is still reasonably high at the loudspeaker unit. This ensures that effective acoustic loading is presented to the loudspeaker cone and small excursions of the cone at high pressure are manifested as much larger low pressure movements of air out of the port at the bottom of the enclosure.

Such a process, similar to horn loading, contributes to efficient bass frequency operation with low distortion, up to a frequency of 200Hz, where direct radiation from the cone takes over. The enhanced bass response produced by this method of loading compared with that from the same unit in a 10 litre sealed enclosure is shown in Fig.1, where the curves were obtained under identical measurement conditions.

Bearing in mind this result, it can be seen that this enclosure not only satisfies the requirements of being free-standing, with the drive units at a convenient height, but also provides an enhanced bass response, using the space that would otherwise have been taken up by a stand. Furthermore, only small cone excursions are required in the bass loaded region and this places the minimum of demands on linearity of the cone suspension and the magnetic field in the voice coil gap, allowing reasonably low priced drive units to be employed.

The effect on power handling was quite dramatically demonstrated to the author when two nominally identical bass drive units were compared: one in a 10 litre completely sealed enclosure and the other in a quarter-wave loading enclosure. Switching from one to the other and slowly increasing the power level, the unit in the sealed enclosure was the first to show signs of distress.

Continuing the quest for a low price design, it is tempting to consider a wide range twin-cone unit for use in this enclosure. As can be seen in Fig.2, the high frequency response of a 165mm diameter paper cone bass unit used in this position showed considerable ripple in the response due to cone break-up modes. Also, when a small tweeter cone is added to the main cone to widen the frequency range, any improvement in frequency response is accompanied by main cone break-up ripple as shown in Fig.3.

A smoother performer was found to be a 165mm polypropylene cone bass unit with the frequency response as shown in

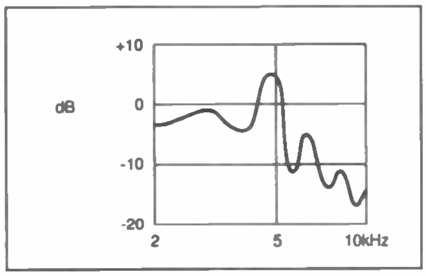


Fig.2. Frequency response for a 165mm paper cone bass unit.

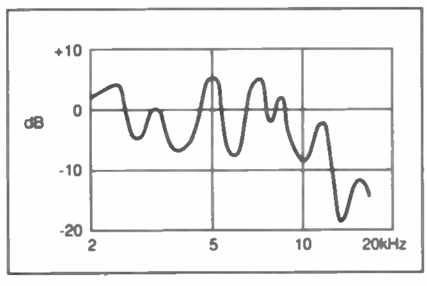


Fig.3. Response of a twin-cone unit.

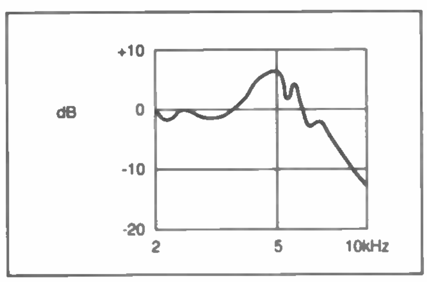


Fig.4. Frequency response of 165mm polypropylene bass unit.

Fig.4 and this type is recommended for use in this design. (Needless to say the latest polypropylene bass unit adopted for this updated design is even smoother!)

HIGH FREQUENCIES

Because of the unsatisfactory response of twin cone units, space is provided in the top of the quarter-wave enclosure (see Fig.10 and Fig.11) to house a suitable high frequency "tweeter". Referring again to Fig.10 and Fig.11, it can be seen that the speaker unit baffle board has been kept as small as possible both for the sake of rigidity and the need to keep the frontal area to a minimum for good stereo performance.

The top of the bass enclosure also serves to stiffen the unit baffle. The baffle is deliberately sloped to time-align the outputs from the two units and to improve the coupling of the bass unit to the air column in the enclosure.

The original speaker units used in this design were supplied by Tandy and a simple crossover arrangement, where the tweeter was fed from a capacitor, kept the overall cost to a minimum whilst yielding a very good performance for the money. However, as the original speaker units are no longer available, it provided an ideal opportunity to investigate the possibility of upgrading the choice of loudspeaker driver units.

The advantage of the quarter-wave loading is that it is not sensitive to the bass driver characteristics in the way that the bass reflex cabinet design is. All that is asked for is a reasonably low bass resonant frequency.

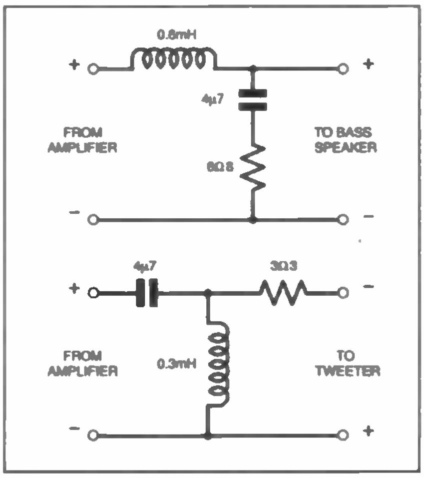


Fig.5. Crossover circuit diagram.

One further consideration was that of the type of crossover to employ. The original capacitor feed to the tweeter and direct connection to the bass speaker meant that the bass unit worked up to 6kHz or so before its contribution was taken over by the tweeter. This is fine in some respects, such as maximum damping from the amplifier, but the directivity of the bass speaker increases with operating frequency and the optimum stereo listening position becomes quite restrictive and critical at the higher frequencies.

Also, the tweeter capacitor feed with its low rate of cut-off with frequency means that the drive voltage at tweeter resonance can be embarrassingly high. Thus an upgrade also meant the adoption of an improved crossover arrangement.

At this point, the author sought the assistance of South Coast Speakers of Southampton for help in the choice of loudspeaker units and a crossover design. After several visits, and a review and analysis of the existing design, speaker units from the Norwegian firm SEAS were considered for the upgrade.

The units finally chosen were the P17REX polypropylene bass speaker and the 25TTF fabric dome tweeter (see *Shoptalk*). These were installed in the QWL enclosure and delivered to South Coast Speakers where a 2nd order Linkwitz-Riley crossover was designed and evaluated.

CROSSOVER

The Linkwitz-Riley crossover design originated as a measure to control the direction of the main lobe of the forward radiation of a two-unit speaker system. It is unusual in that, at the crossover frequency, each filter response is 6dB down (as opposed to 3dB) and the drivers are wired in *opposite* polarity to achieve an in-phase contribution to the overall radiated sound. As far as the phase response of the two sections of the crossover is concerned the Linkwitz concept is to aim at a constant phase difference between the two output signals to achieve a good group delay response.

The final circuit of the QWL crossover is shown in Fig.5 and the measured loudspeaker frequency response from 500Hz to 20kHz is shown in Fig.6, where it is

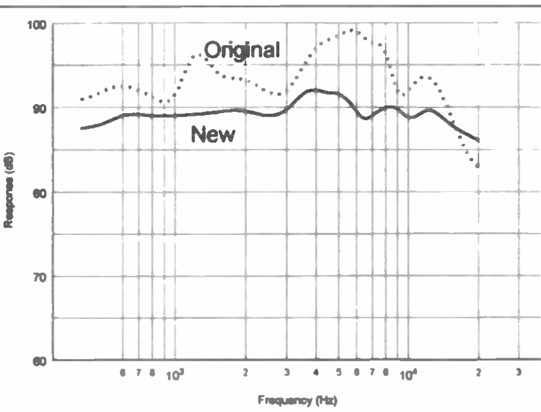


Fig.6. New frequency response compared with original design.

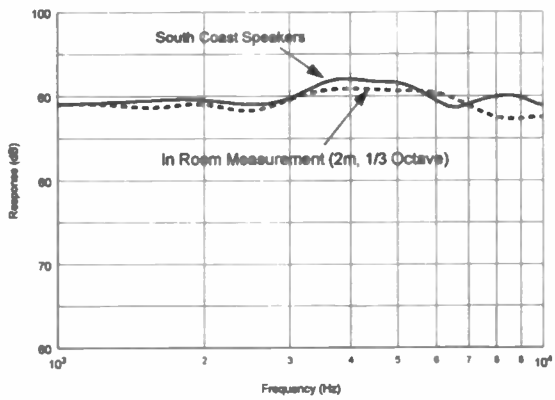


Fig.7. Frequency response comparison test results.

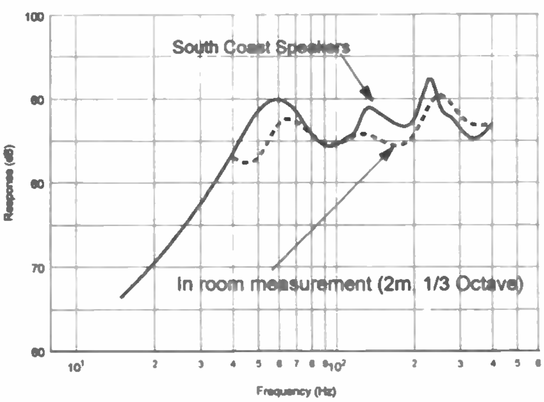


Fig.8. Low frequency response comparison.

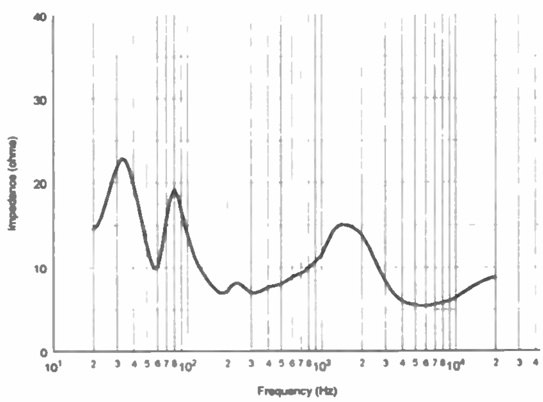
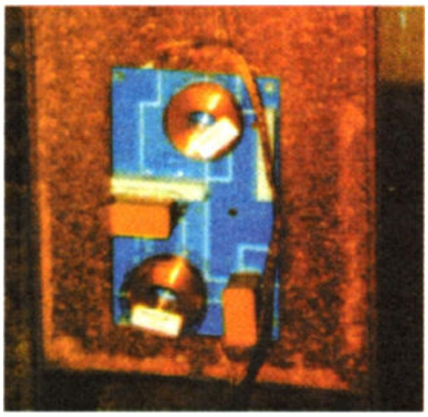


Fig.9. System impedance characteristic.

compared with the response of the original 1988 design. The advantage of the new drivers and a more complex crossover is readily apparent from the responses. There is also an improvement in power handling from 25W to 80W, which perhaps is not surprising considering that the weight of the magnet of the bass speaker, for example, represents an increase of over a factor of two.

The frequency response measurements, using 1/3 octave noise between 1kHz and 10kHz, have also been repeated in the author's own room with a capacitor microphone at two metres. The upper frequency was limited to 10kHz because of the response of the microphone available. The results are shown in Fig.7, where it can be seen that a comparison between the South Coast Speaker calibration and the in-room measurements is most encouraging.



The crossover board mounted on the rear panel, just above the rear port.

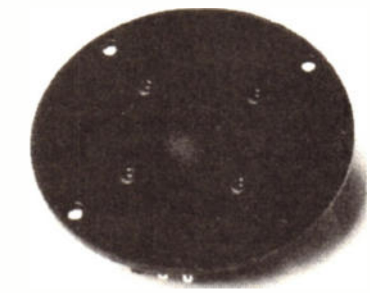
As far as the frequency response below 500Hz is concerned measurements become a little more difficult. At low frequencies the loudspeaker produces sound both from the cone of the bass unit and the rear port. It is the achievement of a true representation of the combined response that presents a problem.

A straightforward summation of the output of the cone and port from the South Coast Speaker's measurements is shown in Fig.8 and again in-room 1/3 octave noise measurements compare quite favourably. This time the microphone response cannot be trusted much below 40Hz.

Taking a view of the frequency response as a whole, it can be seen that the response extends from 40Hz to 20kHz with an SPL(1W/1m) of 89dB, deviating by ±3dB from 1kHz to 20kHz and by +3dB/–6dB from 40Hz to 500Hz. The low frequency properties of the cabinet can be associated with an intriguing mixture of tuned pipe and horn loading, the advantages of which are evident in terms of an improved transient response from the bass unit.

The penalty for this improvement, is the increase in response deviation below 400Hz. However, these deviations are small compared with standing wave effects in the listening room at these frequencies and the overall

SEAS P17REX bass driver



The 25TTF (H457) tweeter from SEAS.

response compares very favourably with other speakers of, what might be termed, an audiophile status.

Finally, the impedance characteristic shown in Fig.9 illustrates that the loudspeaker will present a relatively easy load to most amplifiers, producing really loud results with amplifiers in the 50W range.

CONSTRUCTION

Now we have discussed the various merits and selected our speakers, it is time to undertake the construction of the QWL enclosure. This is made up from 12mm (1/2in.) thick chipboard and 6mm (1/4in.) thick plywood as shown in Fig.10.

The enclosure has been designed to make the construction as simple as possible, and if the various pieces shown in Fig.10 are cut accurately square then there should be no difficulties in assembly. Referring to Fig.10 and Fig.11 it can be seen that there are only two angle cuts to be made, those at the top of both the long front and back panels. All the rest are simple 90 degree butt joints and it is left to the individual constructor to decide whether to attempt the angle joints or simply butt the joints and fill the wedge shape gaps with whatever technique and material is convenient.

Dimensions quoted are not critical provided everything is checked to fit as shown in the diagrams so that airtight joints are obtained, particularly in the high acoustic pressure areas in the tapered wedge and around the speaker unit. (It should be noted that the baffle cut-out dimensions in Fig.10 are for the *new* loudspeaker units and existing cabinets will satisfactorily house the new units simply by opening up the cut-out for the bass unit by about 2mm (1/16in.) or so, and the vertical dimension of the right hand cut-out for the tweeter by 6mm. It is desirable to ensure that the surrounds for the two units almost touch on the vertical axis.)

The front, back, bottom, top, and internal partition members are all made of nominally 12mm (1/2in.) thick chipboard and should all be matched to the same width of 178mm (7in.). The two side panels are made of nominally 6mm

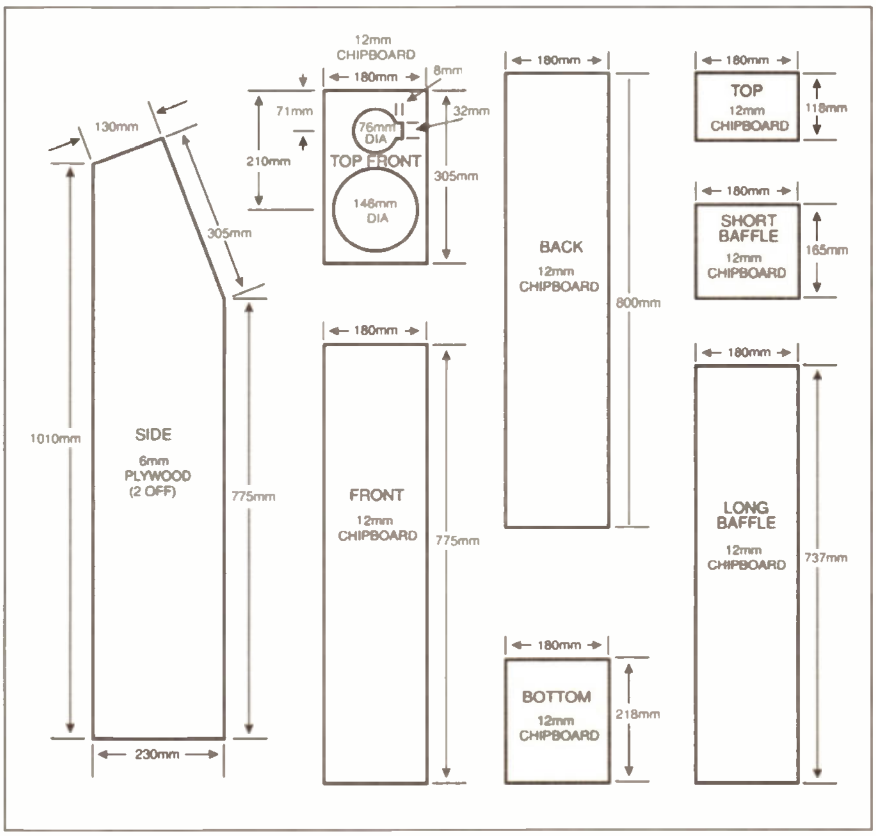


Fig.10. Cutting details and dimensions for a single enclosure (two for stereo).

(1/4in.) thick plywood and it is recommended that one of the panels is marked out to indicate where the 12mm thick panels are located. These can then be cut to size and checked for fit and the assembly pinned and glued together to form the structure drawn in Fig.11.

As the assembly progresses check it for squareness and, if necessary, secure one or two cross-pieces of plywood offcuts with pins driven a little way in to hold the assembly square while the glue sets. Being reasonably liberal with the glue should ensure airtight joints but pay particular attention to the pointed end of the wedge section, and, if necessary run a fillet of glue along this particular joint.

Finally, complete the assembly by glueing and pinning the second plywood panel into place. It will be noted that the enclosure is reasonably light and stiff and this minimizes the energy storage in the enclosure walls.

Tapping the sides of the enclosure produces different notes at different positions indicating that the internal bracing and asymmetry is working to minimize undesirable reflections and panel resonances. Finishing tasks involve punching the pins home, filling, and sanding prior to painting or covering with material or an iron-on veneer.

Once the wiring to the crossover is completed it's time to face the music.

The enclosure was checked for any undesirable resonances by very slowly sweeping through the low frequencies with a sine wave generator as well as taking account of the impedance characteristic of Fig.9. The damping material is obtained by buying a square metre of Terylene wadding from the dressmaking department of your local store. It should weigh about 100 grams and is cut in two: a piece for each enclosure. Each piece is folded lengthwise in two and the resulting strip is folded again twice to form a 25cm square, ready for insertion as shown in Fig.11.

LOUDSPEAKER MOUNTING

One final task now remains, and that is to mount the speaker units and crossovers on each completed enclosure. The loudspeaker units are mounted from the outside of the enclosure and the bass unit needs a sealing gasket fabricated from, preferably a rubber based, draught sealing strip. It is also recommended that the tweeter is mounted on a sealing strip to avoid any extraneous noise set up between tweeter surround and the cabinet.

Use chipboard screws and do not over tighten. Matching black screws can be obtained and with their extra length it is advisable to glue small soft wood blocks behind each screw hole location.

The bass speaker signal lead is simply passed down through the bass enclosure and out through the rear port, whilst the screened tweeter lead is secured by clips down the back of the enclosure, see photograph. Connections can then be made to the crossover board fastened to the back of the cabinet and the board enclosed, if desired, in a plastic box. Readers may also wish to experiment with the provision of steel or plastic spikes in the base of the enclosure.

PERFORMANCE

The choice of loudspeaker is often a very personal decision and the present design is the result of many hours of measurement and listening. Over a period of time friends have been invited to audition these speakers and their performance received very favourable comments by even the most candid listener. It is felt that the majority of readers will not be disappointed with the final results of this project.

In summary then, these loudspeakers are relatively cheap for the performance obtained (as a useful rule of thumb they compare very favourably with commercial designs costing in the order of three times the cost of the speaker units and crossovers in this design) and are fairly simple to build. They occupy very little floor space, are easily moved to a desired position for serious listening, and are of the right height to preclude the need for stands. □

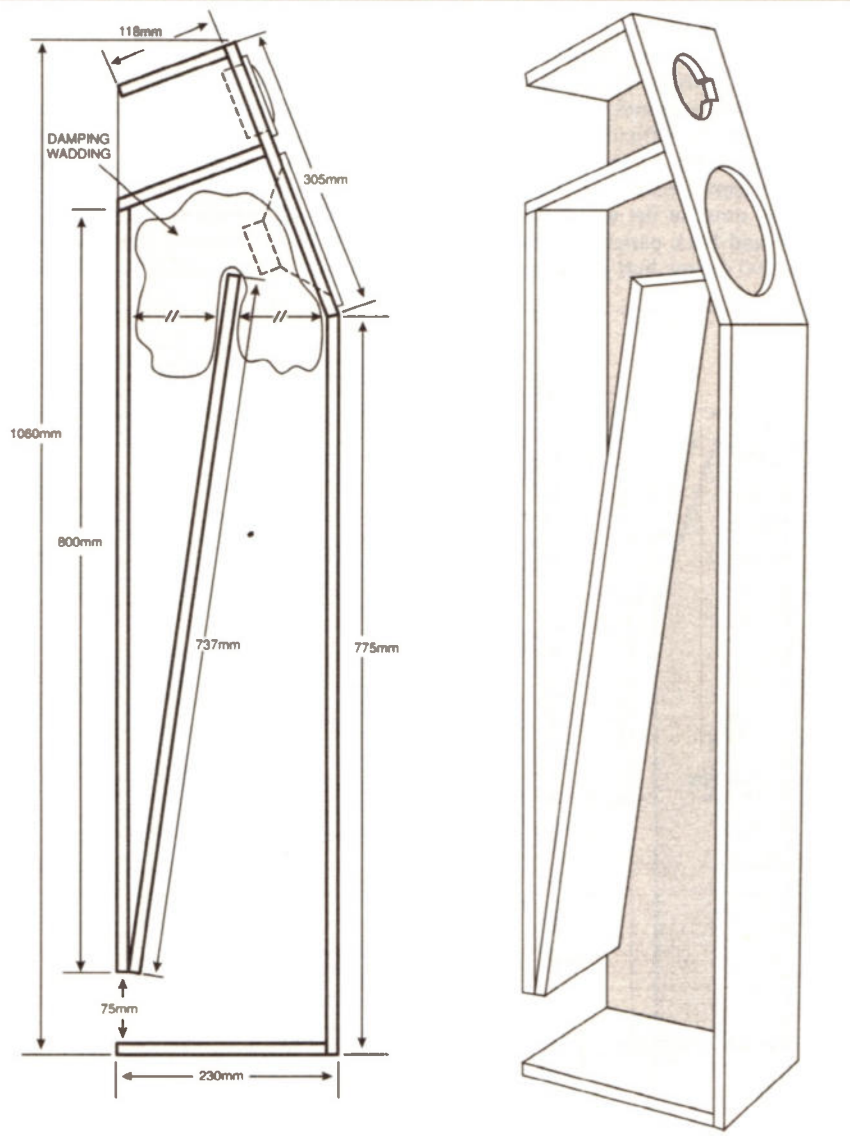
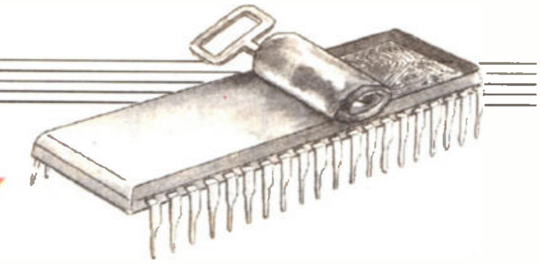


Fig.11. Enclosure dimensions and construction.

Special Feature



PIC16F87x MINI TUTORIAL

JOHN BECKER

Taking a programmer's look at some of the PIC16F87x family's facilities.

PCFG3: PCFG0	AN7(1) RE2	AN6(1) RE1	AN5(1) RE0	AN4 RA5	AN3 RA3	AN2 RA2	AN1 RA1	AN0 RA0	VREF+	VREF-	CHAN / REFS
0000	A	A	A	A	A	A	A	A	VDD	VSS	8/0
0001	A	A	A	A	VREF+	A	A	A	RA3	VSS	7/1
0010	D	D	D	A	A	A	A	A	VDD	VSS	5/0
0011	D	D	D	A	VREF+	A	A	A	RA3	VSS	4/1
0100	D	D	D	D	A	D	A	A	VDD	VSS	3/0
0101	D	D	D	D	VREF+	D	A	A	RA3	VSS	2/1
011x	D	D	D	D	D	D	D	D	VDD	VSS	0/0
1000	A	A	A	A	VREF+	VREF-	A	A	RA3	RA2	6/2
1001	D	D	A	A	A	A	A	A	VDD	VSS	6/0
1010	D	D	A	A	VREF+	A	A	A	RA3	VSS	5/1
1011	D	D	A	A	VREF+	VREF-	A	A	RA3	RA2	4/2
1100	D	D	D	A	VREF+	VREF-	A	A	RA3	RA2	3/2
1101	D	D	D	D	VREF+	VREF-	A	A	RA3	RA2	2/2
1110	D	D	D	D	D	D	D	A	VDD	VSS	1/0
1111	D	D	D	D	VREF+	VREF-	D	A	RA3	RA2	1/2

U-0	U-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	—	—	—	PCFG3	PCFG2	PCFG1	PCFG0
bit7							bit0

Note 1: These channels are not available on the 28-pin devices.

Fig.1. Selectable functions of the ADCON1 register.

AT LONG last Microchip's new PIC16F87x family of microcontrollers is actually available through component distributors and retailers. Forecast in late 1998, production release commenced in July 1999.

The author has had engineering samples for some months and has examined them with considerable interest. A general look at the family was taken in the *PIC16F87x Review* (Apr '99). Now we can encourage you to explore the possibilities of these very welcome PICs, knowing that you can obtain the production devices.

The aim of this Mini Tutorial is to share with you some of the findings made by the author when designing the *8-Channel Analogue Data Logger*, published in Aug/Sept '99. The findings relate to investigations using the PIC16F877 but apply in principle to the PIC16F873, '874, and '876 devices as well.

Readers should also study the 200-page data sheet that covers the devices, Microchip code DS30292A (see later).

The following *EPE* subject material is also referred to in this Mini Tutorial:

- *PIC Tutorial* (Mar-May '98)
- *PICtutor* (CD-ROM version of the *PIC Tutorial*)
- *PIC Toolkit Mk1* (Jul '98)
- *PIC Toolkit Mk2* (May-Jun '99)
- *Virtual Scope* (Jan-Feb '98)

PROTOCOL

In the course of this article, reference is made to figures from Microchip data sheet DS30292A and the reference style used is, for example, DS-FIG.11-2 – meaning data sheet Figure 11-2.

Note also the use of the $ (dollar) sign when referring to hexadecimal numbers, and the % (per cent) sign for binary numbers, e.g. $9F and %11001111.

Where PIC source code examples are given, the dialect used is TASM (the differences between TASM and MPASM were discussed in *Toolkit Mk1*, *PIC Tutorial* and *PICtutor*).

All registers and bits referred to by name should have those names and their values "equated" at the head of any program that uses them.

PAGES 0 TO 3

The subject of Pages in relation to PIC16x84 devices was well covered in the *PIC Tutorial* and *PICtutor* texts, and a lot of readers expressed gratitude for the explanation.

Whereas the 'x84 had only PAGE0 and PAGE1 to be set in relation to the use of some Special Registers, the 'F87x devices have four Pages (Microchip actually calls them Banks – but we'll stick with Pages).

In the STATUS register, two bits (instead of one) control the Page selection, bits 6 and 5 respectively. Consequently, the shorthand technique used with the 'x84 of defining the instruction PAGE0 or PAGE1 to mean clearing or setting of STATUS bit 5 accordingly, is less easy to use when two STATUS bits are affected. Therefore, in common with the Microchip data sheet, the STATUS bits will be referred to by their allocated names, of RP1 (bit 6) and RP0 (bit 5).

Their settings are as follows:

PAGE	RP1	RP0
PAGE0	0	0
PAGE1	0	1
PAGE2	1	0
PAGE3	1	1

You will make life easier for yourself if you "equate" these two bits at the head of your programs:

```
RP0:   .EQU 5
RP1:   .EQU 6
```

The Register File Maps in DS-FIG.2-3 and DS-FIG.2-4 show which registers are in which Pages (Banks).

PIC PORTA AND PORTE

PORTA is a 6-bit bi-directional I/O (input/output) port whose bits RA0 to RA3 and RA5 can alternatively be used for analogue input.

PORTE is a 3-bit bi-directional I/O port whose bits RE0 to RE2 can alternatively be used for analogue input.

The first matter of interest that came to light when experimenting with the PIC16F877 was that its PORTA did not behave as expected when used as a normal I/O data port.

The PIC16F877 was originally loaded with the TUTTEST program that allows users of the *PIC Tutorial* and *PICtutor* development boards (which are for use with PIC16x84 devices) to initially test their system. PORTB behaved as expected, but not so PORTA.

Examination of the data sheet revealed that PORTA's default mode is not for digital data I/O, but for analogue data input.

The register which controls PORTA's digital or analogue use is ADCON1, whose settings options are shown in Fig.1 (taken from data sheet DS-FIG.11-2). This same register controls PORTE as well.

Register ADCON1 is at address $9F, which is in PAGE1. Fig.1 shows that PORTA and PORTE are jointly set for analogue use when ADCON1's bits 0 to 3 are set to 0000 (the default condition on power-up). To jointly use PORTA and PORTE for digital purposes, the bits are set to 0111 (or 0110 since bit 0 can be 0 or 1 in this instance), i.e. ADCON1 has to be loaded with %xxxx111x – where x can be 0 or 1.

You will already be familiar with having to set the data direction (TRISx) registers depending on whether a port's bits are to be used for input or output. So, for both PORTA and PORTE to be fully set for digital output, TRISA and TRISE have to be cleared, which also has to be done in PAGE1.

Thus, an example of initialising your code to use PORTA and PORTE for digital output is:

```
BCF STATUS,RP1      ; clear
                    ; PAGE2/3 bit
BSF STATUS,RP0      ; set PAGE1
                    ; bit
MOVLW %00000111     ; all-digital
                    ; I/O code
MOVWF ADCON1        ; load it
                    ; into
                    ; ADCON1
CLRF TRISA          ; all PORTA
                    ; for output
CLRF TRISE          ; all PORTE
                    ; for output
BCF STATUS,RP0      ; reset to
                    ; PAGE0
```

Conversely, an example of initialising your code to use PORTA and PORTE for digital input is:

```
BCF STATUS,RP1      ; clear
                    ; PAGE2/3 bit
BSF STATUS,RP0      ; set PAGE1
                    ; bit
MOVLW %00000111     ; all-digital
                    ; I/O code
MOVWF ADCON1        ; load it into
                    ; ADCON1
MOVLW %00111111     ;
MOVWF TRISA         ; all PORTA
                    ; for input
MOVWF TRISE         ; all PORTE
                    ; for input
BCF STATUS,RP0      ; reset to
                    ; PAGE0
```

Note that TRISE ignores bits 3 to 7.

A-TO-D PREPARATION

From Fig.1, you will recognise that ADCON1 is set to xxxx0000 when PORTA and PORTE are to be used for analogue input. You also need to set the two associated TRIS registers for input (in the same way as setting them for digital input).

There is another option that can be chosen for ADCON1 as well – its bit 7 (ADFM) controls how the 10-bit digital value of the converted analogue signal is stored in the PIC's registers dedicated to this purpose, ADRESH ($1E – PAGE0) and ADRESL ($9E – PAGE1).

There is the choice of whether the result is justified to the left or right in these bytes. Take the example of a conversion result of 1023 (the maximum for a 10-bit conversion). The binary value of 1023 is, as two bytes, 00000011 11111111, stored as 00000011 in ADRESH and 11111111 stored in ADRESL.

This is the case when the ADFM bit (bit 7) is set to 1 (DS-FIG.11-8). However, if the ADFM bit is set to 0, the result is formatted as 11111111 11000000. This choice can be useful in some post-processing operations where it can save the use of multiplying (rotation commands).

As used in the *Data Logger*, a right-justified result was required, and so ADFM was set to 1. Since this design uses all of PORTA and PORTE for analogue input, the ADCON1 register was set with the commands:

```
BCF STATUS,RP1      ; clear
                    ; PAGE2/3 bit
BSF STATUS,RP0      ; set PAGE1
                    ; bit
MOVLW %10000000     ; all-analogue
                    ; input code
MOVWF ADCON1        ; load it into
                    ; ADCON1
MOVLW %00111111     ;
MOVWF TRISA         ; all PORTA
                    ; for input
MOVWF TRISE         ; all PORTE
                    ; for input
BCF STATUS,RP0      ; reset to
                    ; PAGE0
```

ADFM ANOMALY

When the first tests were made using the PIC16F877 samples provided by Microchip, the above commands were duly given in the *Data Logger* software that was being developed. To the author's consternation, the ADFM bit had no affect on the justification, which remained doggedly to the left when the result was displayed on an alphanumeric l.c.d.

It was eventually found that bit 5, not bit 7, was being used as the ADFM bit, and using that bit produced the required justification. What led the author to the conclusion that it should be bit 5 rather than bit 7 is that DS-Table 2-1 showed the power-on-reset condition for ADCON1 as being --0-0000, even though ADFM was shown as bit 7 on the left of the table.

Taking it up with Microchip, it transpired that the samples provided were Microchip's *early* engineering samples (version A) in which bit 5 was indeed the ADFM. They went on to say that production devices (version B) do have bit 7 as ADFM. This was proved when they sent version B samples to the author.

However, Microchip have asked us to advise anyone who has early engineering samples that this situation exists. Readers buying the chips from distributors or retailers should automatically be supplied with the production devices where bit 7 is the ADFM.

The fact remains, though, that the ADCON1 reset values given in DS-Table 2-1 of the 1998 DS30292A data sheet are incorrect and should read as 0---0000. Other tables in the same data sheet are similarly incorrect (3-1, 3-9, 3-12, 11-2).

A-TO-D CONVERSION

We have seen that ADCON1 is the register that sets PORTA and PORTE bits for analogue or digital use, and that ADRESH and ADRESL hold the 10-bit conversion value. A fourth register, ADCON0 ($1F – PAGE0) is responsible for the A-to-D control modes, as itemised in DS-FIG.11-1, but summarised as:

Bits 7-6	Conversion clock rate
Bits 5-3	Channel selection
Bit 2	Conversion status
Bit 1	Not used
Bit 0	A/D facility on/off

Prior to an A-to-D conversion being made, all bits have to be set appropriately. An example of the conversion sequence is shown in Listing 1, with entry point at ADCGET.

LISTING 1

```
ADCGET:  BCF STATUS,C       ; clear carry flag
         MOVF CHAN,W        ; get channel number
         MOVWF STORE        ; temporarily store it
         RLF STORE,F        ; multiply it by 8
         RLF STORE,F        ; to set it into correct bits
         RLF STORE,F        ; suited to ADCON0
         MOVLW %10000001    ; set clock Fosc/32 with A/D on
         IORWF STORE        ; OR this with stored value
         MOVWF ADCON0       ; move new value into ADCON0
         CLRF DELAY         ; set delay counter to 0
WAIT1:   DECFSZ DELAY,F     ; dec delay 256 times
         GOTO WAIT1         ;
SAMPLE:  BCF PIR1,ADIF      ; clear A/D interrupt flag bit
         BSF ADCON0,GO      ; start A-D conversion
WAIT2:   DECFSZ DELAY,F     ; again delay for 256 cycles
         GOTO WAIT2         ;
WAIT3:   BTFSC ADCON0,GO    ; is conversion complete?
         GOTO WAIT3         ; no
GETVAL:  MOVF ADRESH,W      ; get conversion high byte
         MOVWF MEMHI        ; store it in MEMHI
         BCF STATUS,RP1     ; clear Page 2/3
         BSF STATUS,RP0     ; set Page 1
         MOVF ADRESL,W      ; get conversion low byte
         BCF STATUS,RP0     ; reset Page 0
         MOVWF MEMLO        ; store low byte in MEMLO
         RETURN             ;
```

The channel number is held in CHAN and could be any value between 0 and 7. It has to be set into ADCON0 bits 5-3, consequently the first six commands are concerned with taking a copy of the CHAN value and rotating it to fill bits 5-3 of the temporary STORE. If the Channel number is 7, for example, CHAN holds %00000111, and the rotation into STORE produces %00111000.

The conversion clock rate is determined from DS-Table 11-1. The *Data Logger's* crystal clock runs at 3.2768MHz and the nearest value to this, as shown in DS-Table 11-1, is 5MHz and that a conversion factor of 32Tosc is required, which is set into ADCON0 with the bit 7-6 code of binary 10 (DS-FIG.11-1).

The converter is obviously required to be On, so bit 0 is set to 1.

The values for bits 7, 6 and 0 are thus set into W as %10000001, which is then ORed with the channel bits 5-3 held in the STORE (%00111000 in this example).

This composite value (%10111001) is then MOVed into ADCON0. Notice that bit 2, the Start bit (quaintly called the GO/DONE bit by Microchip!), is still at zero. The conversion does not start until this bit is set to 1. Also note that ADCON0 bit 1 has no function.

SOPHISTICATION

At this point it is possible to get rather sophisticated – but we're not going to!

The sophisticated way would be to use interrupt routines and precise timings, and a lengthy section in the data sheet discusses the options. They include calculation of the time taken to acquire the sample (which is relative to temperature, line impedance and capacitance values), and then to wait for an interrupt to occur on completion of the conversion.

Since the *Data Logger* is only required to take samples at the maximum batch rate of eight (all eight channels) every 0.5 seconds, time is not at a premium and so two simple delay loops are used, shown in Listing 1 as WAIT1 and WAIT2.

When WAIT1 has ended, the conversion is started by first clearing the A/D interrupt flag bit (bit 6 of register PIR1 – $8C, PAGE0), and then setting ADCON0 bit 2 (the GO bit).

The delay in WAIT2 then occurs, after which the GO bit is polled in WAIT3 until it is read as 0, signifying that the conversion is complete.

The values of the 2-byte conversion can now be read. The high byte (MSB) is held in ADRESH, which is in PAGE0 and so can be immediately read and stored in the user's own nominated location, in this case MEMHI. The low byte (LSB), however, is held in ADRESL, which is in PAGE1, which has to be set before the byte can be read. After which a reset to PAGE0 occurs and the byte is stored in MEMLO, so ending the conversion sequence.

As used in the *Data Logger*, the sequence is somewhat more padded than shown here since it is written to read a conversion for each of eight channels in turn, and then to store the 2-byte result in a chain of eight serial EEPROM memories, and to decimalise the result for showing on an alphanumeric l.c.d. screen.

Apart from the ADFM problem mentioned earlier, no surprises occurred when using the A/D facilities on all eight PIC16F877 channels, and the program worked first time. Which is more than can be said for storing the result in the serial EEPROM memories, as we shall reveal in a moment, plus the solution, of course!

ADC REFERENCE VOLTAGES

Referring again to Fig.1, you will see that pins RA2 and RA3 can be used as the pins on which external ADC reference voltages can be set, depending on the code set into ADCON1 bits 0 to 3. The columns 10 and 11 show how the reference voltage selection takes effect.

Although not discussed in the *Data Logger* text, the p.c.b. for that unit has been designed so that preset potentiometers can be inserted on it to set desired reference voltages on pins RA2 and RA3 for other applications. (The *Data Logger* itself does not offer this option through its software – readers must write their own software to suit their personal needs in this respect.)

The circuit diagram and p.c.b. assembly details for the insertions are shown in Fig.2 and Fig.3. Note the additional two link wires that are needed in order to complete the circuit between the wipers of the presets and their respective RA2/RA3 pins.

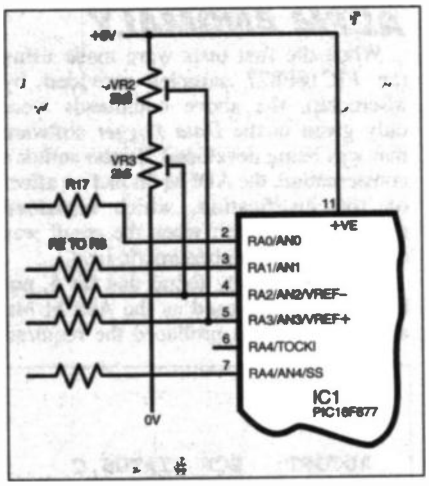
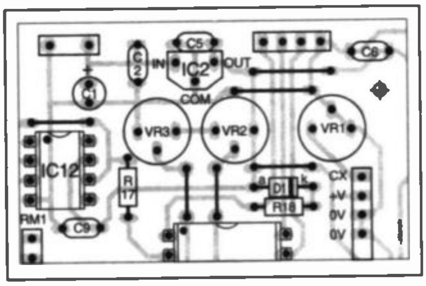


Fig.2. Reference voltage setting presets added to Data Logger circuit diagram Fig.1, and (below) Fig.3, their positioning on the Data Logger p.c.b.



Preset VR2 allows a reference voltage variation between approximately 2·5V and 5V on RA2, whilst VR3 allows variation between 2·5V and 0V on RA3. The use of a narrower range of reference voltage (which is normally 0V to 5V i.e. V_{ss} to V_{dd}) has the effect of providing amplification to the analogue input signal being converted.

By variously selecting different values for ADCON1 bits 0 to 3, different reference voltage combinations could be chosen for individual input channels.

It should be noted that when either RA2 or RA3 is selected as a reference voltage input, the selected pin cannot be used as an A-to-D input channel.

SERIAL MEMORY ACCESS

Once you get to know them, Microchip's 24LC256 serial EEPROM memories are really rather super little chips! It was their data sheet (DS21203D, 1998) that the author had difficulty with.

Attempts were made to write the routine which would store data at consecutive addresses in a 24LC256. Somehow, the logic of the data sheet's description and illustration eluded the author (it's not often he fails in such situations, but he failed this time!)

Running out of patience, he resorted to seeing if programs were available amongst Microchip's Applications Notes (on their CD-ROM and web-site).

There were several options available, of which the programs 2WDPOLL.ASM and 2WSEQR.ASM were selected as appearing to have the best options available (even though they were not written for PIC16F87x devices) and disk copies were made.

Being Microchip's own programs, they were naturally written in MPASM, whereas the author has a great preference for working in the TASM dialect. Consequently, the MPASM source codes were processed by the author's *PIC Toolkit Mk2* and converted to a TASM format.

Various modifications were then made to the programs to suit them to the *Data Logger's* needs, whereupon success was achieved! Data could now be written to the serial EEPROMs and, equally importantly, could be read back as well.

Those of you studying the *Data Logger* source code will find entry into the serial memory Write routine at label WRBYTE, and entry to the Read routine at READ. The routines are far too lengthy to list or describe here.

As a further plug for Microchip's Application Notes, they are well worth examining for all sorts of information and ideas, plus an awful lot of source code listings as well. Do have a good browse through them.

SERIAL OUTPUT

With the ability to write/read serial data assured, the next stage to be solved was that of instructing the PIC16F877 to output the data as a serial stream at a known baud rate. This turned out to be very straightforward.

The PIC16F87x family have a built-in structure which allows serial output through a dedicated pin, RC6, and for the rate of output to be selected according to the needs of the destination for that data (e.g. a PC) and in relation to the PIC's crystal controlled clock rate.

Additionally, these PICs can be instructed on such matters as synchronous or asynchronous transmission, parity, stop bits and byte size.

The 'F87x data sheet, once you have studied it for details of serial interfacing, is actually quite helpful.

It was decided to use asynchronous serial transmission from the PIC to the PC. This requires only two lines to be connected between the two systems, one for data and one for the ground (0V).

It was further decided that the rate of transmission should be at the maximum likely to be found on the majority of readers' PCs, 9600 baud, with no parity, one stop bit and with 8-bit transmission.

The registers associated with serial transmission are:

SPBRG ($99 – PAGE1) Baud rate generator
TXSTA ($98 – PAGE1) Transmit status and control
RCXTA ($18 – PAGE0) Receive status and control
PIE1 ($8C – PAGE0) Peripheral interrupt control

Data sheet tables are provided for establishing the value to be set into register SPBRG in relation to several examples of clock rate: DS-Table 10-4 and DS-Table 10-5. Since these do not quote a value for a 3·2748MHz clock, as used in the *Data Logger*, the formula quoted in the data sheet's Example 10-1 was more useful on this occasion.

TIMING FORMULAE

In fact, two formulae can be derived from Example 10-1, depending on whether the PIC is to divide the clock rate by 64 or 16. The idea is to select a division rate to produce as large an SPBRG value as possible, up to a maximum of 255 (it's an 8-bit register).

In Listing 2 is shown a Basic program derived from the formula in Example 10-1. It calculates the SPBRG value in relation to the baud rate required, the clock rate available, and the two division factors of 64 and 16. Bit BRGH (bit 2) of the TXSTA register has to be set low if 64 is the divider, and high for a divider of 16.

LISTING 2

```
'calculate SPBRG for required baud rate

BAUD = 9600    ; replace this value with your own
FOSC = 3276800 ; replace this value with your own
X = (FOSC / (64 * BAUD)) - 1
Y = (FOSC / (16 * BAUD)) - 1
PRINT "BAUD ="; BAUD, "CLOCK ="; FOSC
PRINT "SPBRG at div 64 = "; X; "bit BRGH = 0"
PRINT "SPBRG at div 16 = "; Y; "bit BRGH = 1"
```

Running the program in Listing 2 produces SPBRG answers of 4·333333 (BRGH = 0) and 20.3333 (BRGH = 1). Since the latter is the higher, the BRGH bit has to be set to 1.

The bit which tells the PIC whether it is required to transmit synchronously or asynchronously is TXSTA register bit 4 (SYNC). DS-Table 10-1 shows that for asynchronous transmission the SYNC bit is set to 0.

Prior to commencing transmission, the basic transmission parameters are set as in Listing 3, with entry at label SETBAUD.

Since some of the affected registers are in PAGE1, this is set first, as in command lines 1 and 2. Then the integer of the chosen SPBRG value (20) is stored into the SPBRG register, register TXSTA is conditioned for SYNC = 0 and BRGH = 1, TRISC bit 6 is cleared for pin RC6 to be used as an output, and the transmission interrupt bit (PIE1,4) is cleared (interrupt not required). A reset to PAGE0 is made and the SPEN bit (bit 7) of register RCSTA is set.

This sequence is in accordance with the first three steps listed in the data sheet at Section 10.2.1. Step 4 (9-bit transmission) is not required. Step 5 (enable transmission) requires a reset to PAGE1, and the transmission bit (bit 5) of TXSTA is set, followed by a reset to PAGE0. The scene is now ready for data to be transmitted from PIC pin RC6, and the SETBAUD routine is exited.

SERIAL FORMAT

In the *Data Logger* the SETBAUD sequence is performed when power is first switched on and it remains in a state of readiness to send data to the PC until power is switched off again.

Consequently, having read the 2-byte sample data stored in the selected serial memory, it can be sent to the computer through the routine commencing at label SENDPC, shown in Listing 4.

However, before it can be sent, a slight readjustment of the data format is needed. The PC register which receives the serial data shifts it left by one place (multiplying it by two). This means that the PIC cannot send a data byte whose value is greater than 127. If it were to, bit 7 would be "lost" at the PC end.

To over come this, the least significant byte of recalled data (held in MEMLO, as discussed earlier) has to be limited to a value of less than 128 and its eighth bit (bit 7) combined with the most significant byte (MEMHI), whose recalled value is never greater than three.

On entry into routine SENDPC in Listing 4, this rearrangement takes place in the first four lines. An example of what happens is as follows:

Suppose MEMHI holds a value of %00000011 and MEMLO holds %11111111. MEMLO is first rotated left into the W register (leaving MEMLO itself untouched) so that its bit 7 "drops" into the Carry register. MEMHI is now rotated left and in doing so the Carry bit is rotated into it from the right. MEMLO's bit 7 can now be cleared, limiting MEMLO's value to less than 128.

The result is that MEMHI now holds %00000111 and MEMLO holds %01111111 and it is these values that are

LISTING 3

```
SETBAUD: BCF RP1         ; clear PAGE2/3
         BSF RP0         ; set PAGE1
         MOVLW 20        ; BRG val for 9600 baud
                         ; from 3.2768MHz, brgh=1
         MOVWF SPBRG     ; put into SPBRG reg
         MOVLW %00000100 ; sync=0 (bit 4), brgh=1
                         ; (bit 2), clear other bits
         MOVWF TXSTA     ; put into TXSTA
         BCF TRISC,6     ; set RC6 as output
         BCF PIE1,4      ; clear interrupt bit (TXIE)
         BCF RP0         ; set back to PAGE0
         MOVLW %10000000 ; set SPEN bit of RCSTA reg
         MOVWF RCSTA     ;
         BSF RP0         ; set for PAGE1
         BSF TXSTA,5     ; enable transmission (TXEN)
         BCF RP0         ; set for PAGE0
         RETURN          ;
```

LISTING 4

```
SENDPC:  BCF STATUS,C    ; clear Carry flag
         RLF MEMLO,W     ; rotate MEMLO left into W,
                         ; bit 7 enters Carry
         RLF MEMHI,F     ; rotate MEMHI left, Carry
                         ; enters bit 0
         BCF MEMLO,7     ; clear MEMLO bit 7
         MOVF MEMLO,W    ; get MEMLO
         CALL SERIAL1    ; send it to PC
         MOVF MEMHI,W    ; get MEMHI
         CALL SERIAL1    ; send it to PC
         RETURN          ; end of routine
```

LISTING 5

```
SERIAL1: BTFSS PIR1,4      ; wait for bit 4 = 1
                           ; (showing TXREG empty)
         GOTO SERIAL1      ;
         NOP               ;
         MOVWF TXREG       ; put val in TXREG ready
                           ; for auto-transmission
         RETURN            ; end of routine
```

transmitted to the PC via the called routine whose label is SERIAL1 (see Listing 5). How they are restored to their "true" values will be discussed shortly. Once that byte pair has been transmitted, the next pair can be read from one of the serial memories, and again transmitted via the SENDPC routine.

REGISTERS TXREG AND TSR

The routine that allows each byte to be transmitted, SERIAL1, has only three active commands. As soon as the PIC's serial transmission register (TXREG) is loaded with a byte of data, transmission is started by the PIC's own internal facilities.

To summarise the PIC data sheet, the heart of the transmitter is the Transmit Serial Register (TSR), which obtains its data from the read/write transmit buffer register TXREG. The user's software loads TXREG with the data byte to be transmitted, where it stays until the Stop bit from the previously loaded data has been sent.

As soon as the Stop bit has been transmitted, the TSR is automatically loaded with the new data from TXREG. Once this has occurred, TXREG is now empty and a flag bit is set in register PIR1 – its bit 4, named TXIF. When this flag is set, the software can load the next byte of data into TXREG, an action which clears the TXIF bit.

The routine entered at SERIAL1 first checks the status of PIR1 bit 4. If the bit is low, a previous transmission is still taking place. The routine loops continuously checking bit 4 until it is set. Prior to entry to SERIAL1, the W register was loaded with the data byte (as in Listing 4). When PIR1 bit 4 is found to be set, the W data is loaded into TXREG, to be automatically transmitted out by the PIC.

As soon as TXREG has been loaded, the SERIAL1 routine ends, and software can get the next byte, or do whatever it is told to do, such as end the full transmission sequence because all the bytes have been sent.

IRREGULAR TRANSMISSION

The *Data Logger* sends its serial data to the PC in consecutive blocks of data. However, in a another design on which the author is working, the need is for serial data to be output to the PC at irregular intervals, two bytes a time.

Whereas for consecutive data blocks, setting the Baud Rate factors at the head of the program proved satisfactory, in the random transmission design, the author found it necessary to send a byte of zero prior to each double-byte being sent.

What subtlety of difference between the two programs makes this action necessary has not been established, although it is believed that it might be to do with PORTC being read between data words in the second design. PORTC is that which has to be used for serial input/output, and it seems possible that reading it (for switch status) between data words might affect the serial registers. It has yet to be more fully investigated.

PC RECEPTION

A program for use on a PC to receive serial data from a PIC is not included in Microchip's Applications Notes software listings library. A browse of the Internet for suitable software did not reveal anything that the author felt was suitable either. Consequently, he wrote his own routines specifically to import double-byte serial data from the *Data Logger*.

The program is written in a mixture of Basic (suited to running from QBasic or QuickBASIC) and machine code. The Basic program loads and calls the machine code, which does the actual serial data importing, and then, formats the data for output to disk, in several different file styles, as discussed in the *Data Logger* text.

There are, in fact, several ways in which machine code can be accessed from Basic. The example shown in Listing 6 is the one on which the author has standardised for several years.

The majority of the Basic routines are self-explanatory to anyone who knows QBasic or QuickBASIC and will not be discussed here. However, the routines which access the machine code, and the machine code itself, deserve a bit of explanation.

On running the Basic program, integer variable array MA%(x) is first DIMmed for the maximum number of separate values (32766) as are required for access by the machine code. All the values are in consecutive order within the PC's memory and their exact locations are accurately predictable.

Referring to Listing 6, the machine code whose file name is held in FILE$ is then loaded as binary data into string variable SERIAL$, at label LOADDATACODE. The address at which MA%(0) resides is then obtained, and POKED into the machine code at two predetermined consecutive addresses.

Note that in line 10 (MC =) attempting to multiply by 256 as a "live" value would result in an "overflow" error and so variable A is used, having been allocated that value in line 6. Also, because integer variables whose true values are greater than 32767 are returned as negative numbers, line 8 intercepts them if they occur, restoring them to their correct positive value. Additionally note that variable MB is used for two different purposes.

Once the routine in Listing 6 has been run, the machine code is accessed through the command:

CALL ABSOLUTE(SADD(SERIAL$))

When the machine code routine has ended, the program reverts to Basic.

It is important to note that there is a slight difference between using QBasic and QuickBASIC in that QuickBASIC has to be loaded with the command QB/L, which automatically loads an additional library program (part of the QuickBASIC suite) which allows machine code to be run. QBasic does not require the additional library program and is simply loaded in the usual way with the command QB.

The machine code routine is shown in Listing 7. It is based on two PC interrupt calls to INT 14H, whose functions are documented in the *PC Sourcebook* – a publication which itemises the principal registers and interrupt calls for base-standard PCs (seemingly compatible with processors from the 8086 upwards, including Pentiums).

On entry to the machine code, the address of MA%(0) is acquired from the value held at label SETSEGMENT, as previously POKED there from Basic.

Transmission format data passed from Basic (held in MA%(0)) is then read and loaded into the AX register. The data details the baud rate, parity, stop bit, and bit count configuration (assembled from

LISTING 6

```
LOADDATACODE:                       ' load machine code subroutine
OPEN FILE$ FOR BINARY AS #1         ' open file named in FILE$
B = LOF(1)                          ' get length of file
SERIAL$ = INPUT$(B, #1)             ' load file into SERIAL$
CLOSE 1                             ' close file
A = 256                             ' define A as value 256
MA = VARSEG(MA%(0))                 ' get segment address of MA%(0)
IF MA < 0 THEN MA = MA + 65536!     ' correct for negative value
MB = VARPTR(SERIAL$)                ' get pointer to SERIAL$
MC = PEEK(MB + 3) * A + PEEK(MB + 2) ' get address of SERIAL$
MD = INT(MA / 256)                  ' get MSB
MB = MA - (MD * 256)                ' get LSB
POKE MC + 5, MB                     ' poke LSB into machine code
POKE MC + 6, MD                     ' poke MSB into machine code
RETURN                              ' end of subroutine
```

the details in Table 1). The Basic software also passes details on which COM port (COM1 or COM2) is to be read (held in MA%(1)). This is loaded into the BX register to be then loaded into register DX, whereupon interrupt INT 14H is called, which passes the data to the PC's serial operating system.

Routine WAITDATASET is now called, in which INT 14H is polled until register AX returns with a value less than 256, signifying that a byte of serial data has been received and that it is now available in the low byte (AL) of register AX.

This data byte is an inversion of the byte presented to the PIC for transmission and is shifted left by one place. The inversion is corrected by subtracting the byte from 255.

Returning to the calling point, the byte is stored in register CL as the least significant byte of the double-byte required. WAITDATASET is again called, where the second of the two bytes needed is similarly acquired, and then stored in register CH. Note that CH and CL are the high and low bytes, respectively, of register CX.

Now a mixture of rotation and ANDing reconstitutes the double-byte data to its original value as stored in the *Data Logger's* serial memory. The value is then stored in the pre-determined location in the PC's memory relative to the integer array position back in Basic (from MA%(0) onwards).

The value is also checked to see if it is the end marker value transmitted by the PIC when a serial memory has been fully read. If it is not that value (two bytes each of value 127), the next double byte of transmitted data is acquired, and stored at the next consecutive PC memory location.

Back in Basic, the locations in which the machine code was stored (MA%(0) onwards) is then saved as a block whose length is the count value reached at the end of the machine code sequence.

LISTING 7

```
JMP STARTALL           ; entry point from Basic

SETSEGMENT:
MOV DS,01111           ; value changed from Basic
RET                    : for VARSEG(MA%(0))

STARTALL:
PUSH DS                ; store current data segment
CALL SETSEGMENT        ; get MA%(0) segment address
MOV SI,0               ; set source address count to zero
MOV AX,[SI]            ; get baud rate etc from MA%(0)
MOV BX,[SI+2]          ; get COM port number from MA%(1)
MOV DX,BX              ; load config data via
INT 14H                ; interrupt call INT 14H

GETDATA:
CALL WAITDATASET       ; get first data byte
MOV [SI],CL            ; temporarily store it
CALL WAITDATASET       ; get second data byte
ROR CL,1               ; rearrange bytes to orig format
MOV [SI+1],CL          ; and store them
RCR [SI+1][B],1        ; rotate byte right
RCR [SI][B],1          ; rotate byte right
AND [SI+1][B],127      ; clear bit 7
INC SI                 ; double-increment store address
INC SI                 ;
CMP [SI-2][B],255      ; is this byte = 127?
JNE GETDATA            ; no, so get next sample
CMP [SI-1][B],63       ; yes, is this byte now = 63?
JNE GETDATA            ; no, so get next sample
MOV [SI][W],0          ; yes, clear last stored word
MOV CX,SI              ; get count value
ROR CX,1               ; multiply by 2
MOV SI,0               ; and store it
MOV [SI],CX            ; in MA%(0)
POP DS                 ; recall orig data segment
RETF                   ; exit back to Basic

WAITDATASET:           ; get data byte
MOV AH,2               ; set interrupt factors
MOV AL,0               ;
MOV DX,BX              ;
INT 14H                ; call interrupt INT 14H
CMP AX,255             ; is returned value =< 255?
JA WAITDATASET         ; no, repeat INT call
MOV CL,255             ; yes, invert received value
SUB CL,AL              ; (subtract from 255)
RET                    ; return to calling routine
```

KEYBOARD INTERRUPT

A second serial input machine code routine is included with the *Data Logger* software. This includes the ability to press "Q" to quit from the machine code without waiting for the data transfer to be complete. This routine makes use of the INT 16H keyboard access interrupt to read which keys are pressed and to return a value accordingly.

A point of interest, however, is that although three of the author's computers would respond to the INT 16H call, a fourth (a "custom-built" machine used at *EPE* HQ) would not. This is puzzling since it was believed that the basic interrupt calls on PCs are upwards compatible – seemingly not in some instances. Can anyone throw light on this?

TABLE 1: INT 14H Com port parameter byte

7	6	5	4	3	2	1	0	Description	Allowable Values
✔	✔	✔						Baud rate	000=110 baud 001=150 010=30 011=600 100=1200 (default) 101=2400 110=4800 111=9600
			✔	✔				Parity	00=No parity 01=Odd parity 10=No parity 11=Even parity
					✔			Stop bits	0=1 stop bit, 1=2 stop bits
						✔	✔	Word length	10=7 bits 11=8 bits

PIC EEPROM DATA MEMORY

The routines for writing to and reading from the PIC16F87x family's internal EEPROM data memory are worth highlighting. You will no doubt be familiar with the same routines as used with the PIC16x84 devices, and the 'F87x routines are similar, but not exactly the same since the 'F87x devices use different register locations to those used by the 'x84, as shown in Table 2.

The EEPROM data memory Write/Read routines are shown in full in Listing 7 and Listing 8. More information on them is on Microchip data sheet DS30292A page 43.

As with the 'x84 programming examples given in the *PIC Tutorial* and *PICtutor* texts (to which readers are also referred – either text source will do), the EEPROM Write routine at label SETPRM is entered with W holding the EEPROM byte address at which data is to be stored.

The data to be stored is held in STORE1. Whereas the 'x84 routine was actioned in PAGE0 and PAGE1, the 'F87x routine is actioned in PAGE0, PAGE2 and PAGE3, hence the various RP0 and RP1 paging instructions.

It is worth noting that the 'F87x data sheet gives a programming example (page 43) in which a SLEEP command and interrupt are used to determine when the EEPROM Write function has been completed, rather than polling EECON1 bit 4. However, when the author tried the SLEEP method it failed to work. It is probable that another undocumented action has to be taken in addition to those shown, but this has not been investigated.

The EEPROM Read routine in Listing 8 is entered at label PRMGET with W holding the EEPROM byte address to be read. It is exited with W holding the data read from the EEPROM.

LISTING 7

```
SETPRM: BSF STATUS,RP1     ; set for PAGE2
        BCF STATUS,RP0
        MOVWF EEADR        ; copy W into EEADR to set
                           ; EEPROM address
        BCF STATUS,RP1     ; set for PAGE0
        MOVF STORE1,W      ; get data value from STORE1
                           ; and hold in W
        BSF STATUS,RP1     ; set for PAGE2
        MOVWF EEDATA       ; copy W into EEPROM data
                           ; byte register
        BSF STATUS,RP0     ; set for PAGE3
        BCF EECON1,EEPGD   ; point to Data memory
        BSF EECON1,WREN    ; enable write flag

MANUAL: MOVLW $55          ; these lines cause the action
        MOVWF EECON2       ; required by the EEPROM to
        MOVLW $AA          ; store the data in EEDATA
        MOVWF EECON2       ; at the address held by EEADR.
        BSF EECON1,WR      ; Set `perform write' flag
        BCF STATUS,RP1     ; set for PAGE0
        BCF STATUS,RP0     ;

CHKWRT: BTFSS PIR2,EEIF    ; wait till bit 4 of PIR2 set
        GOTO CHKWRT        ;
        BCF PIR2,EEIF      ; clear bit 4 of PIR2
        RETURN             ;
```

LISTING 8

```
PRMGET: BSF STATUS,RP1     ; set for PAGE2
        BCF STATUS,RP0     ;
        MOVWF EEADR        ; copy W into EEADR to set
                           ; EEPROM address
        BSF STATUS,RP0     ; set for PAGE3
        BCF EECON1,EEPGD   ; point to data memory
        BSF EECON1,RD      ; enable read flag
        BCF STATUS,RP0     ; set for PAGE2
        MOVF EEDATA,W      ; read EEPROM data now in
                           ; EEDATA into W
        BCF STATUS,RP1     ; set for PAGE0
        RETURN             ;
```

ASSEMBLER SOFTWARE

Readers who are interested in learning how to program in machine code suited to the 8086 and above processors are recommended to obtain the *excellent* shareware *A86/D86 Assembler/Disassembler* from the Public Domain Shareware Library (PDSL) whose details are given later.

The author has been using it for many years and for many PC-controlled *EPE* projects, including the *Virtual Scope* and *PIC Toolkit MkI*. It is nearly as easy to learn as PIC programming, but has far more commands available. A useful associated book is Intel's *8086/8088 User's Manual*.

OBTAINING BASIC

Until fairly recently, by far the vast majority of PCs will have been supplied with either QBasic or QuickBASIC installed. However, *EPE* does sometimes get questions from readers who do not have either and ask where they can obtain one or the other.

So far as is known, neither of the programs is actually supplied with PCs any longer – Microsoft wishing, perhaps, that users should acquire the more advanced VisualBASIC. The once-popular GW-Basic has long since been outdated and is not compatible with regard to using it with the QB machine code routines illustrated here.

Readers who would like to get one or other of the QB versions are recommended to obtain it through the Internet. There are quite a lot of sites once you start looking. A general "search" call with the keyword QBASIC should begin to unravel the web of leads.

TABLE 2: Comparison of EEPROM data memory registers

PIC16F87x			PIC16x84 Equivalent		
Register	**Address**	**Page**	**Register**	**Address**	**Page**
PIR2	$0D	0	None	–	–
EEDATA	$10C	2	EEDATA	$08	0
EEADR	$10D	2	EEADR	$09	0
EECON1	$18C	3	EECON1	$88	1
EECON2	$18D	3	EECON2	$89	1
Register	**Bit**	**Name/No**	**Register**	**Bit**	**Name/No**
PIR2	EEIF	4	EECON1	EEIF	4
EECON1	RD	0	EECON1	RD	0
EECON1	WR	1	EECON1	WR	1
EECON1	WREN	2	EECON1	WREN	2
EECON1	EEPGD	7	None	–	–

SOURCES

The full data sheets for the Microchip devices used in the Data Logger are available from Microchip: PIC16F87x family, code DS30292A, serial EEPROM memories: DS21203D (24AA256), DS21191C (24AA128), DS21189B (24AA64), DS21162C (24AA32). There are three ways to obtain them from Microchip: as downloads from their web site, from their fully inclusive CD-ROM (all products data and applications info), or as individual booklets.

Microchip Technology Ltd., Microchip House, 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel: 0118 921 5800. Fax: 0118 921 5835.

E-mail: techdesk@arizona.co.uk. Web: http://www.microchip.com.

Public Domain Shareware Library: PDSL, Dept EPE, Winscombe House, Beacon Road, Crowborough, East Sussex TN16 1UL. Tel: 01892 663298. Fax: 01892 667473.

Intel data books are available from Electromail, Tel: 01536 204555. □

The Programmer's PC Sourcebook is a Microsoft Press publication, ISBN 1-55615-321-X.

Everyday Practical Electronics are pleased to be able to offer all readers these

ELECTRONICS CD-ROMS

NEW

ANALOGUE ELECTRONICS

by Mike Tooley

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

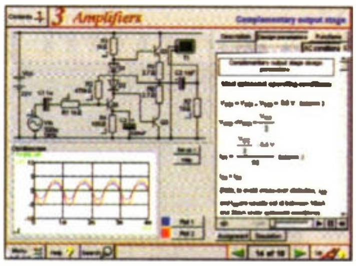
FUNCTIONS

The component values on all circuits can be edited and the user can use the simulation engine to see how the value of each component affects circuit performance. You can, for instance, alter frequency and phase angle and plot outputs on a virtual oscilloscope or show load line graphs etc.

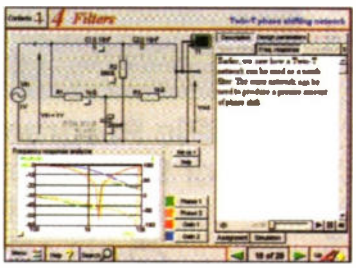
COVERAGE

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

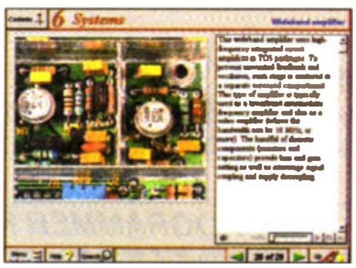
- **Includes SPICE circuit simulator with over 50 circuits**
- **Unique virtual laboratories**
- **Editable assignments**
- **Design parameters for circuits included**
- **Complete hi-fi amplifier case study**



Complimentary output stage.



Twin-T phase shifting network

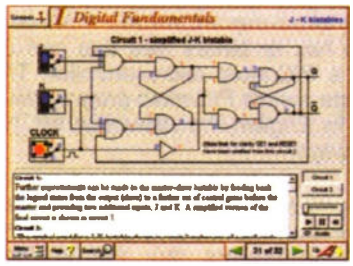


Gallery – Wideband Amplifier

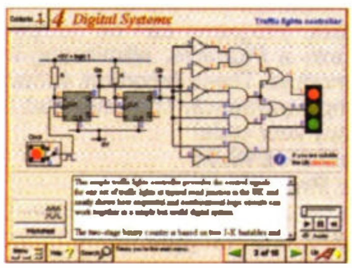
DIGITAL ELECTRONICS

by Mike Tooley

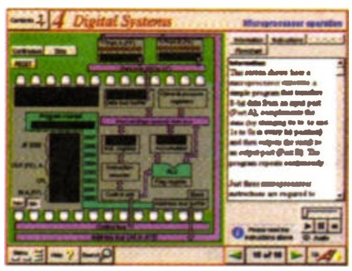
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (below), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.



Virtual laboratory – Flip-Flops



Virtual laboratory – Traffic Lights



Microprocessor

FUNDAMENTALS

Fundamentals introduces the basics of digital electronics including binary and hexadecimal numbering systems, ASCII, basic logic gates and their operation, monostable action and circuits, and bistables – including JK and D-type flip-flops.

COMBINATIONAL LOGIC

Multiple gate circuits, equivalent logic functions and specialised logic functions such as majority vote, parity checker, scrambler, half and full adders. Includes fully interactive virtual laboratories for all circuits.

SEQUENTIAL LOGIC

Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers.

DIGITAL SYSTEMS

A/D and D/A converters and their parameters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units.

GALLERY

A catalogue of commonly used IC schematics taken from the 74xx and 40xx series. Also includes photographs of common digital integrated circuits and circuit technology.

Prices for each of the two CD-ROMs above are:

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry)..............£99 *plus* VAT
Institutional 10 user (Network Licence)..........£199 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

TWO APPLICATIONS ON ONE CD-ROM

ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY by Mike Tooley

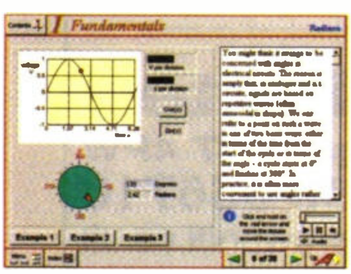
Electronic Circuits & Components provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding as they proceed through the sections on the CD-ROM. Sections on the disk include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits . Active Circuits***

The Parts Gallery – many students have a good understanding of electronic theory but still have difficulty in recognising the vast number of different types of electronic components and symbols.

The Parts Gallery helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Selections on the disk include: ***Components ,Components Quiz, Symbols, Symbols Quiz, Circuit Technology***

Hobbyist/Student ....£34 inc VAT
Institutional (Schools/HE/FE/Industry) ....£89 *plus* VAT
Institutional 10 user (Network Licence) ....£169 *plus* VAT

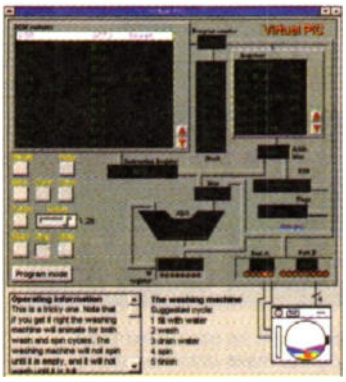
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)



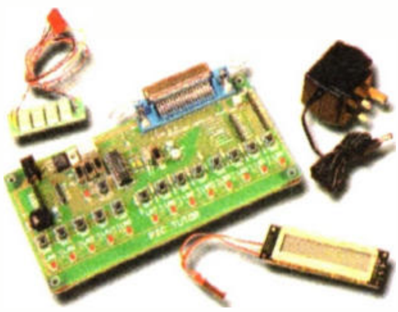
Virtual laboratory – sinusoids

Circuit technology screen

Interested in programming PIC microcontrollers? Learn with PICtutor by John Becker



The Virtual PIC



Deluxe PICtutor Hardware

Developed from John's *EPE* series, this highly acclaimed CD-ROM, together with the PICtutor experimental and development board, will teach you how to use PIC microcontrollers with special emphasis on the PIC16x84 devices. The board will also act as a development test bed and programmer for future projects as your programming skills develop. This interactive presentation uses the specially developed **Virtual PIC Simulator** to show exactly what is happening as you run, or step through, a program. In this way the CD provides the easiest and best ever introduction to the subject.
Nearly 40 Tutorials cover virtually every aspect of PIC programming in an easy to follow logical sequence.

HARDWARE
Whilst the CD-ROM can be used on its own, the physical demonstration provided by the **PICtutor Development Kit**, plus the ability to program and test your own PIC16x84s, really reinforces the lessons learned. The hardware will also be an invaluable development and programming tool for future work once you have mastered PIC software writing.
Two levels of PICtutor hardware are available – Standard and Deluxe. The Standard unit comes with a battery holder, a reduced number of switches and no displays. This version will allow users to complete 25 of the 39 Tutorials.
The Deluxe Development Kit is supplied with a plug-top power supply (the Export Version has a battery holder), all switches for both PIC ports plus l.c.d. and 4-digit 7-segment l.e.d. displays. It allows users to program and control all functions and both ports of the PIC and to follow the 39 Tutorials on the CD-ROM.
All hardware is supplied **fully built and tested** and includes a PIC16F84 electrically erasable programmable microcontroller.

PICtutor CD-ROM

Hobbyist/Student .... **£45 inc. VAT**
Institutional (Schools/HE/FE Industry) .... **£99 *plus* VAT**
Institutional 10 user (Network Licence) .... **£199 *plus* VAT**

HARDWARE

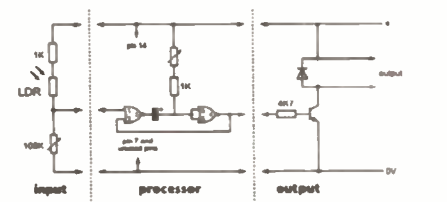
Standard PICtutor Development Kit .... **£47 inc. VAT**
Deluxe PICtutor Development Kit .... **£99 *plus* VAT**
Deluxe Export Version .... **£96 *plus* VAT**
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

MODULAR CIRCUIT DESIGN by Max Horsey and Philip Clayton

Developed from Max Horsey's *Teach-In* series *A Guide to Modular Circuit Design* (*EPE* Nov '95 to Aug '96). This highly acclaimed series presented a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects.
Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

Single User Version £19.95 inc. VAT
Multiple User Version £34 *plus* VAT
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

designing your circuit
simply select your modules from the wide choice available, read how they work and join them up to make your circuit



"I found that I could design a circuit without my teacher's help. And it worked! Everything was to hand – which chips to use – and which pins did what." Andrew Preston (GCSE student)

A Web Browser is required for Modular Circuit Design – one is provided on the *EPE CD-ROM No. 1* (see below) but most modern computers are supplied with one.

Minimum system requirements for these CD-ROMs: PC with 486/33MHz, VGA+256 colours, CD-ROM drive, 8MB RAM, 8MB hard disk space. Windows 3.1/95/98/NT, mouse, sound card (not required for *PICtutor* or *Modular Circuit Design*).

CD-ROM ORDER FORM

Please send me:
☐ **Electronic Circuits & Components +The Parts Gallery**
☐ **Analogue Electronics**
☐ **Digital Electronics**
☐ **PICtutor**

☐ **Hobbyist/Student**
☐ **Institutional**
☐ **Institutional 10 user**

Note: The software on each version is the same, only the licence for use varies.

☐ **PICtutor Development Kit – Standard**
☐ **PICtutor Development Kit – Deluxe** ☐ **Deluxe Export**

Note: The PICtutor CD-ROM is not included in the Kit prices.

☐ **Modular Circuit Design – Single User**
☐ **Modular Circuit Design – Multiple User**

Full name: ....
Address: ....
....
.... Post code: .... Tel. No: ....
Signature: ....
☐ I enclose cheque/PO in £ sterling payable to WIMBORNE PUBLISHING LTD for £ ....
☐ Please charge my Visa/Mastercard: £ .... Card expiry date: ....
Card No: ....
Please supply name and address of cardholder if different to the delivery address.

ORDERING

ALL PRICES INCLUDE UK POSTAGE

Student/Single User/Standard Version price includes postage to most countries in the world
EU residents outside the UK add £5 for airmail postage per order

Institutional, Multiple User and Deluxe Versions – overseas readers add £5 to the basic price of each order for airmail postage (**do not add VAT** unless you live in an EU country, then add 17½% VAT or provide your offical VAT registration number).

Send your order to:
Direct Book Service
33 Gravel Hill, Merley, Wimborne
Dorset BH21 1RW
(Mail Order Only)
Direct Book Service is a division of Wimborne Publishing Ltd. To order by phone ring
01202 881749. Fax: 01202 841692
We cannot reply to overseas orders by Fax
Goods are normally sent within seven days

Demos (not Modular Circuit Design) available on the ***EPE CD-ROM No. 1*** (Free with the November '98 issue) – send £2 for this CD-ROM if you require the demos.
Minimum order for credit card payment is £5.

READOUT

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

WIN A DIGITAL MULTIMETER

A $3\frac{1}{2}$ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

PICK OF THE PICS

Dear EPE,

May I begin by thanking you for the *PIC Tutorial* series. After using it for only three months I have managed to connect a 16C84 to a 6402 UART and have effected MIDI program changes and made a sustain/soft pedal. I was able to do this latter item by "lifting" the two switch routines of TUT11 and adding bits of other Tutorials, adapting them to do what I want.

I suspect I am not on my own when I say that working through the Tutorials "parrot-fashion" is boring. Many years ago I learned Basic by pinching routines out of one program and lifting bits (no pun intended) of another and I am learning PIC assembly language the same way, referring back to your Tutorials when I need to sort out exactly how a particular chunk of code works, usually in order to make it work a different way. With Basic it took me about three years before I was any good, but was able to adapt many games along the way. I'm sure PICs will take just as long.

The advent of the new PIC16F87x series is exciting as, with more memory and more pins, these devices seem even better for inexperienced would-be programmers such as myself. With that in mind, I am writing to ask if there is any chance of a *PIC Tutorial Mk2*. To provide a set of routines that can be mixed and matched to produce the result the aspiring programmer wants but is not able to do on their own without considerable help, which you provide in copious notes, as with the original series.

To date all of my needs are to do with MIDI. I would like to have routines which will: show me how to write to the 16F877 USART and how to configure it to add MIDI start/stop bits; how to write a first-in-first-out buffer with storage for 20 to 40 8-bit bytes and write to the USART or an 8-bit port for external serialising (preferably a "load it into the buffer and forget it" arrangement which leaves the processor free for number crunching elsewhere); how to read the USART; how to write a routine to clock MIDI data out of an ordinary 16C84 pin (a la *MIDI Sustain Pedal*, Feb '99), I can't sort out how it works; a neat routine calling data from STORE1, STORE2, STORE3 etc. would be much better for hackers like me – these routines should enable me to make a MIDI mixer, with the PIC running at 20MHz I should be able to do a lot of manipulation of input data bytes and exotic features such as MIDI mapping, layering and velocity changing should all become possible; how to read the ADCs, allowing me to add pitch blend and variable modulation.

When searching the Internet, countless programs can be found for the 16C5x processor, usually in MPASM, whilst your *PIC Toolkit Mk2* will solve this latter problem for me some help with conversion between PICs would be welcome. Similarly, PIC BASIC compilers are now available as freebies and the one I've got (but cannot try until I build *Toolkit Mk2*) looks useful. I would welcome a discussion article, together with a few demo programs (to pinch the bits I like).

Doubtless other readers will have their own needs and ideas; can they be encouraged to submit them with the promise of the most popular being dealt with in a Mk2 Tutorial along the lines requested. Whilst I have listed a great number of wants, I don't think I'm on my own and suspect I speak for many who are struggling to write their own stuff and using your Tutorials as a bible and guide. Many thanks for a great mag, I don't care what you call it, just keep up the quality.

Derek Johnson, via the Net

You are indeed using the Tutorials as I expected – selecting routines and modifying them to meet your own needs. One of the purposes of us publishing any project software, whether on page or on disk, is to let others share the code and select sections or just gain ideas for other designs. This too, of course, is what people do with the electronic circuits as well – select and modify for other functions. No-one is cheating by doing so, it's using common sense and cuts down on the wasted effort of "re-inventing wheels" each time!

Tutorial-wise, my PIC16F87x Mini Tutorial *is in this current issue, of course. In it I highlight a fair number of points about using the new PIC family, with particular emphasis on the PIC16F877 (as used in the* Data Logger *of Aug/Sept '99). The article does not attempt to cover all aspects of using 'F87x devices, but gives practical advice based on my experience with them so far – the implementation of some functions proved to problematic, the data sheet not being the easiest of documents to follow in some instances. Hopefully you will be saved such puzzlement as I encountered from time to time!*

Regarding MIDI routines, I can't offer help since I am not a MIDI user, but other readers may be able to, and I also plant the suggestion before Robert Penfold, who does know about MIDI (well, Robert?).

Nor am I familiar with PIC BASIC compilers – anyone care to comment on them?

PhizzyBLY CARING

Dear EPE,

I would like to place on record my deep appreciation of the time and effort Alan Winstanley and "Max" Maxfield have put in trying to help me find the solution to a *PhizzyBot* problem I have. Also to your Editor and his secretary for the efficient and courteous manner in which they have handled my correspondence.

What a change these days to find a magazine run by such a caring crew.

R. Tipping, Batley, W. Yorks

Thank you Mr Tipping. We do care and try to let it show.

VIRUS FEEDBACK

Dear EPE,

In *Readout* Aug '99, Pete Kelly of Australia said that the plural of *virus* is *viruses* or *viri*. Well, according to some VERY good Virii Creators it is *Virii* and not *Viri/Viruses*. Since *virii* exist because of them we should use the terminology they use. By the way, one virii creator created a virus that infects all .COM files in the current directory. The virii was only 27 bytes long!

Thanks for the great mag and keep up the good work. If you publish my letter please correct my spelling (except for Virii, Viri, Viruses).

Ian Galpin, via the Net

You've got a point, Ian, but I for one have absolutely no respect for those malicious vandals who do write viruses and shall not take any lessons in English or Latin spelling from them. They would appear to have brains that can achieve a working program, but it would be far better to use their brains in a constructive manner, not a destructive one. It is impossible to conceive what goes through their minds when they create a virus, some of which have caused untold distress to many, including patients relying for their survival on hospital computers.

There is no way in which we can condone this behaviour and should we somehow learn the name and address of a virus creator, we would have no hesitation in reporting it to the Police. The severest of penalties would not be too great for such criminal idiots.

As requested, we have corrected your spelling in non-viral matters (do we gather from your E-mail address that you come from Zambia?). Thanks for contacting us, my anger is not with you, but with virus writers.

DESCALING REVISITED

Dear EPE,

Living in a hard water area where the lime factor in the water had got to the point of being ridiculous, I was prompted to search out some means of getting rid of or reducing the amount of lime.

I contacted a company selling a commercial water descaler, but the price quoted was disappointing. I then remembered reading about a water descaler in one of my back issues of *EPE* (Oct '97) that worked the same way.

I obtained a kit from Magenta Electronics, finding it fairly easy to build and put together. The only difficult part being the winding of the coil around the copper pipe in a confined space. I lost a lot of skin from my knuckles but succeeded in completing the task.

I am glad to report that the device is working satisfactorily. My wife is especially delighted as to its effect, the periods between descaling are longer and the water feels softer. Magenta Electronics is an excellent company to deal with.

A.J. Lewis, Harlow, Essex

A couple of years back we had quite a lot of correspondence in Readout *concerning water descalers. Good to know that between us, Mark Stuart, Magenta and EPE have provided you with a working product. It is one of those areas in which no real scientific evidence appears to exist.*

PIC TOOLKIT V2.3

Last month in Readout, *the introduction of* PIC Toolkit Mk2 *software version V2.2 was announced. Since then I have been extensively using the program in connection with probably my most complex PIC software program to-date, a* Tide Machine *(based on a PIC16F873), scheduled for Spring next year.*

As a result, I have also made a few more minor improvements to Toolkit Mk2, *making it even easier to use. The latest files, V2.3, were released onto our* Toolkit Mk2 *disk and the* EPE FTP *site on 6 Aug '99. Just follow the instructions in text files that accompany the main software. Version V2.3 incorporates all previous changes. The changes are stated near the head of each .BAS program listing, which can be read from DOS EDIT.*

As was said last month, I shall no doubt make further improvements to Toolkit Mk2's *software in the light of experience – make suggestions if you wish. (But please remember that I write such things only in my spare time!)*

EDITING EDIT

Dear EPE,

I have been actively interested in radio/electronics for many years, and when microcontrollers became available, was very interested in these because of their flexibility. But, because of the prohibitive cost of computers to program them, I never used them at that time. Recently, though, I acquired an old 386SX computer running DR DOS V.6 plus Windows 3.1.

I have always read your magazine and always found something of interest in it, but when you published your *PIC Tutorial* series and *Toolkit Mk2*, I couldn't help myself, I had to have a go and get to grips with these marvellous little things. I constructed the hardware and obtained your software on disk and loaded it up on the 386. Hey presto it all worked straight away.

I followed your instructions in the use of *Toolkit Mk2* and programmed my first PIC using your test program – magic! Then on pressing the E key to enter the DOS Editor, the program leaves the main menu, pauses, then immediately returns to the main menu. During the short pause, the following appears on screen:

C:\PIC>tk2
C:\PIC>cd\pic
C:\PIC>edit c:\pic\decode.asm
command or filename not recognised
C:\PIC>tk.bat
C:\PIC>main02

and then returns to main menu.

Thinking that the command line **C:\PIC>edit** needed to be changed to **C:\PIC\editor** on my machine for the program to work and access the editor from the menu and back, I amended the .BAT file accordingly.

Then I entered the C:\PIC directory and entered TK. The main menu came on screen and on entering E on the keyboard to go to the editor, the message: Main Program Unforeseen MS DOS Error 62 Route came up. On pressing a key to restart the program as instructed, the screen flickered but the program refused to restart. Reloading the program, it all works, except the DOS editor, although I am no longer getting the Unforeseen DOS Error message.

Have you any suggestions how this can be overcome? To access the DOS editor, I have to quit the program, enter DOS, edit the file and then restart the Toolkit program each time. Apart from this I am delighted with *Toolkit's* ease of use and would like to thank you for all your hard work and efforts in producing the *PIC Tutorial* series and *Toolkit* so that us lessable enthusiasts can get to grips with these latest chip developments.

R.A. Hooper, Caterham, Surrey

Thank you for your kind words about PIC Tutorial *and* Toolkit Mk2, *I am delighted you have taken to PICs.*

On the Edit situation, this command word is placed in the .BAT file from within TKMAIN02.EXE, which also updates the file name as necessary. In order to change from Edit to Editor you would need to possess and know how to use QuickBASIC. In this case you would amend the TKMAIN02.BAS so that the statement:

PRINT #2, "edit ";edit$ becomes:
PRINT #2, "editor ";edit$.

You would then recompile the .BAS file to .EXE. I don't know any way round this, unless you obtain a version of (MS) DOS which will recognise EDIT as the operative command. I am not familiar with DR DOS.

NAMING PICS

Dear EPE,

Regarding *Readout* Sept '99 in which the question "what does PIC stand for" arose, as far as I am aware, PIC stands for Peripheral Interface Controller. I have heard people (understandably) calling them all sorts of things, like Programmable Integrated Circuits, Programmable In-Circuit Microcontrollers and Programmable Integrated Controllers.

The Peripheral Interface Controller definition can be found on some Arizona Microchip promotional literature, which is at **www.jpixton.dircon.co.uk/pic/history.html.**

This also raises another point: mostly in your mag PICs are referred to as PIC microcontrollers, which is a bit confusing . . . Peripheral Interface Controller Microcontroller. It is a bit like when people say "my PIN number . . ." which means "my personal identification number number"!!

Joseph Birr-Pixton, via the Net

Thanks Joseph! However, as a personal reaction, your preferred definition doesn't really call up in my mind the sophistication of what a PIC can actually do. The added term "microcontroller" is somehow far more evocative. We also feel obliged to include this word when referring to PICs in order to clarify to readers who may not be familiar with the type of device that they are. In itself the term PIC is only meaningful to those who already use them.

As surprising as it may seem to some readers, there are others who do not yet know about PICs. For the sake of those who are perhaps reading EPE *for the first time, we have to spell out definitions in various ways somewhere near the beginning of an article. The abbreviation l.e.d. is an example, we usually spell it out at least once in an article as light emitting diode for sake of anyone who has not yet come across it. There is sometimes more to educational publishing than meets the casual eye!*

IC MASTER

Dear EPE,

With regard to the June 1999 issue of *EPE*, in your *Readout* column you advise Alan J. Munday about a chip source, and you suggest he checks the *IC Master* at a library. It just so happens that the *IC Master* has become available online free of charge.

You previously had to be a subscriber to the rather expensive hard copy version in order to access the online version and/or the online updates, but recently they've made it free to anyone, and they have updated and improved the online search facilities. The URL is: **http://icmaster.com.**

Though the site is generally intended for commercial users, and you do have to fill out an online registration with a company name, they do not restrict access. Fortunately, the time difference between the US and UK should preclude any access conflicts as a result of excess user demand.

Bob Schoonmaker,
Woodside, New York, via the Net

Highly useful info Bob, many thanks.

MEASURING DOWN (AND UP)

Dear EPE,

Good news! I have now got the PIC and l.c.d. working together on the *PIC Tape Measure*.

Richard Wilkinson, via the Net

That's actually the end of the story – let's go back some weeks:

Occasionally, readers run into difficulties when trying to get a PIC-controlled project to work for the first time. A not-uncommon situation manifests itself with projects that use an alphanumerical liquid crystal display as the readout device. All that the puzzled reader obtains is a single line of dark cells on the top line, and nothing but blanks on the second line.

In practically all cases, the answer has been that either the connections to the l.c.d. have not been satisfactorily made, or the reader has used a seemingly sub-standard l.c.d. whose timing requirements do not conform to full-spec devices. As a result, and particularly with the required opening delay period during which the l.c.d. must be allowed to "stabilise" itself, the l.c.d. fails to accept the initialisation commands that set it into the 4-bit control mode.

I have run my PIC software routines on many different types of l.c.d. from several different manufacturers, and obtained "as full-spec" devices from major distributors/retailers. All have been equally responsive to the timings built into the PIC code.

Where timing has been the cause of a reader's problem, the recommendation to increase the length of the delay prior to initialisation, and that introduced during the transmitting of data to the l.c.d., has allowed the situation to be satisfactorily resolved.

Such was part of the advice I gave to Richard when he could not get his PIC Tape Measure *(Nov '98) l.c.d. to start-up, and without it starting-up, of course, there wasn't a hope of him being able to use it!*

As I recollect, I was in communication with Richard on several occasions, but still he could not get the device to work. Then, along came the above E-mail. Let Richard continue his story:

It turned out that the problem was with the programmer (a commercial kit), hence any changes to the code were not making any difference, even though something appeared to be programed into the PIC. This all came to light when I assembled a new programmer from another supplier (this one based on the *EPE* design).

The only problem I could find with the first programmer was that it could only muster 9V at the MCLR pin during programming from the PC's port.

The advice I would recommend to other readers who are programming PICs for the first time is obviously to check absolutely everything in the process. Thank you very much for all your help, it has been much appreciated.

Another satisfied reader! I heartily concur with Richard's sentiments that everything should be thoroughly checked. There are instances when some readers do not even take the most elementary steps to find out why they cannot get their project to work before contacting us (especially by E-mail, which seems to have become a medium people use all too spontaneously without first pondering the possible reasons for malfunction).

Whilst we and our contributors try to be helpful when people have problems with a project, we cannot judge what degree of competence the troubled reader has and what elementary things he might have done wrong. Years ago, a customer of mine returned a unit which he had assembled from a kit saying he could not get it work – when I turned over the board to examine his soldering, several components fell out!

As any experienced electronics constructor or software programmer will tell you, don't assume that all aspects are correct – check them one by one, even the most unlikely!

INTERFACE

Robert Penfold

A SERIAL APPROACH TO PC ADD-ONS

THERE seems to be a steady stream of letters from readers enquiring about using the PC *serial* ports with user add-ons. This is understandable, since most PCs have at least one serial port left unused.

With the increasing use of mouse port mice and internal modems it is not uncommon for both serial ports to be left unused. The single parallel port, on the other hand, is usually occupied by a printer, and a switching unit or parallel port card is therefore needed to use parallel interfacing.

As pointed out in previous *Interface* articles, provided speed is not important it is possible to interface practically any add-on project to a PC serial port, but serial interfacing is never as easy as the parallel variety. A circuit based on a UART (Universal Asynchronous Receiver Transmitter chip) is needed to provide parallel to serial and (or) serial to parallel conversion. These days there is the alternative of basing the project on a microcontroller such as a PIC, which helps to keep down the cost and complexity.

Single File

Serial interfacing circuits have been covered in previous *Interface* articles, and this aspect of things will not be considered here. Unfortunately, getting the hardware successfully connected to the computer is only half the battle. Most programming languages have some form of support for the serial ports, but it is normally in a form that is of limited use with user add-ons.

With your own add-ons it is byte by byte communications that is usually needed, but the serial port support invariably seems to handle things on a one file at a time basis. It is really intended for swapping large amounts of information between the PC and another PC, a printer, a modem, etc.

One way around this is to make add-ons emulate computer terminals, so that they communicate with the PC using the correct protocols. Where relatively small amounts of data are involved this is a slightly clumsy way of doing things though, and is difficult to implement at all unless the peripheral device is based on a microcontroller.

Direct Approach

It is generally more practical to ignore any built-in support and control the port directly. At its most basic level this just involves writing transmission data to the appropriate address, with the baud rate and word format being set via the operating system. At the other extreme the baud rate and word format are set by writing to the control registers in the serial chip, and the status registers are used to regulate the flow of data into and out of the chip.

The serial chip used in PCs is the 8250, or in recent PCs it will actually be a chip from the 16550 family. To be more precise, the serial interfaces will actually be handled by one of the support chips. This will include circuitry that is functionally the same as a device from the 16550 family. So do not bother looking on the motherboard to see which serial chip is used, because it will not be there.

The manual for the motherboard should indicate which chip is being mimicked by the support chips, but it does not really matter which "virtual" chip is used. The main control registers are exactly the same for 8250 and all versions of the 16550. It is only some of the more obscure functions that are different.

Serial ports one and two are at base addresses &H3F8 and &H2F8 respectively, and these are the addresses used when reading and writing data. The seven addresses above each base address are used for reading status information and writing to the control registers.

The following is a full list of the registers:

Address	R/W	Register	DLAB
Base	Read	Received data	0
Base	Write	Data for transmission	0
Base	R/W	Clock divider latch (LSB)	1
Base + 1	R/W	Clock divider latch (MSB)	1
Base + 1	Write	Interrupt enable	0
Base + 2	Read	Interrupt identification	
Base + 3	R/W	Line control	
Base + 4	R/W	Modem control	
Base + 5	Read	Line status	
Base + 6	Read	Modem status	
Base + 7	–	Reserved	

Baud Rate

Matters are complicated slightly by the base address having three functions and the address above this having two different functions. This is made possible by having a control bit that is used to switch these addresses between two modes.

This bit is called the Divisor Latch Access Bit (DLAB), and it is at bit seven of the line control register. With this bit set at 0, which seems to be its default state, the base address is used for reading and writing data and the one above is the interrupt enable register.

With DLAB set at 1 the base address and the one above are used for the clock divider latch. This works in the usual serial interface fashion, with a clock signal fed to the UART by way of a divide by "*N*" circuit. The two bytes in the divider latch together form a 16-bit value, and the clock signal is divided by this amount.

The baud rate can therefore be set by writing a suitable value to the divider latch, which offers a useful alternative to using the operating system. The clock frequency is at 1·8432MHz, but the UART has an internal divide-by-16 action.

This gives a maximum baud rate of 115200 with a value of 1 written to the divider latch. With some PCs it is supposedly possible to obtain a rate of 23400 baud with zero written to the divider latch, but in practice this does not normally seem to work.

It is possible to set any of the standard baud rates by using a suitable division rate, but it is not essential to use standard rates for you own add-ons. On the other hand, crystals intended for standard baud rate generation are readily available at low prices, so it is probably best to use a standard rate unless there is good reason not to.

The division rate is obtained by dividing 115200 by the required baud rate. Most user add-ons will operate at baud rates of 115200, 19200, or 9600 baud, which respectively need 1, 6, and 12 to be written to the divisor latch LSB, and zero to be written to the MSB. User add-ons will normally operate at high baud rates, so the required division rate is written to the LSB and the MSB is just set at zero.

Interrupts

The interrupt enable register is used to select the sources that will generate interrupts, and the easy way of handling the serial port is to simply disable all interrupts. It is not essential to use interrupts in order to utilize the serial port, and switching them off should ensure that conflicts between the operating system and your own routines are avoided.

If you should need to use interrupts, the following table shows the function of each bit in the interrupt enable register. To enable an interrupt source set the appropriate bit of the interrupt enable register high:

Bit	Interrupt Source
0	Received data available
1	Transmitter holding register empty
2	Receiver line status
3	Modem status
4	Enables sleep mode (16750 UART only)
5	Enables low-power mode (16750 UART only)
6	Reserved
7	Reserved

To determine whether or not an interrupt is pending, and if so its source, the three least significant bits of the interrupt identification register are read. If bit 0 is at 0 an interrupt is pending, and the binary code in the other two bits indicates the source.

This table shows the code for each of the four possible sources:

Source	Bit 2	Bit 1	Priority
Receiver line status	1	1	1
Receiver data	1	0	2
Transmitter register	0	1	3
Modem status	0	0	4

Word Format

The word format can be controlled via the operating system, but direct control ensures that the serial port always works with the correct format for the add-on. The line control register is used to set the required format. The format for transmission and reception has to be the same incidentally, and any normal format can be set.

The functions of the line control register are as follows. There is always one start bit:

Bit 0	Bit 1	Data bits
0	0	5
0	1	6
1	0	7
1	1	8

Bit 2 at 0	One stop bit
Bit 2 at 1	Two stop bits (1·5 with 5 data bits)
Bit 3 at 0	No parity checking
Bit 3 at 1	Parity checking enabled
Bit 4 at 0	Odd parity (if parity enabled)
Bit 4 at 1	Even parity (if parity enabled)
Bit 5	Stuck parity bit
Bit 6 at 0	Normal operation
Bit 6 at 1	Forces data output terminal to logic 0
Bit 7	Divisor Latch Access Bit (DLAB)

Rationalisation

Suppose that we need to set up the serial port for operation at 9600 baud, and require the usual word format of eight data bits, one stop bit, and no parity. A value of 12 must be written to the divisor latch, but DLAB must be set to 1 to give access to these latches.

DLAB must then be set back to 0 and at the same time the other bits are set-up to give the required word format. Bits 0 and 1 must be set high, all the others have to be set low, giving a value of three to write to this register.

In GW BASIC (or Visual BASIC with the input and output functions added) these four instructions will set up serial port two correctly:

```
OUT &H2FB,128
OUT &H2F8,12
OUT &H2F9,0
OUT &H2FB,3
```

Bytes for transmission are then written to the base address, which is &H2F8 for serial port 2. If a value of 255 is written to the MSB of the divider latch at address &H2F9 the baud rate will be set at a very low value. In fact, it will be so low that an l.e.d. used to monitor the data output line (see Fig.1) will flash slowly enough for the binary output patterns to be observed.

Hold-Off

There is a potential problem when writing data to the serial port, and this is due to the relative slowness of a serial interface. With the speed of modern computers and programming languages it is easy to write data to the port at an excessive rate, causing bytes of data to be corrupted or lost.

There should be no problem if two bytes are written to the port in rapid succession, because the serial chip's buffering should store the second byte until it can be transmitted. Writing three or more bytes in rapid succession will almost certainly result in an error.

There are two ways of ensuring that data is not sent to the port at an excessive rate. The time taken for each byte to be sent is easily calculated, and it is ten times the duration of each bit. At 9600 baud each bit lasts 104μs (1/9600 = 0·000104s). Ten bits therefore have a duration of 1·04ms (1040μs). Using a software-generated delay of at least this duration will therefore ensure that the serial chip is not overloaded.

The alternative is to hold-off the loading of data until the serial chip indicates that it is ready for the next byte. This can be achieved using interrupts, but the easier way is to monitor the appropriate status flag in the Line Status Register.

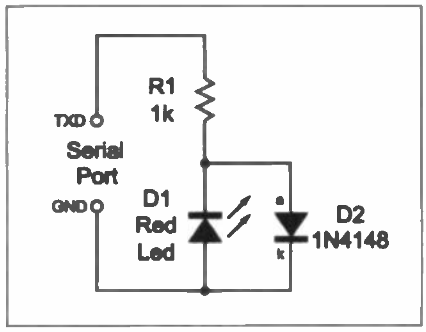


Fig.1. Simple l.e.d. serial port monitor circuit diagram.

A full list of the bit functions in the Line Status Register follows:

Bit	Function
0	Received data ready
1	Overrun (unread data overwritten)
2	Parity error
3	Framing error (no stop bit detected)
4	Break interrupt indicator
5	Transmitter buffer register empty
6	Transmitter register empty
7	Unused (reads logic 0)

When a byte of data is written to the chip it is first placed in the transmitter buffer register, but it is immediately transferred to the transmitter register if it is empty. Otherwise the data is transferred as soon as the transmitter register becomes empty. The data is then shifted out bit-by-bit, with any additional bits such as stop bits being added.

There are two transmitter status flags, and the one at bit 5 is set to 0 when the transmitter buffer register is full. The flag at bit 6 is set at 0 when there is data in either register.

A software loop can provide the required hold-off by monitoring either of these flags, and preventing further data being written to the port until the flag has returned to logic 1. This requires a loop along the lines of "repeat until (&H2FD AND 32) = 32".

Receiving data is trickier than sending it, and is something we will consider next time.

INGENUITY UNLIMITED

Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been 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 preferably be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**
Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BS21 1PF.
They could earn you some real cash **and a prize!**

WIN A PICO PC BASED OSCILLOSCOPE
- 50MSPS Dual Channel Storage Oscilloscope
- 25MHz Spectrum Analyser
- Multimeter • Frequency Meter
- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every six months, Pico Technology will be awarding an ADC200-50 digital storage oscilloscope for the best IU submission. In addition, two single channel ADC-40s will be presented to the runners-up.

Auto Supply Crowbar – A Sharp Drop

When power is removed from CMOS logic, the rail voltage can wander for a few seconds, causing unpredictable behaviour in the circuit. If the power has been temporarily removed, then in order to "reset" the circuit it is often necessary to count to ten before re-applying the power to ensure proper operation.

A small power supply "crowbar" circuit, which has been used in a burglar alarm where it was necessary for the supply rail to drop sharply to zero when the power was removed, is shown in Fig.1. However, in order to save the standby battery if it is running during a mains failure, the crowbar must not present too high a load on the power rail.

During normal running, with +12V present on the rail, the Zener diode D1 conducts and feeds a small current into transistor TR1 base (b). This turns on TR1, which keeps TR2 switched off. The current consumption is approximately 0·1mA at this time.

If power is removed, as soon as the rail voltage drops below approximately 10V, the Zener diode ceases conduction, TR1 turns off and TR2 turns on. This effectively places resistor R3 across the rail. The resistor has a relatively low value, and the increased current will pull the rail down much sharper than allowing it to decay naturally, especially if the circuit contains filter capacitances.

Since most logic devices switch at around half the rail voltage, there should be no misbehaviour during the initial drift down to 10V. If a 5V rail is used, a 3·3V Zener diode can be substituted.

Barny Connell, Stoke Newington, London.

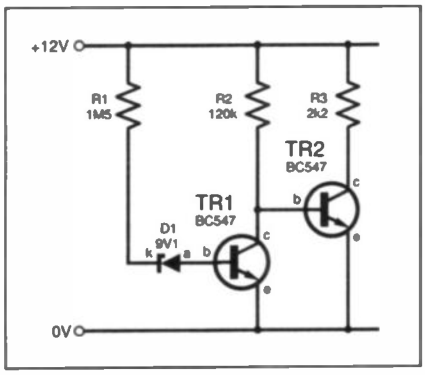
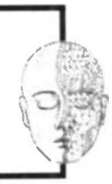


Fig.1. Auto Supply Crowbar circuit.

INGENUITY UNLIMITED
BE INTERACTIVE
IU is *your* forum where you can offer other readers the benefit of your Ingenuity. Share those ideas, earn some cash and possibly a prize!



Shoestring MW Radio – On A Budget

The Medium Wave Radio circuit diagram of Fig.2 uses relatively few components but delivers 500mW (1/2W) into an 8 ohm loudspeaker. In Cape Town, with high selectivity selected, the radio picks up the *Voice of America* clearly after dark.

In the circuit, coil L1 is 80 turns of approx. 30s.w.g. enamelled copper wire, close-wound on a 5cm (2in.) diameter piece of p.v.c. piping. A centre tap at 40 turns provides greater selectivity and may be selected with switch S1. The value of tuning capacitor VC1 is not critical.

The Volume control VR1 controls the gain in preamplifier IC1. The output of IC1 is fed, via treble control/low pass filter capacitors C4 and C5, to a standard LM380 audio amplifier i.c.

A good aerial and earth are essential. The aerial may be attached to a metal window frame or a long wire. The earth connection may be a metal spike sunk into the ground. Experimenters could try using a crystal earpiece wired between diode D1 cathode (k) and 0V which may give fair listening volume even with the battery (B1) disconnected.

Rev. Thomas Scarborough, Cape Town, Republic of South Africa.

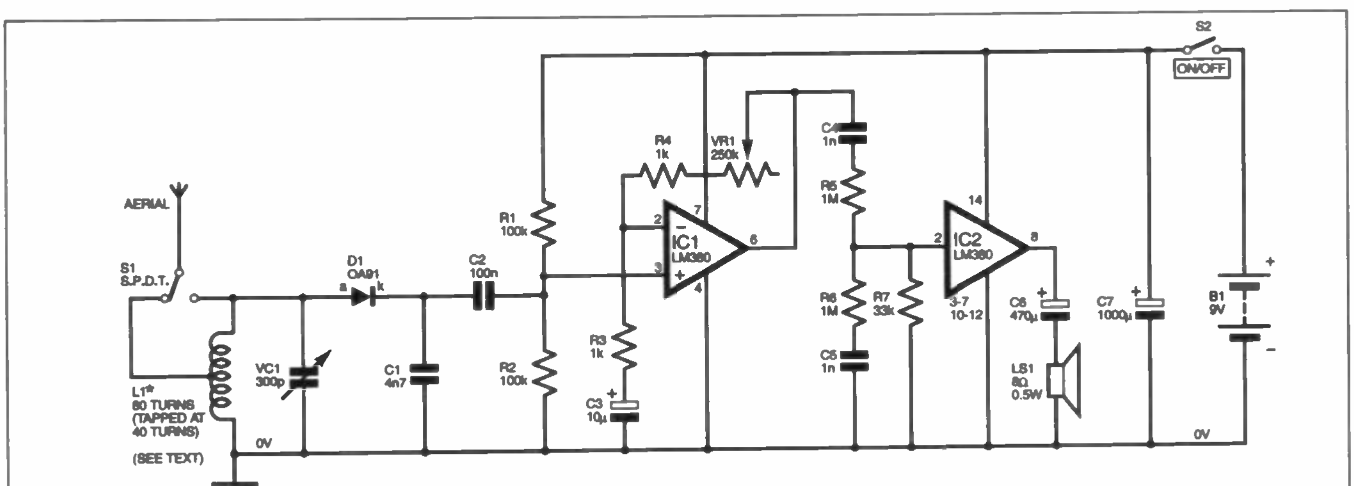
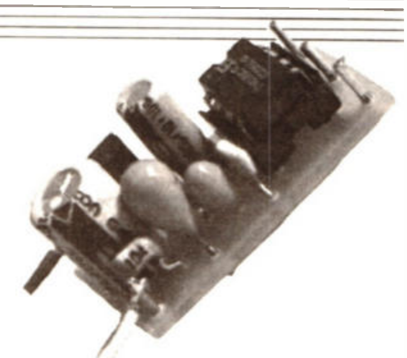


Fig.2. Circuit diagram for the Shoestring MW Radio.

Constructional Project

MICRO POWER SUPPLY



ANDY FLIND

A low-cost, low-power, mini board project that will provide a regulated supply of plus and minus 5V.

THIS little project first saw the light of day when it was realised that much time was being wasted in the workshop constructing regulated five-volt supplies on breadboards. With the ever-increasing use of logic and microcontrollers such as the PIC many projects now require such a supply voltage.

The introduction of new op.amps capable of high performance from low supply voltages means that analogue circuits can use it too, though an auxiliary negative supply is often still useful for these, especially where the negative rail of the primary supply is to be used as common or "ground". Where this is the case it is usually preferable to generate the extra supply rail electronically, particularly when the finished project is to be operated from a battery.

Also, with battery supplies in mind, it was decided that this project should use micropower components and the regulator should be a "low dropout" type. Finally, it was decided that the project should be miniaturised as far as possible so that it would take up minimum space on the breadboard or in a case used for testing a prototype. In fact, it could even be included in a finished project if desired.

REGULATIONS

The choice of active components for the project was straightforward. The regulator is the LP2950, which is very similar to the popular 78L05 3-terminal +5V regulator, even to the extent of having the same pinout connections.

It does have improved regulation however, draws a much lower supply current and can operate with a very low differential between input and output voltages, typically down to 100mV. This makes battery operation more economical since the supply voltage can be much lower before replacement is necessary.

ON THE FLY

The auxiliary negative supply is generated by an SI7660 voltage converter chip (see *Shoptalk* page) which is intended specifically for this function, especially with 5V supplies. These are sometimes known as "flying capacitor" devices, and a short description of the way in which they operate may be of interest.

The basic principle, with capacitor C1 connected to the supply rails by a 2-pole two-way switch S1a and S1b, is shown in Fig.1. When in the position shown, the switch allows the capacitor to charge from the main supply voltage V_{IN}.

The switch is then set to the opposite position, so the voltage across capacitor C1 appears across the output and is partially transferred to capacitor C2. If the switch positions are alternated repeatedly, C2 will become charged to virtually the same voltage as the supply, but connected as shown it appears as an additional, *negative* output.

ELECTRONIC SWITCHING

In a practical circuit, having realistic capacitor values, the switches should be electronic of course, and they must operate at high speed, typically several kilohertz. They should have low "on" resistances and no "offset" voltages, such as the forward voltage drop of a diode, so CMOS devices are preferable. An oscillator is required to drive them, and problems of protecting them from reverse voltages must also be overcome.

Fortunately, all these issues are already overcome for users of the SI7660 which contains an oscillator, drive logic and the output switches. With a 5V input it requires only a pair of capacitors to complete the circuit.

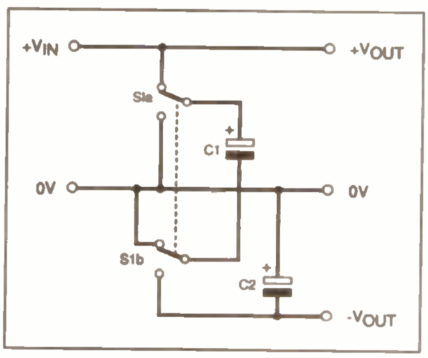


Fig.1. Principle of "flying capacitor" negative rail generator.

For a zero load the output voltage is virtually the same as that of the input but it tends to fall with load. The output is often described as being similar to the input voltage in series with an 80 ohm resistor, so for a 10mA loading it would drop to −4·2V. Although often better in practice, this makes it unsuitable for use as a reference source, but as an auxiliary supply for op.amps it is ideal.

MICRO POWER SUPPLY

The full circuit diagram for the Micro Power Supply appears in Fig.2 and is fairly straightforward in nature. The input voltage is first reduced to a positive 5V supply by the LP2950 micropower regulator IC1. Capacitors C1 and C2 decouple the input to IC1 whilst C3 and C4 decouple its output.

The smaller value, non-electrolytic, capacitors C2 and C3 are often omitted by circuit designers, but the construction of electrolytic capacitors, using layers of foil wound into a cylindrical shape, gives them a fair degree of self-inductance which can make them ineffective at high frequency. The small ceramic capacitors by contrast work very well indeed at high frequencies so they are included to take care of these where necessary.

The negative supply is generated by the SI7660 negative supply generator chip IC2. The "flying capacitor" is C5, a 10μF solid tantalum type. The output, taken from pin

COMPONENTS

Capacitors

C1	220μ radial elect. 16V
C2, C3, C6	100n resin-dipped ceramic (3 off)
C4	100μ radial elect. 10V
C5	10μ tantalum bead, 16V
C7	47μ tantalum bead, 16V

Semiconductors

IC1	LP2950 low power +5V regulator
IC2	SI7660, "switched capacitor" voltage converter

Miscellaneous

Printed circuit board available from the *EPE PCB Service*, code 243; 8-pin d.i.l. socket; solder pins (5 off); solder, etc.

Approx. Cost Guidance Only **£12**

5, is decoupled by ceramic capacitor C6 and electrolytic C7, another tantalum component.

The reason for the use of tantalums is that these have a much lower self-inductance than ordinary electrolytics and should therefore cope with the 10kHz operating frequency of IC2 more efficiently. IC2 is another micropower component, so the overall quiescent supply current for this circuit from a 9V supply is just 140μA.

CONSTRUCTION

All the components for the Micro Power Supply are accommodated on a small (32mm × 17mm), single-sided printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 243. The topside component layout, together with the underside copper foil master, is shown in Fig.3.

The maximum allowable depends to some extent on ambient temperature, but a practical limit of 200mW seems reasonably safe. It should be remembered that current supplied by the negative rail generator also comes from the regulator. For many small low-power applications such as signal processing with op.amps, CMOS logic or PIC microcontrollers dissipation will not be an issue.

NEGATIVE USE

The negative output should be regarded only as an auxiliary supply as it is not nearly so well regulated as the positive one. Its main purpose is to supply op.amps so that the common rail may be used as "ground" by allowing their inputs and outputs to operate below this value.

Because the output of the SI7660 behaves as though in series with an 80 ohm load, the output voltage will vary with load.

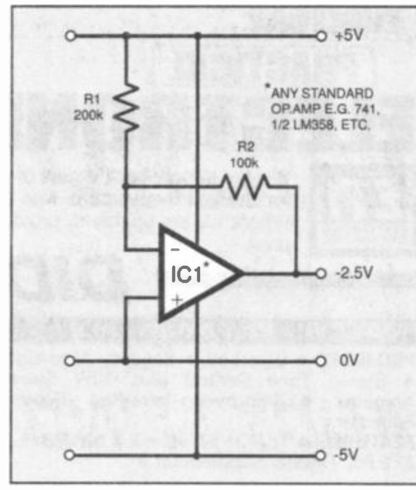


Fig.4. Circuit diagram for generating a negative reference voltage.

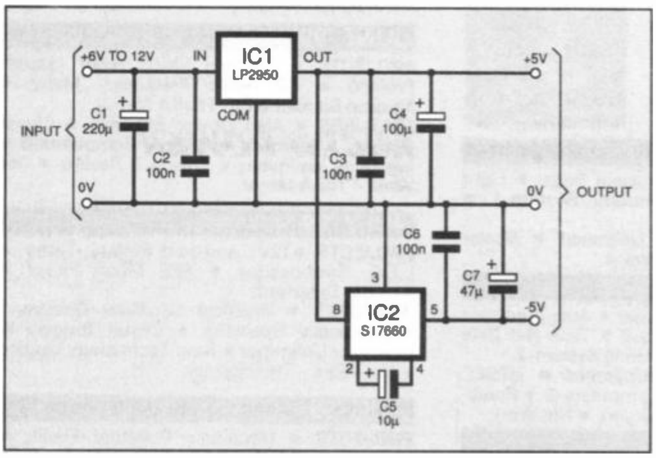
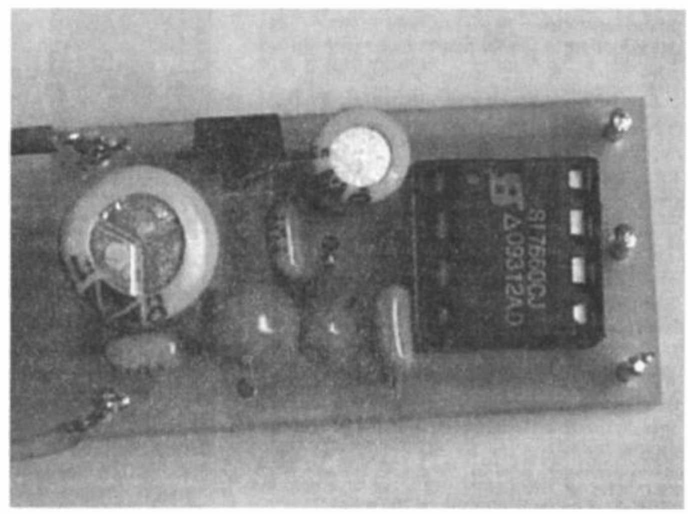


Fig.2. Complete circuit diagram for the Micro Power Supply.



Construction of the unit consists of fitting all the components except IC2, taking care to fit all the electrolytics with the positive side towards the top edge of the p.c.b., as viewed in the diagram. The markings on tantalum bead capacitors are sometimes less than models of clarity, so care may be needed to interpret these correctly. An 8-pin d.i.l. socket should be provided for IC2.

TESTING

The first test is to apply an input voltage of between 6V and 12V and check for the presence of the positive 5V output. The current drawn should be tiny, just 140μA or so, though there will be a small surge as the electrolytics, especially C1, take up their initial charge.

If the +5V output is present and correct, IC2 can be inserted into its socket and, when the unit is powered again, the *negative* output voltage should appear at the appropriate point. And that's it! Testing is now complete and the unit is ready for use.

Although the +5V output is capable of more than 100mA output a watch should be kept on its internal power dissipation to prevent overheating. This is calculated by subtracting the output voltage (5V) from the maximum input voltage (9V for a PP3 battery) and multiplying by the output current in milliamps (mA), for regulator dissipation in milliwatts (mW).

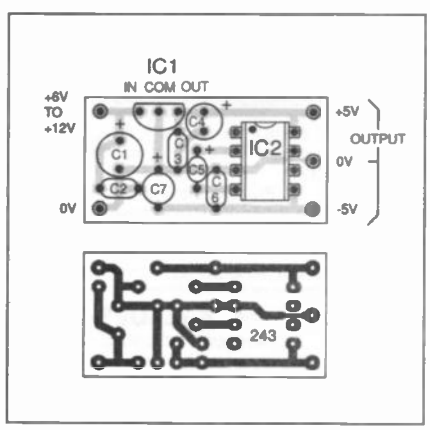


Fig.3. Printed circuit board component layout and full size copper foil master.

Measured results taken with the prototype were −5V for no load, −4·75V at 5mA, and −4·5V at 10mA.

If a reference voltage of some kind is needed, it should be taken from the positive supply. If it is essential to have a negative reference, one way to generate this would be with an inverting op.amp, as shown in Fig.4. The output voltage for this is given by 5(R2/R1) volts.

There will inevitably be some 10kHz ripple on the negative output, although this is very small. Measured values of this were 25mV at 5mA and 50mV at 10mA. In most cases this should not cause any difficulties, but some very sensitive circuits may need careful design or extra filtering to avoid its effects. Where the negative supply is not required IC2 can be removed, though in many cases it will be more convenient to just leave it in place.

IN USE

This little circuit should prove invaluable to those who like to experiment with their own circuits. These days it is often far simpler to regulate the supply to a circuit than to try to design it so that it will ignore supply voltage variations and the option of just dropping this little regulator board into designs with a blob of Blu-Tack or similar will save much valuable time, effort and space.

In fact, it could even be incorporated into complete projects where these are one-offs, perhaps constructed on stripboard, although if a p.c.b. is used it is more likely that it will be copied onto the board design in some form. The layout is not critical in any way save that the decoupling capacitors should be kept reasonably close to the i.c.s. Where it is to be used with the plug-in type of breadboard, short lengths of single-core insulated wire could be connected to the outputs and the other ends of these pushed into the board where needed.

EVERYDAY PRACTICAL ELECTRONICS BACK ISSUES

ETI ELECTRONICS TODAY INTERNATIONAL

We can supply back issues of *EPE* and *ETI* (see panel) by post, most *EPE* issues from the past five years are available. An EPE index for the last five years is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one article* (or *one part* of a series) can be purchased for the same price.

DID YOU MISS THESE?

MAY '98 Photostats Only

PROJECTS • Dice Lott • Security Auto-Light • Stereo Tone Control plus 20W Stereo Amplifier • Improved Infra-Red Remote Repeater.
FEATURES • TEACH-IN '98 – 7 • Net Work • *EPE* PIC Tutorial Supplement 3

JUNE '98

PROJECTS • EPE Mood Changer • Simple SW Receiver • Atmel AT89C2051/1051 Programmer • Reaction Timer.
FEATURES • 8051-based EEPROM Microcontrollers • TEACH-IN '98 – An Introduction to Digital Electronics – 8 • Circuit Surgery • Techniques – Actually Doing It • Ingenuity Unlimited

JULY '98

PROJECTS • PIC16x84 Toolkit • Noise Cancelling Unit • Low Battery Indicator • Greenhouse Computer – 1.
FEATURES • Using the L200CV Voltage Regulator • TEACH-IN '98 – 9 • Ingenuity Unlimited • Circuit Surgery • Net Work.

AUG '98

PROJECTS • Lightbulb Saver • Float Charger • PC Transistor Tester • Greenhouse Computer – 2 • Time Machine Update.
FEATURES • TEACH-IN '98 – 10 • Circuit Surgery • Techniques – Actually Doing It • Ingenuity Unlimited.

SEPT '98

PROJECTS • Mains Socket Tester • Personal Stereo Amplifier • Greenhouse Radio Link • PIC Altimeter.
FEATURES • TEACH-IN '98 – 11 • Ingenuity Unlimited • Circuit Surgery • Interface • Net Work • Crocodile Clips Review.

OCT '98

PROJECTS • Voice Processor • Digiserv R/C Channel Expander • Reliable Infra-Red Remote Control • PC Capacitance Meter.
FEATURES • Easy PCB Making • Using LM335 and LM35 Temperature Sensors • Circuit Surgery • Ingenuity Unlimited • Net Work.

NOV '98

PROJECTS • PIC Tape Measure • T-Stat Electronic Thermostat – 1 • PhizzyB Computers – 1 • 15-way Infra-Red Remote Control.
FEATURES • Circuit Surgery • Ingenuity Unlimited • New Technology Update • Net Work – The Internet • Easy PC for Windows 95 Review • *FREE* EPE CD-ROM No.1.

DEC '98 Photostats Only

PROJECTS • EPE Mind PICkler–1 • Fading Christmas Lights • Handheld Function Generator • Damp Stat Electronic Thermostat • PhizzyB Computers–2.
FEATURES • PhizzyB Computers–2 Understanding Computers • Circuit Surgery • Ingenuity Unlimited • Index • *FREE* 48-page Understanding Passive Components booklet.

JAN '99

PROJECTS • Alternative Courtesy Light Controller • Twinkle Twinkle Reaction Game • Volume Compressor • PhizzyB Computers–3 • EPE Mind PICkler–2.
FEATURES • New Technology Update • From Russia With Love • Circuit Surgery • PhizzyB Computers–3 • Net Work.

FEB '99

PROJECTS • PIC MIDI Sustain Pedal • Light Alarm • Wireless Monitoring System–1 • PhizzyB Computers–4.
FEATURES • Ingenuity Unlimited • Scolar Project • PhizzyB Computers–4.

MAR '99

PROJECTS • Smoke Absorber • Auto Cupboard Light • PhizzyB Computers–5 • Time and Date Generator • Wireless Monitoring System–2.
FEATURES • Ingenuity Unlimited • I/ITSEC Show Report • PhizzyB Computers–5 • Practically Speaking • Circuit Surgery • Net Work.

APRIL '99

PROJECTS • Mechanical Radio • Voice Record/Playback Module • Versatile Event Counter • PhizzyB Computers–6 • Ironing Board Saver.
FEATURES • Ingenuity Unlimited • PIC16F87x Microcontrollers • PhizzyB Computers–6 • MAX761 D.C. to D.C. Converter • Interface • Circuit Surgery • Net Work • *FREE* 48-page Basic Soldering Guide booklet.

MAY '99

PROJECTS • MIDI Handbells • A.M./F.M. Radio Remote Control • PhizzyB Computers–7 • PIC Toolkit Mk2–1.
FEATURES • PC Engines – From 4004 to Pentium III • Ingenuity Unlimited • Practically Speaking • PhizzyB Computers–7 • Circuit Surgery • New Technology Update • Net Work • *FREE* pull-out 7400 series Pinout Data Chart.

JUNE '99

PROJECTS • Clipping Video Fader (Starter Project) • PC Audio Frequency Meter • Musical Sundial • PIC Toolkit Mk2–2.
FEATURES • Alan Dower Blumlein • Circuit Surgery • Interface • PhizzyB Computers–8 • Ingenuity Unlimited • Edison 3 Review • Net Work – The Internet.

JULY '99

PROJECTS • 12V Lead-acid Battery Tester • L.E.D. Stroboscope • EPE Mood Picker • Intruder Deterrent.
FEATURES • Practical Oscillator Designs–1 • Practically Speaking • Circuit Surgery • Ingenuity Unlimited • New Technology Update • Net Work – The Internet.

AUG '99

PROJECTS • Ultrasonic Puncture Finder • Magnetic Field Detective • Freezer Alarm • 8-Channel Analogue Data Logger–1 • Sound Activated Switch.
FEATURES • Practical Oscillator Designs–2 • Power Generation from Pipelines to Pylons–1 • Ingenuity Unlimited • Circuit Surgery • New Technology Update • Interface • Net Work – The Internet.

SEPT '99

PROJECTS • Loop Aerial SW Receiver • Child Guard • 8-Channel Analogue Data Logger–2 • Variable Dual Power Supply.
FEATURES • Practical Oscillator Designs–3 • Power Generation from Pipelines to Pylons–2 • Practically Speaking • Circuit Surgery • Ingenuity Unlimited • New Technology Update • Net Work – The Internet.

BACK ISSUES ONLY £2.75 each inc. UK p&p.

Overseas prices £3.35 each surface mail, £4.35 each airmail.

We can also supply issues from earlier years: 1992 (except March, April, June to Sept. and Dec.), 1993 (except Jan. to March, May, Aug., Dec.), 1994 (except April, May, June, Nov.), 1995 (except Jan., May to Sept., Nov., Dec.), 1996 (except Jan., Feb., April, May, July, Aug., Nov.), 1997, 1998 (except Jan., March to May, Dec.).

We can also supply back issues of *ETI* (prior to the merger of the two magazines) for 1998/9 – Vol. 27 Nos 1 to 13 and Vol. 28 No. 1. We are not able to supply any material from *ETI* prior to 1998. Please put *ETI* clearly on your order form if you require *ETI* issues.

Where we do not have an issue a photostat of any *one article* or *one part* of a series can be provided at the same price.

ORDER FORM – BACK ISSUES – PHOTOSTATS – INDEXES

☐ Send back issues dated ....

☐ Send photostats of (article title and issue date) ....

☐ Send copies of last five years indexes (£2.75 for five inc. p&p – Overseas £3.35 surface, £4.35 airmail)

Name ....

Address ....

....

☐ I enclose cheque/P.O./bank draft to the value of £..

☐ Please charge my Visa/Mastercard £..

Card No. .... Card Expiry Date ....

Note: Minimum order for credit cards £5. Please supply name and address of cardholder if different from that shown above.

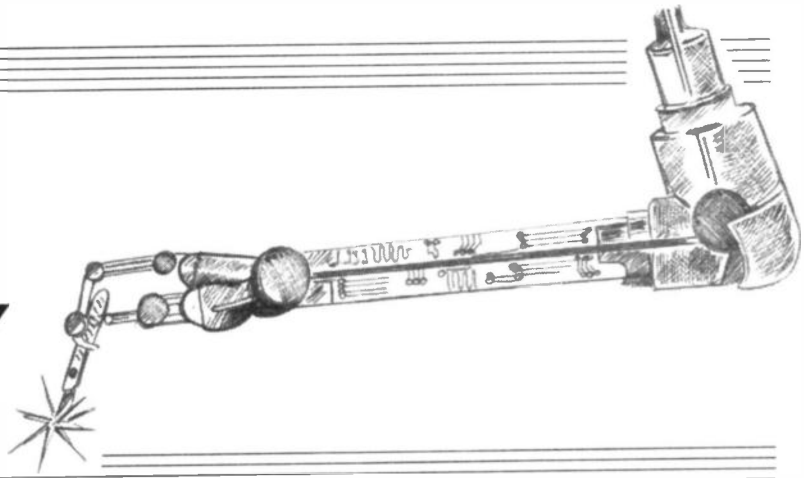
SEND TO: **Everyday Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF.**
Tel: 01202 881749. Fax: 01202 841692. (Due to the cost we cannot reply to overseas queries or orders by Fax.)
E-mail:orders@epemag.wimborne.co.uk

Payments must be in £ sterling – cheque or bank draft drawn on a UK bank. Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.

M10/99

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY and IAN BELL

A new variant of the 555 timer chip, also we return to the topic of digital panel meters, followed by a maths-intensive analysis of a 22-step logarithmic volume control.

ONE event in the integrated circuit world seems to have gone unnoticed so far in the hobbyist arena. Quite a long time ago we were tipped off by a reader about a new offering from the chip manufacturer Zetex, who introduced a new version of the good old 555 timer.

Now that the device has become readily available through some of the better mail-order channels, some of the features of this intriguing "new" device can be described.

Low Voltage 555

The Zetex ZSCT1555 low voltage timer looks like any other 555 timer but it has one very important difference – ***it is guaranteed to operate down to +0·9V supply voltage, even though it is a bipolar device!*** This opens up new applications for this veteran part number, especially using low-voltage power supplies (lithium coin cell batteries for example) for which the device is eminently suitable. Its current consumption is reduced too, drawing a meagre 75μA at 1·5V, claims Zetex. The maximum supply rail is +9V d.c.

This third generation 555 timer has been co-produced by Zetex in association with Hans Camenzind, the designer responsible for the original Signetics 555 timer over 25 years ago. The new device is pin-compatible with older versions but there are slight changes to the formulae. In the monostable timer of Fig.1, the period is $1{\cdot}63R_AC$, and in the astable of Fig.2, the frequency is $0{\cdot}62\ (R_A+2R_B)\ C$.

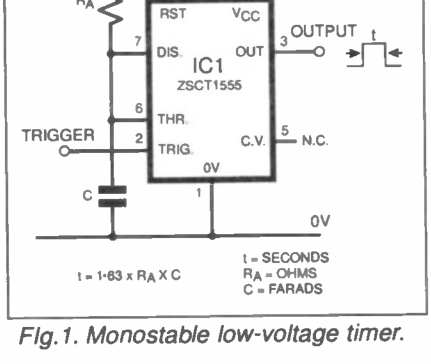


Fig.1. Monostable low-voltage timer.

My own tests proved that it did indeed operate as, say, a piezo disc sounder below 1·5V or so. But there is, of course, a severe restriction placed on the usefulness of the output signal at that sort of level, so don't expect to produce an ear-splitting siren powered by a coin cell! (It's about as noisy as a peeved bluebottle.) By tuning the oscillator frequency to match a piezo's resonant frequency, maximum output level will be obtained.

A full data sheet in Adobe PDF format and an application note for the ZSCT1555 are available from the Zetex web site at **www.zetex.com**. The chip is now available for purchase from Farnell Components (tel. 01132 636311), their part number is 698-155, price £1.25 + VAT for one-offs (minimum cash order £10). A surface mount version is also produced. (*ARW*.)

Digital Panel Meters

I have a mechanical analogue project meter with a 64mV full-scale deflection (f.s.d.) and would like to convert it to a digital display. I noticed that most digital modules indicate 200mV. Can you tell me how to use one in my project? D. Lee, ***Birkenhead.***

Most digital panel meters (DPM) tend to be 200mV types and are designed as a basic voltmeter. The end user must decide how to "scale" the DPM, whether as an ammeter (using the meter to read the voltage drop across a series resistor) or as a voltmeter for use at a higher voltage range, which is usually how they are utilised.

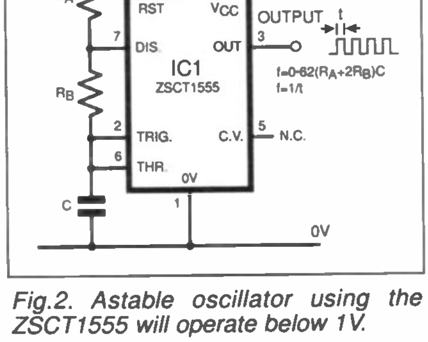


Fig.2. Astable oscillator using the ZSCT1555 will operate below 1V.

Such a module often uses a 7106 chip and will directly read 199·9mV (which is why they are called 3½ digit types – the leading "1" being the half digit). This topic was briefly described in *Circuit Surgery*, September 1998.

An external attenuator must be added to a 200mV digital panel meter's input to extend its range. You can assume that the module will have an extremely high input impedance (>100MΩ so the attenuator should be about one tenth of this resistance to avoid loading.

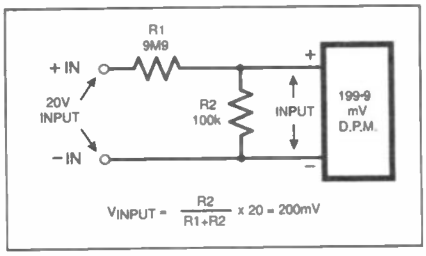


Fig.3. A voltage divider on a DPM input, produces a 20V f.s.d. meter.

To produce a 20V d.c. voltmeter a series input resistor of 9·9 megohm would be used, followed by a 100 kilohm (100kΩ) resistor *across* the meter's input terminals, see Fig.3. Thus, most of the input voltage is dropped across the 9·9MΩ resistor and at an input of 20V only 200mV appears across the DPM input terminals. A 200V voltmeter would use 9·99MΩ and 10kΩ instead.

As regards fitting it into your project, due care is needed with 7106-based meter modules as they may require a completely independent d.c. supply voltage, which cannot necessarily be tapped from an existing supply. Problems arise when the DPM supply and the DPM signal input 0V rails are commoned together.

A good supplier of very competitively-priced panel meters is Vann Draper (Tel. 0116 277 1400 or **www.vanndraper.co.uk**) who advertise regularly in our pages. Full instructions come with every meter and their l.c.d. model can be modified with a couple of track cuts ready for "commoning" of the 0V rails. Vann Draper tells me that they can also provide an l.e.d. type, subject to lead times.(*ARW*.)

Sound Levels and Decibels

Last month we discussed in some detail the rather involved mathematics behind Root Mean Square (r.m.s.) values, and we examined the meaning (or actually the total lack of any meaning whatsoever!) of audio p.m.p.o. ratings (Peak Music Power Output). This month, *Circuit Surgery* embarks on another mathematical extravaganza, courtesy of Ian Bell (whom as regular readers will know hails from the School of Engineering at the University of Hull).

The material that follows is maths-intensive and is written with the more advanced reader in mind. However, non-mathematicians shouldn't be disheartened as we are sure they will pick up plenty of snippets of valuable information along the way.

Unfortunately in the complex where I live, I have to keep the noise down! For my stereo system I would like to build a switched volume control for which purpose I have acquired a 22-position dual control rotary switch with gold-plated contacts. How could I calculate the resistor values? My source impedance is 50 kilohms.

*I'm still keenly interested in electronics and always enjoy your column. Many thanks from **Johnny Bruyns**, Benoni, South Africa.*

This is a good example of a simple question which in the event has a very involved reply: unfortunately it isn't always clear at the beginning just how tricky the solution really is, until it's actually been worked out!

One very simple solution (used on my trusty Marantz audio amplifier – *ARW*) is to use an ordinary logarithmic potentiometer with a "detent" mechanism on the shaft: the Volume control was calibrated in decibels and it clicks into one of 20 or 30 positions when rotated.

On The Threshold

Before we tackle the query directly though, we need to consider why it is not a straightforward case of using 21 or 22 *equal value* resistors. The quick answer is that volume controls usually have a **logarithmic** response, with the consequence that a given turn of the control at the "low" volume end results in a much *smaller* change in output voltage than the same turn at the "high" volume end.

This means the resistors will have to be scaled logarithmically. We need logarithmic volume controls because human hearing, or more specifically our perception of loudness, is logarithmic in nature. This is one of those everyday facts many of us know and take for granted, and which we decided to investigate in more detail.

The human ear is able to hear sounds of a very wide range of intensities (which is measured in Watts per square meter – Wm^{-2}). The quietest sound which can be perceived is called *the threshold of hearing* and is about 1×10^{-12} Wm^{-2}. The *threshold of pain* is about 10,000,000,000,000 times more than this at about 10 Wm^{-2} (these threshold figures are only approximate and vary with individuals and frequency). For those readers interested in loud audio – a rock concert can reach 0·1 Wm^{-2} or more if you are positioned close to the speakers!

An **exponential** increase in sound intensity, from the quietest audible to the loudest tolerable sound, is perceived basically as a **linear** increase in loudness. Whilst sound intensity in Watts per square meter is rigidly defined, loudness is a matter of human perception and will vary between individuals and with frequency, however, the general *exponential* nature of the relationship just described remains valid.

Exponential is the inverse of logarithmic – the intensity varies exponentially but our ears respond logarithmically, which is why we perceive a *linear* increase in loudness. Put another way: each **ten-fold increase** of sound intensity gives an **equal step** increase in loudness. We could also say each doubling of sound intensity gives an equal step increase in loudness – these would be smaller steps than for a ten-fold increase of course.

Going Decibels

Exponentially varying quantities can be difficult to deal with (try plotting the full range of sound intensities mentioned earlier on normal graph paper!) so a special scaling system is often used. First, we take a reference level (say the threshold of hearing) and then the sound intensity level we are interested in, and then we find the ratio between them – i.e. by what factor our intensity is larger than the reference.

Now, taking a logarithm of the ratio we get a value related to the perceived loudness. In fact this approach is the basis of the commonly used **decibel** notation.

The definition of a decibel (dB) is based on the logarithm of the power ratio of two signals P_1 and P_2, such that the power ratio in decibels is given by $10 \times \log_{10}(P_2/P_1)$ dB. If we are expressing *power gain* (e.g. of an amplifier) then P_1 would be the input power and P_2 the output power.

For measuring a power *quantity* relative to a reference, P_1 would be the reference level and P_2 the value we are measuring. Note that because power ratios are used in the decibel definition it does not matter if P_1 and P_2 are expressed as peak or r.m.s. values as long as both are expressed in the same way.

As an example, if your personal stereo is delivering 2×10^{-2} Wm^{-2} of sound power to your eardrums this would be 103dB relative to a threshold of hearing reference at 1×10^{-12} Wm^{-2}. The calculation is: $10 \times \log_{10}(2 \times 10^{-2}/1 \times 10^{-12}) = 103$. Note if the measured value is equal to the reference, or if the gain of the system is 1 then we get 0dB.

Reduced Power

If a circuit reduces power, i.e. it is an *attenuator*, then we actually get *negative* decibel values. For example, if the power output is 50 times smaller than the input then the "gain" is −17dB ($10 \times \log_{10} \times 1/50$). If the power is reduced by one half then the output is at **−3dB**.

This is a figure that many readers may know as the *cut-off frequency* of a filter (or the bandwidth of an amplifier) which is usually quoted as the point when the gain falls to 3dB below the value in the passband. At this frequency the output power from the filter is half the value it is in the passband (for equal input power). It is worth noting at this point that a volume control is an attenuator and that a useful response to the reader's question would be to design a control with 22 attenuation ratios in equal decibel steps. Before we go on with this we need a few more comments about decibels though.

So far we have only discussed power ratios – this was obviously appropriate for sound intensities, but in circuits we often measure signals as voltages and currents. Power is related to the square of voltage or current. If we square something inside a logarithm, it is equivalent to multiplying the log by two (without the square). That is, $\log(V^2) = 2\log(V)$. So to express a voltage gain (V_1/V_2) in decibels we use $20 \times \log_{10}(V_2/V_1)$. Note that we are multiplying by **20**, not by 10 as we did with the power gain.

Strictly speaking this formula is only valid if the two voltages are across the same resistance value, but in many cases we are only interested in the voltage gain (not the power gain) and the $20 \times \log_{10}(V_2/V_1)$ formula is widely used for this purpose (V_2 being the output, V_1 is the input). Similarly current gains can be expressed in decibels using $20 \times \log_{10}(I_2/I_1)$.

Divided Volume

To design the volume control we will use the simplified situation shown in Fig.4. The volume control is a potential divider placed between two amplifiers, it therefore attenuates the output of the first amplifier, A1, before passing it to A2.

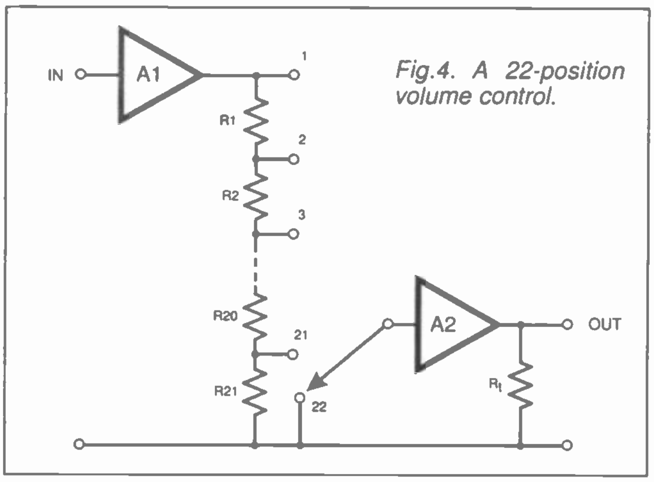


Fig.4. A 22-position volume control.

We will assume that the total value of the resistor chain in the potential divider is R_t and that the second amplifier drives a load of value R_t also, this means that voltage gain in dB will equal the power gain. We will also assume that the amplifiers have low output impedance and are not loaded heavily by R_t, and that the second amplifier has a high input impedance and does not load the potential divider. Let's also assume that both amplifiers have unity gain (1).

In a real circuit these assumptions may not be valid but the effect will generally be to shift the actual power output from A2 by a constant amount, or multiply it by a constant factor. Since it is the relative loudness produced by each step of the volume control which interests us this will not matter. It is still important, however, that the resistor chain does not heavily load, and is not loaded by, the amplifiers.

Referring to Fig.4, the switch S1 has 22 positions so there are 21 resistors. The first position (1) bypasses the divider and connects the amplifiers directly together. This is full volume (0dB attenuation). The 22nd position connects the input of the second amplifier to ground so no signal will be output (infinite attenuation): we could label this position "Mute". This leaves 20 remaining positions for different volume levels.

We can decide over what range in dB we would like to control the volume. 90dB might be reasonable – the range from a whisper to a loud personal stereo is of this order. If we chose 90dB each of the 20 switch positions increases the attenuation by 4·5dB.

Calculated Fun

Now for the fun bit – how do we calculate the resistor values? Recall that the formula for a standard two-resistor potential divider is $V_{out} = V_{in} \times R_B/(R_A+R_B)$, as shown in Fig.5. We can write R_A+R_B as R_t, the total value of the resistors in the potential divider. The "gain" of the potential divider is V_{out}/V_{in} which is simply R_B/R_t. Expressed in decibels this is $20 \times \log_{10}(R_B/R_t)$.

Our potential divider is a little more complex as it has many resistors, however it still has a total resistance that we will call R_t. For now we will not limit the number of resistors in the volume control divider, in fact we can assume there is an infinite number getting ever smaller as we move down the chain from the amp output to ground. We can label the nth resistor in the chain from the amp output as R_n.

If we consider taking an output from the volume control divider below the nth resistor and compare this with the basic potential divider, the equivalent to R_B will be the sum of the resistor values from R_{n+1} to infinity (the sigma symbol meaning "sum of"). This is a gain of:

$$20\log_{10}\left(\frac{\sum_{r=n+1}^{\infty} R_r}{R_t}\right)$$

If we move up the chain to just below the previous (i.e. $(n-1)$th) resistor the gain will be

$$20\log_{10}\left(\frac{\sum_{r=n}^{\infty} R_r}{R_t}\right)$$

The difference between these two adjacent steps in the volume control must be equal to whatever increment in gain we require for each switch position. We chose 4·5dB earlier, but we will keep things general here by using A to represent the constant step in dB attenuation for each switch position.

Thus A =

$$20\log_{10}\left(\frac{\sum_{r=n}^{\infty} R_r}{R_t}\right) - 20\log_{10}\left(\frac{\sum_{r=n+1}^{\infty} R_r}{R_t}\right)$$

$$\text{so } A = 20\log_{10}\left(\frac{\sum_{r=n}^{\infty} R_r}{\sum_{r=n+1}^{\infty} R_r}\right)$$

by dividing by 20, taking 10 to the power of each side, and taking the reciprocal we get

$$\left(\frac{\sum_{r=n+1}^{\infty} R_r}{\sum_{r=n}^{\infty} R_r}\right) = 10^{(-A/20)} = k$$

In which it is convenient to write $10^{(-A/20)}$ as a constant k as shown. Rearranging, we get

$$\sum_{r=n+1}^{\infty} R_r = k\sum_{r=n}^{\infty} R_r$$

From which it can be inferred the resistor values for a geometric sequence with coefficient k and initial value R_1. That is, the resistor values are R_1, kR_1, k^2R_1, k^3R_1... and $0<k<1$ so the series converges, that is the sum of all resistance values is finite. This should not be too surprising given the logarithmic nature of the response we are after.

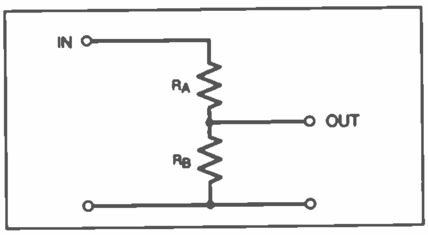


Fig.5. Basic potential divider.

From the properties of a geometric series we know that the sum of resistances to the nth resistor, S_n is:

$$S_n = R_1\,\frac{(1-k^n)}{(1-k)}$$

Note that S_n is the equivalent of R_A in Fig.4, if we take the output from just below R_n. By taking the limit in the above equation, in which $n\rightarrow\infty$, we get the value of R_t (the total resistance of all the resistors).

$$R_t = \frac{R_1}{(1-k)}$$

This is useful because it allows us to calculate the value of the first resistor in the volume control (R1 in Fig.4) once we have decided on the attenuation step and the total resistance value we want to use. From there we can use the fact that each resistor in the chain can be found by multiplying the previous value by k.

This is easy to do if you have a "constant" facility on your pocket calculator – just keep pressing "equals" after multiplying R1 by the constant k to get all resistor values. By using the equation for S_n for the total to two adjacent resistors (say R_{n-1} and R_n) and taking the difference between them we can also get an expression for the value of the nth individual resistor as follows: $R_n = R_t(k^{n-1}-k^n)$

Table 1: Divider resistor chain

Resistor	Value	Total(Ω)	Gain (dB)
1	202kΩ	202169	-4·5
2	120kΩ	322593	-9
3	71·7kΩ	394326	-13·5
4	42·7kΩ	437054	-18
5	25·5kΩ	462505	-22·5
6	15·1kΩ	477666	-27
7	9·03kΩ	486696	-31·5
8	5·38kΩ	492076	-36
9	3·20kΩ	495280	-40·5
10	1·91kΩ	497188	-45
11	1·14kΩ	498325	-49·5
12	677Ω	499002	-54
13	403Ω	499406	-58·5
14	240Ω	499646	-63
15	143Ω	499789	-67·5
16	85·3Ω	499874	-72
17	50·8Ω	499925	-76·5
18	30·2Ω	499955	-81
19	18·0Ω	499973	-85·5
20	10·7Ω	499984	-90
21 *(Re)*	15·8Ω	500000	off

Remember $0<k<1$ so k^{n-1} is larger than k^n so this will give a positive value for R_n as required. The only problem remaining is that we have assumed an infinite series of resistors, which is not very practical! For a practical circuit we need to terminate the sequence after a certain number of resistors (20 in our example).

Special Case

The last resistor must be treated as a special case. Its value must be equal to the sum of all the resistors left in the infinite series after we stop using it.

We shall call this resistor R_e (e for end). We will also use N to signify the number of resistors in the first part of the divider ($N = 20$ in our example). The value of R_e is obtained simply by subtracting the sum of the N resistors in the main part of the chain from the total, that is $R_e = R_t - S_N$, where S_N is obtained by putting $n = N$ in the equation for S_n given above.

By substituting the formula for S_n and R_t given above into $R_t - S_N$ and simplifying we get: $R_e = R_t k^N$

As an example if we use $A = 4{\cdot}5$dB (4·5 dB steps) we get $k = 10^{(-4.5/20)} = 0{\cdot}5957$. If we choose a total resistance of 500kΩ (kilohms) and require 21 resistors (20 in the sequence, plus R_e) we get $N = 20$ and $R_t = 500000$, from which $R_1 = 500000 \times (1 - 0{\cdot}5957) = 202$ kΩ, and $R_e = 500000 \times (0{\cdot}5957^{20}) = 15{\cdot}8\Omega$. The other resistors can be found by multiplying successively by k, i.e. $R_2 = 0{\cdot}5957 \times R_1 = 120$ KΩ; $R_3 = 0{\cdot}5957 \times R_2 = 71{\cdot}7$ kΩ; and so on. It useful to add up all the resistor values (including R_e) to check that they equal R_t.

Finally, Table 1 gives all the values for our example, plus the gain at each point at the tap below the resistor concerned, and the accumulated resistance total. We do not know what the most appropriate values are for the reader's application so the values we have used are as an example only. However, it should be straightforward to apply the formula given to whatever attenuation step size, total resistance, and number of resistors are required. Phew! Well you did ask...! *(IMB.)*

Everyday Practical Electronics Books

TEACH-IN No. 7 plus FREE Software
ANALOGUE AND DIGITAL ELECTRONIC COURSE
(Published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE

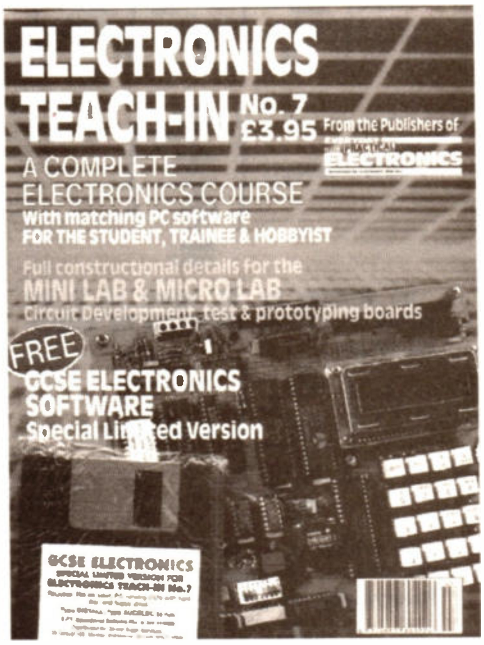
FREE SOFTWARE

The highly acclaimed *Teach-In* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a FREE DISC covering the first two parts of the course is included with the book.

An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.

If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics then this is for you. If you are teaching electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.

152 pages Order code TI7 £3.95



DIRECT BOOK SERVICE

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

For another selection of books see the next two issues

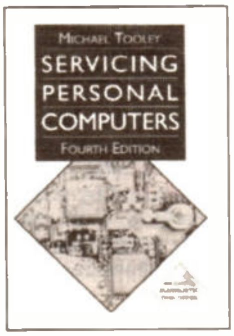
Testing and Test Gear

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

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

104 pages Order code BP267 £3.50

SERVICING PERSONAL COMPUTERS – 4th EDITION
Mike Tooley BA



The revised and enlarged forth edition has been completely re-written to cover the latest technology, such as 32-bit microprocessors and serial communications servicing. It includes a diagnostic disk offer. Essential for anyone concerned with the maintenance of personal computer equipment or peripherals, whether professional service technician, student or enthusiast.

387 pages Hardback Order code NE15 £30

Radio

BASIC RADIO PRINCIPLES AND TECHNOLOGY NEW
Ian Poole

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

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

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

263 pages Order code NE30 £14.99

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

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

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

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

92 pages Order code BP304 £3.95

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.

This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages Order code BP257 £4.99

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold

Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.

The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.

Contains everything you need to know in order to get started in this absorbing hobby.

88 pages Order code BP275 £3.95

Computers and Computing

MULTIMEDIA ON THE PC
Ian R. Sinclair

In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.

184 pages Order code PC112 £11.95

HOW TO BUILD YOUR OWN PC NEW
Morris Rosenthal

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

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-Intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98.

The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format Order code MGH2 £19.99

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)

If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

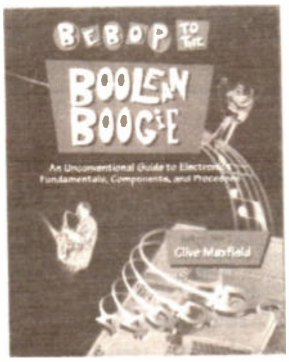
128 pages Order code BP282 £4.95

Theory and Reference

Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield

Specially imported by EPE – Excellent value



An Unconventional Guide to Electronics Fundamentals, Components and Processes

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean algebra and Karnaugh maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day....

470 pages – large format **Order code BEB1** **£24.95**

DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality) FREE SOFTWARE
Richard Monk

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

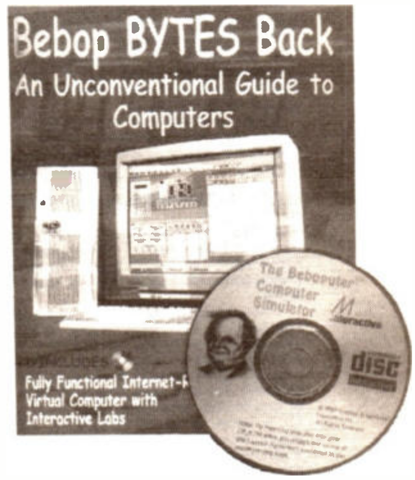
250 pages **Order code NE28** **£16.99**

Bebop Bytes Back

FREE CD-ROM

By Clive "Max" Maxfield and Alvin Brown

Specially imported by EPE – Excellent value



An Unconventional Guide To Computers

Plus **FREE CD-ROM** which includes:
Fully Functional Internet-Ready Virtual Computer with Interactive Labs

This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

over 500 pages – large format **Order code BEB2** **£29.95**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

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

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

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

200 pages **Order code PC106** **£8.95**

Music, Audio and Video

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages **Order code BP256** **£3.99**

ACOUSTIC FEEDBACK – HOW TO AVOID IT
V. Capel

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce a reduced feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages **Order code BP310** **£4.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR **NEW**
R. A. Penfold

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

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

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

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

124 pages **Order code PC115** **£9.95**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

174 pages **Temporarily out of print**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

110 pages **Temporarily out of print**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

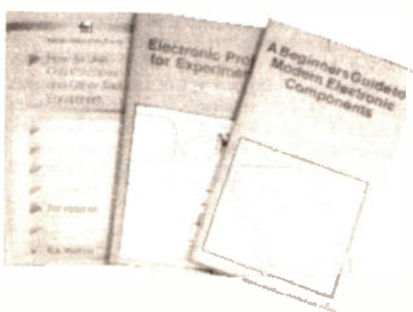
Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£3.99**

Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
88 pages **Order code BP299** **£4.99**

ELECTRONIC HOBBYISTS DATA BOOK
R. A. Penfold
This book should tell you everything you are ever likely to want to know about hobby electronics, but did not know where to ask or refer. Comprehensive contents pages makes it easy to quickly locate the data you require.
The subjects covered include: Common circuits, and related data (including helpful graphs and tables of values); Colour codes for resistors, capacitors and inductors; Pinout details for a wide range of CMOS and TTL devices, plus basic data on the various logic families; Pinout details and basic data for a wide range of operational amplifiers; Data and leadout information for a wide range of transistors, FETs, power FETs, triacs, thyristors, diodes, etc; General data including MIDI message coding, radio data, ASCII/Baudot coding, decibel ratios, etc.
242 pages **Order code BP396** **£5.95**



50 SIMPLE LED CIRCUITS
R. N. Soar
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
64 pages **Order code BP42** **£2.99**

BOOK 2 50 more l.e.d. circuits.
50 pages **Order code BP87** **£2.99**

CIRCUIT SOURCE BOOK 1
A. Penfold
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.
The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.
Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
182 pages **Order code BP321** **£4.99**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world"
142 pages **Order code BP332** **£4.95**

HOW TO USE OP.AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
160 pages **Order code BP88** **£3.99**

CIRCUIT SOURCE BOOK 2
R. A. Penfold
This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.
The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.
The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.
Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
192 pages **Order code BP322** **£4.99**

Project Building

ANDROIDS, ROBOTS AND ANIMATRONS
John Lovine
Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.
The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.
224 pages **Order code MGH1** **£20.99**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.
138 pages **Temporarily out of print**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.
132 pages **Order code BP374** **£4.95**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:
Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain metrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.
In fact everything you need to know in order to get started in this absorbing and creative hobby.
135 pages **Order code BP392** **£4.95**

A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold
The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.
166 pages **Order code BP285** **£4.99**

BOOK ORDERING DETAILS

Our postage price is the same no matter how many books you order, just add **£1.50** to your *total* order for postage and packing (overseas readers **add £3** for countries in the EEC, or **add £6** for all countries outside the EEC, surface mail postage) and send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or credit card details, Visa or Mastercard – minimum credit card order is £5 – to: **DIRECT BOOK SERVICE, 33 GRAVEL HILL, MERLEY, WIMBORNE, DORSET BH21 1RW** *(mail order only).*

Books are normally sent within seven days of receipt of order, but please allow 28 days for delivery (more for overseas orders). *Please check price and availability (see latest issue of* Everyday Practical Electronics) *before ordering from old lists.*

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

DIRECT BOOK SERVICE IS A DIVISION OF WIMBORNE PUBLISHING LTD. Tel 01202 881749
Fax 01202 841692. Due to the cost we cannot reply to overseas orders or queries by Fax.
E-mail:dbs@epemag.wimborne.co.uk

BOOK ORDER FORM

Full name: ....

Address: ....

....

.... Post code: .... Telephone No: ....

Signature: ....

☐ I enclose cheque/PO payable to WIMBORNE PUBLISHING LTD for £ ....

☐ Please charge my Visa/Mastercard £ .... Card expiry date ....

Card Number ....

Please send book order codes: ....

....

Please continue on separate sheet of paper if necessary

2a

VIDEOS ON ELECTRONICS

A range of videos selected by *EPE* and designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc

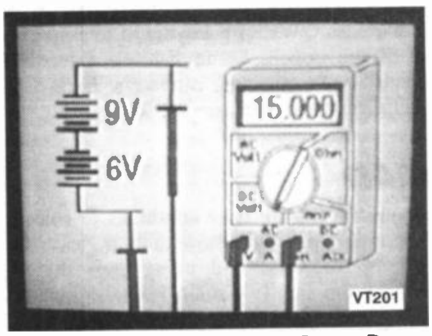
BASICS

VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.

VT201 54 minutes. Part One; **D.C. Circuits.** This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

VT202 62 minutes. Part Two; **A.C. Circuits.** This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits. **Order Code VT202**

VT203 57 minutes. Part Three; **Semiconductors.** Gives you an exciting look into the world of semiconductors. With basic semiconductor theory. Plus 15 different semiconductor devices explained. **Order Code VT203**



VT204 56 minutes. Part Four; **Power Supplies.** Guides you step-by-step through different sections of a power supply. **Order Code VT204**

VT205 57 minutes. Part Five; **Amplifiers.** Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

VT206 54 minutes. Part Six; **Oscillators.** Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits. **Order Code VT206**

£34.95 each
inc. VAT & postage
Order 8 or more get one extra FREE
Order 16 get two extra FREE

VCR MAINTENANCE

VT102 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the NTSC VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

DIGITAL

Now for the digital series of six videos. This series is designed to provide a good grounding in digital and computer technology.

VT301 54 minutes. Digital One; **Gates** begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation. **Order Code VT301**

VT302 55 minutes. Digital Two; **Flip Flops** will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 54 minutes. Digital Three; **Registers and Displays** is your next step in obtaining a solid understanding of the basic circuits found in today's digital designs. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

VT304 59 minutes. Digital Four; **DAC and ADC** shows you how the computer is able to communicate with the real world. You will learn about digital-to-analogue and analogue-to-digital converter circuits. **Order Code VT304**

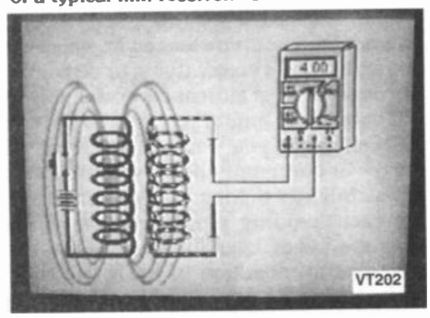
VT305 56 minutes. Digital Five; **Memory Devices** introduces you to the technology used in many of today's memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices. **Order Code VT305**

VT306 56 minutes. Digital Six; **The CPU** gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

RADIO

VT401 61 minutes. **A.M. Radio Theory.** The most complete video ever produced on a.m. radio. Begins with the basics of a.m. transmission and proceeds to the five major stages of a.m. reception. Learn how the signal is detected, converted and reproduced. Also covers the Motorola C-QUAM a.m. stereo system. **Order Code VT401**

VT402 58 minutes. **F.M. Radio Part 1.** F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver. **Order Code VT402**

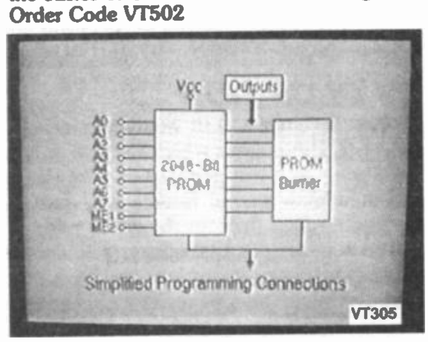


VT403 58 minutes. **F.M. Radio Part 2.** A continuation of f.m. technology from Part 1. Begins with the detector stage output, proceeds to the 19kHz amplifier, frequency doubler, stereo demultiplexer and audio amplifier stages. Also covers RDS digital data encoding and decoding. **Order Code VT403**

MISCELLANEOUS

VT501 58 minutes. **Fibre Optics.** From the fundamentals of fibre optic technology through cable manufacture to connectors, transmitters and receivers. **Order Code VT501**

VT502 57 minutes. **Laser Technology** A basic introduction covering some of the common uses of laser devices, plus the operation of the Ruby Rod laser, HeNe laser, CO_2 gas laser and semiconductor laser devices. Also covers the basics of CD and bar code scanning. **Order Code VT502**



Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. We are the worldwide distributors of the PAL and SECAM versions of these tapes. (All videos are to the UK PAL standard on VHS tapes unless you specifically request SECAM versions.)

ORDERING: Price includes postage to anywhere in the world.

OVERSEAS ORDERS: We use the VAT portion of the price to pay for *airmail* postage and packing, wherever you live in the world. Just send £34.95 per tape. All payments in £ sterling only (send cheque or money order drawn on a UK bank).

Visa and **Mastercard** orders accepted – please give card number, card expiry date and cardholder's address if different from the delivery address.

Orders are normally sent within seven days but please allow a maximum of 28 days, longer for overseas orders.

Send your order to: Direct Book Service, 33 Gravel Hill, Merley, Wimborne, Dorset BH21 1RW (Mail Order Only)

Direct Book Service is a division of Wimborne Publishing Ltd., Publishers of *EPE*

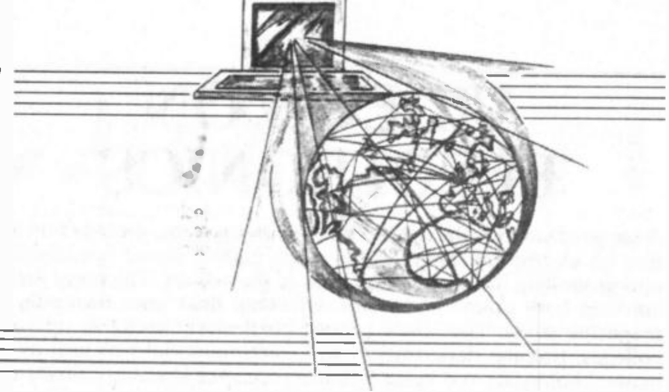
Tel: 01202 881749. Fax: 01202 841692

Due to the cost we cannot reply to overseas orders or queries by Fax.

E-mail: editorial@epemag.wimborne.co.uk

SURFING THE INTERNET

NET WORK



ALAN WINSTANLEY

REGULAR users of the *EPE* web site (**www.epemag.wimborne.co.uk**) will have noticed the addition of a new search engine on our home page. It uses the Excite engine and will hopefully help to point you in the right direction if you're searching for particular project details or keywords on the web site.

It's worth remembering that having arrived on the suggested web page, the quickest way of pin-pointing the precise keyword is to use the "Find" facility of your browser. In Microsoft Internet Explorer, this is located under the Edit menu ("Find on this Page") and it's an often underused but useful option when wading through pages of text.

EXPLORE NEW OPTIONS

This month, I'll suggest a few ways in which your Microsoft Internet Explorer browser can be improved. Version 5 is the one to go for, but don't bother trying to download it from the net as it will be found on most current cover disk CD ROMs!

There was a time when all web browsing had to be performed on-line, and if you wanted to view or print a copy for later reference or consumption you would have to do it on-line when the phone bill was ticking away. Alternatively, you could use one of the cache-reading programs such as Nearsite or Unmozify to read the pages later on. The ability to "work off-line" was a welcome introduction in MSIE V4, but it's a facility which is tucked away on a menu rather than being readily accessible on the button bar. This omission is quite tiresome and not a little annoying, as in my experience it's one of the browser's most used features.

The same is true of Internet Explorer Version 5. Just as I was cussing at this missed opportunity to improve this latest browser's functionality, I unearthed several browser enhancements on the Microsoft site (**www.microsoft.com/windows/ie/webaccess**) and I recommend that readers hop over and have a look.

The most useful one is (fanfare!) a toolbar button for enabling off-line working. This loads an "off-line" button shortly after the browser has booted. Unfortunately, the only way you can actually tell that you're in off-line mode is to check for a small icon in the browser's command bar underneath the main window.

More tools for MSIE 5.0 are also on offer. I especially like the optional extras for the right mouse-click menu, including (at last) the ability to highlight in yellow any text of interest. I find this a great idea when checking through long pages, or perhaps lengthy lists of software options for downloading: the highlighter enables me to scroll back up to the areas of interest and to focus on getting my work done.

IN CLOSE-UP

Web developers will enjoy the new View Partial Source and Images List functions which are also only a right mouse-click away. Now you can select portions of a web page which look interesting, and then View Partial Source will reveal the HTML just for that selection, rather than for the entire page.

The new Images List option will also be a tremendous boon for many developers; it displays the file size and dimensions in pixels of every image on a page, as well as the images themselves. More importantly, it totals up the image content per page and calculates the typical download time at a variety of speeds.

Other MSIE 5.0 "tweak" options are provided on the Microsoft site, including the ability to decorate the toolbar with a bitmap. The toolbar "wallpapers" supplied are unimaginably dull but you could always create your own bitmap using a graphics program. You will also discover that several third party developers now offer plug-in toolbars, including Alta Vista's search engine toolbar which integrates into MSIE 5.0. It's nice to see one or two worthwhile additions, not before time, which simplify the work of experienced users and developers for a change.

1984 AND ALL THAT

It isn't often that your scribe has the time or inclination to indulge in any navel-gazing, but it is sometimes stimulating to step back a little and maybe hazard a guess as to which way the "wired" world is going. The February 1984 issue of *Everyday Electronics* contained a small but very prophetic news item, the significance of which is only now starting to become apparent. In that issue, which featured a Sinclair ZX81 home computer on its cover, we reported on the advent of the world's first digital television in Japan, which we hailed as "marking a new generation that will serve as the focal point for the home information system of the future." (See the *history2.htm* page of our web site.)

Nowadays the whole world and his dog owns a mobile phone or pager and routinely uses the Internet for chatting, mailing and shopping. Rather than kitting everyone out with a complicated home computer, to my mind the increasingly widespread use of Web TV probably represents the final piece to fall into place in the home consumer information jigsaw. Web TV uses the TV screen as a monitor, and it can use a wireless QWERTY keyboard to communicate from the comfort of the couch. Some E-mails I receive already bear the "webtv.com" or "webtv.net" monikers. Both Sky and On-Digital promise an electronic mail service through digital set-top boxes soon.

LOOKING AHEAD

Looking ahead, as pressure on leisure time continues to soar, I think that consumers will routinely purchase more of their groceries via the Internet for doorstep delivery, and using their digital television which will become the family's main home computer "monitor". Regular standing orders could be placed or modified, relieving the customer of some of the chore and drudgery of shopping. This is already starting to happen via home computer Internet links.

With the arrival of Web TV, viewers will be able to browse through on-line holiday brochures complete with downloadable movie presentations of holiday destinations, reserve a flight or book a weekend break, send E-mails, and even download kids' homework resources, all simply menu driven through their digital TV. Need a plumber? Instead of thumbing through *Yellow Pages*, there will be an interactive web directory (and you can bet that AAA Plumbing will be there at the top of the search engine results).

You will be able to leave video messages for others in a "video box" using integrated cameras, messages being downloaded on command. However, the more sophisticated personal computer user will continue to use separate PC desktop or laptop systems allied to a suite of imaging and printing peripherals, connected to the Internet via wireless or cable modems or eventually ADSL. But those unable to get to grips with a PC system should find Web TV a breeze.

Twenty years after prophesying the impact of the home information revolution, the use of Web TV as an interactive home information resource will gradually become as routine as using teletext. American users are already being exhorted to prepare for Web TV by buying a 28-inch or 30-inch television!

This is to compensate for the computer-screen orientated web material which is designed for PC monitors and is prevalent today: they invariably feature small graphics, tiny print and contain far too many navigation options. A Web TV window cannot scroll sideways, either.

Before long, web sites will have to be augmented or completely redesigned to allow for this new method of viewing them, eight feet away on a low resolution TV tube. One thing is for sure, there are interesting times and choices ahead for the consumer, and the way in which new generations will organise their lives is about to be transformed yet again.

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to The PCB Service, ***Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: orders@epemag.wimborne.co.uk**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details.

Please check price and availability in the latest issue.
Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
Child Minder Protection Zone	JUN'97		
– Transmitter		153	£6.58
– Receiver		154	£6.42
Pyrotechnic Controller		155	£6.93
★PIC Digilogue Clock		156	£7.39
Narrow Range Thermometer		158	£6.37
Micropower PIR Detector – 1	JULY'97	152	£6.69
Infra-Red Remote Control Repeater (Multi-project P.C.B.)		932	£3.00
Karaoke Echo Unit – Echo Board		159	£6.40
– Mixer Board		160	£6.75
Computer Dual User Interface		161	£6.70
★PEsT Scarer		162	£6.60
Variable Bench Power Supply	AUG'97	932	£3.00
Universal Input Amplifier		146	£6.55
Micropower PIR Detector – 2 Controller		163	£6.72
★PIC-OLO		164	£7.02
Active Receiving Antenna	SEPT'97	140	£6.59
Soldering Iron Controller		157	£6.63
★PIC Noughts & Crosses Game		165	£7.82
Micropower PIR Detector – 3 Alarm Disarm/Reset Switch		166	£5.72
Ironing Safety Device		167	£5.12
Remote Control Finder	OCT'97	168	£6.32
Rechargeable Handlamp		169	£6.23
★PIC Water Descaler		170	£6.90
★EPE Time Machine	NOV'97	171	£8.34
Auto-Dim Bedlight		172	£6.63
Portable 12V PSU/Charger		173	£6.61
Car Immobiliser	DEC'97	175	£7.00
Safe and Sound (Security Bleeper)		179	£7.32
Surface Thermometer	JAN'98	174	£7.64
Disco Lights Flasher		178	£8.30
Waa-Waa Pedal (Multi-project PCB)	FEB'98	932	£3.00
★Virtual Scope – Digital Board		176	£14.49
Analogue Board (per board)		177	£7.34
★Water Wizard		180	£7.69
Kissometer		181	£7.67
★EPE PIC Tutorial	MAR'98	182	£7.99
The Handy Thing (Double-Sided)		183	£6.58
Lighting-Up Reminder		184	£5.90
★Audio System Remote Controller – PSU		185	£7.05
Main Board		186	£8.29
Simple Metal Detector (Multi-project PCB)	APR'98	932	£3.00
Single or Dual-Tracking Power Supply		187	£7.90
★RC-Meter		188	£7.66
Security Auto-Light	MAY'98	189	£8.10
Stereo Tone Control plus 20W Stereo Amplifier			
Tone Control		190	£7.78
20W Amplifier		191	£8.58
★Dice Lott		192	£8.05
EPE Mood Changer	JUNE'98	193	£7.75
★AT89C2051/1051 Programmer			
Main Board		194	£8.50
Test Board		195	£8.69
★Reaction Timer **Software only**		–	–
★PIC16x84 Toolkit	JULY'98	196	£6.96
★Greenhouse Computer			
Control Board		197	£9.08
PSU Board		198	£8.10
Float Charger	AUG'98	199	£6.59
Lightbulb Saver		202	£3.00
Personal Stereo Amplifier (Multi-project PCB)	SEPT'98	932	£3.00
★Greenhouse Radio Link		200	£8.32
★PIC Altimeter		201	£8.15
Voice Processor	OCT'98	203	£7.18
★Digiserv R/C Expander		204	£7.69
IR Remote Control			
Transmitter		205	£3.00
Receiver		206	£3.50
★PIC Tape Measure	NOV'98	207	£6.82
Electronic Thermostat			
T-Stat		208	£4.00
PhizzyB			£14.95
A–PCB B–CD-ROM C–Prog. Microcontroller		Bee (A)(B)(C)	each
15-Way IR Remote Control			
Switch Matrix		211	£3.00
15-Way Rec/Decoder		212	£4.00

PROJECT TITLE		Order Code	Cost
Damp Stat	DEC'98	209	£4.50
Handheld Function Generator		213	£4.00
★Fading Christmas Lights		215	£5.16
PhizzyB I/O Board (4-section)		216	£3.95
Twinkle Twinkle Reaction Game	JAN'99	210	£7.55
★EPE Mind PICkler		214	£6.30
PhizzyB I/O Board (4-section)		216	£3.95
Alternative Courtesy Light Controller		217	£6.72
Light Alarm	FEB'99	218	£6.78
★Wireless Monitoring System – Transmitter		219+a	£9.92
Receiver		220+a	£8.56
★PIC MIDI Sustain Pedal **Software only**		–	–
★Wireless Monitoring System–2 F.M. Trans/Rec Adaptors	MAR'99	219a/220a	See Feb'99
★Time and Date Generator		221	£7.37
Auto Cupboard Light		222	£6.36
Smoke Absorber		223	£5.94
Ironing Board Saver	APR'99	224	£5.15
Voice Record/Playback Module		225	£5.12
Mechanical Radio (pair)		226A&B	£7.40 pr.
★Versatile Event Counter		207	£6.82
★PIC Toolkit Mk 2	MAY'99	227	£8.95
A.M./F.M. Radio Remote Control			
Transmitter		228	£3.00
Receiver		229	£3.20
★Musical Sundial	JUNE'99	231	£9.51
PC Audio Frequency Meter		232	£8.79
★EPE Mood PICker	JULY'99	233	£6.78
12V Battery Tester		234	£6.72
Intruder Deterrent		235	£7.10
L.E.D. Stroboscope (Multi-project PCB)		932	£3.00
Ultrasonic Puncture Finder	AUG'99	236	£5.00
★8-Channel Analogue Data Logger		237	£8.88
Buffer Amplifier (Oscillators Pt 2)		238	£6.96
Magnetic Field Detective		239	£6.77
Sound Activated Switch		240	£6.53
Freezer Alarm (Multi-project PCB)		932	£3.00
Child Guard	SEPT'99	241	£7.51
Variable Dual Power Supply		242	£7.64
Mains Cable Locator (Multi-project PCB)	OCT'99	932	£3.00
Micro Power Supply		243	£3.50
★Interior Lamp Delay		244	£7.88

EPE SOFTWARE

Software programs for *EPE* projects marked with an asterisk ★ are available on 3.5 inch PC-compatible disks or *free* from our Internet site. Four disks are available: **PIC Tutorial** (Mar-May '98 issues); **PIC Toolkit Mk2** (May-Jun '99 issues); **PIC Disk 1** (Apr '95–Dec '98 issues); **EPE Disk 2** (Jan '99 issue to current cover date). The disks are obtainable from the *EPE PCB Service* at £2.75 each (UK) to cover our admin costs (the software itself is *free*). Overseas (each): £3.35 surface mail, £4.35 each airmail. All files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code **Project** **Quantity** **Price**

....

Name..

Address..

....

I enclose payment of £..............................(cheque/PO in **£ sterling only**) to:

Everyday Practical Electronics

MasterCard or Visa No.
Minimum order for credit cards £5

VISA EUROCARD MasterCard

Signature..Card Exp. Date.......................

Please supply name and address of cardholder if different from the address shown

NOTE: You can order p.c.b.s via our Internet site on a *secure* server:
http://www.epemag.wimborne.co.uk

EVERYDAY PRACTICAL ELECTRONICS CLASSIFIED ETI ELECTRONICS TODAY INTERNATIONAL

Everyday Practical Electronics/ETI reaches twice as many UK readers as any other independent monthly hobby electronics magazine, our audited sales figures prove it. We have been the leading independent monthly magazine in this market for the last fourteen years.

If you want your advertisements to be seen by the largest readership at the most economical price our classified and semi-display pages offer the best value. The prepaid rate for semi-display space is £8 (+VAT) per single column centimetre (minimum 2·5cm). The prepaid rate for classified adverts is 30p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Everyday Practical Electronics/ETI Advertisements, Mill Lodge, Mill Lane, Thorpe-le-Soken, Essex CO16 0ED. Phone/Fax (01255) 861161.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

THE BRITISH AMATEUR ELECTRONICS CLUB

exists to help electronics enthusiasts by personal contact and through a quarterly Newsletter.

For membership details, write to the Secretary:

Mr. M. P. Moses,
5 Park View, Cwmaman,
Aberdare CF44 6PP

Space donated by Everyday Practical Electronics

Miscellaneous

EPE NET ADDRESSES

EPE **FTP site: ftp://ftp.epemag.wimborne.co.uk**

Access the FTP site by typing the above into your web browser, or by setting up an FTP session using appropriate FTP software, then go into quoted sub-directories:

PIC-project source code files: **/pub/PICS**

PIC projects each have their own folder; navigate to the correct folder and open it, then fetch all the files contained within. *Do not try to download the folder itself!*

EPE text files: **/pub/docs**

Basic Soldering Guide: **solder.txt**

EPE TENS Unit user advice: **tens.doc** and **tens.txt**

Ingenuity Unlimited submission guidance: **ing_unit.txt**

New readers and subscribers info: **epe_info.txt**

Newsgroups or Usenet users advice: **usenet.txt**

Ni-Cad discussion: **nicadfaq.zip** and **nicad2.zip**

UK Sources FAQ: **uksource.zip**

Writing for *EPE* advice: **write4us.txt**

Ensure you set your FTP software to ASCII transfer when fetching text files, or they may be unreadable.

Note that any file which ends in **.zip** needs unzipping before use. Unzip utilities can be downloaded from:
http://www.winzip.com or
http://www.pkware.com

On-line readers! Try the new EPE ***Chat Zone*** **– a virtually real-time Internet "discussion board" in a simple to use web-based forum!**

http://www.epemag.wimborne.co.uk/wwwboard

Or buy ***EPE Online*****: www.epemag.com**

ADVERTISERS INDEX

A.L. ELECTRONICS .776
ANTEX .759
A.S.A. .759
N. R. BARDWELL .776
BELL COLLEGE OF TECHNOLOGY 752
B.K. ELECTRONICS Cover (iii)
BRIAN J. REED .776
BULL ELECTRICAL Cover (ii)
COOKE INTERNATIONAL .775
CROWNHILL ASSOCIATES 749
DISPLAY ELECTRONICS 706
EPT EDUCATIONAL SOFTWARE Cover (iv)
ESR ELECTRONIC COMPONENTS .714
FML ELECTRONICS .775
FOREST ELECTRONIC DEVELOPMENTS 735
ICS .775
J&N FACTORS .710
JPG ELECTRONICS .775
LABCENTER ELECTRONICS .729
LEADING EDGE TECHNOLOGY .725
MAGENTA ELECTRONICS .712/713
MILFORD INSTRUMENTS .741
NATIONAL COLLEGE OF TECHNOLOGY .752
PICO TECHNOLOGY .711
QUASAR ELECTRONICS .752
QUICKROUTE SYSTEMS .721
SEPIA TECHNOLOGIES .755
SERVICE TRADING CO 775
SHERWOOD ELECTRONICS .776
SQUIRES .725
STEWART OF READING .735
SUMA DESIGNS .708
TELNET 709
VERONICA FM 722
VERONICA KITS .775

ADVERTISEMENT MANAGER: PETER J. MEW
ADVERTISEMENT OFFICES:
EVERYDAY PRACTICAL ELECTRONICS, ADVERTISEMENTS, MILL LODGE, MILL LANE, THORPE-LE-SOKEN, ESSEX CO16 0ED.
Phone/Fax: (01255) 861161

For Editorial address and phone numbers see page 715

Published on approximately the first Friday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Wiltshire (Bristol) Printers Ltd., Bristol, BS20 9XP. Distributed by COMAG Magazine Marketing, Tavistock Rd., West Drayton, UB7 7QE. Subscriptions INLAND £26.50 and OVERSEAS £32.50 standard air service (£50 express airmail) payable to "Everyday Practical Electronics", Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF. E-mail: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS/ETI is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.