EVERYDAY PRACTICAL ELECTRONICS

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JULY 1999

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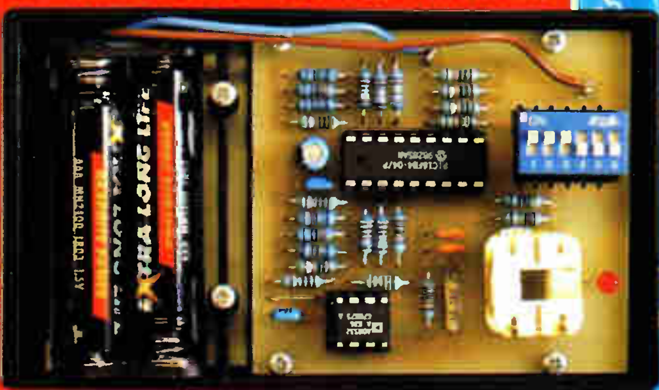
EPE MOOD PICKER

Generates Alpha, Beta, Delta and Theta fields



12V BATTERY TESTER

A 'health' check for lead-acid batteries

LED STROBOSCOPE

Inexpensive Starter Project

New Series

PRACTICAL OSCILLATOR DESIGNS

Part 1: Hartley and its variants

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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

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 delay, 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 toroidial 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 safely with 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 measuring 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 sufficent 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

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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 tne 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

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

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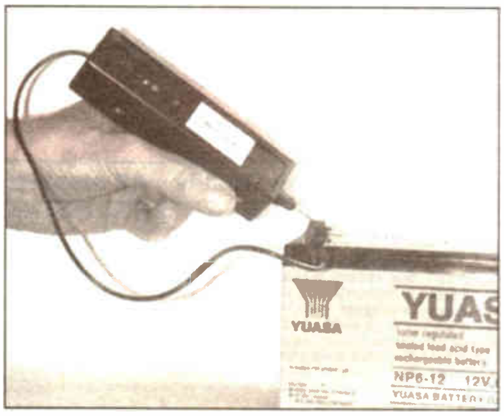
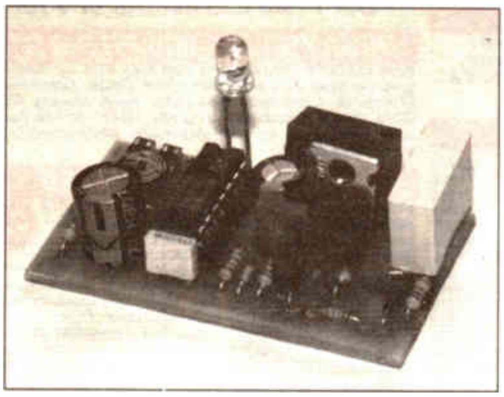
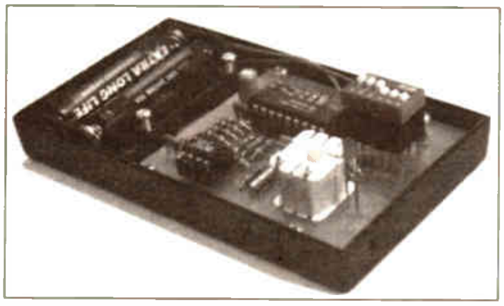
The No. 1 Magazine for Electronics Technology and Computer Projects







Projects and Circuits

Series and Features

Regulars and Services

Our August '99 issue will be published on Friday, 2 July 1999. See page 475 for details.

Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

Surplus always wanted for cash!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

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" **TOSHIBA**MK6409MAV 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 Prodri vp** 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)

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10,000,000 items EX STOCK

For ***MAJOR*** SAVINGS

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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 **Only £119** (E) Order as MITS-SVGA
VGA cable for IBM PC included.
External cables for other types of computers CALL

As New - Ex Film Set
17" 0.28 SVGA Mitsubishi Diamond Pro monitors
Full multisync etc. Full 90 day guarantee. £275.00 (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 13¾" 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.

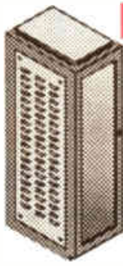
20"....£135 22"....£155 26"....£185 (F)

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 movable 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*

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NEXT MONTH

8-CHANNEL ANALOGUE DATA LOGGER

THERE are three reasons why the author designed this Data Logger:

- *To get to know more about Microchip's new PIC16F87x family*
- *To monitor the* EPE Musical Sundial *(June '99) and record sunlight conditions*
- *Several readers had suggested that one should be published*

The PIC16F87x family are much more powerful than the familiar '84 devices: up to eight channels of ADC; serial communications I/O at controllable baud rates; enlarged program and on-chip EEPROM memories; 20MHz maximum clock rate; external serial data memory read/write.

It is some of these attributes that are put to use in this Data Logger, whose extensive specs include:

- *Up to eight channels of analogue data input and 10-bit digital conversion*
- *Data storage/retrieval using on-board serial memory (2 megabits max)*
- *Sampling rates: 0·5 secs to 62 secs, plus external clock option*
- *Automatic non-volatile storage of current sampling count value and rate when logging session ends*
- *L.C.D. display of sampled data, elapsed time and count value*
- *Serial transfer of recorded data to PC at 9600 baud*
- *Transferred data formatted and stored on Drive C as:*
  Eight uncorrected binary files
  Eight ASCII-converted numeric-value text files
  Microsoft Excel tabbed composite numeric-text file
  Four × dual-channel binary files for EPE Virtual Scope *(Jan & Feb '98)*
- *Prototype has been run under DOS and Windows 3.1/95, on a 20MHz '386 up to 120MHz Pentium (Win '98 compatibility unknown)*
- *Analogue signal input range 0V to +5V*

*A follow-up article (*PIC16F87x Mini Tutorial*) takes a closer look at how the PIC16F87x family can be programmed to implement the type of functions offered by the Data Logger.*

Microchip tell us that the long-awaited PIC16F87x devices will be on sale from the end of June.

SMT ULTRASONIC PUNCTURE FINDER

This device will find most bicycle punctures in record time, eliminating the messy business of immersing the tube in water. All but the very slowest punctures produce a strong ultrasonic signal and can be located to within a few millimetres. It has many other uses as a low cost ultrasound receiver.

FROM PIPELINES TO PYLONS

In the UK we are fortunate enough to enjoy virtually uninterrupted electricity, provided by the world's largest interconnected electrical system which links our power stations together to form the National Grid. The high quality of Britain's electricity supply is taken for granted by us all, although for both the micro-electronics enthusiast as well as the general public there is much mystique surrounding the way in which electrical power is created and delivered safely to our homes.

In this two-part feature, supported by the expertise of the international power generation company National Power plc, Alan Winstanley describes some of the high technology involved in generating power – from a gas pipeline to the turbines and generators and then to the electricity pylon and beyond! We also examine in close-up some of the techniques related to the provision of a 230V supply directly to our housing and industry.

If ever you have wondered what "neutral" really means, why the earth plays such a vital role in safety, or why an electricity power station would ever need gas, or if you just want to brush up on some fundamental theory, this article provides background which is essential reading for electronics users and consumers everywhere.

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LITTLE THINGS

It's the little things that make you smile and sometimes it's the little things that make you want to cry? This month's cover proof from Colette, who does the design and layout, had a little error on it which, fortunately, we spotted before it went to press. My writing is not always as clear as it should be, or so Pam tells me, so sometimes when I scribble out a note words get misinterpreted. (If I don't want to be misunderstood – a song? – then I shout!).

Suffice to say our *Battery Tester* was shown as a check for "bad-acid batteries". If you write "lead" by hand you can see how it became "bad" – or maybe you can't, but you would if I wrote it, if you see what I mean. Since it sounded so good I was tempted to leave it, but only for a moment. We have already had one or two mistakes on the cover and they are one or two too many.

Yes, I check the covers as well as Dave and John but we all seem to be blind to certain things – like the "h" instead of "H" in Hz on the June cover. As I said it's a little thing but when you try so hard to be accurate it is very frustrating.

If you have ever had to check your own work for, say, a dissertation for university, etc., and then asked someone else to go through it you will realise how easy it is to miss mistakes once you have written the item, or read through it once before. In the process of producing the magazine we often read articles three times during the editing and typesetting processes and if we miss a mistake the first time then it is often overlooked again – until, of course, we get the printed issue when we spot it as soon as we look at the page. Sometimes we are so convinced it was not there originally we even get out the old proofs to check.

REALITY

Anyway, it all serves to make life interesting; so, please let us know (nicely if possible) if we have made a mistake in something, but please don't write in to say, as one reader did recently, that we should do better than to have i.c.s facing different ways on the same p.c.b. We do our best but there is no point in trying for miracles – after all p.c.b. layouts are functional and we doubt if anyone anywhere insists on all the i.c.s facing Mecca! Or, maybe that would make things work better – who can challenge such ideas in these days of working laser stun guns? What used to be science fiction is fast becoming reality, all thanks to electronics of course. However, I expect even the best checking software in the world would fall down on bad-acid!

AVAILABILITY

Copies of *EPE/ETI* are available on subscription anywhere in the world (see right), from all UK newsagents (distributed by Seymour) 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 on-line version can be purchased from **www.epemag.com**

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Constructional Project

12V BATTERY TESTER

TERRY de VAUX-BALBIRNIE

A "health" check for lead-acid batteries.

TWELVE-VOLT lead-acid batteries are now found in many walks of life. The most familiar is, of course, the type used in cars. However, smaller ones are used for mobile radio rigs, alarm systems, solar-charged circuits and other specialised applications.

The project to be described here is an instrument which will determine the charge state of such a battery.

OVERVIEW

The 12V Battery Tester is built in the style of a logic probe which gives a neat appearance (see photographs) and also allows for easy use with one hand. The display is provided by a row of l.e.d.s (light-emitting diodes) giving a simple "Low", "Medium" and "High" readout.

There is also a "Crank Test" display l.e.d. for checking car batteries under a high load. This identifies a failing battery and provides a similar result to the device used for the purpose in service centres. It also doubles as a "danger level" signal.

It is important to note that the circuit is only suitable for testing *12V lead-acid batteries*. It will not give accurate results with any other type.

If you are a motorist and do a lot of start-stop driving (therefore using the starter motor excessively), drive mostly with the headlights switched on and use the heated rear windscreen for long periods, the battery may soon lose its charge. This problem will be aggravated if it is nearing the end of its service life. It would then be a good idea to use this instrument every so often and re-charge the battery before it lets you down.

The user of a small battery for some special application often does not know, until the equipment fails, that it has gone "flat". Not only is this inconvenient but it may damage the battery.

This is because leaving it in a poor state of charge (even in a half-charged condition) will cause deterioration over time. This will result in reduced capacity and service life. Having this instrument available will enable you to check the condition of the battery as frequently as you wish.

MEASURING CHARGE

Many lead-acid batteries used today are of the "sealed-for-life" variety. This makes topping-up with distilled water unnecessary and (depending on type) allows them to be used in any orientation.

Some years ago, every self-respecting user had a "battery hydrometer". This consisted of a rubber bulb which, when squeezed and released, allowed a sample of battery acid to be drawn into a glass tube.

In this was a sealed glass capsule often marked with red, yellow and green coloured sectors. The higher the capsule floated in the liquid, the greater was its density ("specific gravity") and the higher was the state of charge. The coloured bands were arranged to give a simple "poor", "medium" and "good" indication.

Hydrometers are still available but they cannot be used with most batteries because the electrolyte is not accessible. This device aims to give a readout which is just as simple but does the job with much less fuss.

CHARGE CHECK

The state of charge of a battery may be determined by measuring its terminal voltage. This falls with loss of charge in a more-or-less linear way. Fig.1 shows a graph of the voltage of a nominal 12V lead-acid battery against charge state. Although there will be small variations, this is largely independent of the physical size or manufacturer.

Note that, over the useful range of charge, the difference is only 1V or so. It is important to also note that "zero" charge means the *practical* end point – not true zero! A battery discharged below this level is likely to suffer irreversible damage even though it would still be capable of delivering current.

In this circuit, the voltage (hence charge) is measured using a set of l.e.d.s – one each, Green, Yellow, Orange and Red. These show though holes in the top of the box. The first three are grouped together but the red is slightly displaced because it performs a different function (the crank test or danger level signal).

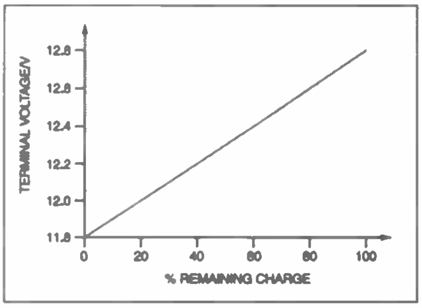


Fig.1. Graph of the voltage of a nominal 12V lead-acid battery against charge state.

To use the instrument, a flying lead is clipped on to the negative (–) battery terminal. Holding the box in one hand, the probe is now touched on to the positive (+) terminal and the l.e.d.s observed.

Some, or all of them, should light up according to the state of charge. Thus, all l.e.d.s on signifies "high", all except green "medium", only orange and red "low".

Disregarding the crank test for the moment, the red l.e.d. will always be on unless the battery is seriously discharged. If it is off ("danger level") the battery must be charged urgently and, depending on type, it may never recover its full capacity.

OPERATING POINTS

Rather than to indicate "full", "half" and "zero" charge, it was decided to provide the "good" point at around 80 per cent but the "low" one towards the end of the useful remaining charge. The orange l.e.d. therefore represents a "charge now" signal.

However, the green one will be on even when the battery is slightly discharged. This prevents it going off almost straight away after a period of use. Experience with the particular application will soon show how these operating points need to be interpreted.

Some manufacturers state that re-charging *must* be carried out on their batteries when the voltage falls to 12V. Others allow it to fall to, say, 11·7V. Taking this into account, these are the selected operating points:

High	*Medium*	*Low*	*Crank Test/ Danger Level*
12·6V	12·3V	12·0V	9·8V

For ease of construction, these operating points are preset and *cannot* be altered unless you are competent at re-calculating the resistor values in a potential divider chain.

HOW IT WORKS

The complete circuit diagram for the 12V Battery Tester is shown in Fig.2. The principle component is a quadruple bipolar op.amp (operational amplifier), IC2, which contains four identical units in a single 14-pin package. The individual op.amps are referred to in the text and in the diagram as IC2a to IC2d. The power supply to the circuit is obtained from the battery "on test" via fuse FS1.

All four op.amp inverting inputs (pins 2, 6, 9 and 13) are connected together and, in turn, connected to the "regulation" (Reg) pin of IC1, a 5V voltage reference device. This behaves rather like a Zener diode, and is connected and drawn as such.

However, it behaves with much greater precision. A voltage equal to or very close to 5V will therefore appear at all the inverting inputs of IC2. IC1 requires a certain small reverse current to flow through it to allow regulation to take place and this is the purpose of resistor R6. Correct operation will be maintained down to a level much lower than that of a battery at its end point.

CHAIN REACTION

The non-inverting inputs of IC2a to IC2d (pins 3, 5, 10 and 12 respectively) are connected to various points along the potential divider chain, made up of resistors R1 to R5. The ends of the chain are connected across the supply so that, according to the individual resistor values, the voltage appearing at these points will be a known fraction of the battery voltage.

They have been selected to provide 5V when the terminal voltage of the battery is at the operating points. Thus, 5V will appear at the non-inverting input of IC2d with a supply of 12·6V, at IC2c with 12·3V, IC2b at 12·0V and IC2a with 9·8V.

With increasing supply voltage (and therefore battery charge), the non-inverting supply voltage of IC2a to IC2d will therefore exceed that at the inverting ones. As this happens, the corresponding output will go high and the l.e.d. (D1 to D4) associated with it will operate. Each l.e.d. has its operating current limited by one of resistors R7 to R10 to a nominal 15mA.

Since the operating points must be known with a fair degree of accuracy, the resistors used in the potential divider chain are *1 per cent tolerance* types. Not only do these have accurately-known values but they will maintain them over time.

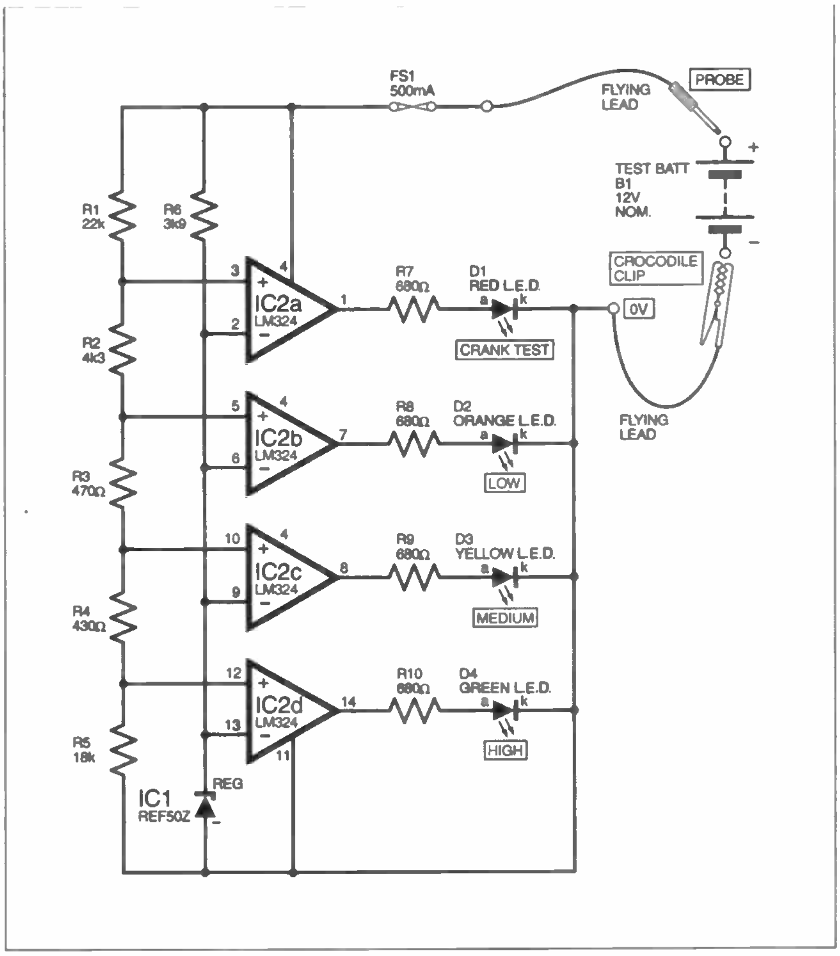


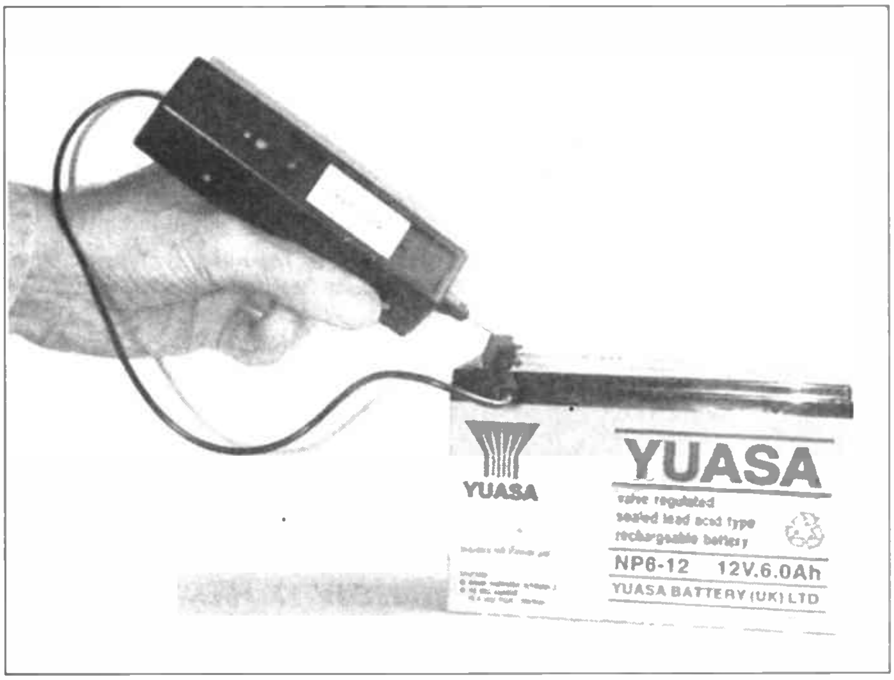
Fig.2. Complete circuit diagram for the 12V Battery Tester.

A fuse, FS1, is included to protect the tester in the event of an error which may result in a short-circuit to the supply. A lead-acid battery can deliver a very high current under such conditions and this could result in wiring or p.c.b. tracks melting. The fuse should protect the circuit in the event of incorrect connection and more will be said about this later.

The usual method of including a diode for reverse-polarity protection is inappropriate here due to its forward voltage drop. This, being slightly voltage-dependent, would change the operating characteristics of the circuit in an unpredictable way as the various l.e.d.s came on.

CONSTRUCTION

All the components for the 12V Battery Tester, except the fuse, are mounted on a single small printed circuit board (p.c.b.) which has been designed to fit the specified probe box. The component layout and full-size copper foil master are shown in Fig. 3



NOTES ON USE

In any particular application, experience will best decide how to interpret the operating points. However, the following hints should help those using the instrument for the first time.

1. Always connect the unit with the correct polarity.
2. Do not perform a test with a charger connected. In fact, allow the battery to rest for at least one hour after charging to allow the voltage to stabilise. This is because it falls slightly with time.
3 Remove any load and allow the battery to rest for a while before testing. This is because the voltage rises slightly so failing to do this would result in an incorrect reading.

Most of the change happens in the first few minutes. However, best results will be obtained if the battery is left idle for at least one hour.

and photographs. This board is available from the *EPE PCB Service*, code 234.

Referring to the component layout in Fig.3, drill the two mounting holes then solder IC2 socket in position (but *do not* insert the i.c. itself at this stage). Follow by soldering all other components in position except IC1 and the l.e.d.s. Take special care to solder each resistor R1 to R5 into its correct position or the operating points will be incorrect.

Taking extra care with the polarity, solder the l.e.d.s in position so that their tops stand about 10mm above the circuit board. They should be level and in a straight line or it will result in a poor appearance to the finished instrument. Note that the cathode end (k) is labelled in each case (this having the slightly shorter end lead).

Before handling IC1, observe some precautions to prevent possible damage to it by static charge which may exist on the body. The simplest method is to touch a water tap immediately before unpacking it and touching the pins. This will earth the body and allow any charge to flow away harmlessly.

Refer to the pinout details in Fig.3 and look at the flat face of IC1. Cut off the *left-hand* end wire (this is connected internally to the substrate and does nothing). Solder the remaining wires in position with the flat face of the i.c. towards the left-hand edge of the p.c.b. (An alternative TO92 pinout outline is included as this version may be offered to readers.)

Solder a 5cm piece of stranded connecting wire to the point labelled +V on the *copper track* side of the p.c.b. and 30cm of black *extra flexible* wire to the 0V point on the topside (this will be the flying lead).

Finally, insert IC2, taking care over its orientation, into its stocket. This is a bipolar device and requires no special handling precautions.

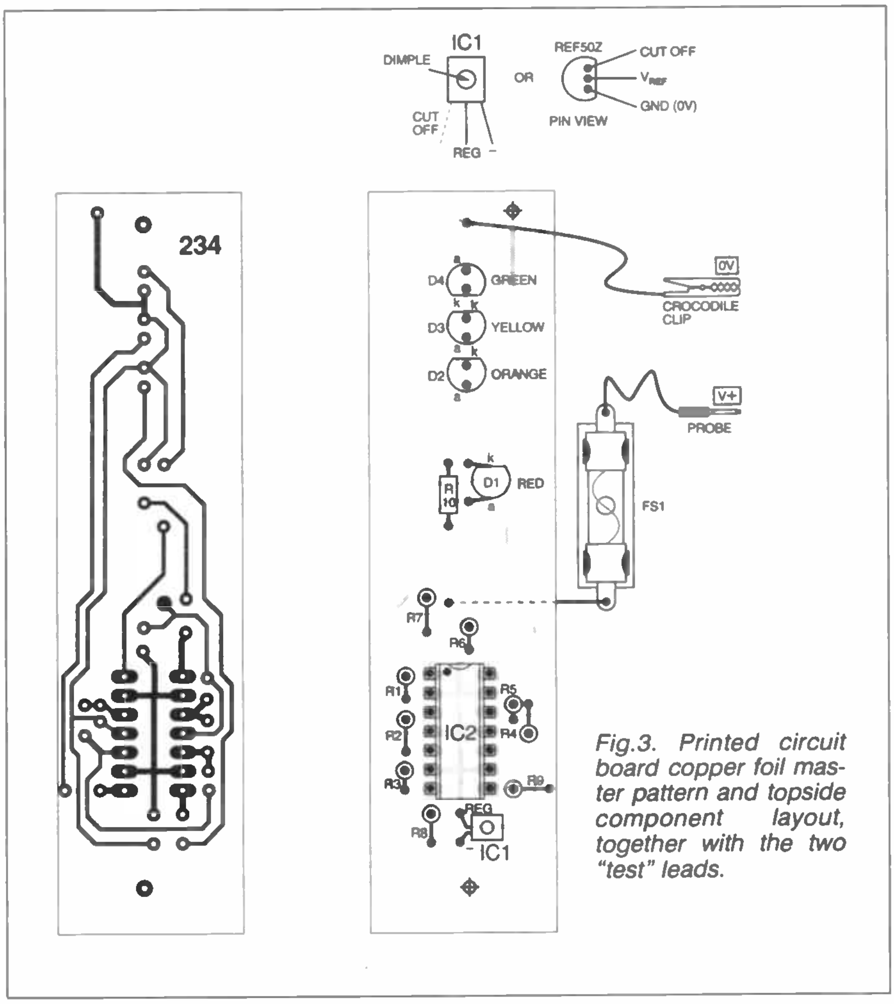


Fig.3. Printed circuit board copper foil master pattern and topside component layout, together with the two "test" leads.

COMPONENTS

Resistors

R1	22k	See SHOP TALK page
R2	4k3	
R3	470Ω	
R4	430Ω	
R5	18k	
R6	3k9	
R7, R8, R9, R10	680Ω (4 off)	

R1 to R5 must be of the 0·6W metal film type having 1% tolerance. All other resistors may be of the 5% 0·5W carbon film type.

Semiconductors

D1	3mm red l.e.d.
D2	3mm orange l.e.d.
D3	3mm yellow l.e.d.
D4	3mm green l.e.d.
IC1	REF50Z 5V reference voltage
IC2	LM324N quad op.amp

Miscellaneous

FS1 20mm chassis mounting fuseholder, with 500mA 20mm quickblow fuse.

Printed circuit board available from the *EPE PCB Service*, code 234; logic probe box (with probe), size 130mm x 34mm x 30mm approx; 14-pin i.c. socket; stranded connecting wire; extra flexible wire; self-locking cable tie; crocodile clip (with black insulation cover), to suit the application; 12·7mm plastic spacers (2 off); solder, etc.

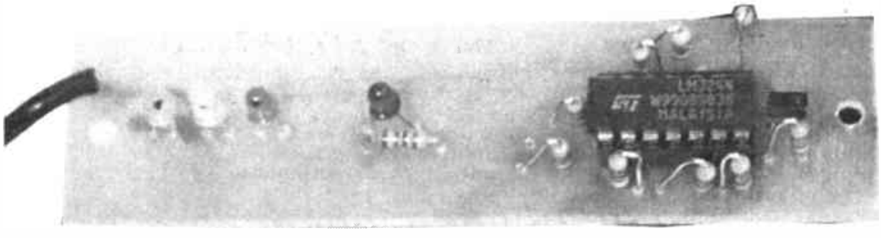
Approx. Cost Guidance Only £15

BOXING UP

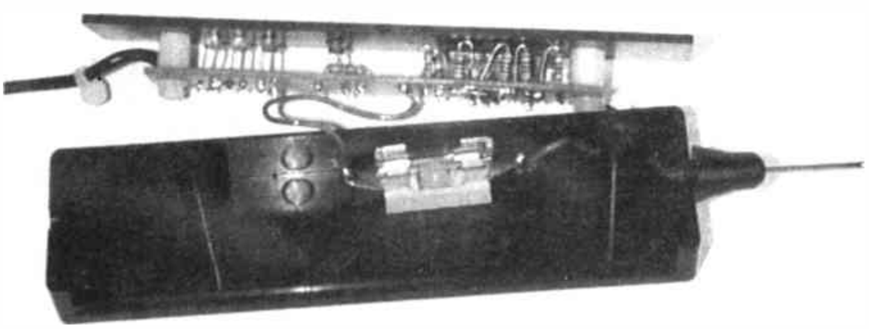
The p.c.b. may now be prepared for mounting on the removable side panel of the specified box. Note that this is done with the copper track side facing outwards – see photographs.

Check the position of the p.c.b. and, by careful measurement, mark the mounting and l.e.d. holes on the panel. Drill all these holes.

In the prototype, those for the l.e.d.s were made slightly smaller in diameter than that of the l.e.d.s themselves. This is because they did not actually protrude through the holes and this was thought to give a better appearance to the finished unit.



Layout of components on the completed circuit board. The method of mounting the p.c.b. on the removable panel and positioning of the fuseholder is shown below.



Having finalised the positioning of the p.c.b., the next task is to establish the position of the fuseholder in the case. This is mounted on the box base and a small hole should be marked and drilled to take the holder fixing bolt.

Now attach the p.c.b on the removable panel, using small nuts and bolts with spacers between to allow the l.e.d.s to take up their correct positions. The spacers are trimmed to the required length by cutting them to size with a small hacksaw. Secure the fuseholder in position and solder the +V wire leading from the p.c.b. to one end of it.

PROBING QUESTION

Prepare the probe which is supplied with the specified box. This needs care and patience. Cut off a 5cm piece of stranded wire and strip a small section (about 2mm) of insulation from the end. Solder "tin" the bared wires and insert them into the hole in the probe.

Now "feed" solder into it until it is almost level with the rim of the hole – it must not bulge above it. *It is very easy to make a poor joint which parts easily* – check carefully.

When satisfied, push the larger plastic bush over the probe. Pass the wire through the smaller bush and engage it with the larger one. This leaves a recess which will be gripped in the larger of the two holes in the ends of the case when this is assembled.

If the recess is too wide, the soldered joint is probably too thick. Solder the end of the wire to the free terminal of the fuseholder. Check the position of the flying lead in the other recess and, leaving a little slack, place a tight cable tie around it to provide strain relief.

Assemble the case using the plastic bushes and screws provided with it. Make sure the probe and flying lead are correctly located in the holes and check that the flying lead cannot be pulled free by any reasonable amount of force.

Make a label to cover the rectangular opening in the face of the front panel of the box. Fit a crocodile clip appropriate to the size of battery to be tested to the end of the flying lead.

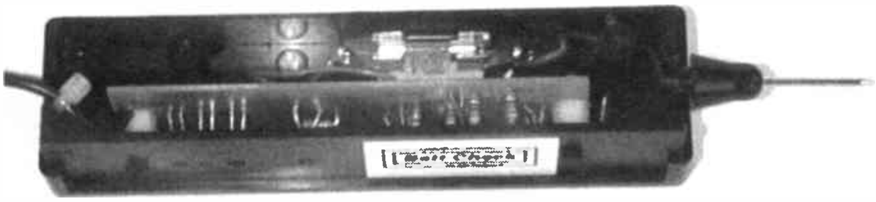
TESTING

Testing is not absolutely necessary. You could use a "proof is in the pudding" approach. However, some kind of basic check is probably a good idea and if you have a digital voltmeter, you could confirm the operating points. In the prototype unit, these were all within 0·05V (50mV) of the nominal values.

Always take care to connect the circuit with the correct polarity. In two tests on the prototype, incorrect polarity resulted in the fuse blowing but everything else survived.

However, this *MUST NOT* be relied on and damage could occur. The value of the fuse is higher than is strictly necessary because the very low values have a significant resistance which would result in an unacceptable voltage drop.

If you are using the instrument to check the state of charge of a small battery, it will be convenient to use a direct method of testing. Begin with a fully-charged battery and run it down using the piece of equipment with which it will be used or a small bulb of comparable power rating.



Completed "checker" with the removable side panel, holding the p.c.b., slotted into position ready for closing-up the box.

Aim to discharge to the low point over a period of 10 to 15 hours – do not try to hurry the job by applying a large load. For example, if the capacity of the battery is 7Ah, it will discharge to the end point if 500mA was drawn for about 14 hours.

This could be obtained using a 5W or 6W car-type bulb. In practice, the capacity may be considerably less than the nominal value depending on the amount of service the battery has given and how carefully it has been used.

TAKING THE LOAD

Connect the load (bulb) for 15 minutes, disconnect it and allow the battery to rest for about 15 minutes. Connect the Tester and note that all l.e.d.s come on.

Connect the load again and continue discharging for set intervals (say, 30 minutes), allowing a 15-minute rest in each case before making the check. Keep track of the total elapsed discharge time.

You should find that the green, yellow and orange l.e.d.s go off at reasonably-spaced intervals. *Do not wait until the red l.e.d. goes off – you could damage the battery.* If it happens by accident, re-charge promptly.

If you are using the unit to test a car battery, it would not be advisable to run it down in the way described above because the car is likely not to start afterwards! Either the operating points will need to be taken on trust or you could test the unit with a bench power supply having a continuously-variable output voltage. Again, a digital voltmeter would determine the operating points accurately.

A BIT CRANKY

As stated previously, the red l.e.d. will normally remain on during the test unless the battery is seriously discharged (below a terminal voltage of 9·8V). You could regard this as corresponding to the minimum state of charge which could be reached by accident and which would demand immediate re-charging. It also provides the "Crank Test" (see below) which is only applicable to car batteries.

A lead-acid battery has such a low internal resistance, that any normal load placed on it will result in only a small voltage drop (very small indeed with a physically large battery such as a car battery). Thus, virtually the full available voltage will appear across it.

However, when the battery is subjected to a very heavy load, even this small internal resistance will result in a significant voltage drop and this is subtracted from the supply to give the "terminal voltage". In this case, it does not mean that the battery is necessarily low on charge.

In a car, the heaviest load is imposed by the starter motor while turning the engine ("cranking"). The voltage may then fall to some 10V.

With a battery nearing the end of its service life, the internal resistance tends to rise and the voltage will fall still further. Eventually, it will reach the point where the starter motor fails to turn quickly enough to start the engine. It may not even turn at all.

To perform a crank test, first ensure that the battery is in a good state of charge. It will be helpful if you can prevent the car from starting (consult the workshop manual to make sure this is safe/possible). The tester is then applied to the battery while an assistant operates the starter. Take great care to avoid hot or moving parts!

The red l.e.d. should remain on (although it may flicker a little). If it goes off immediately or very quickly afterwards, the battery should be renewed.

Do not run the test for more than a few seconds since the battery will run down rapidly and may not start the car next time. There could also be problems with the engine flooding making it more difficult to start. □

New Technology Update

New processes provide improved performance for thick film circuits, reports Ian Poole.

THE frequencies that are being used in today's radio and electronics circuits are always increasing. It was not many years ago that anything above a few hundred megahertz was considered very high, and special techniques were required. A number of developments since then have enabled frequencies at u.h.f. and higher to be used far more easily, and at much less expense. One of the drivers for this has been the phenomenal growth in the cellular telephone business. However, this is not the only growth area. There are many new wireless applications being introduced, many of which we do not see directly in everyday life, yet despite this we still reap the benefits of them.

The success of radio and wireless products means that the lower frequencies in the radio spectrum are becoming very congested. This has resulted in higher frequencies having to be employed. One very good example of this are the cellular telephone systems that operate at frequencies around 1800MHz instead of around 900MHz when the first systems in the UK were positioned.

Thick and Thin

To be able to manufacture equipment cheaply that would operate at these frequencies has forced the development of a number of new techniques. The level of integration that can be achieved in a cellular phone these days is considerably greater than was possible even a few years ago.

The frequencies that can be handled by i.c.s has also risen. However, with frequencies in some services rising even higher new techniques are required now more than ever. This requires further improvements to be made. Often circuits built on what are termed thick and thin films are needed. Both of these techniques have been around for many years and involve the printing of circuits onto low loss substrates.

In terms of performance, thin film technology has been the preferred choice for many r.f. applications because of its superior performance. These designs are usually generated using sputtering and etching techniques on alumina substrates. In contrast, thick film technology has the advantage that it is substantially less demanding on both equipment and the environment than thin film and it is therefore much cheaper. As a result there has been a need to develop new techniques to improve the performance of thick film technologies.

Great care must be taken with these circuits if the required performance is to be realised. To accommodate the high frequencies being used, signal paths must be very carefully designed otherwise performance will be degraded. Not only must the circuit itself be correct, but also many aspects like the materials used, the conductor size and material and many other associated conditions. If these are not optimised correctly then the signal will suffer from noise, crosstalk, attenuation, propagation delays and other problems.

Requirements

To enable the circuits to perform to their requirements, there are a number of conditions that need to be fulfilled. The connections between points on the circuit require a high conductivity, their thickness and width need to be controlled carefully as they determine the characteristics of the way the signal travels. Also the substrate must have a very low loss.

To enable the correct characteristics to be achieved, ultra-fine lines are required. This, combined with the other requirements is often difficult to achieve. The ultra-fine lines, combined with the low levels of resistive loss means that extremely high levels of conductivity are required.

To meet these requirements, researchers at the multinational company DuPont have developed a high density thick film gold conductor process. The tracks that this can create provide low losses at frequencies up to 20GHz whilst being capable of being etched to thicknesses of less than 20μm (micrometres).

The new material for this process is designated QG150, and it is compatible with a wide range of substrates and thick film dielectrics. The new material is based on gold. In itself the use of gold is not new. The metal is used in a number of areas, including on connectors and within i.c.s themselves. It offers very high levels of conductivity, and is very stable chemically. This makes it an ideal metal for use in electronics and as a result it is widely used despite its cost.

Gold is also used in thin film technology where it is also capable of producing very fine conductors, but the lower cost of thick film technology is attractive to manufacturers who are now coming under increasing pressures to improve performance, reduce prices and remain competitive.

New Process

There are three key areas that were addressed to enable the new process to succeed with thick films. The metal that was used had to be in a suitable powdered form. An organic binder was needed to keep the powder in place, and finally an organic material was needed to carry the material during the process.

The gold powder required new development work. It is a new form of powder for which the size and composition has been carefully chosen to give the required properties during the process, and afterwards in use. The actual grains are extremely small, being only fractions of a micron in diameter. With micro-grains of this size it is possible to achieve the required line size, thickness, and etching characteristics.

A material was required to bind the micro-grains together in the process. Experiments were undertaken to ensure it had the correct properties, enabling the required bond strength so that the wire adhered to the substrate whilst still providing the correct pre- and post etching capabilities.

The third and final constituent was the carrier. This was an organic material and it had to provide the right viscosity for enabling the gold micro-grains and the organic binder to pass through the processing correctly. All three constituents needed to be optimised separately and together to produce the correct result.

Results

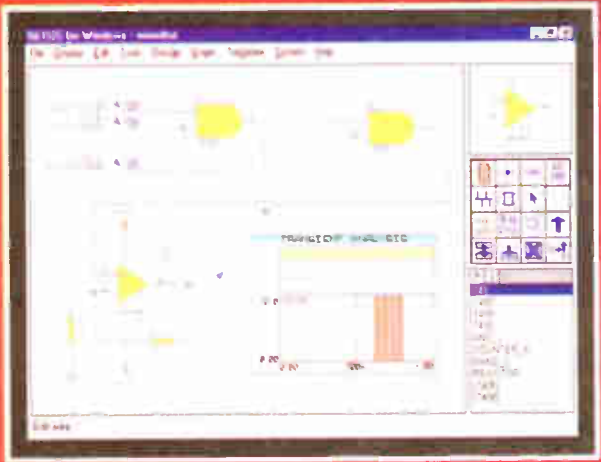
Naturally in proving the technique many tests have been performed. It has been shown that losses for the new process are consistently lower over frequencies up to about 10GHz than a comparable thin film process. Above this the results are reasonably similar. However, as thick film technology is preferred because of the reduced costs, it means that the new technique is likely to be very successful.

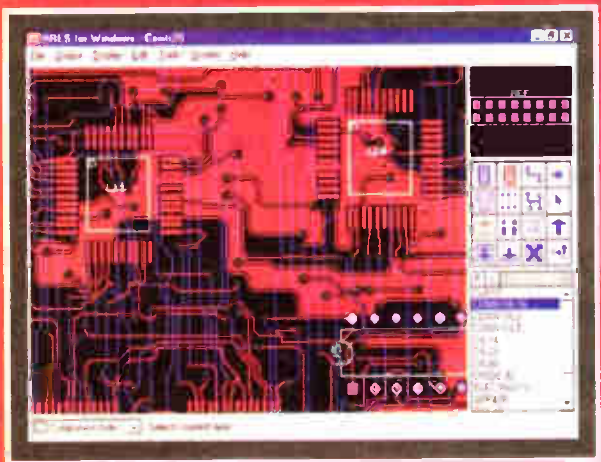
In another demonstration of the success of the product a company named Micro-Precision Technologies of Salem New Hampshire USA developed a single substrate surface mount attenuator and phase shifter based on thick film technology for use in cellular radio systems.

Using the DuPont's QG150 on an alumina substrate along with other materials to enable the specialised surface mount i.c.s to be placed down onto the substrate and to enable soldering with the through holes required for interconnectivity.

It was found that the new design showed significant improvements over earlier versions manufactured using thin films, and in addition to this the manufacturing costs were significantly reduced.

With the use of higher frequencies increasing, along with increased requirements arising from the high levels of complexity and performance required, new processes like the DuPont QG150 will be in much greater demand. As many more wireless applications are being introduced into the home, the cost constraints are also becoming much tighter. Any processes giving improvements in these areas are likely to be taken up very quickly.





Innovations

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

INTERNET TV SHOWDOWN

Getting access to the Internet is becoming increasingly easy. Barry Fox reports.

BRITISH TV viewers will soon be spoilt for choice if they want to go on-line without struggling to use a PC. Although Internet TV has been tried in the US, consumer uptake has been less than expected. Prompted by a unique marketing strategy from Rupert Murdoch, the major service providers are now lining up for a showdown in the UK.

WebTV set-top boxes, which connect between a phone line and TV to display Internet images, first went on sale in the US in 1996. A year later Microsoft bought the company, and re-launched as WebTV Plus. Boxes from Philips, Sony and Mitsubishi cost $200 and have built-in Browser software. Because WebTV gives open access to the Internet, and Web sites are intended for display on a PC monitor, proprietary circuitry tries to modify the image so that it looks acceptable on a lower resolution TV screen.

Microsoft predicted that it would have one million subscribers by the end of 1998, but achieved less than 700,000. Now the company has tied up with the BBC, NatWest bank and the Carlton and Granada TV groups to experiment with 100 homes in London and Liverpool. The BBC adds flag signals to some digital TV programmes, which put icons on the screen of a receiver made by Pace. The viewer uses a remote control to click on the icon. The box then goes on line and searches the Internet for extra information. NatWest says the system could be used for "buying a house and going on holiday".

NatWest's rival Midland is a partner in the Open service which British Interactive Broadcasting are due to trial in readiness for a full-scale launch in the autumn. The other partners in BIB are Rupert Murdoch's Sky, BT and Matsushita (Panasonic). They give a subsidy of over £150 to anyone who buys a Digibox and dish to receive Sky's digital satellite service, and agrees to connect to a phone line for at least a year.

The Digibox contains a 28.8K modem and all the circuitry needed to access an on-line service. So when BIB launches Open service it will already have a captive market.

Walled Garden

Until recently BIB planned to provide Open users with a "walled garden" of vetted safe sites, like the CampusWorld service which BT provides for PC users in educational establishments. BIB also intended to reformat the vetted sites, enlarging text fonts, for clearer display on TV.

BIB has now taken the surprise decision to bar all access to the Internet. Explains BIB's Chief Engineer Alec Livingstone "There is just too much work involved in monitoring and reformatting thousands of sites". BIB's market research also showed that talk of Web Browsers and the Internet scares off customers who just want to watch TV.

BIB will work with an existing Internet provider (believed to be BT) which will give each subscriber an E-mail address. Incoming messages will be flagged on the TV screen. The viewer can then reply by using an infrared keyboard or a remote control which sends pre-packaged replies, like "Yes" or "No".

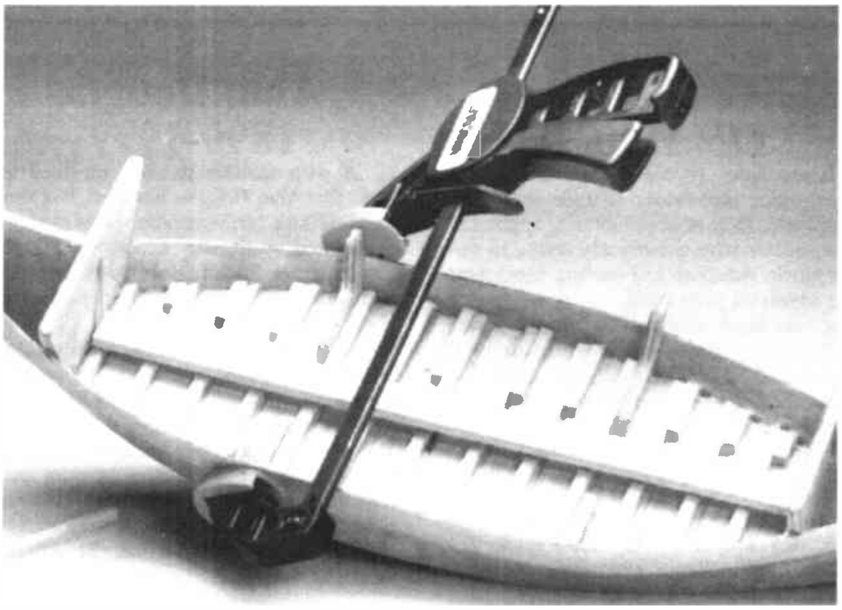
Two transponders on the Astra satellite continually deliver a 68 Megabit/second stream of data and video, such as a multimedia shopping catalogue, direct to the home dish. The receiver dials out when it needs to exchange data, such as encrypted credit card details. Woolworths has already signed up to provide a service.

BIB says it can re-jig Open for use on other TV services, such as Sky's terrestrial rival OnDigital.

NTL is offering a third option, after buying the commercially unsuccessful NetChannel service last year and re-vamping it as TV-Internet. After trials with NTL's staff and friends, the service is now being advertised in the Newcastle area. TV-Internet offers full E-mail and Internet access, except for barred pornography sites.

Hedging bets, Microsoft has bought a five per cent stake in NTL.

CLAMP IT!



THERE are some things that even solder cannot secure in the electronics workshop – from time to time, adhesives of various types have to be used. So what better way to ensure the surfaces stay together while the adhesive hardens than to use a mini-vice, such as the Quick-Grip & Spreader from Minicraft.

The new clamp is a top quality tool made from the finest materials. It incorporates a pumping action that adjusts the clamping area and can also be used in reverse to spread pressure so you have complete control at all times. The bar which the pumping action runs on is made from hardened chrome steel, and the detachable pads are made from a special soft material that will not scratch or mark delicate surfaces.

The pads measure 112mm and the spreader capacity is around 207mm. At a price of only £9.99, the clamp seems ideal for anyone in the model making, hobby and electronics fields.

For more information, contact Minicraft, Dept. EPE, 1 & 2 Enterprise City, Meadowfield Avenue, Spennymoor, Co. Durham DL16 6JF. Tel: 01388 420535. Fax: 01388 817182.

FASTER CHARGING

AN INNOVATIVE new battery charger which reduces the charging time of 9V block PP3 batteries from 14 hours to just two has been launched by leading European power supply specialists, Friwo.

Using a microcontroller, the Speedy 9V automatically switches between three charging modes to maximise the life of the battery, whilst maintaining high performance and durability. Once the battery has received its full charge in fast-charge mode, the charger switches to trickle-mode to maintain peak efficiency. The third mode enables deeply discharged batteries to be recharged, switching to fast-charge mode once the battery has been reactivated.

For more information, contact Haredata Standard Products Ltd., Dept. EPE, Hyde House, Victoria Avenue, Harrogate, N. Yorks HG1 1DX. Tel: 01423 530347. Fax: 01423 524645.

GREENWELD ON HOLD

WE are sorry to report that Greenweld Electronics have ceased to trade at the present time. They have voluntarily appointed a liquidator who is currently trying to sell the stock, database and trading name (see the advert on page 476).

If you have sent orders recently, they will not be fulfilled but cheques etc. will not be cashed, or credit cards charged. We may be able to report more information next month.

MAPLIN WITHDRAWS

MAPLIN Electronics, in a regrettable rationalisation of their product suppliers, have decided to delete from their UK stores the following products supplied by Wimborne Publishing: *EPE*, *Modern Electronics Manual*, *Electronics Service Manual* and UCANDO Videos. **You can, of course, obtain all these products direct from us, and the videos continue to be available from Farnell Components Ltd.**

Note that Maplin South Africa are not affected by the decision made by the UK HQ of Maplin Electronics, and they continue to supply our products.

If you previously purchased your copies of *EPE* from a Maplin store in the UK, please now place an order with your local newsagent or take out a subscription (you save 44p an issue with a subscription – UK prices – see page 483).

Alan Douglas 1899-1999

IT IS with sadness that we received the news that Alan Douglas has died, just short of his 100th birthday. Alan was strongly associated with the Electronic Organ Constructors Society for many decades, and was its President over a period of 19 years.

Older readers may well recall Alan's *Electronic Organ* published in *Practical Electronics* in about 1969 or 1970 – it was a very significant design for its era.

A brief biography of Alan's life is included in the memorial booklet produced by the EOCS. For more information, contact Trevor Hawkins, Hon. Sec. EOCS, 23 Blenheim Road, St Albans, Herts AL1 4NS.

Herbert Howard

WE regret to have to record the passing of Herbert Howard, who died on May 13th after a short illness, borne with great courage and dignity. Many readers knew Herbert through the British Amateur Electronics Club.

Herbert had been an electronics hobbyist for seventy years, a member of the BAEC for twenty years and its chairman since 1990. Always willing to help anyone, he championed the interests of hobbyists through his unstinting work with the club.

Our sympathies go to his family and many friends, he will be sadly missed.

RECYCLED PRINTER CARTRIDGES

ALAN, our On-Line Editor, has filed this interesting item:

Whilst many consumers resort to the messy job of refilling spent inkjet and laser printer cartridges, commercial and educational users often discard empties that contain perfectly good components which they would gladly recycle if only a convenient scheme existed. The empty cartridges merely go to landfill waste, where some types could take up to 80,000 years to biodegrade, it is claimed.

The British Institute for Brain Injured Children (BIBIC) now participates in a collection and recycling scheme which enables many popular brands of empty inkjet and toner cartridges to be recycled. The Somerset-based charity helps in the rehabilitation of brain-injured children and relies totally on voluntary donations for its work. It receives a payment for each suitable cartridge collected. "Last year BIBIC raised enough funds from its 'toner donor' scheme to fully support twelve youngsters for a whole year", explained Erica Wheeler of BIBIC's External Affairs.

Every toner or inkjet cartridge on their approved list is welcomed, which includes many HP, Lexmark, Canon, Apple and Epson types. BIBIC arranges free collection of laser cartridges or provides a Freepost label for inkjets. The system's viability is only maximised when ten or more laser cartridges become available for collection, otherwise a Freepost address can be used to send up to four laser cartridges per parcel. Up to six inkjet cartridges can also be returned in special pouches supplied by BIBIC, but they stress that only approved types of cartridge can be used.

To find out how to support BIBIC's work in treating brain-injured children – as well as helping the environment – contact Erica Wheeler on 01278 684060 or E-mail info@bibic.org.uk. Now you can recycle those empties with a clear conscience.

BT NETS SEGA

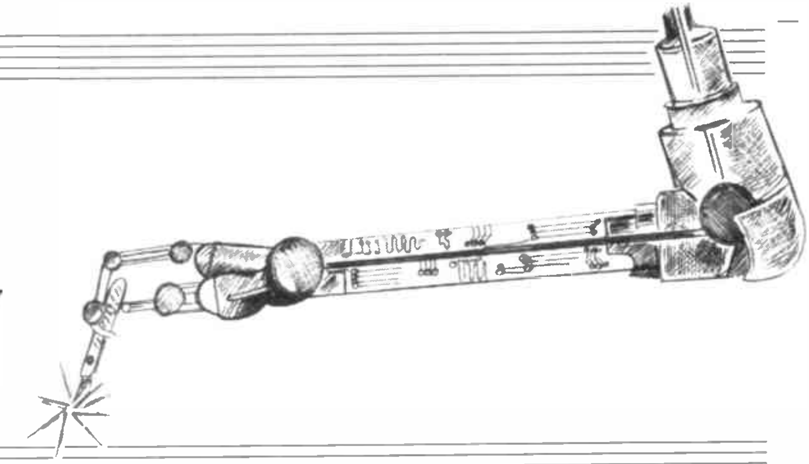
BRITISH Telecom has announced that it has been chosen by Sega to provide a pan-European subscription-free access service for users of Saga Dreamcast. The Dreamcast games console, to be launched later this year, will provide users with Internet access through their TVs on a pay-as-you-go basis via BT's network of European partners. This is the first time that subscription-free Internet access has been made available across Europe in this way.

Dreamcast will include a 33.6K modem and a browser. In addition to Internet access, it will enable users to access E-mail, chat and on-line gaming services. Future plans include the offer of on-line shopping facilities. It is expected to retail at around £199.

For more information, contact your local Sega retailer.

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY and IAN BELL

Our team of Surgeons tackles a further range of readers' queries, sent in by post or E-mail. We look at thyristor basics, re-visit the topic of mains earthing, check out capacitor fundamentals, and more besides in our monthly help-desk round-up.

LET us sift through this month's post-box, starting with this query concerning the use of thyristors:

Gate Post

How can you calculate the required pulse and duty cycle width for triggering the gate of an SCR or triac? ***Satish Kumar*** (by E-mail).

An SCR (silicon controlled rectifier) or *thyristor* is a four-layer *pnpn* device (*p* and *n* type semiconductor) as shown in Fig.1a. Compare this with a bipolar junction transistor (b.j.t.) which is three-layer – either *pnp* or *npn*.

The thyristor can be thought of as two overlapping transistors – the *np* of a *pnp* transistor overlapping the *np* of an *npn* type, as indicated by the dotted boxed in Fig.1a. This leads to the transistor equivalent circuit in Fig.1b.

The circuit symbol of a thyristor is shown in Fig.1c. It is based upon that of a rectifier, which is a unidirectional device, meaning that current will only flow one way. The symbol for a triac is shown in Fig.1d.

The illustration in Fig.2 shows a basic thyristor circuit. Assume the thyristor, CSR1, is not conducting (no anode-cathode current), and also that no gate current is flowing. When the control unit produces a trigger pulse, a small gate current causes a much larger anode-cathode current to flow.

However, unlike a transistor which turns off again if the base or gate current is removed, the thyristor's anode-cathode current *continues to flow*. It will only stop when the load supply voltage is removed or if the anode-cathode current drops below a certain minimum level. Thus the trigger current causes the thyristor to latch on.

We can understand this behaviour by looking at the equivalent circuit of the thyristor in Fig.1b. The "trigger" gate current turns on transistor TR1. The collector current of TR1 provides a base current for TR2, turning it on too. In a similar manner the collector current of TR2 provides more base current for TR1 turning it on even more. This is a positive feedback effect that quickly ensures that both transistors are on.

Once this condition has been triggered by the gate it is self-sustaining, so gate current is no longer needed. The thyristor can only be turned off by reducing its anode-cathode current below some critical point, known as the *holding current*.

The voltage across a thyristor when it is ON typically has a minimum value of around 1V, but may be higher (2V to 3V) for high current devices; the ON current can be very high (tens of amps in high power devices). The OFF current is very small – a leakage current. The maximum OFF voltage (supply voltage) can be very high – hundreds of volts in high power devices.

Consultation

To answer your question specifically, we have to consult the data sheet for the device we want to use. There are a large number of thyristors to choose from, but we will use the BT149B as an example.

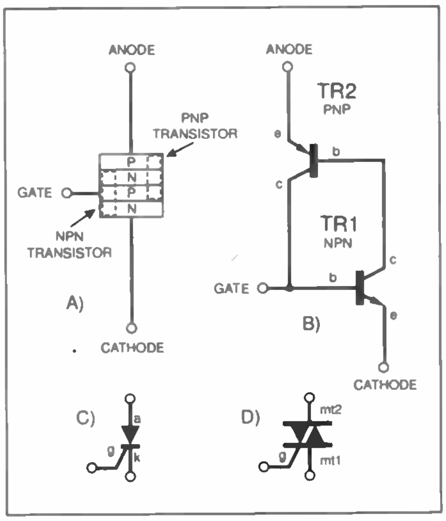


Fig.1. (a) Four layer pnpn *construction of a thyristor (SCR), (b) equivalent circuit, (c) circuit symbol for an SCR and (d) for a triac.*

This is a general-purpose low power device from Philips, intended to be interfaced directly to logic i.c.s and other low power trigger circuits. The BT149B can handle OFF voltages of about 200V and average ON currents of about 0·5A.

We need to consult the switching information – turn-on and turn-off times. For the BT149B, the turn-on time is typically 2μs and the turn-off time is typically 100μs. The trigger pulse must be long enough to allow the device to turn on (2μs in this case).

The duty cycle depends on when we expect the device to turn off – the trigger should have been removed by this time or the device will re-trigger. On this basis the shortest cycle possible would be 102μs (2μs on, plus 100μs off), but this assumes the thyristor is switched off at the same time the trigger is removed, which is not usually the case.

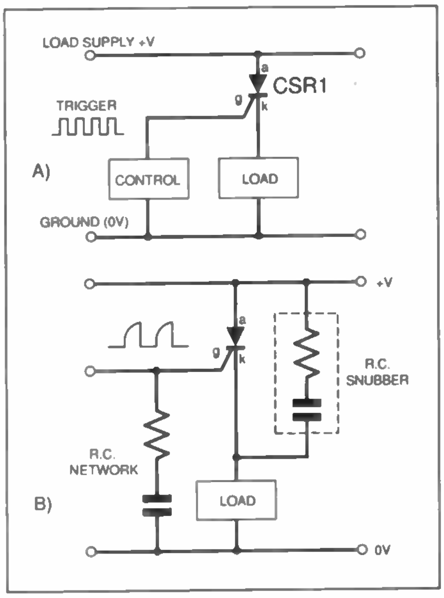


Fig.2. (a) Basic thyristor circuit. Thyristor CSR1 remains in conduction once a suitable triggering signal has been received. (b) The addition of external RC "snubbers" helps avoid false triggering.

Usually the trigger is a short pulse that is long enough to guarantee triggering and the time between pulses is determined by the control circuitry that generates the trigger, which of course depends on the application.

Note that thyristor switching times are different for different devices – compare the 2N5064 from Motorola (also rated at about 200V, 0·5A) for which turn-on takes about $3\mu s$ and turn-off $30\mu s$.

The gate current is, unfortunately, not the only way to turn on a thyristor. A sufficiently fast rising anode-cathode voltage can also trigger the device, due to the capacitances inherent in the thyristor's structure. To prevent this, *RC* "snubber" circuits can be used to reduce the rise-time of voltages across the thryristor, as shown in Fig. 2b and similar treatment may be made on the gate terminal in some cases.

Incidentally, unwanted (or *parasitic*) thyristor structures can occur in CMOS chips. Integrated circuit fabricators and chips designers take care to make sure that these unwanted thyristors cannot switch on, because if they do they "crow-bar" or short-circuit the power supply with disastrous consequences. The problem is known as *latchup*.

Triac

By placing two thyristors "back-to-back" (in inverse parallel), a *triac* is formed, which is suitable for use with a.c. control circuits (a.c. load control, sound-to-light systems, etc.) because current can flow through it in either direction between the two terminals (Main Terminals 1 and 2). Similar arguments would apply to the switching times of the trigger pulse – it helps to consult the data sheet for details. Note that a trigger pulse has to be provided for each phase of the waveform.

Look out also for a *diac* – a bi-directional diode with special characteristics, which may be used for triggering triacs into conduction. *IMB*.

Stripboard and High Voltages

Stripboard prototyping board, of which Veroboard is the best-loved brand, is the ideal medium for developing simple discrete circuits. Although many prefer to develop printed circuit boards using a CAD system, there is still much to be said for the convenience and adaptability of good old stripboard, especially if the circuit has not been finalised.

Provided the circuit is not too complex, stripboard makes it easy to add components or make other changes during the development process. It's also ideal for beginners and is perfectly adequate for constructing many projects in their final form, and has been for thirty years or so.

It does raise questions of safety, though, when used with mains voltages:

*I sometimes use stripboard for projects rather than spending time making printed circuit boards. These can involve 230V a.c. mains voltages. Can anyone provide details of the maximum load capacity of copper strips? (Posted by **Murray Cameron** in the* EPE *web site* Chat Zone.)

Stripboard is now made by several manufacturers of which Vero is the most famous, but it also comes from Far Eastern sources. This means there is no across-the-board (sorry) standard specification. However for typical 0·1in. matrix stripboard, assume a maximum current of no more than roughly 5A. The breakdown voltage between strips is said to be about 800V peak, absolute maximum.

You can use stripboard with mains voltages provided the following precautions are used:

1. Ensure all stand-off pillars are non-conductive types with no possibility of a chassis or mounting screw being in contact with the mains voltage. *Use fully insulated nylon mounting hardware.*
2. If a break needs to be made in mains-carrying copper strips, make at least ***three continuous breaks*** adjacent to each other to completely remove all copper from that section of the board and fully isolate the mains strip.
3. Mains-carrying strips can be reinforced by soldering a length of tinned copper wire along the strip.
4. It is best to use p.c.b. screw-terminal blocks to make a safe mains-voltage "flying lead" connection.

It is preferable to use a quality branded product for circuitry involving mains currents. It is probably far safer to keep any heavy mains currents off the board, and use suitably rated fully insulated hook-up wire instead. *ARW*.

Live Supplies

It's back to the topic of Live, Neutral and Earth. What do these designations actually mean?

*There are three parts to an a.c. socket labelled "hot" or Live, Neutral and Ground. I'm trying to make sense of what these mean. Can someone provide a good explanation of the concept of "Ground"? asks **HMB** via the Internet.*

The meaning of "Ground" depends on its context. In an electronic circuit "ground" nearly always means "0V" and anything "grounded" is connected to 0V.

Elsewhere in the circuit diagram (say in the power supply section) the 0V rail will be shown as connecting to "ground", in the same way that the negative pole of a car battery may be depicted as connected to the "chassis." It saves cluttering up wiring diagrams with lots of lines. In a circuit, a ground symbol usually just means that everything with the ground symbol is connected together.

This does *not* usually mean that the 0V rail is directly connected to physical earth (soil), which is the second meaning of "grounding", although the 0V rail may sometimes be connected to *the* ground as well. The term "ground" as used in the USA is synonymous with "earth" in the UK and Europe. In an electrical installation, grounding means, physically connecting to earth (soil).

Regarding why the mains supply is labelled the way it is, Fig. 3 shows a typical mains supply which would be fed to a domestic installation by an underground cable. At the "power supply" end (e.g. the transformer/sub-station), the neutral is firmly connected to the earth. This is "grounding" in the electrical sense of the word, and it implies that the neutral and earth wires are linked. In the USA, the neutral is the *grounded* conductor whilst the earth wire is the *grounding* wire: live is the *ungrounded* wire.

The live wire alternates between +325V peak and −325V peak. A quick calculation of $325/\sqrt{2}$ gives a value of 230V r.m.s. (the "official" UK mains value). Because of the way in which three-phase electricity is generated, the neutral point has no voltage and the live wire is the one which carries a potential. Appliances are therefore connected between live and neutral at the domestic installation.

Hot Line

The term "hot" is American slang for "live". If you, as a human being, were to touch a live wire, then assuming that you are in contact with the ground, a potentially lethal current would flow from the "hot" or live, through your body and to earth. This is because the earth is connected to the neutral as shown in Fig.3 and so the "escaping" current will seek to complete a circuit back to the neutral point through the earth.

If an RCD (Residual Current Device) – also known as an ELCB (Earth Leakage Circuit Breaker) or GFCI in the USA (Ground Fault Circuit Interrupter) – is installed then the current flowing to earth will be detected, and a high-speed trip switch will operate to hopefully prevent injury. *Without* the benefit of such a device, a fatal shock may be received.

The purpose of the ground/earth connection is to provide a very easy path for leaking current to "escape" through. If an insulation fault arises and a live wire happens to touch exposed metal work, then instead of the user receiving a shock when he touches it, a large current will flow straight to ground and either melt a fuse or trip an RCD.

(The LM1851 is a National Semiconductor chip which forms the heart of a GFCI, should advanced readers care to consider making their own, perhaps for incorporation into a mains-powered project.)

Regular readers may recall that the subject of mains earthing came up approximately 18 months ago (see June and Oct. '97 *Circuit Surgery*), and at the time my

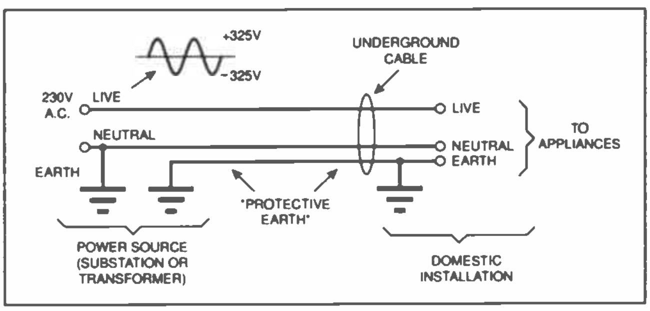


Fig.3. How the Live, Neutral and Earth terminals of a domestic installation are connected to the incoming supply. The "Protective Earth" may not be present in overhead supplies.

simple one-liner reply provoked as many questions as it answered. In spite of the attempts made to check the validity of the material beforehand, it soon became obvious that there were many misconceptions surrounding the way in which electricity was generated and delivered. In fact many of us know how to *use* the mains supply, but a great many more are not entirely sure where electrical power comes from to start with.

Next month I intend to set the record straight with the start of a two-part feature showing how power is generated and transmitted to the home. The author has spent many days as a guest of the renowned international power group National Power PLC **(www.national-power.com)** who generously provided the author with unrestricted access to an entire power station (National Power's Killingholme "A" gas-fired plant near Immingham in Lincolnshire), as well as several National Power engineers all of whom helped enthusiastically with the research.

The entire process from gas pipeline, to the turbines and generators all the way through to the provision of the domestic "230V" a.c. is described and illustrated in full. The feature will answer the above questions and more besides in greater depth: readers will find it fascinating stuff, so be sure to read *From Pipelines to Pylons* starting in the August 99 issue! *ARW.*

Currents and Dielectrics

I'm a frequent reader of EPE, *and one of my favourite columns is* Circuit Surgery. *It's amazing how much one can learn from such articles, and fantastic that someone is ready to read and possibly answer queries that we newcomers to the world of electronics might have.* (Thanks. The words "flattery" and "everywhere" spring to mind! We try to answer every query but we can't always promise a personal reply unfortunately.)

I've got three basic questions to ask:

1. *Everyone knows that a capacitor conducts current briefly, but I don't understand how current can flow between two plates if they are separated by a dielectric.*
2. *Can you help with the physical significance of logic gates? In particular, AND and OR gates. These are constructed with transistors but how is it that one can say that a particular circuit is an AND gate.*
3. *Finally, what is the significance of "double insulation"?*

Regards to all at EPE! **Karl Vassallo Grant** *from Malta, via the Net.*

There's quite a lot to go at, so let's answer your queries in order. First, you are quite correct – the two capacitor plates are separated by an insulating layer, called a dielectric. Catalogues classify their capacitors by dielectric, because different types of dielectric (polyester, polypropylene, silver mica and so on) are more suited in some applications than in others.

Let us use the tried and tested hydraulic analogy; a battery becomes a tankful of water. Imagine an electrical circuit as being a *sealed system*, using water travelling via the tank and through a hosepipe. Imagine also that the capacitor consists of a rubber diaphragm which is placed in the circuit. There is "solid" water in the hosepipe on both sides of the diaphragm, see Fig. 4.

Water cannot pass *through* the diaphragm, but it can "stretch" it. If we squeeze the hosepipe to compress the water, this forces the water up against the diaphragm which stretches "outwards".

Because it is a sealed system, the water on the other side has to go somewhere – so it's forced further around the hosepipe by the movement of the **diaphragm.** *Although no water passed through the diaphragm, never the less, water was seen to move around the circuit for a short time.*

A capacitor operates in roughly the same sense. In the "sealed system" of an electric circuit, electrons have to come from somewhere and go somewhere! A flow of electrons constitutes an electrical current. Adding a charge onto one plate of a capacitor (say, by "sucking" it from one pole of a

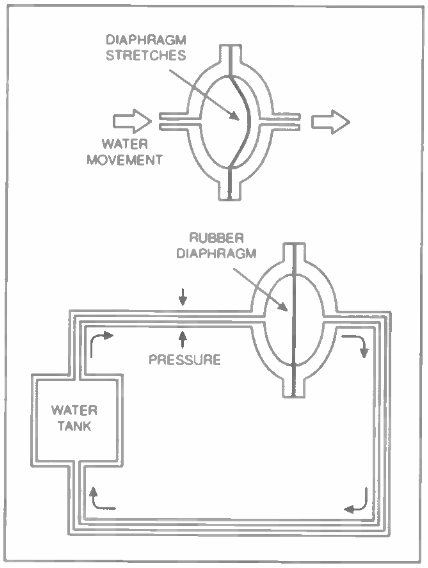


Fig.4. Using the tried and tested hydraulic analogy where the battery becomes a tankful of water and a capacitor the diaphragm. Water, sealed in a hydraulic "circuit", causes the diaphragm to stretch, which displaces water in the circuit. It appears that water has flowed "through" the diaphragm.

battery) causes a corresponding charge to be "sucked" from the other plate, and piled back on to the remaining pole of the battery.

It is a sort of electronics optical illusion, and is the reason why we say that capacitors can allow a current or signal to "pass" through. What we really mean is that a charge flows onto the capacitor on one plate, and a corresponding charge flows off the other side. Thus a current is seen to flow, even though there is a dielectric breaking the circuit. It's not possible to analyse this in greater detail without looking at the physics of the capacitor though.

In Truth

Your second query: I guess you are referring to the "Truth tables" of basic logic gates. These summarise how a logic gate will react with a particular combination of inputs. For example, an AND gate output goes logic high when *all* its inputs are high; an OR gate goes high when *any* of its inputs are high. Other gates such as NAND, NOR and EXOR have their own unique truth tables as well.

These were fully described in our series *Teach-In 98 – An Introduction to Digital Electronics*, which was co-written with the University of Hull. See the November 1997 to September 1998 issues and *Back Issues* page for details. Logic gates and how truth tables work, were explained in Part Four (February 1998). Truth tables exist for more complex logic devices and will be found in manufacturers' data sheets, which these days are commonly available on the world wide web.

Double Insulation

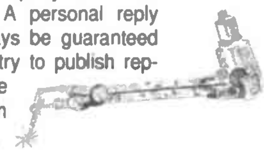
Finally, "double insulation" merely implies that extra precautions have been taken by a manufacturer to fully insulate any live parts, and to make sure that there is no possibility of the user coming into contact with live wires. For reasons explained in the previous question (*Live Supplies*), the earth is used to provide a low-impedance route for any fault currents to flow. Extra insulation and the widespread use of plastic mouldings removes the possibility of any external parts ever becoming live (e.g. through a live wire coming adrift), so there is no longer a need to "earth" the equipment.

Double-insulated units carry a symbol of two concentric squares (check any mains adaptor to see) and have a two-core power cord. Typical examples of double-insulated equipment include power and garden tools, consumer video, TV and audio units, and most kitchen appliances. However, constructional projects which are mains-powered almost always have a compulsory earth wire, which will be connected to the mounting frame of the mains transformer and elsewhere.

All exposed metal parts including switches and bezels, metal panels and mounting screws, which can access the interior of a mains-powered project, must be properly connected to earth to guard against the possibility of them ever becoming live in the future. This protects you *and other users* from electric shock. *ARW.*

CIRCUIT THERAPY

Circuit Surgery is your column. If you have any queries or comments, please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk**. Please indicate if your query is not for publication. A personal reply cannot always be guaranteed but we will try to publish representative answers in this column.



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The *EPE Chat Zone* on our web site is now open as a way for readers to exchange information, views, hints and tips in virtually real time.

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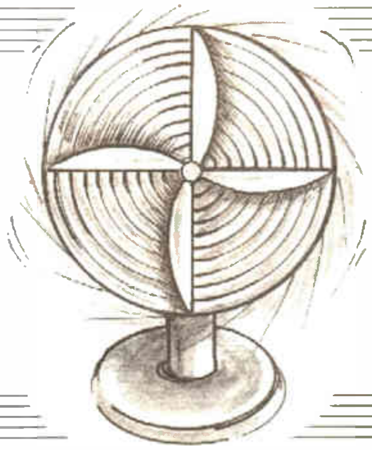
Starter Project

L.E.D. STROBOSCOPE



ROBERT PENFOLD

Freeze the action with the second of our low-cost, easy-build practical starter projects.

THESE days the word stroboscope probably conjures up images of high power flashing lights at a disco rather than a scientific instrument. However, the old style stroboscope still lives on, and units of this type can produce some fascinating results

As many readers will no doubt be aware, the scientific purpose of a stroboscope is to "freeze" moving machinery. The basic idea is to synchronise the flashing light of the stroboscope with the machine so that the light flashes at precisely the same point in each cycle of the machine.

The flash of light must be much brighter than the ambient light level so that any onlookers only see the machine during the pulses of light. Because they only see the machine at the same point in each cycle it seems to be stationary.

In fact, things become more interesting if the stroboscope and the machine are slightly out of synchronisation. With the light flashing slightly later in each cycle the machine appears as though it is operating in slow motion. A lack of synchronisation in the opposite direction makes it seem as though the machine is going slowly in reverse!

By carefully adjusting the flash-rate it is therefore possible to move to any point in the operating cycle of the machine, and to effectively make the machine operate at the desired speed in either direction. This makes it possible to closely analyse the action and see precisely how everything operates.

BRIGHT L.E.D.S

In order to "freeze" large pieces of machinery it is necessary to use a high power stroboscope. Such a device is not necessarily very complicated, but it requires the use of relatively expensive flash tubes that need high operating voltages. Not a project that is usually considered suitable for beginners.

However, as the title suggests, the L.E.D. Stroboscope featured here is based on ultra-bright l.e.d.s that provide comparatively small light levels and is a low-budget project that is ideal for the newcomer to electronics. Consequently this unit must be used in a darkened room and it will only illuminate a small area.

It is adequate for use with things such as watches, small engines, or any small mechanisms that have a repeating action. The use of l.e.d.s keeps the cost to a minimum, enables an extremely simple circuit to be used, and permits safe operation from a low voltage battery supply.

DESIGN CONSIDERATIONS

On the face of it, this application requires nothing more than a low frequency oscillator driving one or more l.e.d.s. In practice the oscillator must provide very brief output pulses if the desired action is to be provided. To be more precise, it is the ratio of the on time of the l.e.d.s to the off time that is of importance.

If the l.e.d.s were simply to be switched on for 50 per cent of the time the machine would go through half a cycle during the course of each flash of light, providing a very blurred image to the users. Practical experiments suggest that an off to on ratio of at least 100 to 1 is needed in order to obtain a reasonably sharp "frozen" image.

This brings a second problem, which is a lack of brightness from the l.e.d.s when they are only switched on for one per cent of the time. A modern ultra-bright l.e.d. will provide good brightness from a current of about 20mA, but pulsing it at this current for one per cent of the time this gives an average drive current of only about 0·2mA. This gives nothing more than a faint glow from even the most efficient of l.e.d.s.

In order to overcome this, the l.e.d.s must be pulsed at a much higher current than normal, and should ideally be pulsed at about two amps (2000 milliamps). This gives an average current of 20mA and good brightness.

Most l.e.d.s are rated to take continuous currents of up to 20mA or 50mA, but they can withstand much higher currents provided they are supplied for short periods and the average current consumption is within the permitted maximum current. The required high current pulsed operation is therefore acceptable provided the minimum frequency is not made too low, which would leave the l.e.d.s switched on for too long during each pulse.

CIRCUIT OPERATION

The full circuit diagram for the L.E.D. Stroboscope appears in Fig.1. The basis of the circuit is a (more or less) conventional oscillator circuit based on IC1. This is a form of relaxation oscillator and it operates by first charging capacitor C2, and then discharging it.

Integrated circuit IC1 is an operational amplifier (op.amp), but it is used here as a voltage comparator. Its output (pin 6) goes high when the inverting input (pin 2) is at a lower voltage than the non-inverting input (pin 3). Reversing the relative states of the two inputs results in the output going low.

Resistors R1 and R2 form a potential divider that biases the non-inverting input of IC1 to half the

supply potential, but the coupling through resistor R3 and potentiometer VR1 to the output of IC1 modifies this potential. When the output of IC1 is high the bias potential is pulled higher, and when it is low the bias is taken lower. The amount of change depends on the setting of VR1, and becomes greater as the resistance of VR1 is reduced.

Initially there is no charge on capacitor C2 and the output of IC1 goes high. Capacitor C2 then charges from the output of IC1 via resistor R5 and the much lower

This is the purpose of potentiometer VR1, which is shown configured as a variable resistor.

Conventionally the frequency of an *R-C* oscillator is controlled by varying the resistance in the timing circuit, but that would be difficult in this case as there are two resistors in the timing circuit (R4 and R5). Simply varying the value of R5 would produce substantial changes in the mark-space ratio of the output signal. Altering the value of the positive feedback resistance gives the required changes in

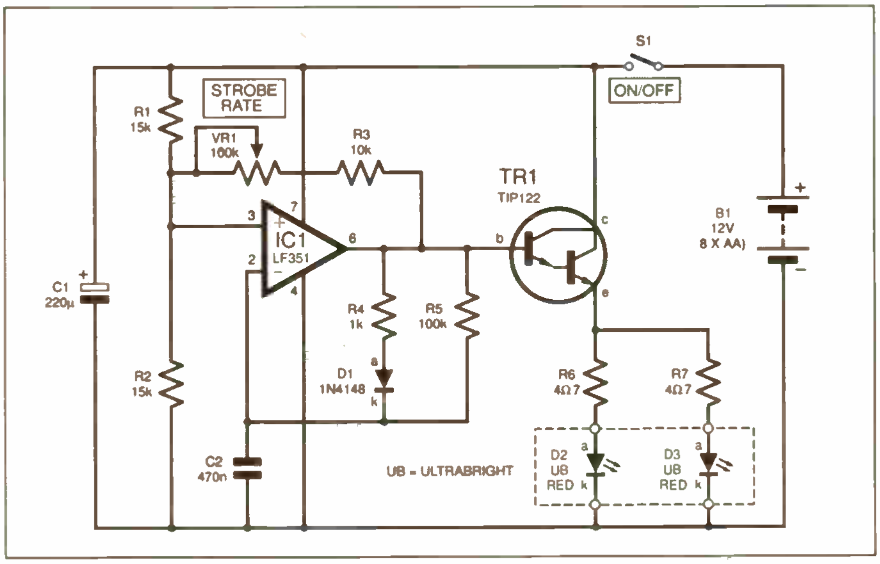


Fig.1. Complete circuit diagram for the L.E.D. Stroboscope. The two "strobe light" l.e.d.s can be housed remotely from the main unit – see photograph.

resistance path provided by R4 and diode D1. The low resistance of R4 results in a rapid increase in the charge potential until it goes above the bias voltage at the non-inverting input. The output of IC1 then goes low, and capacitor C2 starts to discharge via resistor R5.

There is no discharge path through resistor R4 and diode D1 because D1 blocks any flow of current in this direction. Capacitor C2 therefore discharges at a relatively slow rate through R5 alone.

The waveform produced across C2 is a form of sawtooth wave (Fig.2a). More importantly, the output of IC1 produces brief positive pulses, as in Fig.2b. In fact, the pulses are even more brief than those shown in Fig.2b due to the massive difference in the values of R4 and R5. This gives the required mark-space ratio of about 1 to 100.

STROBE RATE

For a stroboscope to be of any practical value it must be possible to vary the output frequency over a reasonable span.

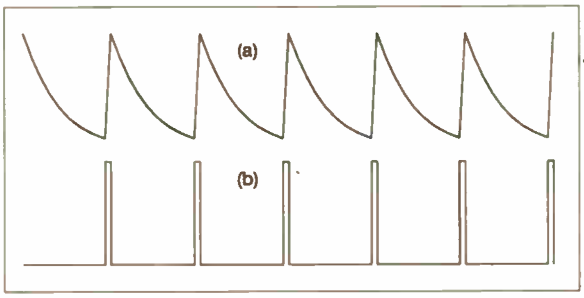


Fig.2. (a) Example waveform at pin 2 of IC1 and (b) at pin 6 of IC1.

frequency without significantly altering the output waveform.

With VR1 at a high value there is little change in the bias potential at the non-inverting input when IC1's output changes state. The charge on capacitor C2 therefore has to change by only a small amount to move from one threshold to the other, and this takes relatively little time.

With VR1 set at minimum resistance the charge and discharge threshold voltages are pulled several volts apart, greatly lengthening the charge/discharge cycle. The flash rate can be varied from approximately 17 to 100 per second. This corresponds to rotation speeds from about 1000 r.p.m. to 6000 r.p.m.

COMPONENTS

Resistors

R1, R2	15k (2 off)
R3	10k
R4	1k
R5	100k
R6, R7	4Ω7 (2 off)

All 0·25W 5% carbon film

See SHOP TALK page

Potentiometer

VR1	100k rotary carbon, lin.

Capacitors

C1	220µ radial elect. 16V
C2	470n polyester, 10mm lead spacing

Semiconductors

D1	1N4148 signal diode
D2, D3	ultra-bright red l.e.d. – see text (2 off)
TR1	TIP121 or TIP122 *npn* power Darlington transistor
IC1	LF351N bifet op.amp

Miscellaneous

S1	s.p.s.t. min. toggle switch
B1	12V battery pack (8xAA size cells in holder)

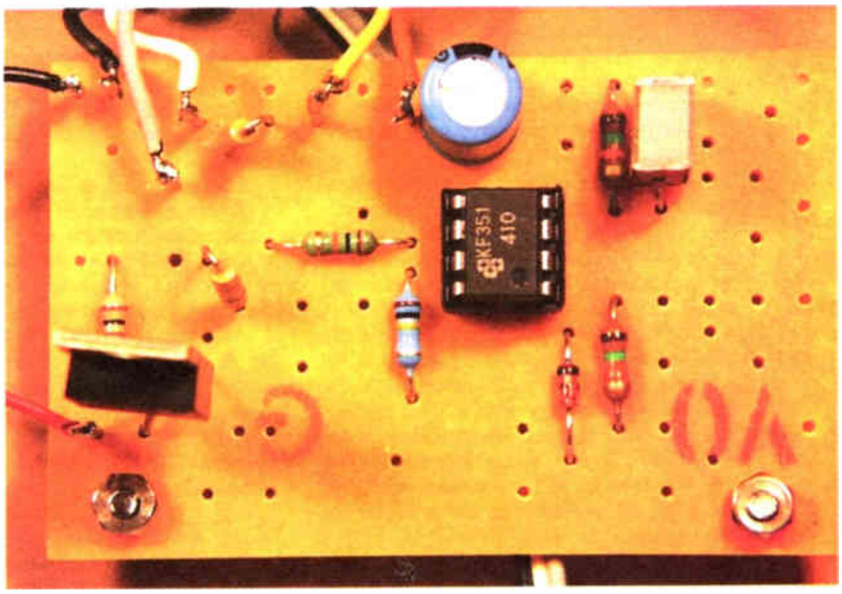
Multi-project printed circuit board, available from the *EPE PCB Service*, code 932; medium size metal or plastic case, size to choice (see text); small box for l.e.d.s (optional); control knob; battery clip (PP3 type); 8-pin d.i.l. socket; multistrand connecting wire; solder pins; solder, etc.

Approx. Cost Guidance Only £9.50 *excluding batts & case*

CURRENT DRIVER

Only output currents of a few milliamps can be provided by IC1, and a large amount of amplification is needed to provide the l.e.d.s (D2 and D3) with suitably high drive currents. This is provided by TR1, which is a Darlington power transistor used as an emitter follower buffer stage.

A Darlington transistor is really two transistors connected so that the output current of one device drives the input of the second.



Component layout on the multi-project p.c.b.

This effectively gives a super high gain transistor having a current gain equal to the product of the current gains of the individual transistors. The current gain of TR1 is typically several thousand, and this enables it to provide output currents of a few amps.

A current of a little over one amp is driven through each l.e.d., which produces an average current of about 10mA per l.e.d. This is high enough to give good brightness but low enough to avoid operating the l.e.d.s close to the point where they are in serious danger of being destroyed. The average current consumption of the circuit as a whole is about 23mA.

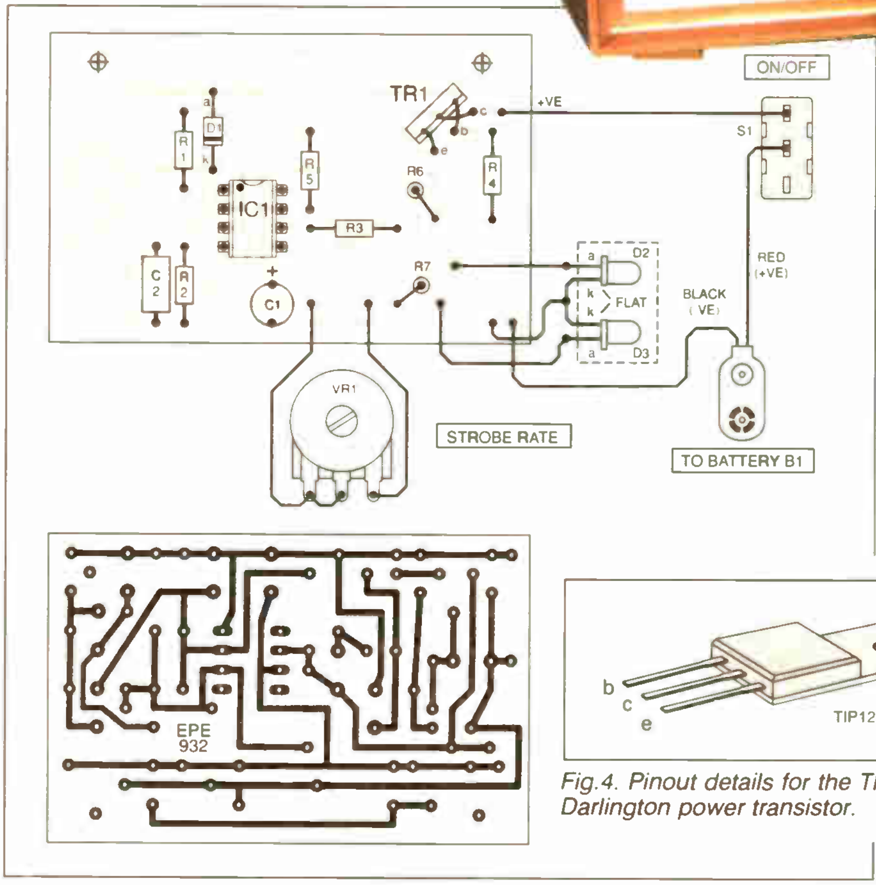


Fig.4. Pinout details for the TIP121/122 Darlington power transistor.

Fig.3. Printed circuit board component layout copper foil master and interwiring details. Check component positions as not all holes are used.

CONSTRUCTION

The *EPE* multi-project printed circuit board (p.c.b.) forms the basis of this project, and it utilizes the component layout, copper foil master and wiring shown in Fig.3. This board is available from the *EPE PCB Service*, code 932.

Although this project is extremely simple the usual warnings about the multi-project p.c.b. have to be repeated here. Unlike an ordinary custom printed circuit board the multi-board has numerous "leftover" holes that tend to confuse things slightly when fitting the components. Take extra care to avoid misplaced components when building this board and double-check the completed board very carefully for errors.

In all other respects construction of the board is largely straightforward. The LF351N used for IC1 is not static-sensitive, but it is still advisable to use a holder for this device.

Fitting TR1 is slightly awkward because the leadouts of the device do not match up properly with the board layout. Things would be much easier if the base (b) and collector (c) terminals of the Darlington transistor were the other way round. In order to fit the device into this layout it is necessary to cross over the base and collector leads, but this is not difficult provided TR1 is given the orientation shown in Fig.3.

The pinout wires of TR1 can be fitted with short pieces of p.v.c. sleeving to ensure that there are no accidental short-circuits. Fig.4 shows the leadout configuration for TR1, and should help you to avoid errors when connecting this component.

Although the TIP122 is a power transistor it only operates at very low average power levels in this circuit, and so no heatsink is required. A TIP122 is used for TR1 on the prototype, but some suppliers stock the TIP121 instead, and this is equally suitable.

L.E.D.S

Virtually any medium size plastic or metal box should accommodate this project, but bear in mind that the battery pack consisting of eight AA size cells is fairly bulky. Remember to allow for this factor when selecting the case. Mount the printed circuit board on the base panel of the case using either plastic stand-offs or 6BA bolts plus spacers.

The two "strobe" l.e.d.s can be mounted on the front panel of the main case, but the unit is easier to use if they are fitted in a separate much smaller case. The l.e.d.s are then connected to the main unit via a piece of three-way cable about 0·5 to two metres long.

The current flow to the l.e.d.s is not sufficient to warrant any form of heavy-duty cable. Twin-screened cable or a three-way lead peeled from a piece of ribbon cable will suffice. The rear panels of both cases must be drilled with holes to take the cable, and if metal cases are used the holes should be fitted with p.v.c. grommets to protect the cable.

Practically any *ultra-bright* l.e.d.s should work well in this circuit, and the higher their efficiency the brighter the pulses of light produced. However, evenness of illumination is also important in this application, and it is worth experimenting with a few l.e.d.s to find the ones that give the best results.

In general, larger l.e.d.s seem to give more even beams of light, but the latest 5mm diameter types give the highest light levels. The 3mm types do not seem to give high enough light output levels to be of use in this application.

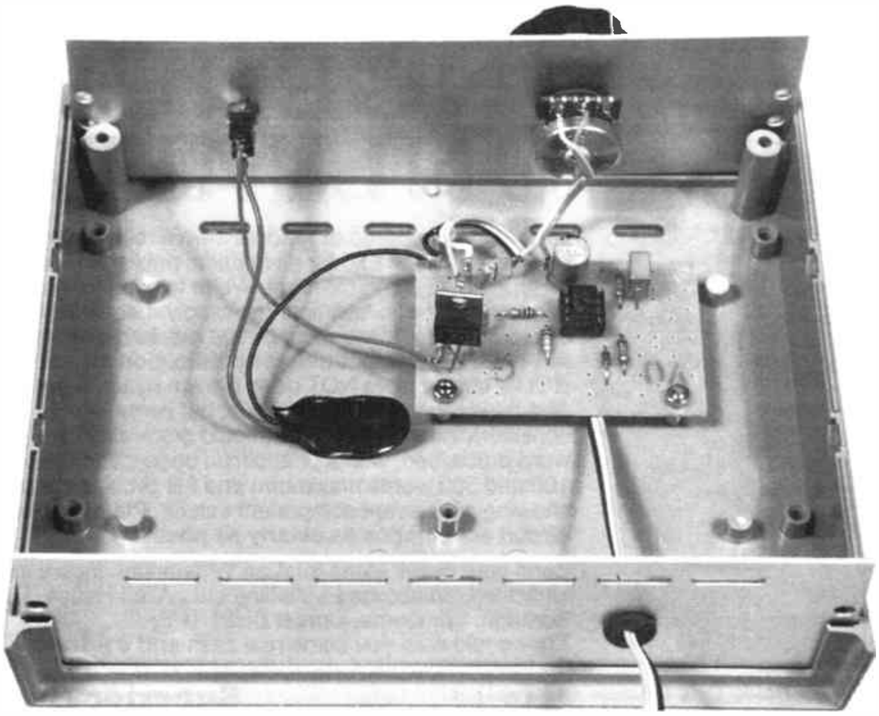
TESTING

Once the small amount of hard wiring has been added the unit is ready for testing. It is essential to thoroughly check the finished unit before connecting the battery and switching on because mistakes could easily result in the l.e.d.s being fed continuously with a high current. This would destroy them in a fraction of a second.

When initially testing the circuit it is not a bad idea to connect a 220 ohm resistor in the cathode (k) connection to the l.e.d.s. This will limit the current to a safe level in the event of a fault.

With control VR1 set at maximum resistance (fully counter-clockwise) the l.e.d.s should flash at a low enough rate for the pulsing action to be seen. Advancing VR1 in a clockwise direction will soon increase the operating frequency to the point where the flashing is too fast to be perceived.

A quick way of checking that the l.e.d.s are still strobing is to simply wave the l.e.d.s around in the air. This should draw a sort of dotted line of light in the air.



Suggested layout of components inside the case. Allow plenty of room for the 8-cell AA size battery pack.

IN USE

Although this unit is only suitable for use with small items of machinery it is still essential to use it with due care so that accidents are avoided. Most ultra-bright l.e.d.s produce fairly tight beams of light, so it should not be necessary to use the unit at very close ranges.

Finding the right setting for frequency control VR1 is largely a matter of trial and error. If the required "freezing" is obtained, but with the machine in two or more positions simultaneously, the flash rate is too high resulting in more than one flash per cycle of the machine. The "freezing" effect will be obtained if the stroboscope is set to flash on every other cycle, every third cycle, etc., but the "frozen" image will be rather blurred. Optimum results are produced at the highest flash rate that gives a single "frozen" image.

The maximum rate of 100Hz (6000 r.p.m.) might not be sufficient for some small pieces of machinery. The maximum output frequency can be increased to about 300Hz (18000 r.p.m.) by increasing the value of VR1 to 220 kilohms, but accurate adjustment of the flash rate will then be more tricky. Using a value higher than 220k is not recommended as it could result in the oscillator stalling. □

SHOP TALK

with David Barrington

EPE Mood PICker

Reading between the lines, the conclusion to be drawn regarding the use of the choke version of the inductor for the *EPE Mood PICker* is – don't! Apart from being an extremely messy operation to produce an air-cored coil from it, the cost is about three times greater than the alternative coil.

Constructors are, therefore, recommended to stick with the "Eagle" LT44 driver transformer and modify it as outlined. The LT44 is sometimes listed by advertisers as a "transistor driver transformer" and should be widely available. If any difficulties are experienced in locating it try a **Maplin** store, quoting code HX82D. The same source was identified as stocking the AD8532 dual op.amp, code OA16S.

A ready-programmed PIC16F84 microcontroller is available (*mail order only*) from the author for the sum of £8 inclusive UK. Overseas readers should add £1 for postage and packing. Orders and payments should be made out to *Mr. A. Flind* and sent to: **Mr. A. Flind, 22 Holway Hill, Taunton, Somerset, TA1 2HB.**

For those readers 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 540. If you are an Internet user, it can be downloaded *Free* from our FTP site:
ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/moodPICker.

12V Battery Tester

Most of the parts required for the *12V Battery Tester* are nearly all standard items and most of our components advertisers should be able to come up with the goods, or a suitable alternative. The extra flexible lead is usually sold as meter lead, but multistrand cable could prove to be just as reliable.

Some readers may experience difficulty in locating a suitable case, with probe, and the REF50Z 5V voltage reference chip. The probe case came from **Maplin** (☎ ***01702 554000***), code JX57M, and the REF50Z voltage reference from **Electromail** (☎ ***01536 204555***), code 283-851.

L.E.D. Stroboscope

We do not expect any buying problems to arise when selecting components for the *L.E.D. Stroboscope*, this month's low-cost Starter Project. Both the specified TIP122 and TIP121 power Darlington transistors should be stocked by the majority of our component advertisers.

Practically any of the ultra-bright l.e.d.s should operate well in this circuit, the higher their efficiency the brighter the pulses of light produced. The latest 5mm types appear to give the highest light levels. It is worth experimenting with several l.e.d.s to find ones that give a nice evenness of illumination. Forget the 3mm types, they lack the light output for this application!

The style of case is left to individual choice. Almost any medium size plastic or metal housing can be used, but bear in mind the bulk of the 8-cell battery pack when making your final choice.

If you intend to mount the strobe light l.e.d.s remote from the main unit, you could try adapting a probe type box or a small torch to give a handheld unit. A probe-case will cost about £2.

Intruder Deterrent

Checking out components for the *Intruder Deterrent* project we came up against a minor problem in finding a source for the neat "plug-box", incorporating a mains outlet socket. We finally tracked it down as one being distributed by **BCL Distribution** and coded as PS13AS. Having contacted BCL, they put us onto **Harrogate Electronic Services** who, they suggested, might be willing to supply readers on a *mail order* basis.

Richard Page of Harrogate informs us that they are happy to supply the specified PS13AS case for the sum of £5.95 all inclusive. (Note that the pin arrangement is the UK three-pin standard.) Orders should be made out to: **Harrogate Electronic Services, 25 Regent Parade, Harrogate, N. Yorks, HG1 5AZ.** (☎ ***01423 564353***), quote code PS13AS.

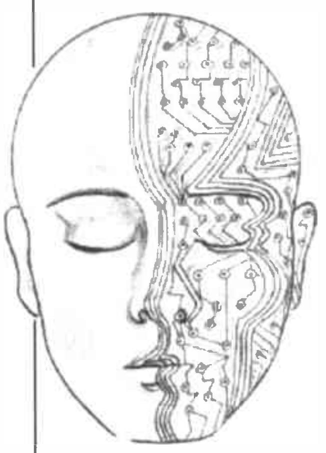
The BP103B phototransistor also took some finding and was found listed by **Rapid Electronics** (☎ ***01206 751166***), code 58-490. It is most important that only a new **Class-X** capacitor rated for **direct** connection across the mains supply be used for C4. One can be purchased from **Electromail** (☎ ***01536 204555***), code 115-196 or 210-500.

Practical Oscillator Designs

Investigating the "practical" circuits presented in the *Practical Oscillator Designs—1* feature we came across a Toko coil number that was alien to us. The one in question was the RHCS45328AC2 i.f. transformer and, referring back to the author, we were informed that it is a replacement for an earlier Toko IFT. It is currently listed by **Bonex Ltd** (☎ ***01753 549502***), code 355328. As far as we are aware, it is *not* listed or carried by **Cirkit**.

For this month's collection of printed circuit boards see page 541.

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 BH21 1PF.
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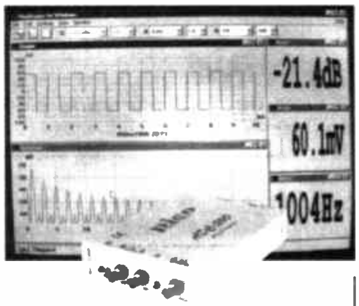

WIN A PICO PC BASED OSCILLOSCOPE

- 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.

Superior Heads-Tails Indicator

This Heads-Tails Indicator (see Fig.1) is superior to other designs in several ways. It is random to a fault, needs no setting up and operates with a single pushswitch to display either red or green on a single l.e.d.

In the circuit diagram of Fig.1, the oscillator based around IC1a and IC1b, feeds a rapid train of pulses via IC1c to IC2a, a D-type flip-flop. As each pulse is received, IC2a changes state from "heads' to "tails" and vice versa. Within 70 milliseconds, IC2a receives about 500 pulses, then timer IC1c stops the clock. Within a further 20ms, IC1d switches on transistor TR1 which causes the tricolour l.e.d. D1 to display either red or green.

The purpose of IC1d/TR1 is to prevent the differing loads related to D1 from biasing the timer IC1c in favour of either heads or tails. Various factors combine to ensure that the Superior Heads-Tails Indicator is virtually completely random.

Rev. Thomas Scarborough, Fresnaye, Cape Town, R.S.A.

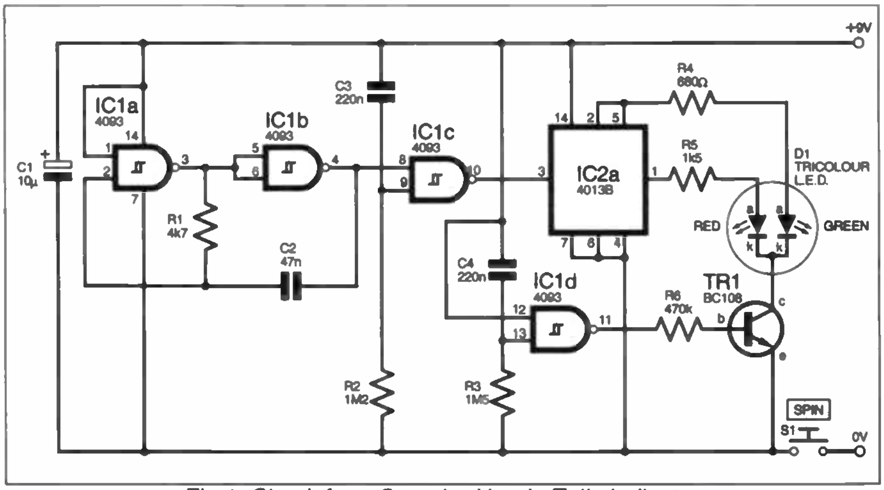

Fig.1. Circuit for a Superior Heads-Tails Indicator.

Home Alarm System

The circuit diagram in Fig. 2 is a simple home alarm system panel designed to provide some of the more useful features of commercial panels at a fraction of the cost. The loops marked as "Zone 1", "Zone 2" and "Entry/Exit" (S4, S5, S7) are normally-closed alarm sensors. The "Tamper Loop" (S6) is also a normally-closed tamper protection circuit.

If Zone 1, for example, was opened then pin 2 of the OR gate IC1a would be brought high via resistor R1, thus causing l.e.d. D5 to light, and the monostable IC5 would also be triggered via transistor TR5. The relay contacts RLA1 will close for a period set by VR2.

A triggering circuit, comprising of TR5 and capacitor C8, is required because if the sensor (S4) connected to the OR gate were to remain permanently open (e.g. a broken window strip), then the alarm would sound indefinitely. Resistor R16 allows C8 to discharge a few seconds after the zone (e.g. a PIR) has been closed again thus resetting the alarm.

The three key switches S1 to S3 may take many forms, but to disarm the alarm they must be closed and to arm the system and trigger the exit timer they must be open. On the prototype, the "Lock" was a 36-way Centronics socket and the "Key"' simply a matching plug with six pins jumpered.

Exit time is provided by means of IC4, another NE555 monostable timer. With "key switch" S1 closed (system disarmed) pin 2 of IC4 is grounded (0V) thus output pin 3 of the timer is held high. This output is inverted by IC3c and fed to one input of IC2a (a 4081 AND gate), the output of which connects to the set input of the bistable latch formed by IC3a and IC3b. Assuming the Exit timer IC4 has timed out then pin 2 of IC2a will be high but pin 1 will be low (Exit/Entry zone closed).

Upon opening of the entry/exit zone the bistable will be set, thus bringing its Q output (pin 4 of IC3b) high. This begins to charge capacitor C3 to give an entry time of about 17 seconds before pin 5 of IC1a is brought high. If the key is inserted during this interval then the Alarm Bell Timer (IC5) is disabled, the exit timer re-established and the bistable is reset. If not then the alarm sounds as before. Capacitor C4 provides power on reset for the bistable and the l.e.d.s. D1 to D4 provide visual indication of zone status.

A power supply circuit capable of charging a lead acid battery is shown separately in Fig.3b. The alarm circuit could easily be modified to accept more zones by the use of the second OR gate in the 4072 package.

Damien Maguire, Co. Wicklow, Ireland.

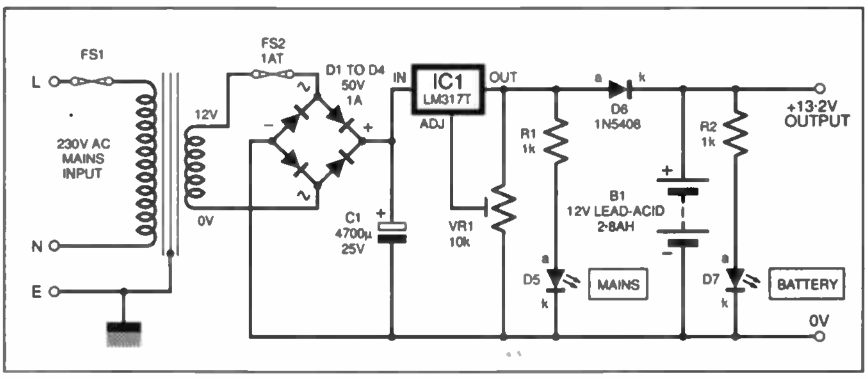

Fig.3. Suggested power supply/charger circuit for the Home Alarm System.

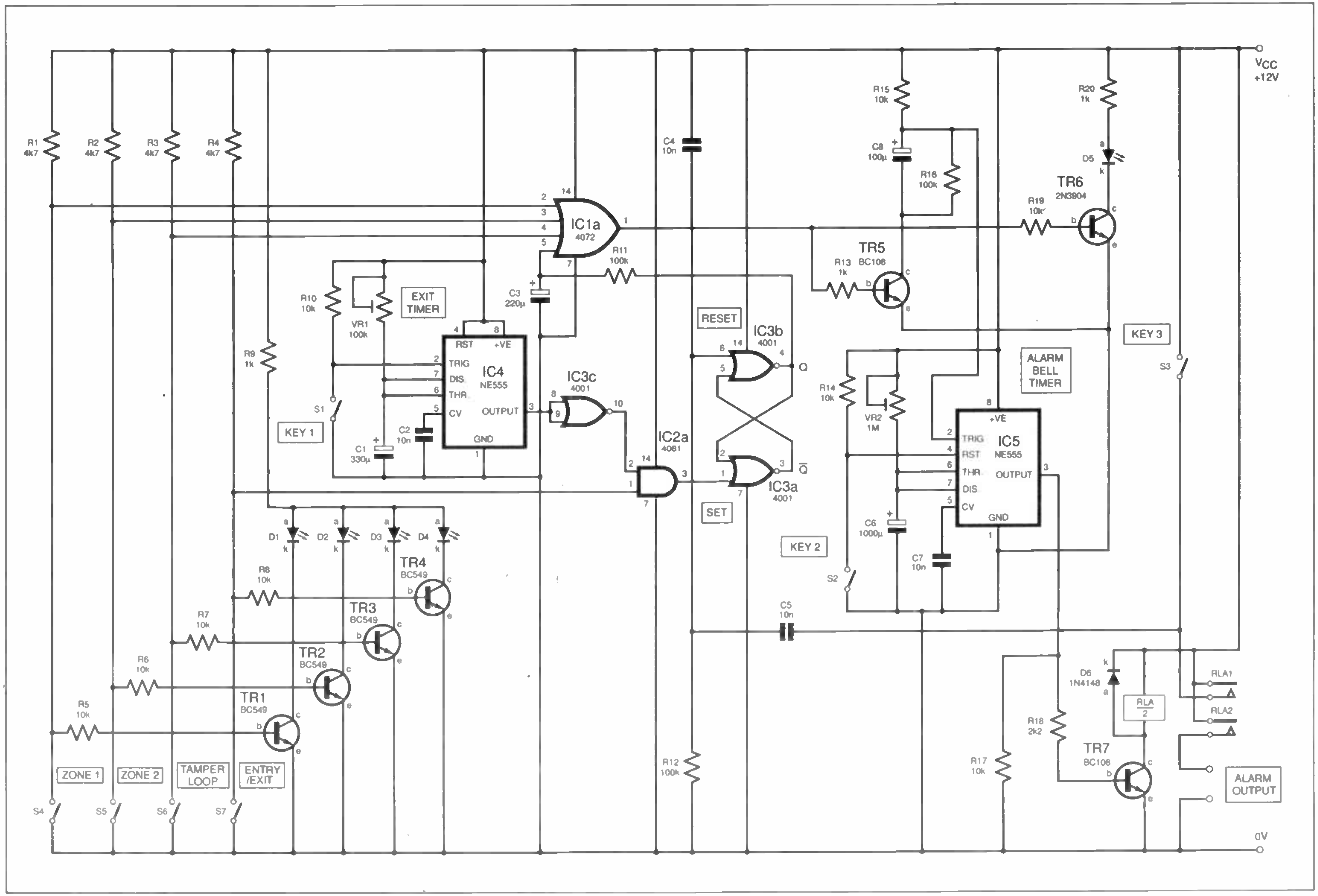

Fig.2. Control circuit diagram for the Home Alarm System

EVERYDAY PRACTICAL ELECTRONICS

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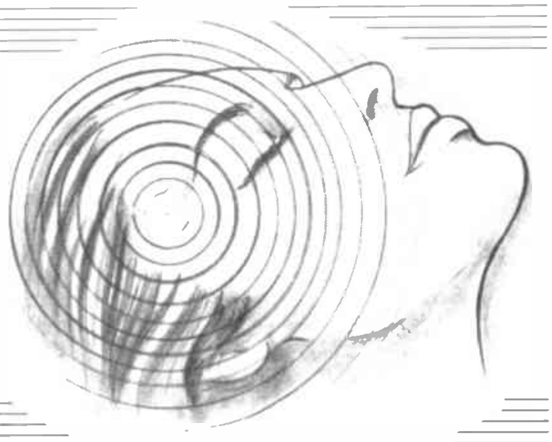
M7/99

Constructional Project



EPE MOOD PICKER

ANDY FLIND

In an age of stress and insomnia let the "force" be with you.

ONE OF the more unusual projects published in *EPE* last year was the *EPE Mood Changer* featured in the June '98 issue, which was an adjustable low-frequency magnetic field generator. Such fields are thought to encourage electrical activity of similar frequency in the brain, which in turn may promote associated moods and sensations such as deep relaxation, creativity or even sleep.

STATE OF MIND

It has been known for many years that the human brain exhibits electrical activity at various frequencies and that to some extent these are related to current moods. For instance, normal waking consciousness, such as that emitted by readers of this article (we hope!) is generally accompanied by activity at about 20Hz, known as the *Beta* frequency.

Lower frequencies have corresponding states, such as the band between 8Hz and 13Hz which is generally supposed to accompany a deeply relaxed but aware state. This band is called *Alpha* and wider interest in it began some years ago when researchers discovered high levels in Zen masters during meditation. More recently there has been interest in the *Theta* band, 4Hz to 6Hz, which is thought to accompany mental imagery and creativity.

The lowest band, 1Hz to 3Hz, is known as *Delta* and is normally only found in deep sleep. Whilst this might not sound very useful, many insomniacs will disagree, arguing that anything that helps them to get into the Delta state is very useful indeed.

ENLIGHTENMENT

Various techniques for using these brainwaves have been developed over the years. The earliest method was to detect them with electrodes placed on the head, so that users would know when they were present and could therefore learn to generate them at will and increase their intensity.

Known as EEG Biofeedback, this was a difficult and sometimes messy technique, requiring high levels of amplification, complex filtering and usually some sort of gel to achieve good electrode to scalp contact through hair. As a result the more proactive "entrainment" became more popular, an example being the *EPE Mind PICkler* featured in the December '98 issue.

Instead of passive detection these use flashing lights and special sounds to encourage the production of the desired frequencies in the user's brain. It is interesting to note that some of the early commercial devices of this type included a magnetic field as part of the stimuli provided.

More recently a small and relatively expensive device was marketed which was claimed to reduce the stress of modern living by providing a weak magnetic field close to the user at frequencies corresponding to those of brain activity. Given the connection between magnetism and electricity it seems quite possible that this could work by simple electromagnetic induction.

This will undoubtedly produce minute currents in conductive brain tissue which may well encourage it to settle into such frequencies of it's own. The mere fact that devices using the technique have been made and sold on a commercial basis suggests that it is worth investigation, especially at home construction costs.

DOES IT WORK

The big question is "Does it work?" All results from something like this are highly subjective and may vary from user to user. However, the author finds that using one of these devices for a while at Alpha frequency does seem to produce a sense of relaxation, and popping it under the pillow with a Delta setting often results in an excellent night's sleep.

Correspondence from constructors following publication of the original *EPE Mood Changer* suggest that it works for them too, especially for insomniacs. Whilst there can be no guarantee that it will be effective for any particular reader this new design does make it much easier to test.

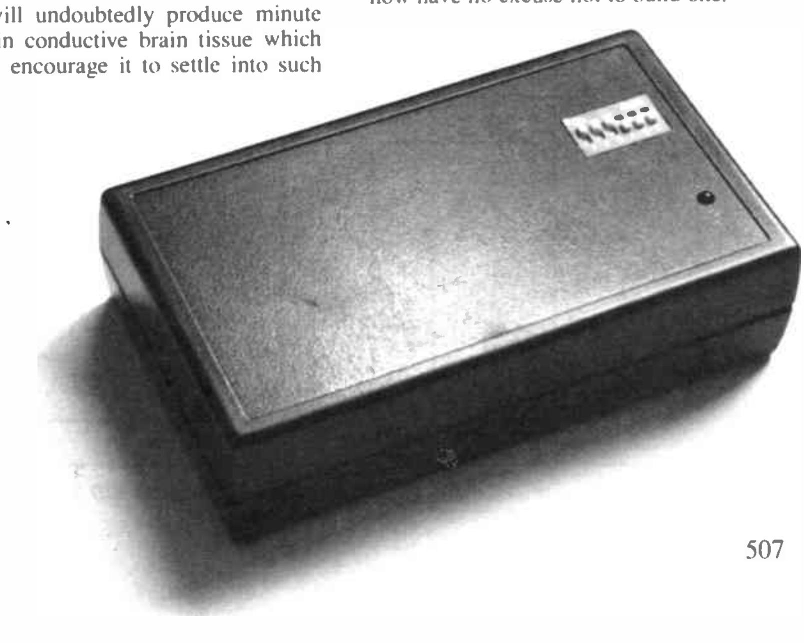
The use of a PIC microcontroller for frequency generation has simplified construction and eliminated the need for calibration and adjustments. At around half the size and weight of its predecessor, it fits easily into a small pocket and the lighter weight makes it more robust, the prototype has even been dropped without sustaining damage.

It is cheaper to build and running costs are lower since it should operate for over two hundred hours from just two AAA cells. Readers wishing to discover if it will work for them, for insomnia, as a meditation aid, or even simply as a stress reliever, now have no excuse not to build one.

WARNING NOTICE

It is known that photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. We would therefore also suggest that it is not wise for such people to try this project.

A user who is not a known epileptic, but when using the *EPE Mood PICker* begins to experience an odd smell, sound or other unexplained effects, should TURN IT OFF IMMEDIATELY and seek professional medical advice.



HOW IT WORKS

The working principle of the device is straightforward. It produces a low frequency sinewave signal which is applied to an air-cored inductor to create an alternating magnetic field. The signal is generated digitally since this eliminates the amplitude control problems often associated with low frequency generation and it is easier to produce precise frequencies using digital techniques.

0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	1
0	0	0	0	0	1	1	1
0	0	0	0	1	1	1	1
0	0	0	1	1	1	1	1
0	0	1	1	1	1	1	1
0	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	0
1	1	1	1	1	1	0	0
1	1	1	1	1	0	0	0
1	1	1	1	0	0	0	0
1	1	1	0	0	0	0	0
1	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Fig.1. Output pattern from PIC port B.

In this design a PIC16F84 microcontroller is programmed to produce the sequence of outputs shown in Fig.1 from the eight outputs of port B. These are combined by a network of resistors with values chosen to produce a single output which is approximately sinusoidal in shape, albeit slightly "jagged" as shown in Fig.2.

It can be seen that the outputs from port B remain in their highest (all "on") and lowest (all "off") states for two cycles, to simulate the flatter parts of the sine curve at these points, so a complete sinewave cycle is simulated with a total of eighteen steps. The signal then goes to an output stage which drives the coil. The "bridge" configuration of this effectively doubles the coil drive voltage to increase output.

To minimise battery consumption it was decided to operate the PIC in LP (low power) mode using a 32·768kHz watch crystal for the oscillator. These crystals are readily available at low cost from many component suppliers.

Readers with knowledge of PIC programming will know that the PIC divides its oscillator by four for the internal clock, so the program chunters along at just over 8kHz which raises interesting problems for the programmer. At this low frequency every program step must be counted as the final output frequency depends entirely on the total number of steps in the program loop generating it. "Structured" programming with tidy modular subroutines was quickly abandoned and instead a straightforward "top-down" approach is used as far as possible.

FLOW CHARTS

The main flow diagram of the program is shown in Fig.3. It begins by configuring the inputs and outputs and setting output RA0 high for two seconds to turn on a "battery check" l.e.d.

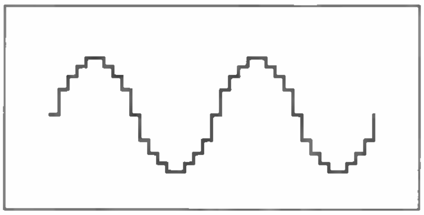


Fig.2. Example of digitally generated "sinewave".

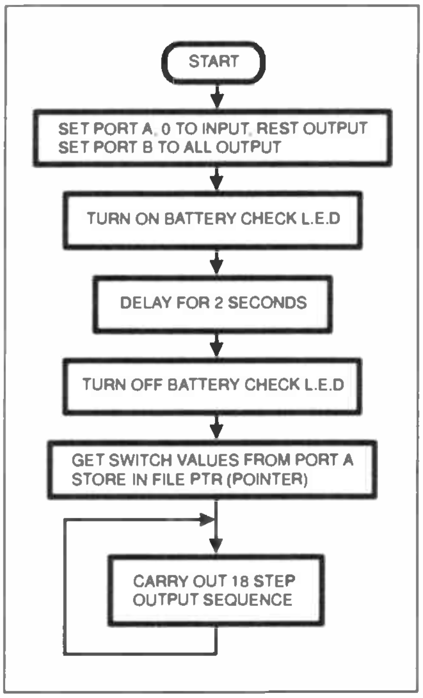


Fig.3. Flow diagram for the EPE Mood PICker main program.

Two interesting points arose from this. The original intention was to drive the l.e.d. with RA4, which is an "open drain" output and can therefore only sink current. However, it was found that the l.e.d. continued to glow slightly when this output was set "high" to turn it off so it would appear impractical to use RA4 in this way.

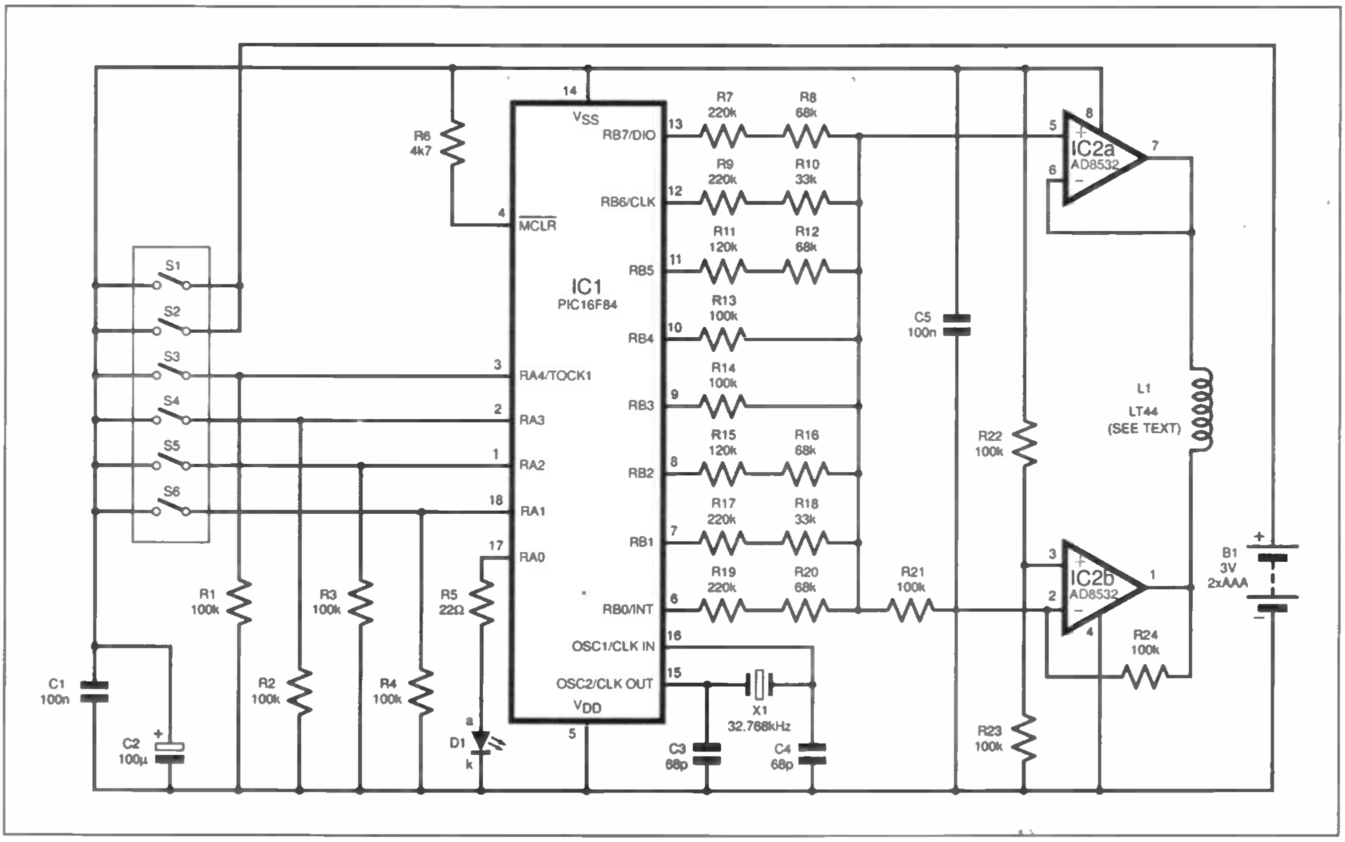


Fig.5. Complete circuit diagram for the EPE Mood PICker.

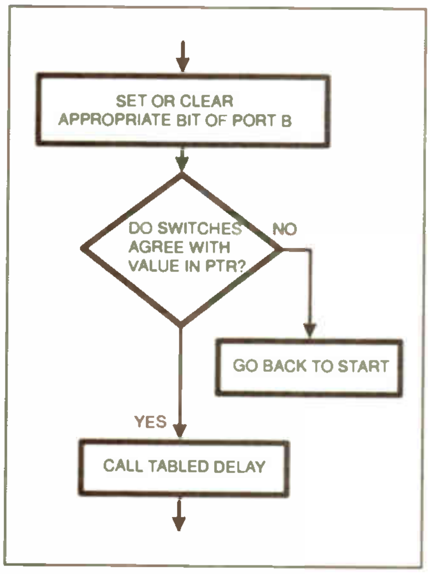


Fig.4. Flow diagram for single step of the frequency generation loop.

Subsequently, RA0 was used for l.e.d. driving and RA4 became one of the four inputs for frequency setting.

The other point to note is that the original data for the PIC16C84 states that toggling RA0 when configured for LP operation may result in a spurious internal clock cycle. Although this did not appear to happen during design with the "F" version, to be on the safe side a couple of "NOP"s (no operation) have been inserted into the program after each change of this bit.

Following the battery test the program stores the states of the four frequency setting switches (see S3 to S6 in Fig.5) in a file. These give a total of sixteen possible combinations which are used to select the desired output frequency. It then continues with an eighteen step repeating loop which generates the output sequence from the eight pins of port B.

The flow of one of these eighteen steps is shown in Fig.4. It begins by setting or clearing the port bit currently due for updating. The switch states are then compared with the value currently held in the file and if they are unchanged a table is called to select a delay associated with the file value.

The delay is one of sixteen which set the overall output frequency. If the switch and file values are at odds the program is sent right back to the start, where it performs the battery check again and stores the new switch values before returning to the frequency generation routine.

Halfway through the eighteen steps, when all the outputs are high, the delay is called twice, and at the final step when they are all low it is again called twice before the process is repeated. A few "NOP"s are inserted as required to ensure the duration of these two steps is exactly twice that of the others in the sequence.

CIRCUIT DESCRIPTION

The full circuit diagram for the *EPE Mood PICker* project is shown in Fig.5. Starting at the left, the top two switches S1 and S2 both perform the on-off function. D.I.L. switches are not normally available in units of five so a six-way version is employed, and rather than leave one unused it is connected in parallel with the power switch.

The next four switches, S3 to S6, are connected to the PIC's (IC1) port A bits 1 to 4, with pull-down resistors R1 to R4 to give logic-level inputs. The battery indicator l.e.d. D1 is connected to RA0 through current limiting resistor R5.

Most red l.e.d.s have a forward voltage of about two volts so when the supply voltage approaches this it will become much dimmer, warning the user that the batteries are reaching the end of their useful life. As mentioned earlier the l.e.d. lights for about two seconds each time the unit is switched on or when the frequency setting switches are altered.

The MCLR function of IC1 is not used and is rendered inactive by connection to the positive supply through resistor R6.

A crystal, X1, is connected across the oscillator terminals with 68pF capacitors C3 and C4 to ground. This capacitor value appears high for this type of crystal which is normally used with around 12pF. The PIC data sheets suggest 68pF however, and the PIC oscillator will not work with 12pF.

Incidentally, if a crystal of this type is used with a 5V supply a resistor should be placed between OSC2 (pin 15) and the crystal to prevent overdriving. A value of 56 kilohms appears generally suitable.

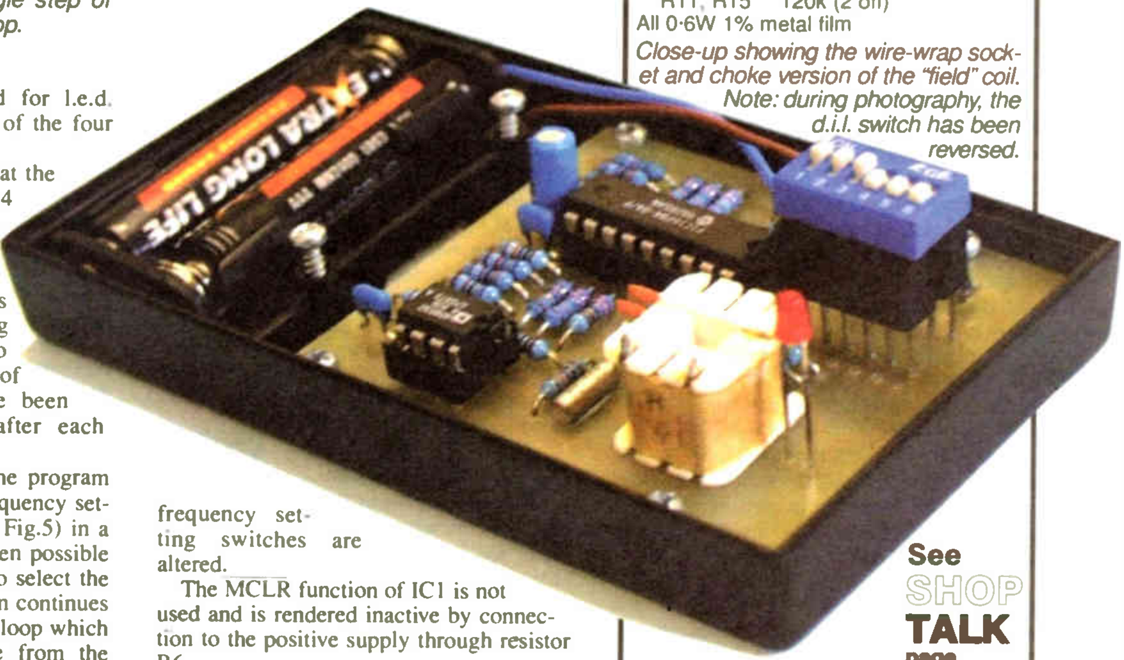
SINEWAVE GENERATION

Resistors R7 to R20 combine the outputs and shape them into a sinewave. Six of the required values consist of two resistors in series giving calculated errors of less than 0·1 per cent at every step, and the resulting waveform looks very good indeed on an oscilloscope. If you have a 'scope, it's well worth checking this.

The total output impedance of the resistor network is a fraction under 22 kilohms (22k). So, loading it with a 100k resistor, R21, reduces the output peak-to-peak voltage to a little less than the supply of 3V at about 2·5V p-p.

Brainwave Frequencies and Effects

Name	Frequency	Conditions
Delta	0·5Hz to 4Hz	Deep Sleep
Theta	4Hz to 8Hz	Creativity, Dreaming
Alpha	8Hz to 13Hz	Deep Relaxation, Meditation, Stress Relief
Beta	14Hz to 25Hz	Normal alert mental state



Close-up showing the wire-wrap socket and choke version of the "field" coil. Note: during photography, the d.i.l. switch has been reversed.

COMPONENTS

Resistors

R1 to R4, R13, R14, R21 to R24 — 100k (10 off)
R5 — 22Ω
R6 — 4k7
R7, R9, R17, R19 — 220k (4 off)
R8, R12, R16, R20 — 68k (4 off)
R10, R18 — 33k (2 off)
R11, R15 — 120k (2 off)
All 0·6W 1% metal film

See SHOP TALK page

Capacitors

C1, C5 — 100n resin-dipped ceramic (2 off)
C2 — 100µ radial elect. 10V
C3, C4 — 68p resin-dipped ceramic (2 off)

Semiconductors

D1 — 3mm red l.e.d., 10mA type
IC1 — PIC16F84 pre-programmed microcontroller
IC2 — AD8532 dual op.amp

Miscellaneous

X1 — 32·768kHz watch type crystal
L1 — air-cored coil (LT44 – see text)
S1 to S6 — s.p.s.t. 6-way sub-miniature d.i.l. switch
B1 — 1·5V AAA cell (2 off), with 2-cell AAA holder

Printed circuit board available from the *EPE PCB Service*, code 233; handheld plastic box, with battery compartment, size 105mm x 61mm x 28mm; 14-pin wire-wrap socket (see text); 18-pin d.i.l. socket; battery connector with leads; solder etc.

Approx. Cost Guidance Only* £19 *excl. batts.

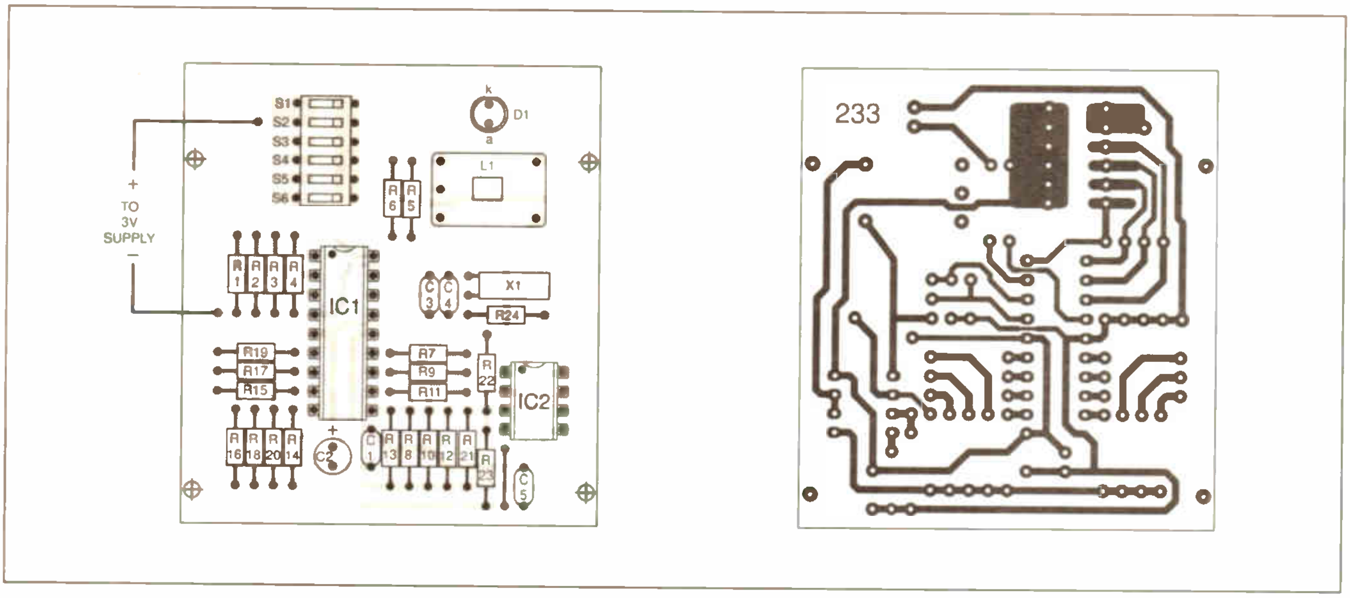


Fig.6. Printed circuit board component layout and full size copper foil master pattern for the EPE Mood PICker. Note the d.i.l. switch should be mounted on the board using a wire-wrap socket, see text.

The output stage is built around IC2, an AD8532 dual op.amp. This device appeared on the market fairly recently and has some very useful features. Its inputs and outputs are both rail-to-rail and the outputs can source or sink up to 250mA. Despite this high output current capability it draws only 1·6mA of quiescent current and is guaranteed to operate from supplies down to 2·7V.

In practice, this circuit operates down to 2V without problems. It is fast, up to 4MHz, and distortion is low enough for audio applications.

The only drawback appears to be an upper supply voltage limit of 7V which makes direct operation in circuits with 9V supplies impossible. For lower voltages though, it opens up new horizons.

In this circuit, IC2a is connected as a non-inverting amplifier and IC2b as an inverter. Between them they provide a "bridge" output to the coil L1, which therefore has a peak-to-peak drive of about 5V, or 1·77V r.m.s. Three decoupling capacitors are used, C1, C2 and C5 which is a 100nF ceramic type placed close to IC2 to prevent any tendency to instability.

CONSTRUCTION

Construction of this project is fairly straightforward since all the components are fitted on a single printed circuit board (p.c.b.). The topside component layout together with the underside copper foil master track pattern is shown in Fig.6. This board is available from the *EPE PCB Service*, code 233.

If the specified case is used, the first task is to check that the p.c.b. fits correctly on the mounting pillars provided. Following this a square hole should be cut in the case for the d.i.l. switches, see photographs.

In the prototype, this was done by holding the p.c.b. against the inside front of the case with the same gap from the top as it had when secured to the pillars to act as a template whilst drilling twelve 1mm holes through the case in the d.i.l. switch pin positions. The switch was then popped into these holes on the other side to position it accurately whilst marking its outline with a knife.

Careful work with a drill, rat-tail files and a sharp knife then resulted in an accurately placed square hole into which the switch fitted neatly. The p.c.b. was also used to mark the position of the hole for l.e.d. D1.

The remaining components should be fitted and soldered in the usual way with the exception of l.e.d. D1 and the switch. The layout of all the components is shown in Fig.6. Crystal X1 lies flat as shown and should be secured with a drop of glue as it is delicate and has thin leads. A socket is recommended for IC1.

COIL DETAILS

The coil L1 should be air-cored as mentioned earlier. There are several possibilites here, but the p.c.b. has been designed specifically to use the coil taken from an "Eagle" LT44 audio driver transformer which should be dismantled as follows.

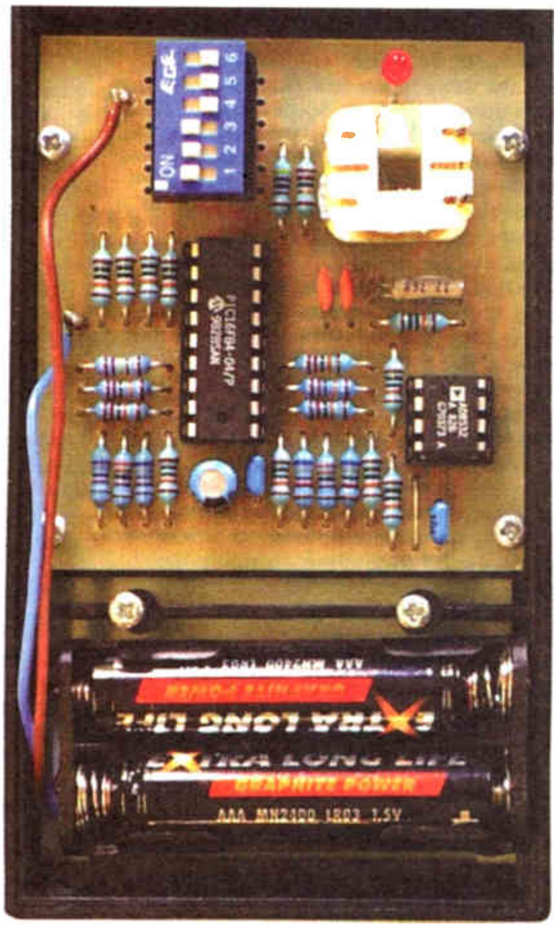
The outer metal casing can be simply pulled apart at the bottom and prised off. Beneath this will be found an adhesive paper tape around the core which is easily removed. The laminations appear to be held by wax impregnation and can be carefully removed using a sharp knife to break the adhesion between them and small pliers or sidecutters to pull them out.

In usual transformer fashion some of them are E-shaped and some are just strips. The more laminations are removed, the easier it becomes to prise out the remaining ones.

This operation will leave just the bobbin with its primary and secondary windings. Only the primary is used in this project although the secondary connections are soldered to the board to secure it.

An alternative to the LT44 bobbin is one taken from a "10 Henry choke" which can be seen in the photographs. The thinking here was as follows. Both the choke and the LT44 primary have about the same d.c. resistance and are physically about the same size. The transformer has two windings but the choke has only one so it probably consists of more turns of thicker wire. More turns, same current, more magnetic field for the same power!

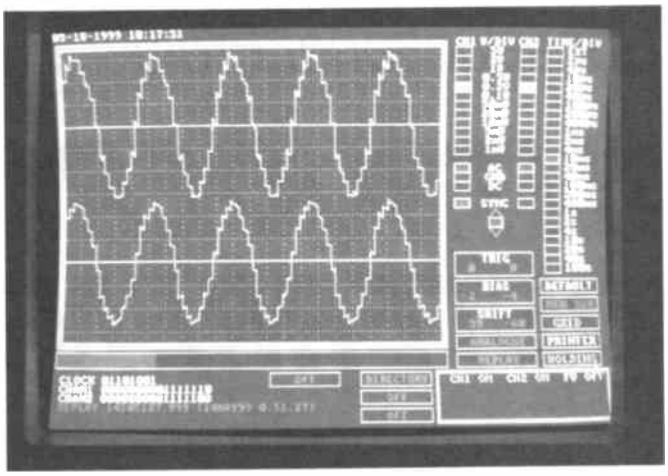
In practice the choke proved far more difficult to dismantle as the laminations appeared to be stuck together with some



Completed unit showing the battery compartment and positioning of the circuit board.

No.	S3	S4	S5	S6	FREQ.	EFFECT
0	OFF	OFF	OFF	OFF	1·50	
1	OFF	OFF	OFF	ON	2·20	DELTA DEEP SLEEP
2	OFF	OFF	ON	OFF	2·99	
3	OFF	OFF	ON	ON	3·99	
4	OFF	ON	OFF	OFF	4·60	THETA:
5	OFF	ON	OFF	ON	5·17	CREATIVITY, DREAMING
6	OFF	ON	ON	OFF	5·99	
7	OFF	ON	ON	ON	7·85	SCHUMANN RESONANCE
8	ON	OFF	OFF	OFF	8·92	
9	ON	OFF	OFF	ON	10·11	ALPHA:
10	ON	OFF	ON	OFF	11·10	DEEP RELAXATION MEDITATION
11	ON	OFF	ON	ON	11·98	STRESS RELIEF
12	ON	ON	OFF	OFF	13·00	
13	ON	ON	OFF	ON	18·96	BETA
14	ON	ON	ON	OFF	20·69	NORMAL CONSCIOUSNESS
15	ON	ON	ON	ON	21·67	OPTIMISM

Fig.7. Switch settings, frequencies and effects.



Virtual Scope *display of the waveforms at (top) IC2a pin 5 and (bottom) IC2a pin 7.*

kind of glue instead of the waxy substance of the LT44. Prising them out was a real touch-and-go operation. The bobbin has only two connections so it was glued to the board though the connections do fit directly into the same holes.

Following all this effort there was only a tiny increase in the field output. Considering the difficulty of dismantling it and the fact that it costs nearly three times as much, constructors are recommended to stick with the LT44 audio transformer as the source of the coil.

SWITCHED-ON

Some options are available when fitting the d.i.l. switch. For simplicity it could be soldered directly to the p.c.b. and operated through a hole in the case, but this might prove awkward.

A socket could be used to raise it a bit, but the same difficulty would apply. It could be glued to the case and then wired to the board.

However, for the prototype a socket with wire-wrap pins was used to raise it so that its surface was flush with that of the case. Wire-wrap sockets do not seem to be as common as they once were, and 12-pin ones may well not exist. A 14-pin one was modified for the prototype by pulling out the unwanted pins and then cutting off the unused bit of the body with a sharp knife. This would also work for a 16-pin socket.

However, even 14- and 16-pin wire-wrap sockets are becoming rare. A couple of alternatives that are still readily available are strips of wire-wrap socket that can be cut to length, and 28-pin sockets that can be cut to provide two such strips.

To fit the socket the d.i.l. switch was first fitted into it, then the socket was inserted into the board with a large dollop of Blu-Tack beneath it. The p.c.b. was then screwed to the mounting pillars and the top half of the case was held in place whilst the switch was pressed down against the Blu-Tack into the exact required position. The board was then carefully removed and the socket pins soldered, then the Blu-Tack was removed.

This admittedly fiddly operation results in a switch that is mounted directly onto the p.c.b. but is perfectly flush with the case front when the unit is assembled, providing easy operation and a really neat appearance. A further advantage is that if the switch should fail a replacement can be simply plugged in. A similar procedure was used to fit l.e.d. D1, using a large blob of Blu-Tack to hold it in position for soldering.

The batteries are fitted in a 2-cell AAA holder, fixed into the case with double-sided adhesive strip. They have a slight tendency to pop out of the clip if the unit is knocked, but this can be prevented by filling the spare space in the battery compartment with a piece of firm polyurethane foam.

TESTING

Very little testing is required with this project. When switched on the l.e.d. should light for two seconds, then the output should start running. Whilst D1 is lit the circuit draws about 10mA but in normal operation the circuit draws less than 4mA.

Changing any of the four frequency setting switches should result in another operation of the l.e.d. With all four switches in the "off" position the unit will operate at its lowest frequency of just 1·5Hz so it can be checked with an analogue meter; as the pointer should be able to follow the sinewave outputs from IC2a and IC2b to the coil.

All eight port B outputs of IC1 should be alternating high and low at the same frequency. If an oscilloscope is available a higher frequency can be selected so that the output waveform can be observed. With all four switches "on" the frequency should be just under 22Hz.

STAY CALM

To use the unit, an appropriate frequency should be selected. Those available are shown in Fig.7 together with their switch settings and associated effects. The binary equivalent of the number for each frequency is set with the switches - most readers of *EPE* will know how to do this!

All four switches "off" is zero and all four "on" is fifteen, a total of 16 possible combinations. The bottom switch S6 is the least significant bit or "LSB".

The unit should be kept close to the body for maximum effect. For insomnia one of the two lowest frequencies should be selected and it can be placed under the user's pillow, which seems to be particularly effective.

Switching the unit off and then on again immediately should be avoided as this may result in the l.e.d. failing to operate, probably because capacitor C2 has insufficient time to discharge so the circuit never actually powers down. This is not a serious problem as tests show it to be generating the magnetic field correctly even when this occurs.

SPACED OUT

One of the available frequencies is 7·85Hz which is as near as could be programmed to the 7·83Hz "Schumann Resonance". This intriguing phenomena is one of the naturally occurring magnetic fields that have always surrounded us.

It appears that the space between the earth's surface and the ionosphere forms a gigantic resonant cavity with physical dimensions that give it a frequency somewhere between 7Hz and 8Hz. Excitation by phenomena such as lightning starts oscillation and very low attenuation at these frequencies allows it to keep going more or less continually.

Enthusiasts of the effects of fields at this frequency say that modern man is missing out on its supposed beneficial effects because it tends to be masked by more powerful fields from the electrical equipment and wiring which nowadays surrounds us all. There is even a story that NASA installed Schumann frequency field generators in spacecraft after finding that space sickness was in part due to the astronauts travelling beyond the range of this field.

If any reader knows the truth of this story we would be very interested hear from them. Meanwhile, in an age of stress and insomnia, it is hoped that this project will bring some beneficial calm and relaxation to its constructors. □

COMING SOON

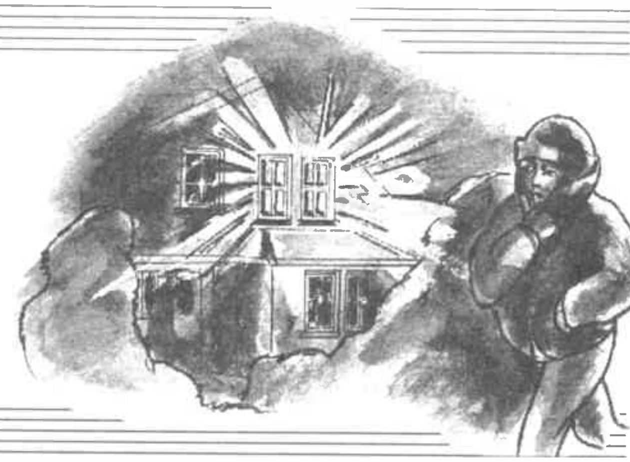
Micro-Tesla!

A Sensitive Magnetic Field Sensor

Capable of indicating the tiny fields generated by the *EPE Mood PICker*. It is also capable of detecting an ordinary permanent magnet at a range in excess of three metres, which could lead to a variety of interesting experiments and applications for the enthusiast.

Constructional Project

INTRUDER DETERRENT



BART TREPAK

Is there anyone at home?

AT NIGHT, an intruder alarm bell box may not be noticed and a would-be intruder might attempt a break in if the house appears unoccupied. However, a light burning in an upstairs room is a good deterrent and it is quite a simple matter to build a light sensitive switch to switch the lights on automatically when it gets dark.

The deterrent effect can be made even greater by automatically switching the lights on and off every so often, so that it appears that there is somebody there to do the switching.

Obviously too rapid an on-off switching cycle would be unrealistic and a period of a few minutes would seem ideal. Since the light being on would be more of a deterrent than if the potential intruder happened to come along while the light was off, the circuit should keep the lights on for longer than the period for which they are switched off.

DISCO LIGHTS

Building a light sensitive switch is easy enough, but setting one up to switch on the lights in the same room is not quite so simple. Great care must be taken to place the sensor in a position where it will sense the external light level but not respond to the light being switched on in the room.

Failure to ensure this will result in a feedback effect with the light switching on when it gets dark, resulting in it being light thus causing the light to switch off again, and so on. The effect is likely to be far from realistic, although the would-be intruder may be led to think that there is a disco party going on inside!

However, the device described here has been designed in such a way that it can be plugged into any convenient wall socket and the lamp plugged or connected to it without regard as to which way the sensor is facing or the power of the lamp being controlled. To allow this, it samples the light level only when the lamp being switched is off. When the lamp is on, the brightness level is ignored so that feedback cannot occur.

As the light level falls, the circuit begins switching the lights on and off at predetermined intervals and, when in the off state and the light level has increased above a set level, this action stops and the lights remain switched off.

SCHMITT NAND

The circuit is based on a quad 2-input Schmitt trigger NAND gate. To understand how the circuit works, it is important, therefore, to know what a Schmitt NAND gate does.

The truth table for a 2-input NAND gate is shown in Fig.1. When both inputs are high, the output will be low, but if either or both of the inputs go low, the output will go high.

A	B	O/P
0	0	1
1	0	1
0	1	1
1	1	0

Fig.1. NAND gate and truth table.

A Schmitt trigger NAND gate differs from an "ordinary" NAND gate in the way it responds to input signals, as illustrated in Fig.2. Assuming that one input of the NAND gate is connected to the positive rail (logic high) and a slowly rising ramp voltage is applied to the other, the ordinary NAND gate output will be high while the input is below the lower logic threshold.

For most CMOS gates the lower logic threshold below which a logic 0 value is guaranteed by the manufacturer lies at about one-third of the supply voltage. Similarly, the guaranteed logic 1 condition lies above about two-thirds of the supply voltage. The region between the two levels is considered indeterminate, in that neither logic level can be guaranteed.

When the input voltage level enters the indeterminate region, the circuit begins to behave like a very high gain amplifier so that any noise superimposed on the input (particularly when it is near the middle of the indeterminate region) will cause the output to switch between states giving rise to the output waveform shown in Fig.2a.

Once the input level is above this indeterminate region, it will now be considered to be at a logic 1 level, and the output will settle into its low state as determined by the NAND gate's inversion function.

A similar action will happen with a falling input voltage. The indeterminate region does not normally cause problems in well-designed digital circuits because the input voltages switch so fast that the output has no time to oscillate. It can be a great problem, though, if slow or poorly defined logic signals are applied.

The waveform in Fig.2b shows how a Schmitt trigger gate responds to the same slowly rising or falling input and it can be seen that no oscillation occurs. The circuit achieves this by having two well-defined

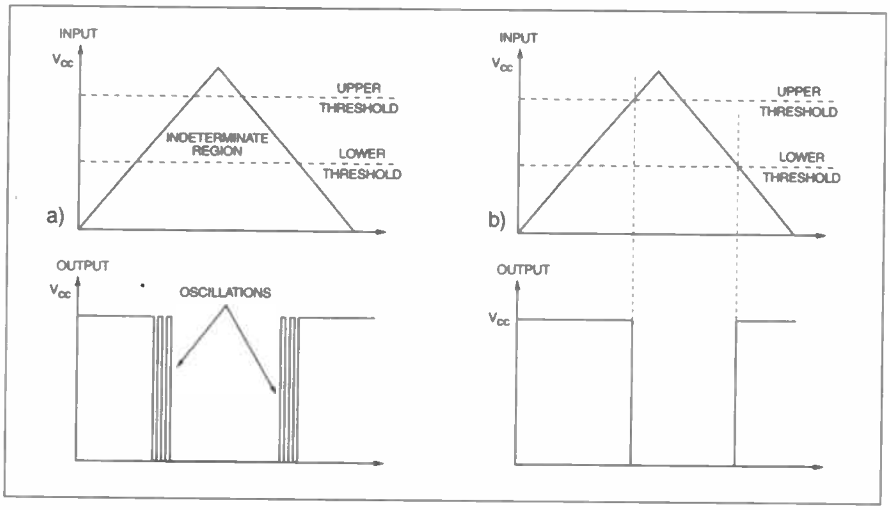


Fig.2. Response of (a) "ordinary" and (b) Schmitt trigger gates to slowly rising and falling input levels.

input thresholds and no indeterminate region.

As the input voltage rises, nothing happens until the upper threshold is reached whereupon the output switches to a low level. Any small amount of noise on the input is ignored and the circuit will remain in this state until the input has fallen below the lower threshold, when the output will switch high.

SCHMITT OSCILLATOR

Not only is this characteristic extremely useful in this intruder deterrent application, where the voltage from the sensor will inevitably change slowly as darkness falls or day breaks, but it also allows the construction of simple oscillators, as shown in Fig.3.

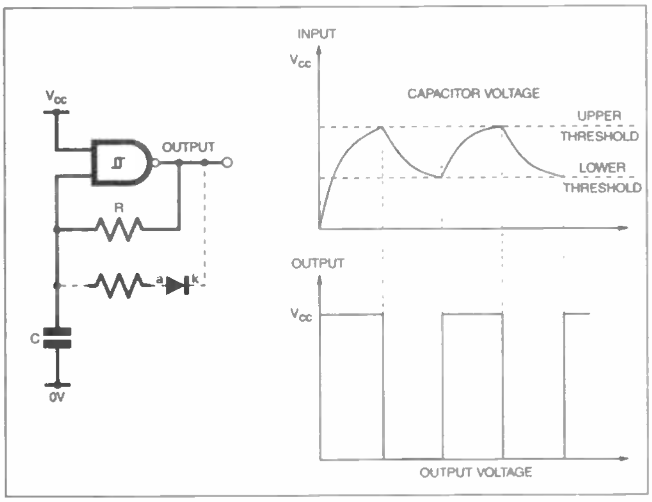


Fig.3. Schmitt trigger oscillator and its waveforms.

When the circuit in Fig.3 is switched on, the capacitor *C* will be discharged so the input voltage will be low, resulting in the output being high. Current will now flow via resistor *R* and the capacitor voltage will rise exponentially until the upper threshold is reached.

At this point, the output will switch low, causing the capacitor to discharge exponentially via resistor *R* until the lower threshold is reached, when the output will go high again, and so on.

The output will be approximately a square wave (except for the initial cycle) because the *RC* time constant will be the same whether the capacitor is charging or discharging. This can be easily modified, however, by connecting a diode in series with another resistor across resistor *R* as shown dotted in Fig.3.

Depending on the direction of the diode, this will effectively reduce either the charging or discharging resistance, causing a corresponding change in the mark space ratio of the output waveform. Alternatively, a resistor in parallel with a diode placed in series with resistor *R* would achieve the same result.

The circuit of Fig.3 is shown with one input tied to the positive rail, but the gate still retains its NAND characteristics. By connecting the spare input to 0V, the output will switch high and oscillation will stop. This input can, therefore, be used to switch the oscillator on or off if required.

CIRCUIT DETAILS

The operation of the Intruder Deterrent circuit shown in Fig.4 can now be described. Assuming for the moment that the point marked "A" in the circuit is high, it will be seen that the output of IC1a will oscillate at a rate determined by C1, R2, R3 and D1.

Because of the orientation of diode D1, the charging period (during which the output of this gate is high) will be shorter than the discharging period so that the output will be low for longer than it is high. As this oscillator controls the time for which the light is switched on and off, the components have been chosen to give a "lights on" period of around 540 seconds and a "lights off" period of about 100 seconds.

The output of this oscillator is fed to IC1b, which simply inverts the oscillator output. The output of this is in turn connected to another oscillator, based around IC1c, C2, R4, R5 and D2.

In this oscillator, the values of the capacitor and resistors are much lower than with IC1a so that the circuit oscillates at a much higher frequency, of about 2·5kHz. This gate oscillates when the output of IC1b is high and D2, R5 ensure that the transistor TR1 is switched on for only a short period (around 30μs) while remaining off for most of the cycle (about 400μs).

This is done to reduce the average current drawn by the circuit and enable a simple capacitive dropper to be used in the mains-derived power supply. Transistor TR1 is used to trigger the triac CSR1, which in turn switches the light on.

From this it should be clear that the lights are only switched on when the control input of IC1c is high, because, when this input is low, the gate's output will be forced high causing TR1 (a *pnp* device) and the triac to switch off.

With the control input low and the lights off, the potential divider formed by R1, VR1 and phototransistor TR2 is effectively connected across the supply rails and comes into play. In high light levels, TR2 will conduct and if the light level sensed by TR2 is such that the voltage at point *A* falls below the lower threshold of IC1a, this oscillator will be disabled and its output will stay high, causing IC1b output to stay low ensuring that the lights stay off.

As darkness falls, TR2 will begin to switch off and the voltage at point *A* will

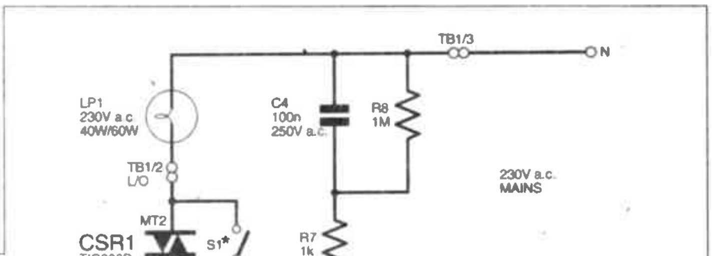
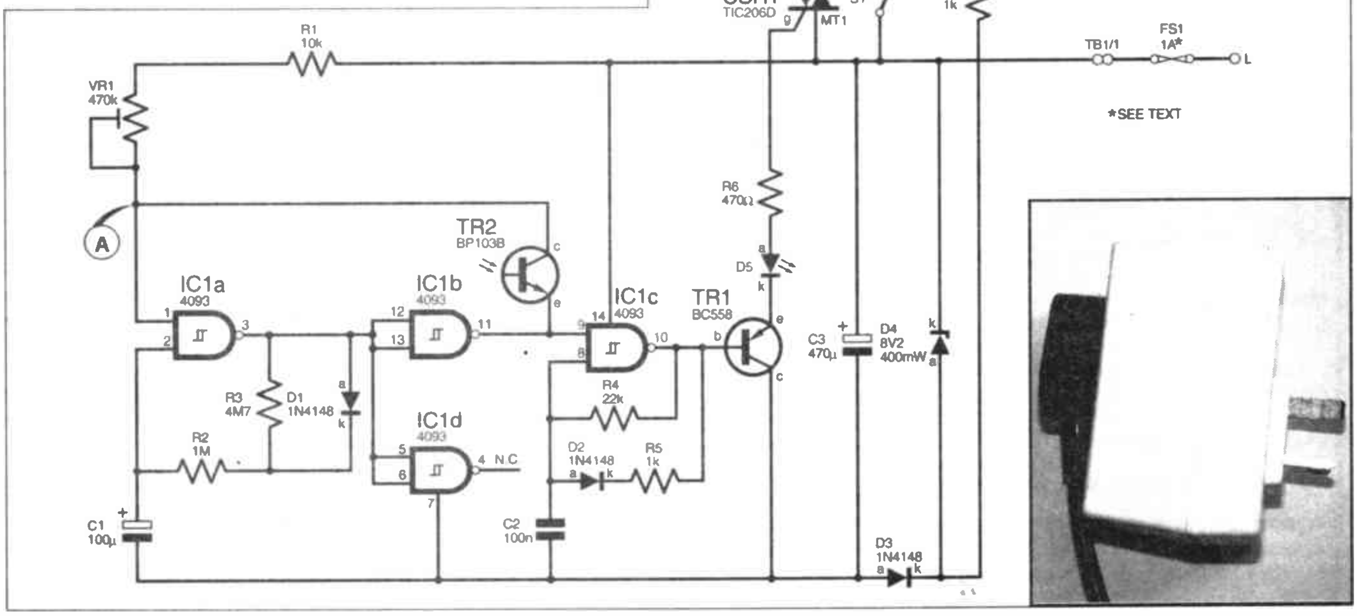



Fig.4. Complete circuit diagram for the Intruder Deterrent.

rise. When the upper threshold is reached, the output of IC1a will go low, causing the output of IC1b to go high, thus switching the lights on. (Note, of course, that capacitor C1 will have been charged since the output of IC1a remains high when it is disabled so that this input will also be high.)

Both ends of the potential divider formed by R1, VR1 and TR2 will now be high so point *A* will also be high, irrespective of the light level being sensed by TR2. Only when the lights switch off again at the end of the cycle (when IC1a output goes high) will the ambient light level be sampled again, ensuring that the lights being switched are ignored.

POWER SUPPLY

Power for the circuit is derived from the normal household mains supply. Capacitor C4 and Zener diode D4 drop the mains voltage to around 8V with D3 rectifying and C3 smoothing the output to give a d.c. supply of just over 7V. This value will vary depending on the current drawn by the circuit, especially when the triac is switched on, but will have no effect on the circuit operation.

Resistor R7 is included to protect the Zener diode from the high current which could flow when the circuit is first connected to the mains with capacitor C4 discharged. Resistor R8 serves to discharge C4 when the circuit is disconnected from the mains, ensuring that high and potentially lethal voltages are not stored by the capacitor.

COMPONENTS

Resistors

R1	10k	**See**
R2, R8	1M (2 off)	SHOP
R3	4M7	
R4	22k	**TALK**
R5, R7	1k (2 off)	**page**
R6	470Ω	

All 0.25W 5% carbon film or better

Potentiometer

VR1	470k min. horiz. preset

Capacitors

C1	100µ radial elect. 16V
C2	100n ceramic plate, 63V
C3	470µ radial elect. 16V
C4	100n 250V a.c. Class X

Semiconductors

D1 to D3	1N4148 signal diode
D4	8V2 400mW Zener diode
D5	red l.e.d.
TR1	BC558 *pnp* transistor
TR2	BP103B phototransistor
CSR1	TIC206D sensitive-gate triac, 400V
IC1	4093 quad 2-input Schmitt NAND gate

Miscellaneous

S1	s.p.s.t. insulated switch, mains rated (see text)

Printed circuit board, available from the *EPE PCB Service*, code 235; l.e.d. clip; 3-way terminal block, 14-pin d.i.l. socket, plug-box with integral mains outlet socket, in-line fuseholder and fuse (see text), mains rated connecting wire; solder, etc.

Approx. Cost Guidance Only **£10** *excl. case.*

The l.e.d. D5 is included to show when the triac is being triggered, to assist in setting up the circuit if no load is connected.

An on/off switch may be considered an unnecessary luxury as there will normally be one fitted to the socket into which the device will be plugged. However, an s.p.s.t. switch connected across the triac (as shown in Fig.4) could be useful to select On or Automatic mode allowing the unit to be plugged permanently into a socket and bypassed if not required, allowing the light to be switched on and off manually. The switch should, of course, be rated for mains applications.

CONSTRUCTION

Because this circuit is mains powered, it is not suitable for beginners. If you are in any doubt about connecting it correctly, consult a qualified electrician.

The circuit is assembled on a small printed circuit board, whose layout and track details are shown in Fig.5. This board is available from the *EPE PCB Service*, code 235.

The p.c.b. should be assembled and checked carefully before making any connections to the mains supply – any mistakes could easily result in the instant destruction of your work and many of the components.

Construction should follow normal practice with low profile components such as resistors and diodes being mounted first before progressing to the taller devices such as capacitors. Note that capacitor C4 rests above resistors R7 and R8. A socket should be used for IC1.

There is one wire link on the board between IC1 and the terminal block – a short piece of component lead trimmed from a resistor will serve.

Take care to mount all polarity sensitive components such as diodes, electrolytic capacitors and semiconductors the right way around. Transistor TR1 may be almost any small signal *pnp* type, such as a BC212, BC327, 2N3702, ZTX500 etc., but make sure that the type chosen has the same lead configuration as the device specified (see Fig.5).

Phototransistor TR2 is housed in a clear 2-pin 5mm l.e.d.-type package with the base connection being omitted. The collector connection is the one adjacent to the flat portion on the rim of the package (as shown in Fig.5).

Other phototransistors could possibly be used, although this has not been tried. The one specified has the great advantage of being cheap and easy to mount in a panel as a standard l.e.d. clip can be used. Although it is shown mounted on the p.c.b., it will probably be best mounted in the side of the box and connected to the p.c.b. by flying leads.

POWER RATINGS

Two components worthy of special note are capacitor C4 and triac CSR1. Both of these ***must*** be rated for mains operation, which means that C4 should have a voltage rating of 250V a.c. and CSR1 a rating of at least 400V a.c.

Note that on many capacitors the voltage ratings usually refer to d.c. values and the breakdown voltage on a.c. supplies may be very much lower. A Class X device rated for connecting directly across the mains supply ***must*** be used for C4.

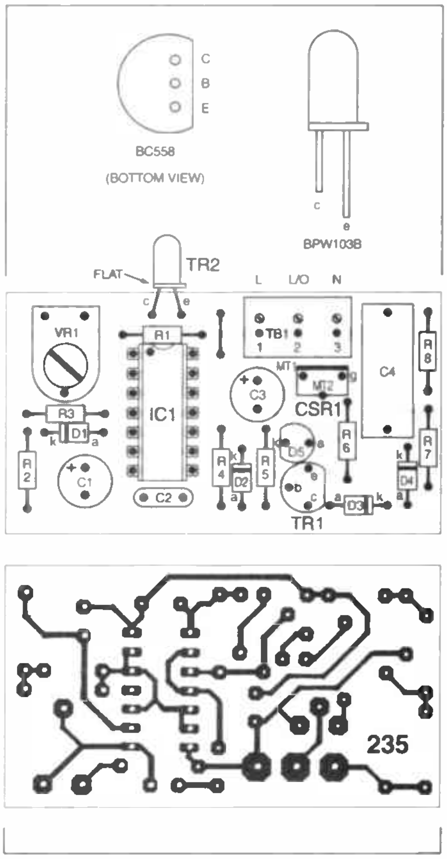
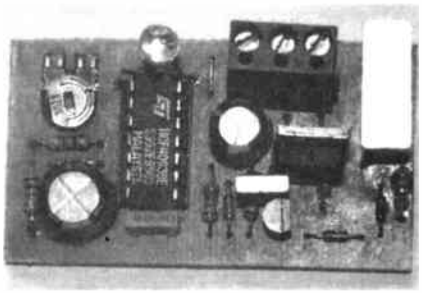


Fig.5. Component layout and full-size p.c.b. track details. Plus pin-outs for TR1 and TR2.



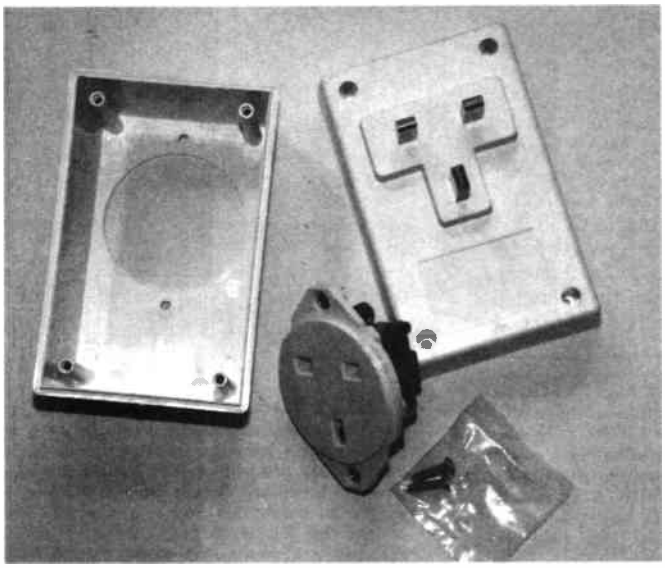
Because of the limited current which this kind of power supply circuit can provide, it is important to use a *sensitive-gate* triac to ensure that the device will trigger in all situations. The TIC206D specified has a maximum trigger current requirement of 5mA and any replacement should also have this value or less.

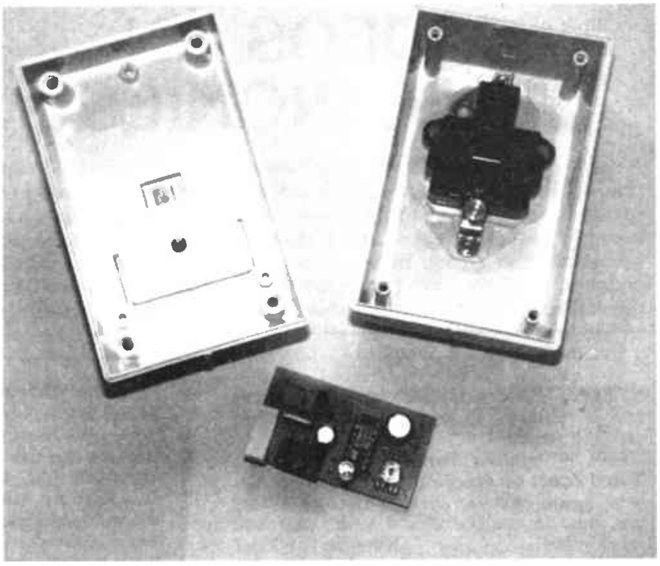
In practice, this will mean that devices with a load current rating of 3A or less will be suitable, limiting the maximum load power to 750 watts in the case of the device specified.

Even this can only be achieved with the device mounted on a suitably large heatsink and a more realistic maximum power of 200W to 300W should be respected if no heatsink is fitted. This should in any case be more than sufficient for the intended application where a 40W or 60W lamp will probably be used. No provision for a heatsink has been made on the p.c.b. or in the suggested plug-box.

VARIABLE TIMING

Variable resistor VR1 is specified as a preset component and determines the ambient light level at which the circuit will





Constituent parts of the specified plug-box (left) and (right) two halves of the box, with outlet socket fitted, together with the completed p.c.b.

begin to switch. There should not be any need to keep adjusting this, especially if the unit is always mounted in the same location, but it can be replaced by a panel mounted potentiometer of the same value if required.

If you decide to do this, choose a device with a *plastic* spindle and connect it to the p.c.b. with flying leads. As mentioned earlier, the On time is determined by capacitor C1 together with R2 and R3 while the Off time depends on the value of resistor R2.

As these times are not critical, other values for these components could also be used, although for realism the resulting times should be measured in minutes rather than seconds, and the Off time should be relatively short compared to the On time.

The nature of the circuit ensures that the On time will always be longer than the Off time (provided diode D1 is not reversed) and with the component values specified these will be around nine minutes on and almost two minutes off. Longer times may be achieved by making C1 and/or R2 and R3 larger.

There is little advantage in making these times variable but, again, panel mounted potentiometers (with suitable series resistors) could be used if required.

The relatively long time constants can make testing the circuit a bit of a chore and it is therefore recommended that, initially, the circuit is built with C1 equal to (say) 4·7μF and once circuit operation is proved the larger specified value can be substituted.

FIRST TESTS

With safety in mind, it is probably best to temporarily bypass capacitor C4 with a wire link and power the circuit from a 9V battery or a low voltage power supply by connecting the positive to terminal *L* and the negative to *N*. This part of the testing should be done before mounting the unit in its plug-box.

No load should be connected to the triac as the l.e.d. can be used to indicate the output status.

This approach will enable the circuit to be checked and set up at a low safe voltage before it is connected to the mains supply for a final check. **Remember to remove the C4 bypass link before mounting the unit in its box and connecting it to the mains.**

ENCLOSURE

The unit is intended for fitting into a plug-box which also has an integral mains outlet socket. Since the circuit requires both live and neutral mains connections, *it is not suitable as a replacement for a wall light switch*. If an alternative case is used it ***must*** be fully insulated and no metal parts i.e. p.c.b. fixings should pass through the case walls.

The interwiring between the p.c.b. and the plug-box is shown in Fig.6. Mains rated cable of an amperage suitable to the lamp being powered should be used.

The phototransistor can be mounted in the box by drilling a suitable hole and using a panel mounting l.e.d. clip. A suitable hole should also be cut for switch S1, positioned so that there is no danger of the switch touching the plug or socket terminals. Ensure that the switch is securely mounted. Note that no metal parts should pass through the case walls.

For safety, an in-line fuse (rated to suit the lamp used – e.g. 1A or 2A) should be included in the live lead if one is not already fitted in the mains plug.

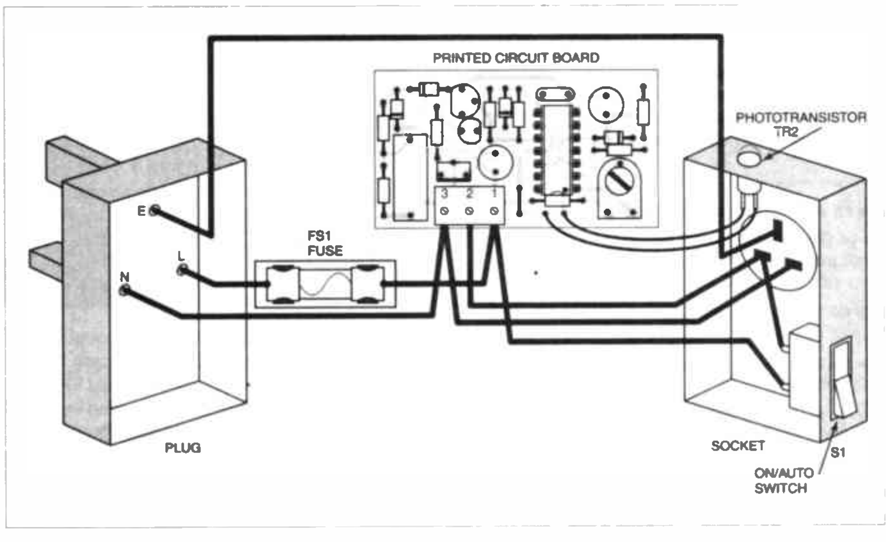


Fig.6. Details of interconnections between the p.c.b. and plug-in enclosure.

FINAL CHECKS

Remember that this circuit operates at mains potential. Check all connections carefully before switching on the supply and *do not touch any part of the circuit when it is on.*

Having satisfied yourself about the correctness of your complete assembly, plug the circuit into the mains. Using a *mains-insulated* screwdriver, adjust VR1 to set the level of brightness (or rather darkness) at which operation will start.

When IC1a output switches high in high ambient light conditions, as well as switching the light off, capacitor C1 will continue to charge to the supply rail. This means that the first On period following a reduction in the ambient light level will be much longer than normal, because C1 has to discharge from 100 per cent of the supply rail instead of 60 per cent of the supply as occurs on subsequent occasions.

IN USE

The unit can be positioned anywhere in the room (using a mains extension cable and connector if necessary), preferably facing a window and not shielded by furniture or other obstacles so that the light level outside can be sensed, although a darker location can be compensated for to a certain extent by suitably adjusting VR1. □

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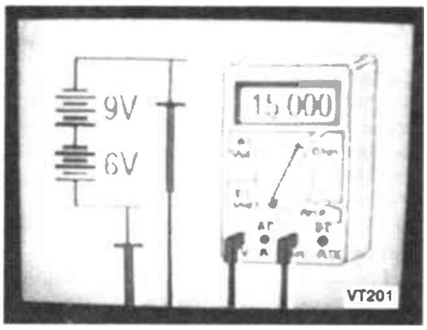

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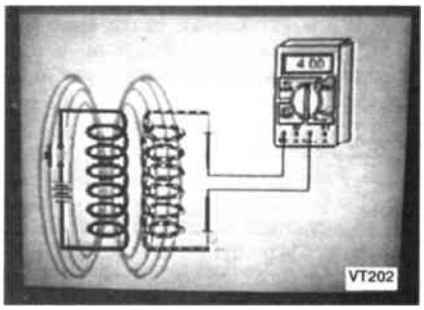

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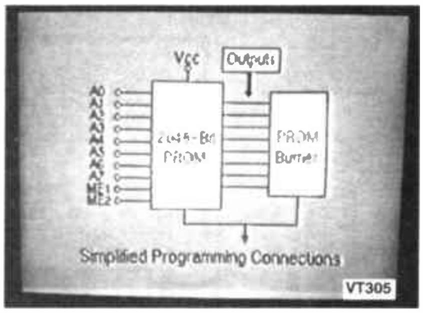

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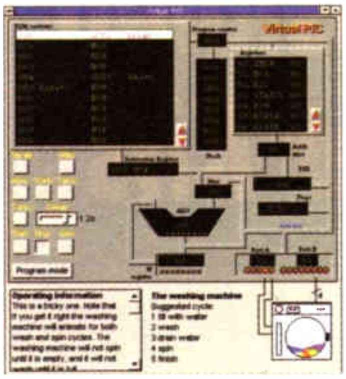

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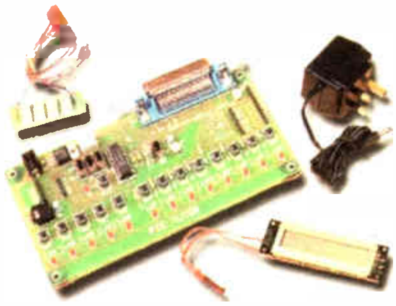

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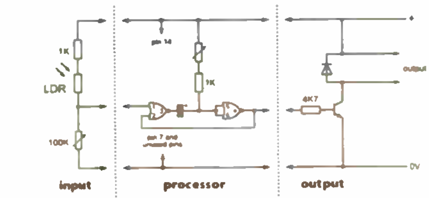

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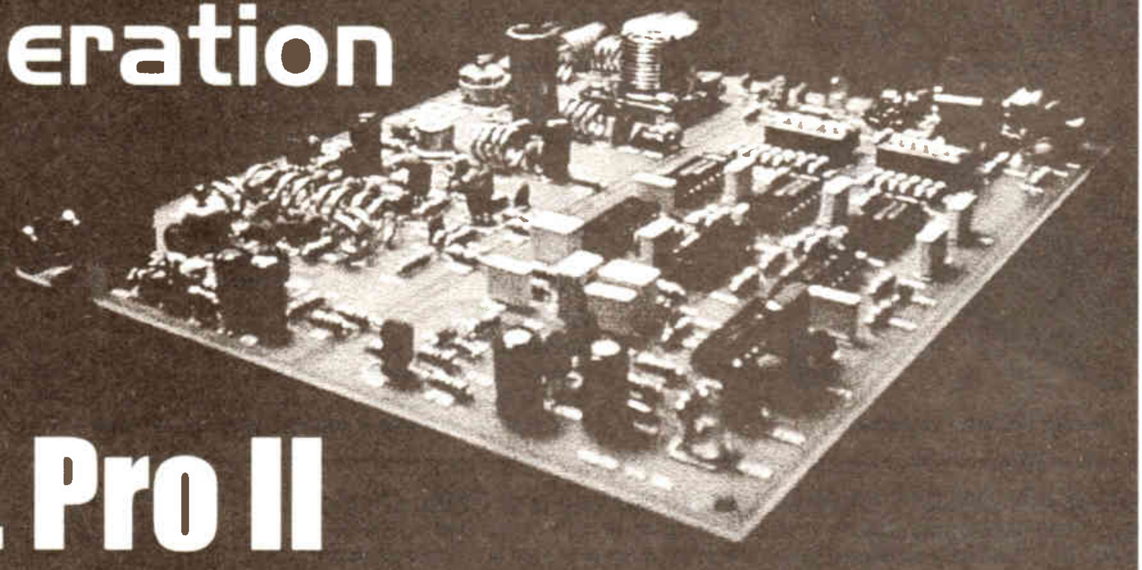

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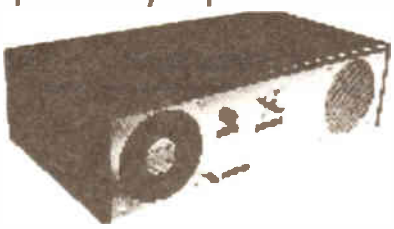

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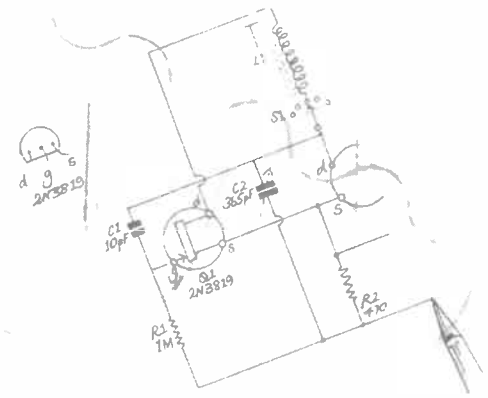

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Defining oscillators is one thing, classifying them is quite another. Some authorities place them in two categories: *feedback* or *negative resistance*. Whilst there are circuits which clearly depend on the phenomena of negative resistance, any oscillator can be analysed from either standpoint, and this approach can be confusing.

Another method of classification depends on whether the circuit action is of the *harmonic* or the *relaxation* type. Oscillators in the former category generate more or less sinusoidal waveforms, whilst those in the latter usually produce a square or sawtooth output. Harmonic and relaxation oscillators have fundamentally different circuits, and this leads us to a more useful method of classification.

All oscillators comprise two basic elements: a frequency determining section and an amplifier or negative resistance device which maintains the oscillations. The passive, frequency determining components are of three kinds: an inductor and capacitor forming a tuned circuit; a quartz crystal or ceramic resonator; or resistors and capacitors. In this series of articles, the various circuits will be considered under these three headings.

BRIEF HISTORY

The invention of the *triode valve* was crucial to the development of all three classes of oscillator, and most of the circuits in use today were developed during the valve era.

In 1906, Dr Lee de Forest produced the first electronic amplifying device by adding a control grid to Fleming's diode valve. Lee de Forest named his invention *The Audion*, and it was Eccles (of flip-flop fame) who subsequently called it a triode.

When attempts were made to use the new device for r.f. signal detection and amplification, its ability to maintain oscillations in a tuned circuit soon became apparent. The phenomena was exploited by Armstrong, de Forest, Meissner, and others, and, from 1913, several patents for valve oscillator circuits were filed both in Europe and America.

In 1924, after seven years of acrimonious litigation, control of oscillating valve patents in America was awarded, on a legal technicality, to de Forest. In Europe, patents were held by the German, Alexander Meissner, and an Englishman, Captain H. J. Round. It was during these early years that Colpitts, Franklin, Hartley and others devised their classic *LC* (inductance/capacitance) circuits which, together with later variants, have survived into the transistor age.

The *multivibrator*, a two-valve circuit in which resistors and capacitors fix the operating frequency, was first described by Abraham and Bloch in 1918. Gill and Morrel published details of their work on negative resistance oscillators in 1922. The following year, W. G. Cady demonstrated, to G. W. Pierce of Harvard University, the way in which a quartz crystal can determine the frequency of a valve oscillator. Within a few months, Pierce had developed his own circuits of this kind.

All of the basic oscillators we use today were, therefore, conceived within two decades of the invention of the triode valve.

VALVES AND TRANSISTORS

The gradual shift from valves to transistors during the sixties and seventies has not been without its drawbacks. Valves, for the most part, are fragile, microphonic, power-hungry devices which generate comparatively large amounts of heat. But, despite these failings, they have advantages over transistors, particularly when used as the maintaining device in an oscillator circuit.

Valves are highly linear, and their characteristics and inter-electrode capacitances do not vary much with changes in temperature and signal levels, or moderate shifts in supply voltage. The characteristics and internal capacitances of transistors, on the other hand, display significant variations. This can make biasing arrangements more complicated and frequency stability more difficult to achieve, despite the minimal heat generation.

The introduction of the field effect transistor (f.e.t.) with its high gate resistance and more valve-like characteristics made it easier to adapt the classic oscillator circuits. However, as frequency increases through v.h.f. and into u.h.f., the gate impedance of a f.e.t. reduces and it becomes more like its current-driven bipolar counterpart.

A limited range of valves is still retailed. Whilst some are suitable for use in oscillator circuits, they are fairly expensive and require high-voltage power supplies. Because of this, all of the circuits described in this series incorporate semiconductors as the active devices. Any reference to valves is in a purely historical context.

MAINTAINING OSCILLATION

The sudden application of a direct voltage to an *LC* tuned circuit initiates, or shock excites, oscillations. Because of resistive losses,

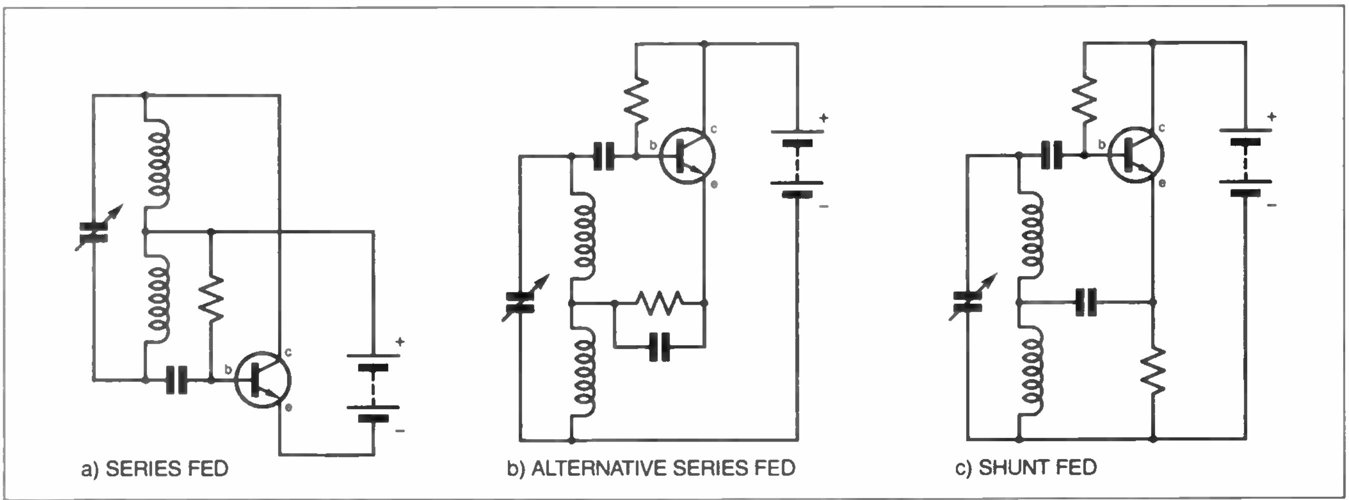


Fig. 1. Simplified circuits for series and shunt (parallel) fed Hartley oscillators: a) series fed; b) alternative series fed and c) shunt (parallel) fed. With series feed, power is supplied to the transistor via the feedback winding.

the oscillations 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 in such a way that energy is fed back in phase (i.e., by continuing the excitation). This positive feedback can be applied via an additional winding inductively coupled to the tuning coil (Armstrong, Meissner), or via a tapping on the coil itself (Hartley).

Sometimes the feedback is capacitively coupled (Butler, Colpitts, Franklin), and it can be a mixture of both (Reinartz). 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 which display negative resistance can also be used to maintain oscillation, despite the fact that they do not amplify. An electric arc, a neon lamp, the Esaki or tunnel diode, all have a characteristic which exhibits rising voltage with falling 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.

TUNED CIRCUITS

Before we begin to consider our first group of oscillators, those where a tuned circuit determines the operating frequency, a brief review of the relationship between inductance, capacitance and frequency may prove helpful.

A tuned circuit resonates at the frequency at which the reactances of the inductor (coil) and capacitor are equal. With increasing frequency, inductive reactance rises whilst capacitive reactance falls. Resonance at any particular frequency can, therefore, be achieved by a range of inductance and capacitance combinations; i.e. more L and less C, or more C and less L produces the same result. When parallel LC circuits are used in oscillators, it is desirable to keep the ratio of capacitance to inductance as high as possible, consistent with reliable operation.

Q-FACTOR

The performance of a tuned circuit is defined by a figure of merit known as the Q factor. High Q tuned circuits resonate sharply, and oscillators incorporating them produce a purer waveform with lower harmonic content. Moreover, less power has to be supplied by the maintaining device to keep the circuit oscillating, and this is conducive to reliable starting, stable operation and reduced drift.

The Q factor of most tuning capacitors is extremely high, and only the Q of the inductor need be considered. Values between 50 and 100 or more are usual. Unfortunately, some of the ways in which the Q of a coil can be increased have drawbacks as far as oscillators are concerned. More will be said of this later.

The oscillators illustrated all have parallel tuned circuits. With this arrangement, increasing the ratio of capacitance to inductance makes the Q of the circuit rise and its impedance, at resonance, fall. This last factor improves the matching to the transistor, thereby reducing damping, particularly when a bipolar device is used. Moreover, the large amount of tuning capacitance in circuit swamps the effect of small changes in the internal capacitances of the transistor and this can help to reduce drift.

Tuned Circuit Calculations

Table 1 and Table 2 (later) give details of coil and variable capacitor combinations which resonate over a 150kHz to 30MHz range.

Some experimenters will, of course, wish to design their own tuned circuits to resonate at particular spot frequencies, to cover different ranges, or to make use of components that are to hand. The basic formula relating frequency to inductance and capacitance is:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where f is in Hertz, L is in Henries, and C is in Farads. Inserting the value of π:

$$f = \frac{0{\cdot}159}{\sqrt{LC}} \quad L = \frac{0{\cdot}025}{f^2C} \quad \text{and} \quad C = \frac{0{\cdot}025}{f^2L}$$

Henries and Farads are unwieldy for our purpose, and the formula is more conveniently expressed in smaller units. Accordingly, when f is in kHz, L is in mH and C is in μF:

$$f = \frac{159{\cdot}155}{\sqrt{LC}} \quad L = \frac{25{\cdot}33}{f^2C} \quad C = \frac{25{\cdot}33}{f^2L}$$

and when f is in MHz, L is in μH and C is in pF:

$$f = \frac{159155}{\sqrt{LC}} \quad L = \frac{25330}{f^2C} \quad C = \frac{25330}{f^2L}$$

Capacitance should be as high as possible consistent with satisfactory circuit operation. As a rough guide, assume the following tuning capacitances when calculating the inductance required for a particular spot frequency:

FOR FREQUENCIES IN THE REGION OF	VALUE OF C
100 Hz	0·47 μF
1 kHz	0·1 μF
20 kHz	0·01 μF
100 kHz	4700 pF
1 MHz	1000 pF
10 MHz	470 pF
20 MHz	220 pF

Inductors for frequencies lower than 50kHz are best wound on ferrite pot cores. This ensures a high Q factor, and a known inductance value per turn simplifies coil design. Resistor and capacitor (*RC*) tuned oscillators are generally more suitable for these lower frequency ranges, and they will be covered later in the series.

The tapping point for the Hartley oscillator can range from 10 per cent to 50 per cent of the total number of turns on the tuning coil. The usual figure is 20 per cent to 25 per cent, and this should always be adopted as a starting point when hand-winding coils. Increasing the percentage increases the signal available at the tapping point, and the quoted r.m.s. output voltages assume the use of the specified coils.

Fixed tuning capacitors should have a polystyrene, mica, or, for the larger values, Mylar film dielectric. High value ceramic capacitors have a comparatively low Q, and this can inhibit oscillation.

HARTLEY OSCILLATOR

Separate feedback windings are not required with the Hartley oscillator, and this simplifies coil construction and band switching when several frequency ranges have to be covered. Because the maintaining amplifier is so effectively coupled to the tuned circuit, the arrangement oscillates readily and is very easy to get working and to adapt for a variety of purposes. The output can be made reasonably constant over a wide frequency range, and waveform purity is good enough for most radio receiver and signal generator applications.

With these advantages in mind, the Hartley oscillator, and its Lampkin and Dow variants, will be the first to be discussed.

SERIES AND SHUNT POWER FEEDS

The Hartley circuit (and others for that matter) can be arranged in either series or shunt fed modes. Simplified circuit diagrams depicting the alternatives are given in Fig.1.

Series feeds, so called because the transistor and the feedback winding are connected in series across the power supply, are depicted in Fig.1a and Fig.1b. The shunt (parallel) fed, arrangement, with the power supply connected across the active device, is given in Fig.1c.

Versions Fig.1b and Fig.1c enable the moving vanes of a variable capacitor to be connected to the negative supply rail. These are, therefore, usually the preferred options when continuously variable tuning is desired.

SPOT FREQUENCY OSCILLATOR

A bipolar transistor version of the series fed Hartley circuit is illustrated in Fig.2. It thrives on a high ratio of capacitance in the tuned circuit. Indeed, above 15MHz or so it becomes reluctant to oscillate unless the "tuning" capacitor C3 has a value of 100pF or more. (Reducing the capacitance in a parallel tuned circuit lowers Q and increases impedance at resonance. The latter makes the mismatch with the bipolar transistor even worse, and oscillation becomes less reliable as the active device is operated closer to its f_T).

Turning to the circuit diagram of Fig.2, capacitor C2 is a d.c. blocking capacitor which couples the base of transistor TR1 to the tuned circuit formed by coil L1 and capacitor C3. The coil and capacitor combination shown can be adjusted to resonate at 100kHz. Note that the tapping is located towards the end of the coil furthest from the collector (c) of the transistor.

Resistor R1 and preset potentiometer VR1 are base (b) bias components, and preset VR2 sets the bias voltage on the emitter (e). They enable the biasing to be optimised for the best waveform.

The preferred signal take-off point is the transistor base end of the tuned circuit, as this minimises damping. An output taken from this point can be fed into impedances as low as 4 kilohms. (The specified coil is tapped at less than 20 per cent of the total turns: larger tapping percentages will require a higher load impedance).

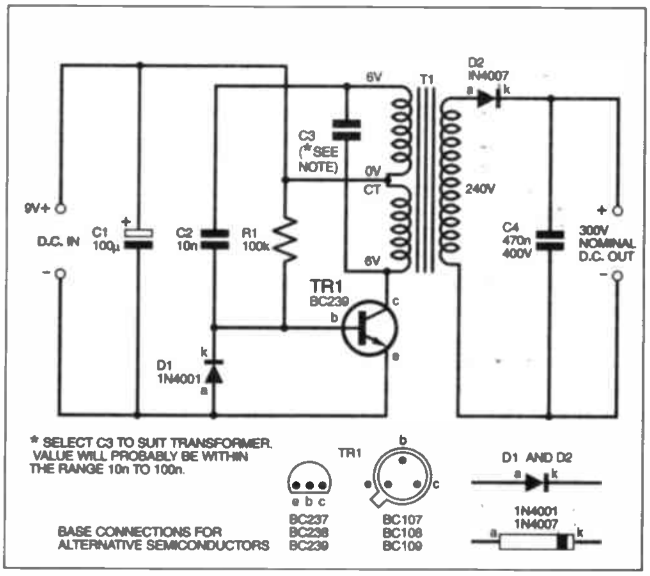


Fig.3. Circuit diagram for a simple DC-to-DC Converter using a series fed Hartley oscillator.

This version of the Hartley circuit oscillates so vigorously that the signal can also be extracted from the "hot", or collector end of the coil. The voltage developed here is greater, but it has to be fed into an impedance of 470 kilohms or more or the circuit may stop oscillating.

Capacitor C1 decouples the power supply. At low frequencies (10kHz down) a 100μF electrolytic may have to be substituted for this component, and C2 should be increased to 100nF.

At 1MHz and below, the circuit is sufficiently drift-free for spot frequencies or markers (at, say, 10kHz, 100kHz and 1MHz), and their harmonics, to be used for receiver calibration purposes. Although not as stable as a crystal oscillator, *LC* instruments of this kind can produce sufficiently accurate dial calibrations for most purposes. The markers must, of course, be set to zero beat with a known standard, or set with a frequency counter.

SIMPLE DC-TO-DC CONVERTER

DC-to-DC converters require an oscillator of some kind to enable the voltage transformation to be effected. An example of the series fed Hartley circuit being used in this way is given in Fig.3. No claims can be made for the conversion efficiency of the circuit, but it does have the advantage of great simplicity. There can be few experimenters who couldn't assemble it from their spares boxes.

Basic Series Fed Hartley Oscillators

Two examples of the basic series fed circuit are given in Fig.2 and Fig.3.

The arrangement shown in Fig.2 works reliably from below 100Hz to more than 10MHz. Above 15MHz, tuning capacitors have to be at least 100pF or the circuit displays a reluctance to oscillate. Above 20MHz or so, operation can become erratic.

Neither end of the tuned circuit is connected to ground, and this makes the arrangement unsuitable for continuously variable tuning. It is, however, useful for generating spot, or marker, frequencies, and the sinewave output is of good purity. Provided impedance limitations are observed, this oscillator will deliver an output in the region of 4V r.m.s. when connected to a 9V supply.

How the series fed circuit can be used as the basis of a simple DC-to-DC Converter is shown in Fig.3. The iron-cored inductor T1 with its 50 per cent tapping point results in a waveform which is a series of spiky pulses. Frequency of oscillation ranges between 3kHz and 6kHz or more, depending on the output current drawn.

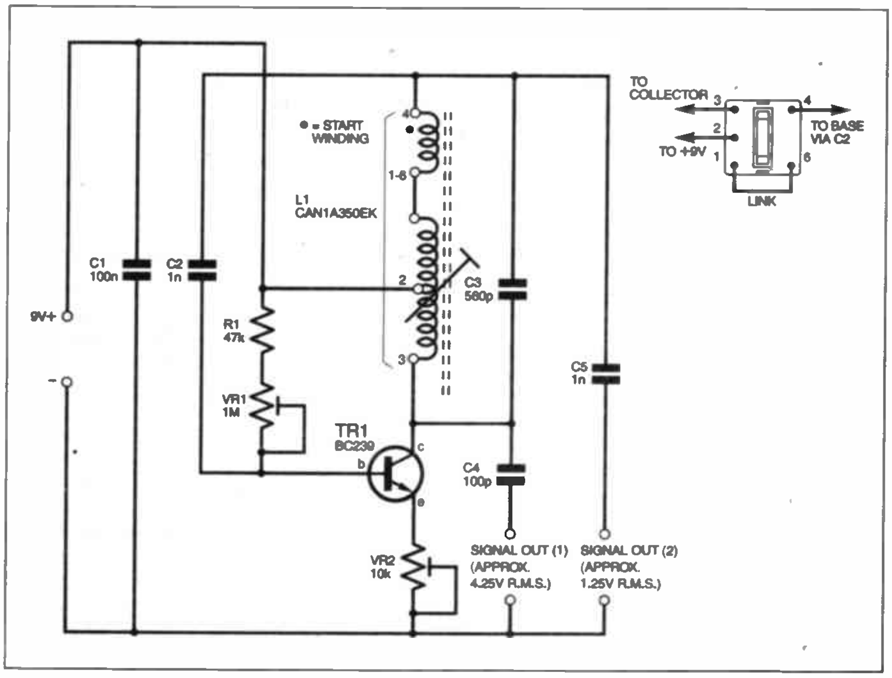


Fig.2. Circuit diagram for a series fed Hartley for generating spot or marker frequencies between 100Hz and 10MHz. The LC combination shown can be set to 100kHz (see Fig.3. for alternative transistors).

The low voltage winding (secondary) of a miniature mains transformer is used as the inductor in a tuned circuit brought to resonance by capacitor C3. Positive feedback, applied via the centre tap (CT) makes the circuit oscillate, and a voltage increase is achieved by the step-up ratio of the transformer (primary winding). In this form, the circuit generates a chain of spiky pulses, and the frequency of oscillation ranges from around 3kHz to 6kHz depending on the loading. (D.C. output current flows through the transformer mains winding. As current flow rises, tuned circuit inductance falls, and frequency of oscillation increases.)

Blocking capacitor C2 couples the base of the transistor TR1 into the feedback circuit, and bias is applied by resistor R1. Diode D1 limits the negative going voltage swings on the base of TR1 and greatly increases the voltage delivered by the circuit. Diode D2 and capacitor C4 rectify and smooth the output and C1 is the d.c. supply decoupling capacitor.

Tuning capacitor, C3, needs to be selected for optimum performance. Its value depends on the actual transformer used, but will almost certainly lie within the range 10nF to 100nF.

Miniature mains transformers appear to give the best results. With a 9V supply and a 6V-0V-6V transformer, around 300V will be developed across capacitor C4. This can give a very unpleasant shock, and the unit should be handled with care. Try reversing the connections to the transformer mains winding if the output voltage seems low (there is an optimum way of feeding the spiky pulses to the rectifier).

Output voltage falls rapidly when currents in excess of a few tens of microamps (μA) are drawn, making the unit safe to handle despite the high voltage. With an output current of 0·5mA the voltage falls to around 100V and the current drawn from a 9V supply is approximately 20mA. Oscillation is maintained with d.c. inputs down to 3V or less, but output is, of course, correspondingly reduced. If starting becomes uncertain at very low supply voltages, reduce resistor R1 to about 22 kilohms.

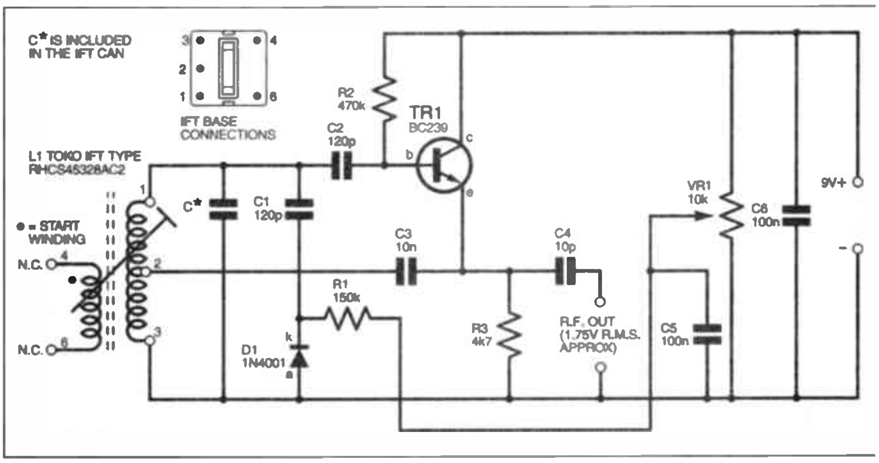


Fig.4. Circuit for an add-on B.F.O. Unit using a parallel (shunt) fed Hartley oscillator (see Fig.3 for alternative transistors).

B.F.O. UNIT

An add-on beat frequency oscillator (b.f.o.) will make carrier wave (Morse) and amateur single-sideband (SSB) transmissions audible on a domestic shortwave radio. The circuit diagram of Fig.4 shows how a shunt fed Hartley oscillator can be used in this way.

Inductor coil L1 is a miniature 450kHz to 470kHz i.f. transformer, coupled to the base of transistor TR1 by capacitor C2. Feedback is taken from TR1 emitter (e), via d.c. blocking capacitor C3, to a tapping on the tuned winding. Resistors R2 and R3 bias the transistor, and C6 bypasses the power supply.

The unit functions by injecting an r.f. signal into the receiver at its i.f. frequency. This beats with Morse to produce an audible tone, or reinstates the missing carrier in SSB transmissions so that the set's diode detector can make them intelligible.

The injected signal has to be tuned across the receiver's i.f. passband. This is achieved by exploiting the "varicap" action of a reverse biased rectifier diode, D1. Potentiometer VR1 functions as the tuning control by varying the reverse bias. Capacitor C1 couples D1 across the tuned circuit, R1 acts as an r.f. blocker, and C5 eliminates potentiometer noise. Signal output is taken from TR1 emitter via capacitor C4.

TUNING-IN

Use a short length of wire to couple the b.f.o. unit to the receiver. Place it near the set, wrap it around the rod aerial, or even connect it to it: experiment to find out which arrangement gives the best results.

Tune in a steady signal on the receiver, set control VR1 to mid-travel, and adjust the ferrite core (slug) of coil L1 until a strong whistle is heard from the receiver's speaker, gradually fading to a slow fluttering as zero beat is achieved. Tunc the receiver to one of the amateur bands (7MHz or 14MHz).

If the band is active (sometimes they are completely dead), careful adjustment of VR1, which acts as a fine tuning control, should clarify the amateur SSB transmissions. Try connecting an extra 3m or 4m of wire to the set's rod aerial to improve reception. Although inexpensive and easy to construct, the unit will enable a domestic portable to produce results comparable to those achieved by some of the simpler amateur-bands receiver designs.

Almost any 450kHz to 470kHz transistor radio i.f. transformer will work in this circuit. If a salvaged item is available, use an ohmmeter to determine the lower resistance portion of the tapped tuned winding, and connect this to the negative rail.

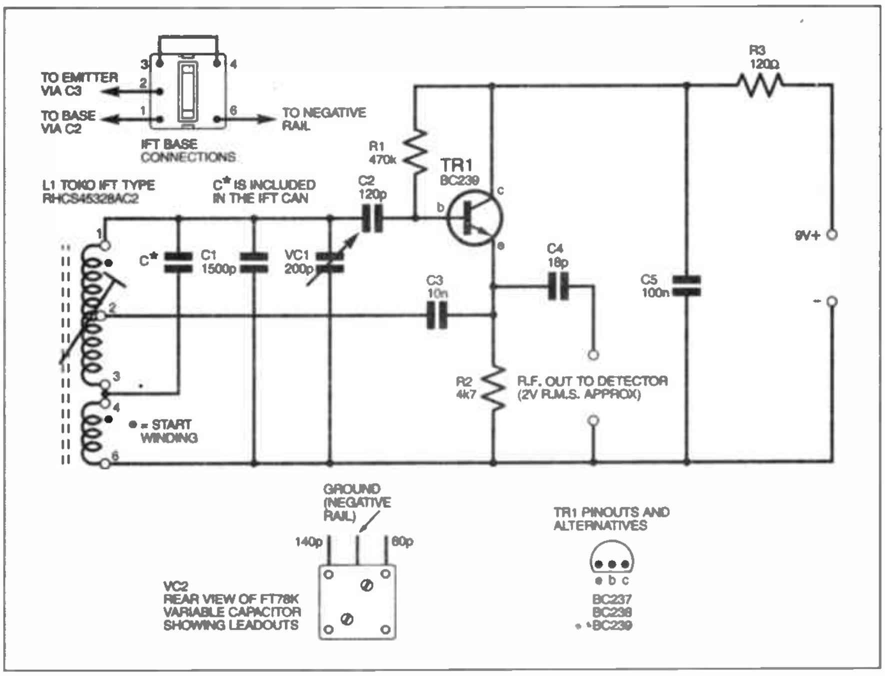
Shunt Fed Hartley Oscillators

Circuit diagrams Fig.4 and Fig.5 show how a shunt fed Hartley circuit can be used as a b.f.o. (beat frequency oscillator) unit for radio receivers, and to form a simple metal detector. The arrangement works well between 10kHz and 1·5MHz, and a good sine wave is produced.

Operation becomes uncertain when the tuning capacitance is reduced below 100pF, and also at frequencies above 1·5MHz or 2MHz. If a wide operating range is required, the series fed circuits illustrated in Fig.6 and Fig.7 are more suitable.

The signal voltage available at the tapping point (see S1b in Fig.6) is dependant upon the tapping ratio. With the specified inductors, it is approximately 2V r.m.s.

Oscillation may cease if the value of the capacitor which couples the transistor emitter to the coil tap is reduced. Together with the emitter resistor, this component forms a potential divider in the feedback path.



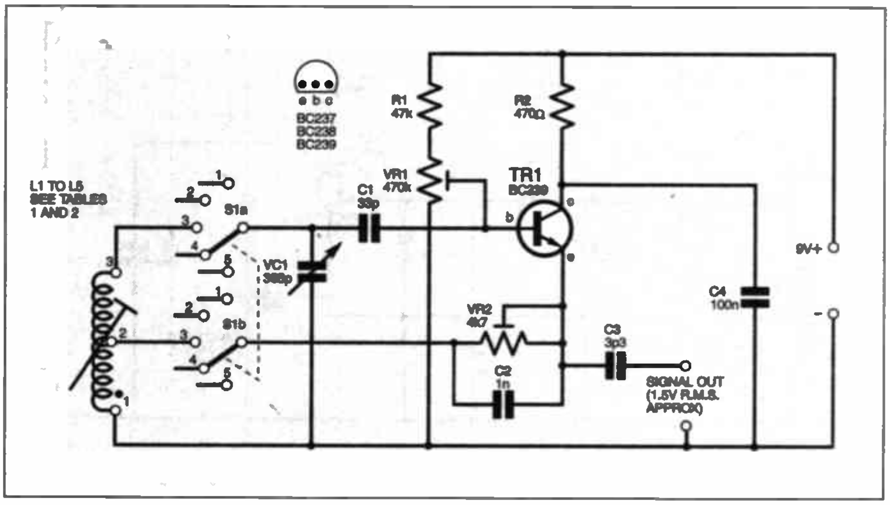


Fig.6. Circuit diagram for an r.f. oscillator, covering 150kHz to 30MHz, using a bipolar transistor series fed Hartley oscillator. See Tables 1 and 2 for suitable coils.

METAL DETECTOR

Simple metal detectors work on the beat frequency principle. An oscillator, tuned by a search coil, is kept close to zero beat with a second oscillator located within the instrument.

When the search coil is brought near to metal its inductance changes and the frequency of oscillation shifts (lower for ferrous metals, higher for non-ferrous). This results in an audible change in the beat note. The extent of the change depends on the proximity and size of the metal object. Fig.5 shows how a shunt fed Hartley circuit can be used for both the search head and the beat frequency oscillator.

Under current UK legislation, the maximum operating frequency of equipment of this kind is 148·5kHz. In order to tune to this frequency, all of the windings of a 450kHz to 470kHz i.f. transformer, L1, are connected in series to increase the inductance, and additional capacitors C1 and VC1, are wired across it. These measures lower the resonant frequency to around 120kHz.

Capacitors C2 and C3 couple transistor TR1 to the tuned circuit. Resistors R1 and R2 set bias levels, capacitor C5 and resistor R3 decouple the circuit from the power supply, and the r.f. output is taken from TR1 emitter via C4.

The frequency of the beat oscillator has to be kept within a kilohertz or so of the frequency of the search oscillator in order to produce a clearly audible tone. The actual terrain over which the search coil is moved (wood floors, dry concrete, wet grass, wet sand, etc.) affects the frequency of the search oscillator. To accommodate this, variable capacitor VC1 is brought out as a panel control so that the beat oscillator can be set close to it under all conditions of use.

ALMOST IDENTICAL

The circuits of the two oscillators are virtually identical. The only differences being the omission of variable capacitor VC1 from the search coil circuit, and its larger, hand-wound inductor, which is detailed in Fig.5b.

How signals from the two oscillators are combined, in a simple product detector, to obtain an audible tone is shown in Fig.5c. Capacitor C4 should have the lowest possible value, consistent with an adequate output, so as to inhibit locking. Any small audio amplifier i.c. will be suitable: the TBA820M, the TDA7052, or, if headphone listening is acceptable, just a couple of transistors.

Although the arrangement is extremely simple it does work quite well. Indeed, a much greater degree of complexity is required before any real improvement in sensitivity is obtained.

CONTINUOUSLY VARIABLE TUNING

A bipolar transistor version of a series fed Hartley oscillator is given in Fig.6. Switched inductors, L1 to L5, tuned by a 10pF to 365pF air-spaced variable capacitor, VC1, cover the frequency ranges quoted in Table 1 and Table 2.

Maintaining oscillation over the full swing of a 365pF tuning capacitor becomes more difficult as frequency rises through the h.f. region. Also, biasing becomes more critical and more specific to individual transistors. Accordingly, preset potentiometers VR1 and VR2 are used so that the voltages can be optimised.

Capacitor C1 couples the tuned circuit to the base of transistor TR1. Feedback is via emitter preset resistor VR2 and its bypass capacitor C2. Resistor R2 and C4 decouple the unit from the power supply. The r.f. output signal is taken from TR1 emitter, via C3. This capacitor should have the lowest possible value in order to minimise loading on the oscillator.

Almost any *npn* small-signal transistor will work in this circuit provided its f_T is high enough: r.f. types are not necessary. In this connection, it is worth noting that most transistors will oscillate close up to their f_T if the associated tuned circuit has a reasonable *Q* factor.

Set preset potentiometers VR1 and VR2 to half travel and get the circuit working on medium waves before proceeding to the h.f. ranges. Adjustment of the presets is not particularly critical, and it should be possible to set them so that the circuit operates reliably from 150kHz to above 30MHz, and over the full tuning capacitor swing on the highest range. If desired, the resistance in-circuit can be measured after setting up and the potentiometers replaced by fixed resistors of the nearest standard value.

Continuous Tuning

Circuit diagrams Fig.6 and Fig.7 depict bipolar and field effect transistor versions of Hartley oscillators which can be continuously tuned over a wide frequency range; i.e., from 150kHz to 30MHz. Coil switching arrangements are simple, and the circuits can be used as the local oscillators in radio receivers, or as the basis of a signal generator. With appropriate inductor and capacitor combinations, the circuits will oscillate down to 100Hz.

Signal output from the bipolar version is greater (approximately 1·5V as opposed to 0·5V r.m.s.), but the biasing arrangements are more complicated and some setting up is required. The higher signal output may be an advantage in some applications, but, with the f.e.t. design (Fig.7), frequency drift is slightly lower, and output more constant over the tuning capacitor swing, and this could make it the preferred version for more demanding situations.

When h.f. (high frequency) coverage is limited to a narrow band (e.g., an amateur band), or when the frequency of oscillation is much above 30MHz, there are more appropriate circuits, which will be described later in the series.

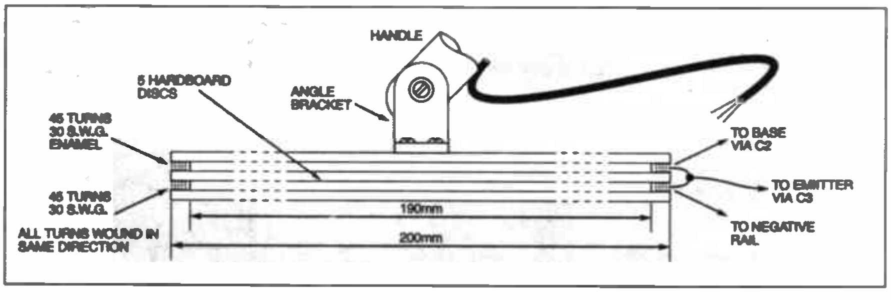


Fig.5b Metal detector search head coil details.

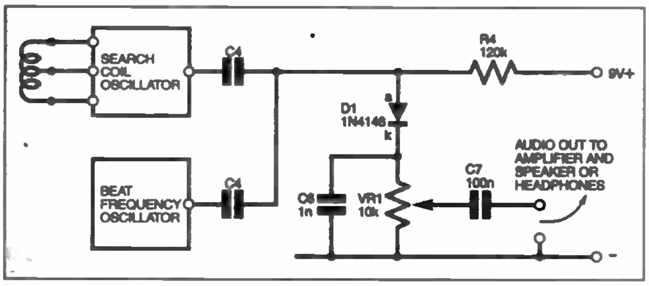


Fig.5a (left). Circuit diagram for search head oscillator and b.f.o. for a simple metal detector.

Fig.5c. Connection of oscillators to product detector circuit.

MULTI-BAND USING A F.E.T.

An alternative r.f. oscillator circuit using a field effect transistor (f.e.t.) is given in Fig.7. Biasing arrangements are much simpler, but diode D1 has to be provided to limit oscillation amplitude and prevent forward conduction of the j.f.e.t.'s gate.

Limiting the amplitude also improves waveform and makes the output more constant over the tuning capacitor (VC1) swing and across the switched ranges (S1). It can also result in some small reduction in frequency drift. Connecting two or three diodes in series fixes different thresholds for the limiting, and the oscillator output increases by roughly 0·2V per additional diode in the chain.

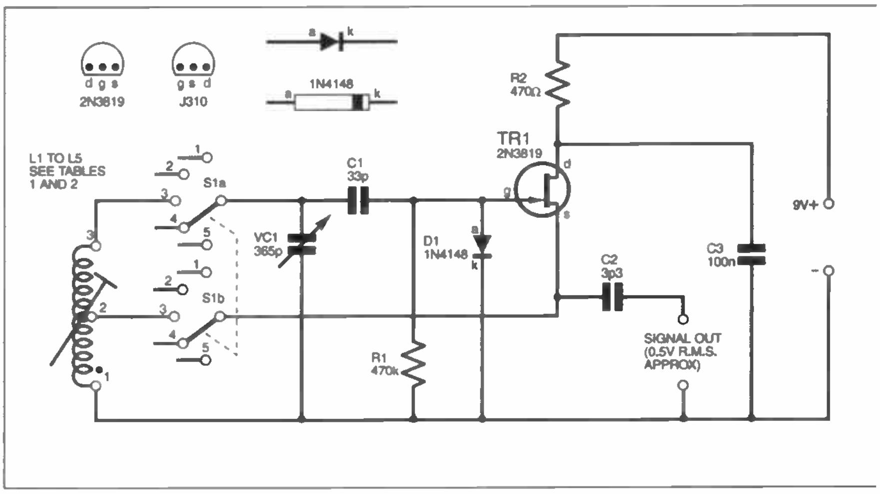


Fig.7. Hartley circuit using a field-effect transistor (f.e.t.) to produce a r.f. oscillator, covering 150kHz to 30MHz. See Tables 1 and 2 for suitable coils.

TUNING COILS

Details of the frequency coverage obtained with a 10pF to 365pF variable capacitor and hand-wound coils are given in Table 1. The coverage with inductors manufactured by Toko is set out in Table 2.

Short lengths of 20mm diameter plastic conduit are used as formers for the hand-wound coils, and the higher inductances have to be pile wound in order to reduce self-capacitance. The piles are best wound between the cheeks of 4mm wide card bobbins after they have been slid onto the former and spaced by 3mm or so.

Glue the bobbin cheeks and sleeves with Durofix or a similar quick-setting adhesive, and cut slots in the cheeks for the entry and exit of the wires. A variety of tappings and coupling windings can be provided on coils produced in this way, and this greatly facilitates experiment with the various circuits.

Table 1: Air-cored coils, hand-wound on 20mm OD formers
(Frequency coverage with a 10pF to 365pF tuning capacitor)

Range	Number Or Turns	S.W.G.	Frequency at max 'cap' MHz	Frequency at min 'cap' MHz
1	400 in 4 piles of 100 turns	36	0·15	0·54
2	120 in 4 piles of 30 turns	28	0·47	1·8
3	70 turns, close wound	28	1·13	4·85
4	30 turns, close wound	24	2·1	9·2
5	8 turns, spaced	24	7	30

Wire gauge not critical: see text for details of construction.

MAKING A POINT

The feedback tapping point for the Hartley oscillator can range from 10 to 50 per cent of the total turns, measured up from the "earthy" or "cold" end of the coil. Increasing the number of turns increases the feedback and the r.f. output voltage available at the emitter (e) or source (s) of the transistor. Up to 20 to 25 per cent is the conventional tapping point, and it should be adopted, at least for initial trials, with the multi-range circuits.

Not all constructors have the time or inclination to hand-wind coils, and Table 2 gives details of suitable components from the Toko range. Different connections can be made to the windings and tapping point in order to optimise results, and these are detailed in Fig.8. Adjustable ferrite cores, within the formers, permit inductance variation, and the frequency ranges quoted in the table can be shifted over fairly wide limits.

When several of the hand-wound inductors are mounted close to one another (within 100mm or so), provision *must* be made to short out the ones not in use. If this is not done, out-of-circuit coils, brought to resonance by stray and their own self capacitance, can absorb energy from the oscillating circuit and cause dead spots. The problem is invariably caused by the coil of higher inductance and next in range to the one in circuit. This problem does not arise with Toko coils, as they usually have a very effective screening "can".

Table 2: Toko, screened, ferrite-cored coils
(Frequency coverage with a 10pF to 365pF variable capacitor

Range	Toko coil type No.	Base connection	Frequency at max 'cap' MHz	Frequency at min 'cap' MHz
1	CAN1A350EK	B	0·15	0·54
2	RWR331208N2	B	0·45	1·8
3	154FN8A6438EK	A	1·4	6
4	154FN8A6439EK	A	4	17
5	KXNK3767EK	A	7	30

See Fig.8 for alternative base connection details. Range 1 and Range 2 coil windings series connected to increase tapping ratio.

COMPONENTS

Resistors can be 0·25W, 5% tolerance types. Fixed capacitors used in tuned circuits must have polystyrene, mica, or, for the larger values, Mylar film dielectrics. Other fixed capacitors can be ceramic types, or electrolytics for the high values.

Toko coils and i.f. transformers can be obtained from:

Bonex, Ltd., 12, Elder Way, Langley Business Park, Slough, Berkshire, SL3 6EP. Tel:0753 549502

Cirkit Distribution, Ltd., Park Lane, Broxbourne, Herts, EN10 7NQ. Tel: 01992 441306

JAB Electronic Components, PO Box 5774, Great Barr, Birmingham, B44 8PJ. Tel: 0121 682 7045

The polythene dielectric "Varicon" tuning capacitor for the Metal Detector circuit is listed by many of our components advertisers. They also list the Jackson 365pF air-spaced tuning capacitors.

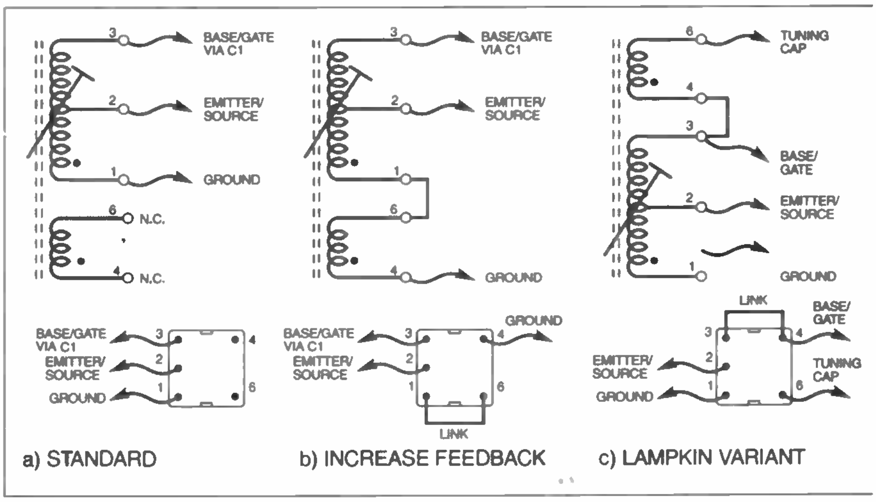


Fig.8. Toko coil connection details for wide range Hartley oscillators.

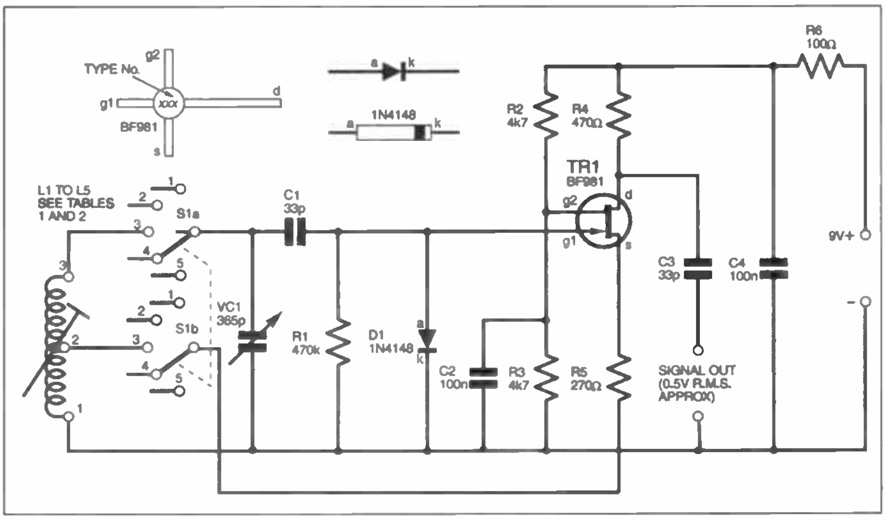


Fig.9. Dow variant of Hartley circuit using a dual-gate MOSFET to produce an r.f. oscillator covering 150kHz to 30MHz. See Tables 1 and 2 for suitable coils.

Lampkin and Dow Variants

Drift becomes a problem as the operating frequency increases through the h.f. spectrum. How the base or gate of a transistor can be tapped down the coil to form the drift-reducing Lampkin variant is shown in Fig.8c.

How a dual-gate MOSFET can be used to simulate Dow's modification, in which the signal take-off point is isolated from the oscillator, is shown in Fig.9. Signal output is not greatly affected by these measures, but drift is reduced and the waveform can be improved.

Experimenters who wish to use the circuits as local oscillators in general coverage receivers will, of course, have to switch appropriate oscillator coils and padder capacitors into circuit to ensure correct tracking with the set's r.f. stages. Full details of these arrangements, for 450kHz and 1600kHz i.f.s, will be given in a later article.

TUNING CAPACITORS

The tabulated frequency coverage is based on the use of a Jackson 10pF to 365pF air-spaced variable capacitor, as these are retailed by a number of suppliers. Other capacitors can, of course, be used, and different swings will affect the coverage achieved.

Polyvaricons, or polythene dielectric variable capacitors, can be substituted, but there will be some deterioration in frequency stability and performance. (The measured Q of a tuned circuit incorporating a polyvaricon is approximately 10 per cent lower than one with an air-spaced component.)

LAMPKIN OSCILLATOR

Bipolar transistors have a low base impedance, and a better match can be obtained, with the tuned circuit, if the base connection is tapped down the inductor coil. When the Hartley circuit is modified in this way it is known as a Lampkin oscillator. Coil switching is more complex but, in more demanding situations, the modification is worthwhile.

The optimum tapping point for the base is best determined by trial and error, but it should be as close as possible to the "earthy" (ground) end of the coil consistent with reliable operation.

The windings of Toko coils can be arranged to give a base or gate tapping point, and the necessary connections are given in Fig.8c. Although the turns ratios are far from optimum for bipolar transistors, it is still an improvement worth making if the complication of an extra switch bank can be tolerated.

Tapping the gate terminal down the coil will also benefit f.e.t. maintained circuits, especially at higher operating frequencies, where the reduction in drift should be noticeable. Tapping the base or gate down the coil reduces damping on the tuned circuit and enhances its operational Q.

OUTPUT LOADING

Extracting the signal from the oscillators described so far loads the tuned circuit and reduces its Q. Too much loading can inhibit oscillation, especially at extreme settings of the tuning capacitor.

It also brings with it other disadvantages associated with a reduced Q factor, namely uncertain starting, erratic operation and increased drift. This is why the value of the output coupling capacitor has to be as low as possible and the impedance of the accepting circuit kept high.

Extracting energy via an isolating buffer amplifier overcomes these problems. There is also a Hartley variant which provides a measure of isolation without recourse to a buffer stage.

DOW OSCILLATOR

Known as electron coupling, J. B. Dow's circuit modification can be applied to the Hartley oscillator. Published in 1931, the development involves extracting the r.f. voltage from the anode of a pentode or tetrode valve, when the oscillating circuit is formed by the cathode, control grid and screen grid.

In this way, the output port (the anode) is isolated from the oscillating circuit, the only coupling being via the flow of electrons through the valve, hence the name. This arrangement eliminates the loading on the tuned circuit caused by the extraction of energy at the feedback tapping, or via a coupling coil.

A dual-gate MOSFET can be used to simulate this type of oscillator, and the circuit is given in Fig.9. The potential divider network formed by resistors R2 and R3 holds gate g2 at half the supply voltage, and the r.f. output is developed across drain load resistor, R4. Resistor R6 and capacitor C4 decouple the circuit from the power supply, and C2 grounds gate g2 at r.f.

The value of the unbypassed source resistor R5 should be increased if the oscillator behaves erratically. This usually manifests itself as a tendency to frequency double, especially on the higher ranges and at low tuning capacitor settings. The value quoted should prove satisfactory with the Toko coils listed in Table 2.

Whilst the degree of isolation afforded by the structure of a solid-state device is not likely to equal that provided by an evacuated valve, there is less drift at high frequencies with this arrangement. Combining Dow's output isolation with Lampkin's reduced tuned circuit loading should produce further improvements in this area.

FREQUENCY DRIFT

Drift in LC oscillators becomes an increasing problem above 5MHz, and a high degree of frequency stability is almost impossible to achieve, without recourse to complex circuitry, above 10MHz. The benefits afforded by the Dow and Lampkin variants will not be fully realised unless care is taken with the choice of components and the actual construction of the oscillator.

Drift reducing measures of this kind will be described in **next month's issue**, which will also cover the construction of a buffer amplifier, and the Colpitts oscillator and its variants.

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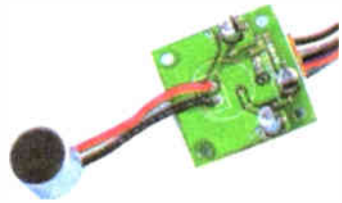

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PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

BUILDING component panels, whether using a custom printed circuit board (p.c.b.) or some form of proprietary board such as stripboard, is not generally too difficult for the beginner. You have to be careful to get the semiconductors and electrolytic capacitors the right way round, and with stripboard you also have the take due care to get the components placed in the right sets of holes.

Accidental short circuits on the undersides of boards can also be a problem, but provided you follow the published plans precisely and thoroughly check the finished board against the circuit and wiring diagrams there will probably be no problems.

Making Connections

The wiring to sockets, controls, etc. can also be perfectly straightforward, but there is probably more scope for confusion to creep in with this aspect of construction. Making the connections is quite easy, and it is just a matter of hooking the end of the leadout wire through and around the hole in the tag, applying the bit of the soldering iron, and then feeding in some solder.

As always, make sure you apply the bit to the joint first and the solder second. This heats up the tag and wire before the solder is applied, which helps the solder to flow properly over the joint. Many modern components have pins rather than tags, and it then becomes a matter of coiling a turn of the wire around the pin and then completing the joint.

It is a good idea to "tin" tags and pins with solder prior to making connections. It is also a good idea to give the ends of the leads the same treatment, but using a thin coating of solder. If you use a large amount of solder it will be difficult to form the wire into a hook shape or to coil it.

With both surfaces "tinned" with solder there is virtually no chance of producing a "dry" joint. If one of the surfaces will not take a coating of solder it is contaminated with dirt or corrosion. Gentle scraping with the blade of a penknife or using a small file should clean things up and permit the surface to be properly "tinned".

We have been assuming here that the controls and sockets will be mounted off-board and hard-wired to the circuit board. Some projects do actually have these components mounted on the circuit board, and this slightly simplifies construction. However, with this type of thing you have to make quite sure that you buy the right components or you may well find that they do not fit onto the printed circuit board.

Dolly Mixtures

Sockets and switches are both potential areas of confusion, mainly due to the large numbers of different types that are available. Sockets were covered in a *Techniques* article not that long ago, so we will concentrate on switches here.

Where a relatively simple switch is required the usual choice is either a toggle or slider type. A toggle switch is operated via a lever (known as a "dolly"), and as its name suggests, a slider switch has a sliding control knob.

The full-size toggle switches are little used in modern projects due to their large size, and it is the miniature and even smaller sub-miniature types that you are more likely to use. Slider switches are the less popular option as they often have rather awkward mounting requirements, and in my many years of experience they do not always operate reliably.

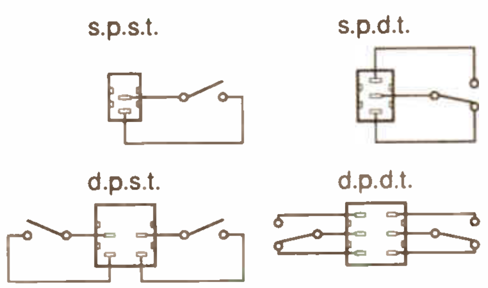


Fig.1. Contact arrangement used for the four normal types of toggle and slider switch.

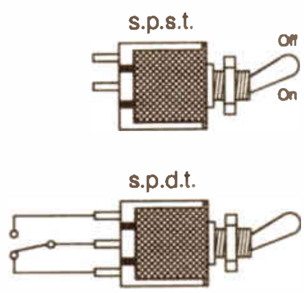


Fig.2. Try not to make the classic mistake of confusing switch settings.

Both types are available in four common forms, and the simplest is the s.p.s.t. (single-pole single-throw) variety. This has just two tags and is a simple on/off switch. The d.p.s.t. (double-pole single-throw) switches are basically just two on/off switches in a single case and operated in unison.

A s.p.d.t. (single-pole double-throw) switch has three tags, and is more commonly called a *changeover* switch these days. The middle tag (the "pole") connects to either one or other of the other two, depending on the setting of the switch. A switch of this type could, for example, be used to select either the square or sinewave output of a signal generator and connect it to the output socket.

A d.p.d.t. (double-pole double-throw) switch is effectively just two s.p.d.t. switches in a single case and operating in unison. Fig.1 shows the tag arrangements normally used for all four types of switch, together with their circuit symbols, which should help to clarify the differences between them.

Mind Of Their Own

Most component catalogues include a few "biased" switches. Probably the most common example of a biased switch is the simple pushbutton variety. These are s.p.s.t. switches, but the pair of contacts is only closed while you press the button. As soon as you release the button it springs out and the switch returns to the off state.

There is actually an alternative type, which is normally switched on, and switches to the off state when it is operated. Both types of switch are biased to one position, and will always take up that position unless the user intervenes.

Some toggle switches are available in biased versions, but this type should only be used when it is specifically called for in a components list. Some toggle switches are available in three-position versions, possibly with a version that is biased to the middle position.

In the middle position the centre tag does not connect to either of the other two. This gives two modes of operation plus a sort of central "off" position where neither mode is selected. Again, switches of this type are only needed for a few specialised applications, and should only be used when specifically requested in a components list.

When using toggle switches do not make the classic mistake of getting the two positions of the switch confused. With an on/off switch there is little risk of this happening, but with a switch that is used to control some other function there is a greater risk of confusion.

Many years ago a number of readers had problems with a transistor tester design of mine. The testers actually worked fine, but an ambiguous drawing resulted in some readers getting the *pnp* and *npn* modes muddled up.

The upper drawing in Fig.2 shows the on and off positions for single-throw toggle switches. With double-throw switches the middle and lower tags are connected together when the dolly is in the "up" position, as in the lower drawing of Fig.2.

Note that slider switches have simpler mechanisms that operate the other way round. The middle and upper tags are connected together when the control knob is in the "up" position.

Rotary Switches

Rotary on/off switches are mainly intended for use with mains powered equipment, and they are d.p.s.t. types that can switch *both* sides of the mains supply. They can be and are sometimes used in battery powered equipment, where both the positive and negative battery leads could be controlled by the switch.

However, this is generally considered to be a bit "over the top". One pole of the switch is left unused and the other normally controls the positive battery lead.

The tag arrangement of rotary on/off switches gives little clue to the correct method of connection, and the same is also true of the switches fitted to "switched" potentiometers. Fig.3 shows the correct method of connection for both single and double-pole operation. For single pole operation the upper pair of tags are used in Fig.3, but the correct switching action will obviously be obtained if the lower set are used instead.

Multi-way Switches

The switches described so far only provide two-way operation, or a sort of 2·5-way operation in the case of switches with a central "off" position. Some applications require switches having three or more positions, and there are two general approaches to this type of switching.

One is to have a bank of linked push button switches, and banks of pushbutton switches are common in ready-made equipment. This method is not popular amongst home constructors though, as it tends to be extremely expensive to implement.

Unless some really complex switching is required a standard rotary switch is the normal choice. These are available in 12-way 1-pole, 6-way 2-pole, 4-way 3-pole, and 3-way 4-pole versions, and all four types look basically the same.

Getting this type of switch connected correctly can be a bit tricky, and you have to proceed with due care. Modern rotary switches are marked with letters and numbers that aid the correct identification of the tags. The pole tags are marked with letters from A to D, and the other tags are numbered from 1 to 12, as in the two examples of Fig.4.

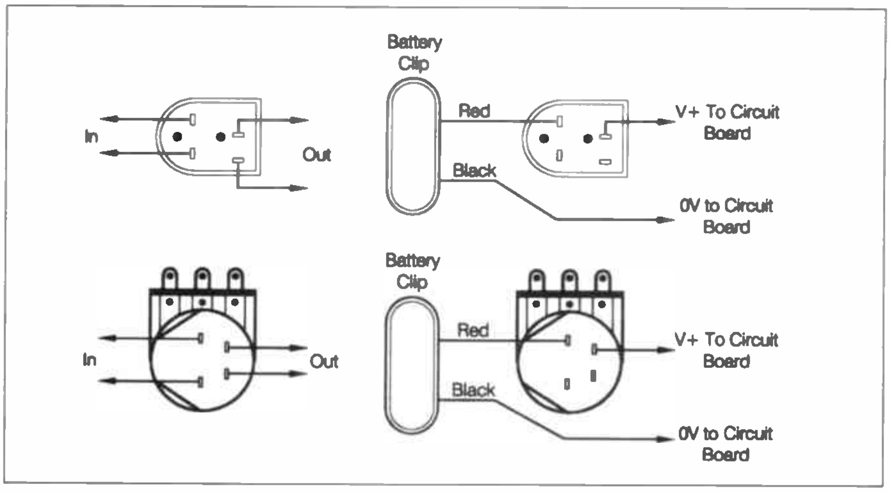


Fig.3. Correct methods of connection for a rotary on/off switch and a switched potentiometer.

With the 6-way switch, pole tags A and B respectively connect to tags 1 and 7 with the switch at position one (set fully counter-clockwise). Moving the switch to position two connects tags A and B to tags 2 and 8 respectively, then tags 3 and 9 at position 3, and so on.

With the aid of a wiring diagram and the markings on the switch itself it should not be too difficult to get everything connected correctly. In practice matters are made more awkward by the fact that the small letters and numbers moulded into the case of the switch are difficult to read once it is mounted in the case.

It is often helpful to mark the position one tags (e.g. tags 1, 4, 7, and 10 of a four-pole switch) with a small blob of paint on the body of the switch. This makes it easy to navigate your way around the switch and helps to avoid errors.

Modern rotary switches have adjustable end-stops so that they can be used with less than the maximum number of settings. Also, in many projects one or more poles of a rotary switch are left unused. If (say) a 5-way 1-pole switch is required, you would actually use a 6-way 2-pole type with the end-stop set for 5-way operation and one pole left unused.

If you remove the fixing nut and washer from one of these switches the metal end-stop can be dislodged using the blade of a small screwdriver or a penknife. With the end-stop relocated in the appropriate slot the switch is ready to be mounted on the project's front panel.

Make or Break

Multi-way rotary switches are normally offered in two versions that are called "break-before-make" and "make-before-break" switches. The difference between the two revolves around what happens as the switch is moved from one position to the next.

With a break-before-make type the pole is disconnected from one tag before it is connected to the next. This leaves the pole tag momentarily connected to nothing. With a make-before-break switch the pole is still connected to one tag when it makes contact with the next. This means that the two non-pole tags are briefly connected together as the switch is adjusted from one position to the next.

If a components list does not specify one type or the other there should be no problem using either kind of switch. If a make-before-break switch is specified and you use the other type it is unlikely that there will be any dire consequences, but the project may glitch in some way each time the switch is operated. For instance, there may be a loud "click" from a loudspeaker, or the pointer of a meter might "twang" across the scale and hit the end-stop.

Using a make-before-break switch instead of a specified break-before-make type almost guarantees dire consequences. Each time it is operated there will be a momentary short circuit on the supply lines, two outputs will be briefly connected together, or something of this nature. Apart from greatly shortening the life of the switch this could also result in expensive damage to other components in the project.

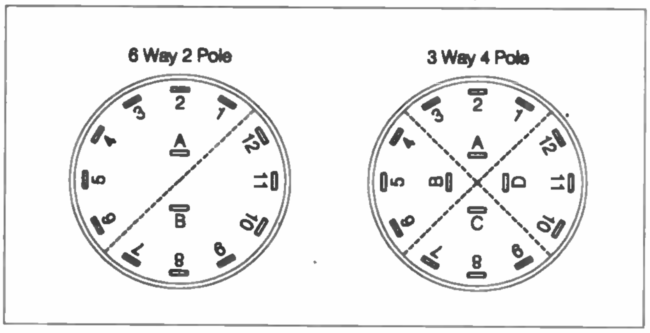
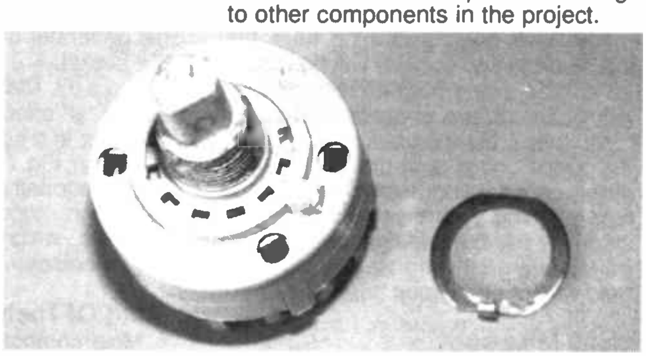


Fig.4. The tags of rotary switches are normally labelled, as in these two examples.



Rotary switches are normally equipped with an adjustable end-stop

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

The DMT-1010 is a $3^1/_2$ 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.

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★ LETTER OF THE MONTH ★

WHAT WONDERS!

Dear EPE,

First I would like to congratulate you on your excellent magazine. I am 16 years of age and have been enjoying the wonderful world of electronics for quite a few years now. There are three main points which I would like to mention.

The first is concerning electronics and the media. Where magazines are concerned, I think they go a long way to help people learn about electronics, *EPE* catering for that nicely, but what about "electronics through TV"? I have never seen a TV programme that is completely about electronics, and given the number of channels available, there's no excuse for the lack of them. I may be wrong (I hope so), so if anyone can tell me of any that have been, or will be shown on TV, then I would be most grateful.

My second point is regarding the cost of components. If I see a company selling reasonably priced components then I will buy them, but there is another place components can be bought cheaply – boot sales. My family enjoy going to them and I have found many electronic component bargains. I know that it's true you run the risk of buying damaged/faulty goods, but that's a risk which I am prepared to take.

My final point is regarding what could be called "Electronics vs Software". A lot of companies and individuals now make all sorts of things that are software driven. I love making all kinds of circuits and repairing things which don't work, and wonder which will become the most favoured – a circuit that is (usually) reduced in size plus software, or a circuit that is (usually) larger in size without software. The former seems to be proving promising and gaining acceptance (PICs are helping a lot – especially the amateur).

Either way, there will always be something to repair (although malfunctions are becoming rarer). This may mean that the electronics engineer may not only be required to have a knowledge of electronics circuitry, but also software.

Matthew Stuart, Romford, Essex

It's good to hear from you Matthew, and I am delighted to choose your letter as this month's leading letter. I trust the meter we are sending you will last for years and not need your skill at repairs!

On your first point, the only fully electronics programs that I have ever seen on TV are those broadcast by the Open University on BBC2, after midnight. Extremely well-presented they have been too. They are not too advanced, and basically take the form of early introductions to different aspects of the subject (at least, those that I've seen have had this nature).

Details of contacting the OU are often given at the end of their programs – which are also broadcast on some mornings (although I've never watched them at that time). If you find out when such broadcasts are going to take place (as the OU should be able to tell you), you could video them.

What may also interest you, are the videos that we sell (advertised in each issue). It is appreciated, though, that they are not pocket-money priced.

Regarding boot sales, I've not used them, but in my early days of electronics I used to be able to buy old TVs and radios from street markets; they were an excellent source of components for a young (nearly pennyless!) experimenter.

Electronics vs software? There's surely no competition – it's not that cut and dried. The whole scene is too intermingled and can't really be fully separated. Software is not just that which you load into your PC, its the code that is written for such things as PICs and other controllers. Then it gets more complicated in that the functions performed by the software often become turned into hardware – chips that have the controlling programs actually designed into them as silicon (or other) semiconductor structures.

Incidentally, PICs are not the only microcontrollers which offer powerful solutions for designers – there are many other types available from many manufacturers.

Periodically we are criticised for the emphasis we put on software projects. In a nut-shell, it is essential that we should. Whilst many simple designs can be constructed using "pure" electronics, once you start getting into slightly more sophisticated or complex requirements, it has become undesirable to attempt to do them without software (and I use the term in a very general sense) in some form or other, whether its loadable code or set in silicon.

All Matthew's points are worthy of further discussion, let's hear from the rest of you!

APPRECIATING PLUGS

Dear EPE,

Thank you very much for taking the time to review our catalogue and your kind words said about it in your June '99 issue. We worked hard on the catalogue and I am pleased that our hard work was worth it.

I am glad you are impressed by our products, it feels good to be praised by the experts!

Phil Goodman,
Marketing Co-ordinator,
Pico Technology, Cambs

Thanks, Phil. On a personal level I know the amount of work that goes into designing products such as yours (my Virtual Scope *of Jan-Feb '98 took months of my time).*

On a wider level, we are always pleased to publicise new products introduced by our advertisers, all of whom are invited to send us a brief description, and a photo as well if appropriate. We have always offered this option through our news pages. The wonder is that so few advertisers actually take advantage of it, it is, after all, FREE publicity.

PC PORTS AND DELPHI

Dear EPE,

I was greatly enthusiastic upon reading your June '99 *Interface* to discover you are finally thinking about dumping the truly fantastic (for its time) language of QBasic, to go into the world of visual programming. However, your Delphi programming code did not recognise **PORT** as a command, although it is in the *Help* file. As with you, I too have had problems getting it to work with Delphi 4. I have an answer, though, the following standalone **.EXE** files work on my '98 machine.

To output in QBasic, you would normally write:

```
OUT PortAddress,Value
```

The same in Delphi 4, in between the **begin/end**, write:

```
ASM
  PUSH DX
  MOV DX,$(Port address, in hex)
  MOV AL,Value
  OUT DX,AL
  POP DX
END;
```

As for the read-from-port variant, before the **begin** statement write:

```
var
ByteValue;byte;
```

Then between the **begin/end** write:

```
ASM
  PUSH DX
  MOV DX,$(Port address, in hex)
  IN AL,DX
  MOV ByteValue,AL
  POP DX
END;
```

Michael Ure, via the Net

We passed your letter to Robert Penfold who says that he too had found a similar solution and that he will discuss it further in a future Interface.

It's interesting to note that much of your code is almost identical to that which I have used for many years when writing in 8086 assembler. There are many examples in my code for such projects as the Virtual Scope *(Jan-Feb '98) and* PIC Toolkit Mk1 *(July '98).*

The assembly software I use is the excellent shareware A86/D86 Assembler/Disassembler, in conjunction with Intel's 8086 User Guide. *The codes are seemingly compatible with processors of the 8086-upwards variety, including Pentiums. A further example of such code will be shown in connection with my forthcoming* 8-Channel Analogue Data Logger, *which uses the new PIC16F877 microcontroller. It can be interfaced to a PC via a mixture of QBasic/QuickBASIC and '86 machine code.*

The A86/D86 software is available from the Public Domain Shareware Library (PDSL), Dept EPE, PO Box 131, Crowborough, East Sussex, TN6 1WS. Tel: 01892 663298: Fax: 01892 667473. It is well worthwhile asking for their catalogue.

PhizzyBLY IMPRESSED

Dear EPE,

My compliments to all concerned on such an excellent product as the *PhizzyB*. The idea behind the concept is just brilliant! I would like to pass on a few ideas that I think all *PhizzyB* users would benefit from.

When people purchase a product such as the *PhizzyB*, you can't beat having a hard copy of the user manuals. If the books were in print people would not mind paying extra for that printed hardback/softback for referring to when experimenting and (playing) with the *PhizzyB* – a home made printout version is not quite the same.

Will you be setting up a web-based user group, where people could submit their designs, circuits and code? Here people could share ideas, and there could be a community of *PhizzyB* users helping each other and learning together.

Is it possible to connect a QWERTY keyboard to a *PhizzyB*. If so, where can I find out more details? As a future venture I am going to add process control, from which I can switch on lights, control temperature and set up cascade loops and much more. The list of ideas is endless. With a QWERTY keyboard connected it will be the ultimate project.

Thanks again for providing me and many other *PhizzyB* users with such an excellent and versatile educational piece of equipment. I am beginning to realise that the back-up behind this board is second to none and that you are available via E-mail to help with any problems. I have found that questions are always answered!

I love the *PhizzyB* and I can't stop using it. My mind just works overtime thinking up new ideas and projects which the *PhizzyB* can be used to control.

Stephen (otherwise ANON), via the Net

We all love to be praised and take the bows, but it's "Max" and Alvin that Stephen is really lauding, so Lord Max, what do you say?

We are thinking about creating a *PhizzyB* book, which would include all of the articles from *EPE* and *EPE Online*, plus some of *PhizzyB's* circuit diagrams which were never published thus far (and discussions on them), plus the manuals – everything in one book.

We think the web-based user group is a great idea if sufficient people are interested. The first stage of this is in the final part of the *PhizzyB* series (June '99), where we suggest that readers might want to submit some *PhizzyB*-related circuits to the *Ingenuity Unlimited* column. Also, if you (or anyone else) did design an interesting circuit (or program), we'd be delighted to add it to the *EPE Online Library*.

A bigger idea is to synthesize the Beboputer into an FPGA or an ASIC to create a real CPU that executes native Beboputer machine code (this would be much faster than the current *PhizzyB* which interprets it).

The real problem is that we're up to our ears in other projects at the moment – one such project is *Bebop Calculates Cunningly* which will be another Beboputer-based book/project. In this case the front end interface to the simulator will be a full-function calculator – the task of the book is to teach integer and floating point concepts, and to create the assembly code that "goes behind" each of the calculator's buttons. The great thing about this is that we're designing it to be *PhizzyB*-compatible.

As to adding a QWERTY keyboard to the *PhizzyB*, this shouldn't be too complicated at all. What you want is a keyboard that when you press a key presents the ASCII code on an 8-bit port that you can connect to one of the *PhizzyB's* input ports. Then you have to write a program that loops around waiting for you to press a key – the program would then have to decide what to do with each key. Our book *Bebop BYTES Back* discusses such programs.

Thanks very much for your enthusiastic support – tell all of your friends! Let us know how you get on. **"Max" Maxfield**

ABSOLUTELY, KELVIN

Dear EPE,

I read with interest your Letter of the Month (June '99). I must agree with all that has been commented on, however – just to throw some salt onto the wound:

When we are using the Kelvin scale for temperature, the word "degree" is always dropped. For example, water freezes at 273 Kelvin, water boils at 373 Kelvin, Absolute is 0 Kelvin.

Now it's my turn to be super critical! I thought this might be of interest to some of your readers.

Maurice Clarke BA, Banbridge, Co Down

Yes, I know so, but forgive a chap when he's hastily keying in (yes, I do my own keyboard thing!) two pages of Readout *to meet a press deadline, if he occasionally overlooks a slip of the tongue!*

In fact, as any dunderhead probably knows, the name "degree kelvin" was discontinued by international agreement in 1967 (though why they should seemingly waste their time even bothering to discuss it is beyond me). The unit is named after Lord Kelvin (1824-1907).

Just to be pedantic, a temperature expressed in °C is equal to the temperature in kelvins less 273·15°C (note the small k for kelvins, although the symbol itself is capital K).

Your criticism is taken in good humour – we're quite happy to be criticised as long as it's courteous and constructive!

BAR QUOTES

Dear EPE,

If you must delve into definitions, you should try to quote correctly! Referring to the letter *Hot Bars* in the June '99 issue, a Bar is defined as 10^5 Pascal and hence a millibar is 100 Pascal, not a hundredth of a Pascal as you quote in Mr Phillips' letter. The hecto prefix means 100× and so a hectoPascal correctly equates to a millibar.

T.B. Owen, Aberystwyth

But I did correctly quote exactly what John Phillips said in his E-mail. What you have spotted is that he "inverted" his reference (excusable, perhaps, as he lives "down-under"!).

DAC VAGARIES

Dear EPE,

Having read the very interesting and practical *Voice Record/Playback Module* article by Robert Penfold in your April '99 issue, his comments on the "vague description" of the "digital-to-analogue converters" in the ISD chip are misleading.

In fact, this chip uses directly sampled analogue voltage storage on what would otherwise be an EEPROM. Normally, such storage devices have their stored voltage quantised as high or low, but in this chip, a voltage is written and read out directly. This allows a whole "sample" to be stored on one cell, and does not require, for example, eight or twelve bits to store a digitised version of the sample.

Keith Lambell, via the Net

Robert replies:

On taking another look at the ISD14xx data sheet, I see what Keith means. The "multilevel storage array" does seem to store voltage samples rather than digitised versions of them. The data sheet for the earlier ISD devices is a bit more forthcoming, but does not go into any great detail about this aspect of things.

These chips are not actually digital storage devices at all, and are more akin to "bucket brigade" delay line chips than a digital storage medium. This would account for the excellent audio quality. Although one might expect the sample voltages to decay over a period of a few years, the data sheet quotes a typical retention period of 100 years!

Robert Penfold

CACHE CATCH

Dear EPE,

Ernest Flint's article on PC microprocessors (*PC Engines*) in the May '99 issue contains a few errors. In particular:

1. Celeron processors which have the 128KB L1 cache (the 'A' types) run the cache at the full CPU clock speed, not half speed as stated. So, although the cache is smaller than in the P II, it's twice as fast. This information can be found at **www.tomshardware.com**, the link given at the end of the article!

2. The original Pentium range started at 60MHz

3. The PIII range starts at 450MHz

As for why IBM used an Intel processor, I believe it was because they wanted to use off-the-shelf components, and all the required support chips were available for the Intel processor, unlike the other 16-bit processors of the time.

I got this information from *Accidental Empires*, by Robert X. Cringely (ISBN 0-14-025826-4). For anyone interested in the history of Microsoft, IBM, Apple and others, and the people behind it all, this book is great.

Anyway, thanks for an interesting article and magazine. And I like the new history section on the web site. The first issue of *EE* I bought was the combined June/July 1980 one. I built my first project – a 1W audio amplifier – from that.

Alan Edmonds, via the Net

Alan's comments were sent to our Dave (Deputy Editor) who felt the reply should come from Ernest Flint's "mighty quill", which prompted the following:

I'm not sure that I'm too keen on people talking about my "mighty quill" in public like this, I don't know what my mother would think:-) Anyway, my response is as follows:

Arrggghhh! Alan E. is perfectly correct and I bow my head in shame to the master (it's a pity he didn't write this article himself and save us all a lot of trouble). The original Pentium range did indeed start at 60MHz, the Pentium IIIs do start at 450MHz, and the Celeron "A" type processors do indeed run their L2 cache at the full clock speed.

In my own defence, I would point out that we are all subject to the occasional finger slip. Even Alan in his point (1) refers to the Celeron's "128KB L1 cache", when in fact he meant to say "L2 cache".

On the brighter side, I'm delighted that Alan found my article to be of interest and I very much appreciate his taking the time to inform me about these errors. I will now retire to my study to chastise myself soundly and enter a disciplinary note into my permanent record.

Ernest Flint, via the Net

We were slightly taken aback by Alan E's comments on the "double EE issue". Checking back on our bound copies for that year, we were reminded that indeed the June and July issues had been combined into one. Editor Mike recalls that in those days problems between IPC (the then publishers) and Unions occasionally came to the fore. On this particular occasion, there was a strike over some matter or other (memory fails on what it was) and once it was over, there was no option but to combine two issues.

These days, as an independent magazine under Mike's ownership, we pride ourselves about being on-time, every time! (Hope I get extra Brownie points for saying so!)

ENBRIGHTENING!

Dear EPE,

Would you know how I can contact Kingbright, the manufacturers of some large 7-segment displays that I bought at a boot sale? I want to obtain the data sheets.

W. Alton, Broadstone, Dorset

Our Online Editor Alan looked it up on the web: their site is at ***www.kingbright.com*** *and Rapid Electronics are one of their distributors, tel: 01206 751166.*

Everyday Practical Electronics Books

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(Published by *Everyday Practical Electronics*)
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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.

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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

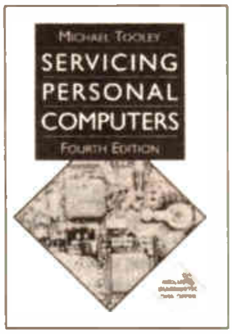
Testing and Test Gear

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 costruct, 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!

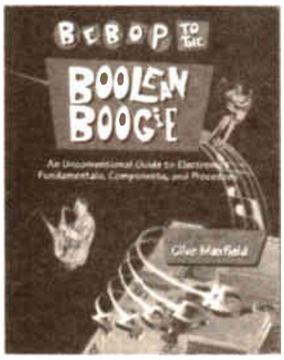
128 pages **Order code BP282** **£4.95**

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.

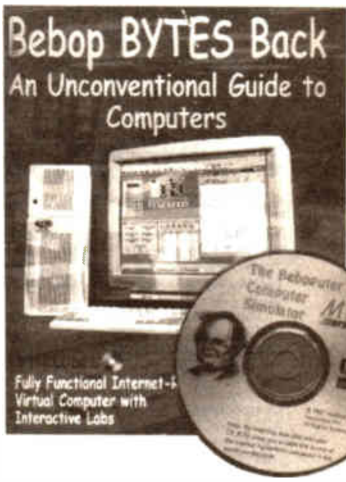
Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

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 **Order code PC107** **£8.95**

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
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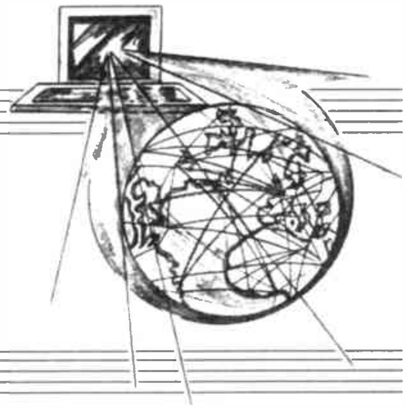

NET WORK

ALAN WINSTANLEY

NET WORK is our column specially written for Internet users. Join us on our web site at **www.epemag.wimborne.co.uk**, where you can leave messages, subscribe, browse our on-line index of earlier volumes and more besides!

IT'S A HOAX!

In previous months I highlighted the difference between computer virii, Trojan Horses and worms. These potentially damaging files can be transmitted via the Internet, and unsuspecting Internet users can find themselves on the receiving end of an unprovoked attack from some malicious or irresponsible elements.

Before I develop this topic any further this month, here's a riddle. What do the three Budweiser frogs and Yellow Teletubbies have in common? They are actually examples of a fourth class of virus, namely the hoax virus. These cause a great deal of unnecessary concern amongst inexperienced users. Typically, a hoax virus arrives in the form of an importunate E-mail message warning of possible dangers that might arise, for example, if a completely unrelated computer file – say a screensaver – is opened. Panic spreads and the warning is flashed to other regular contacts. Thus the virus escalates.

These virii tend to come and go. Whilst some types of hoaxes are obviously harmless fun, there is no doubt that other types really do have a worrying effect on their recipients. The hoax panics people into spreading the word about a possible "new" virus which is alleged to be doing the rounds. It is the actual propagating of these well-meaning messages by the inexperienced which is the "damage" caused by the hoax virus; I have recently received several from concerned and well-intentioned readers.

In view of the current TV advertising campaign in the UK by Budweiser beers (featuring the three frogs), it seems timely to remind readers of the hoax **budsaver.exe** virus. This hoax (also known as the Bud Frogs) relates to a mythical screensaver called **budsaver.exe** which is said to crash a hard drive. It is a complete sham, and there is no need to be worried by any such message. (I suppose this situation is fine until someone really does release a virus under that name.)

A similar hoax called **Buddylst.zip** (or Budweiser) has been on the go for some time using several forms of message which can equally be ignored, as can one relating to Yellow Teletubbies (!). There is a whole raft of hoaxes described on the Symantec web site (**www.symantec.com/avcenter**), and readers should make a habit of checking it occasionally to stay abreast of both hoax and malevolent virii.

FALL OUT

On the other hand, a highly malicious virus which has recently been causing much concern is called **W95.CIH**, also known as **Chernobyl**, **Network Nuke** and other names. It triggers on the 26th of a month (the anniversary of Chernobyl) and infects Windows executables. Worse, it may also try to modify some Flash BIOS chips which can cripple some systems. Symantec has a free tool available from their web site called **kill_cih** which enables users to check for the presence of **Chernobyl**. It runs from the DOS prompt, and although it will not cleanse a system, says Symantec, it will disable the virus and alert the user.

Don't overlook the fact that apart from introducing virii onto your system via E-mail or FTP'd files, there are other ways of inflicting damage, perhaps of a temporary and easily-recoverable nature. Some web sites are deliberately set up in order to demonstrate a possibly harmful feature – e.g. a software bug – or to make a particular point. Hopefully you will be warned of any possible dangers in advance. These events are sometimes called *exploits*.

If you have a Pentium III processor, a good example of an exploit which will test your courage will be found at **www.zeroknowledge.com/p3/**. This informative web site purports to blow the whistle on the serial number embedded in P3 processors. Even with the serial number disabled, the number can still be accessed, says the web page. It clearly warns that after running the demo, your system may lock up afterwards and it also says that any anti-virus warning that your software may generate beforehand, should be ignored. This latter warning is understandably enough to deter some hardened computer users, but you can access the site and see for yourself!

STUCK ON THE ON-RAMP

Having spent many weeks agonising about upgrading to BT Home Highway to obtain ISDN access, I have decided to shelve the idea, at least for now. I found there are several potential "gotchas" which need thinking about. One is that BT won't guarantee the speed of access using ISDN2e anyway, which might defeat the point of installing it to begin with.

Problems with modem speed may also arise in case you find that you have previously been "DACSed" by BT, which involves using a converter to multiplex two phone lines down a single twisted pair copper wire. It saves BT the cost of having to install extra wires. Using ordinary dial-up modem access, some users who have been "DACSed" complained that they could barely scrape much more than 30Kbps, even though they were supposed to be paying for a second "clean" line. After some persistent complaining from users, BT have in some cases relented and installed a separate wire.

Another problem was that, due to my current DACS connection and the way in which telephone numbers are used in "blocks" by BT, they advised that a change of number will probably be required, even though BT's literature states that for the majority of users this won't be the case.

BT Home Highway does offer several advantages though. A primary one is that Internet access is almost instantaneous – a second or two rather than 45-60 seconds. For myself, this would probably be the biggest boon. Faster access times may or may not be enjoyed by Highway users, and by "bonding" two channels together, they could experience a theoretical speed of up to 128K. (Users of earlier Windows 95 versions require later versions of Microsoft Dial-Up Networking (DUN) for this – check the Microsoft web site.)

What readers may not be aware of is that, in using channel bonding, two calls are being made at twice the cost, and two ISP connections are paralleled at the same time. Not every ISP permits this with an ordinary dial-up account, so their terms of service should be consulted.

Other benefits include the fact that one Home Highway line will offer two analogue and two digital ports. You can use any two ports at the same time, i.e. an analogue phone or fax machine alongside either a terminal adapter (an ISDN external "modem") or another phone, or two PCs each on 64K, or two digital ports bonded together to produce a theoretical 128K on one PC.

The economics are reasonably simple to calculate: the cost of calls is the same as an ordinary analogue BT line, and discount number schemes still apply. Presently it costs £40 per month excluding installation, but includes a £15 call allowance. You may be able to recover more of the cost by making an existing BT line redundant, as HH gives you two lines. A BT survey is necessary before ISDN can be installed and more advice from BT is available on Freephone 0800 222444 or **www.homehighway.bt.com**. In the meantime we can only dream of the advent of high bandwidth ADSL (asymmetric digital subscriber line) and 9Mbps download speed, which is likely to be several years away for most UK users.

LINKS

As always, I have gathered more interesting URLs together on the *Net Work* web page and I welcome readers' suggestions for interesting electronics-related addresses. My E-mail address is **alan@epemag.demon.co.uk**.

PCBs FROM PAST ISSUES OF ETI

(prior to the merger of EPE and ETI in March 99). See below for ordering details.

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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.**

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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_unlt.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**

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